schweizerisches implantat-register
registre suisse des implants

SIRIS

Swiss National Hip & Knee Joint Registry

Report 2022

Annual Report of the SIRIS Registry Hip & Knee, 2012–2021

Ten Years of Swiss Hip and Knee Registry

ano

swiss orthopaedics

UNIVERSITÄT BERN

Hip and knee replacement results 2012 – 2021

SIRIS Report 2022

Annual Report of the Swiss National Joint Registry, Hip and Knee

SIRIS – Foundation for Quality Assurance in Implant Surgery

swiss orthopaedics – Swiss Society of Orthopaedics and Traumatology

ANQ – National Association for the Development of Quality in Swiss Hospitals and Clinics

SwissRDL – Medical Registries and Data Linkage, Institute of Social and Preventive Medicine, University of Bern

Preface

This is not the end. It is not even the beginning of the end. But, perhaps, it is the end of the beginning.

Sir Winston Churchill

The idea of a non-for-profit, national Swiss implant registry - initially devoted to monitoring revision rates of total hip and total knee replacements - goes back to 2007. Despite the existence of a foundation with respectable seed money, no firm commitments, organizational structure and funding concept were agreed upon until 2010. It was clear that to be of value, the registry would have to record virtually all primary implantations and guarantee that neither hospitals nor « bad cases» in a given hospital could be excluded. In addition, the revision rates were only valid if any revision performed anywhere in the country could be connected to the original implantation. Lastly, a way of funding the operation of the registry had to be worked out. With the support of the med-tech industry, Swiss Orthopaedics could propose and implement a solution which fulfilled these prerequisites and to which hospitals, the insurance representatives and anq could agree, so that operations could start in 2012. Looking back, the opposition to the registry in these days were by no ways only financial concerns: Certain hospitals or physicians feared that the registry could be abused as an instrument to blame or discredit institutions, companies, or individuals. By now, we know that such concerns are unjustified. The registry is here to assist surgeons, hospitals, and industry to treat patients better.

We always believed in the quality of our procedures. This has been changed. By the registries: We now have data. In the last report of 2021, results of SIRIS have started to become more robust and comparable to the leading registries in Sweden or Australia. The results concentrate on complications and revision within the first two years: It is not an error of the registry but of our interpretation of data if we do not consider that revision is a crucial, but not the only parameter describing the outcome of a total joint procedure. In the long run, to determine the real value of a certain patient-physician-hospital-implant combination, more patient data than revision will be necessary.

Occasionally, registry data can identify parameters which are valid independent of patient, surgeon and hospital and eliminate all doubt: XLPE is better than regular polyethylene. For almost all indications in all registries around the world.

Occasionally, it can disprove clinical concepts of superiority: Cemented femoral stems are not inferior to uncemented stems in terms of revision: interpretation is, however, insufficient to influence our indications: if the analysis of the data would e.g., show, that the increased rate of femoral fractures of uncemented stems applies only for elderly women, it probably would.

Occasionally, a registry suggests that two treatments are equal: in fact, it does not. It only suggests that revision rates are equal. The fact that two approaches for total hip replacement yield comparable longevity of the implants may not be very important for the patient. Conversely that fact whether he is limping, has pain for the fifteen years until revision may be much more relevant for the patient and the surgeon will choose according to such criteria amongst the approaches with comparable revision rates.

What can registries do, what can they not do?

They give us data which are accurate, reliable, representing the real world and not an experimental setting. I submit that they are probably the only source of data which is solid and here to stay. A registry could include a lot more clinical data than just revision. They could come from a minimal data set and increase the potential of medical and socioeconomic registry impact substantially. If minimal preoperative data were available, the registry could ultimately determine the delta brought by our interventions and assist in selection of indications

An optimal analysis and interpretation of the currently available data can already help us for our indications: A or B may overall be better. But for which specific cohort is this true? For which one is it not? Here, the scientific board's questions are crucial, and it is easy to anticipate that artificial intelligence will ultimately be necessary to make a next substantial impact, especially if more than revision data are added.

Despite all these unparalleled advantages, **a registry will not tell us "why".** Strangely, the human being is often more interested to find out why things are so than whether they are so. Registries provide us with the facts. They do not explain them: They thereby furnish the most formidable and relevant research questions.

Registries are not able to address the necessity and adequacy of indications and at least as long as we do not have a minimum of ingo data, they do not identify optimal, but only reflect current practice. A field for professional ethics and character of the physicians and hospitals

The medical literature privileges randomized controlled trials (RCTs) as sources of reliable and valuable information. It is agreed that registries will have to collect more relevant clinical information. Nonetheless, for assessment of treatment value in Orthopaedics, I think that registries are superior to RCTs. In fact, I think that for the above purpose, RCTs are an ineffective, inefficient, and outdated methodology. This is in opposition to their value in assessing risks of medication or procedures as in phase II studies. The problems of RCTs in Orthopaedics in comparison to registries are multiple:

Patient and site selection: RCTs often must exclude probably more than 50% of real patients needing a procedure to have fully comparable cohorts. The excluded patients limit the value, as we do not see highly selected patients with multiple exclusion criteria. The registry does not do that. The sites executing RCTs are often highly specialized centers with potentially certain biasing interests, but they do not represent the care provided by any care provider in the country. The registries do.

Difficulty of organization execution and cost: RCTs are difficult and extremely laborious to organize, to get approved, expensive to carry out and monitor, registries are much less so. RCTs do usually collect more information than registries but this can be corrected by a more comprehensive collection of data in registries.

Results and their impact: RCTs with the same research question and the same methodology have delivered conflicting results. Treatment of the first traumatic shoulder dislocation with or without brace is just an example. RCTs have had little impact: I do not know of many RCTs which would have changed clinical practice in orthopaedic treatment (as opposed to other medical disciplines).

RCTS do not assist in innovation and come after the fact: Neither total joint replacement, nor ORIF, nor arthroscopy nor reverse total shoulder arthroplasty nor pedicular screw fixation were introduced with the help of RCTs or modified by RCTs. In fact, a true innovation is so strong that the community refuses to participate in RCTs. RCTs simply have not had impact on orthopaedic practice

RCTs only study cohorts and not patients. RCTs often find statistically significant differences which are clinically probably not even relevant for the patients within the cohort studied, let alone for an individual in our practice who had three or four exclusion criteria but needs the respective treatment. In a time in which we all demand personalized medicine, analyzing treatment benefit in small to mid-sized cohorts treated by highly selected medical institutions, seems anachronistic.

New, medically, and socio-economically most relevant questions are on the horizon: Is there true patient benefit of personalized, 3-D derived cutting jigs for each total knee? Does augmented reality really increase patient benefit? Does robotic surgery have a relevant patient advantage? If benefit can be proven, is it true for each sub-cohort or are there specific indications? Does the magnitude of the benefit outweigh its increased cost? If there is no benefit, how can such technology, so interesting for industry and so much fun for surgeons be stopped?

A registry like SIRIS has an enormous potential to provide us with realistic, relevant and valid information justifying what we do or justifying the changes we want to implement. SIRIS started from scratch. It is expanding into spine and shoulder. What has been accomplished is spectacular and requires our respect and admiration. And this is just the end of the beginning.

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All information in this report was composed with the utmost care. If any changes or modifications are made after publication, these will be published on our website www.siris-implant.ch, where you can also download the SIRIS Report 2022 and all previous reports.

Content

Introduction and methods

1. Introduction

1.1 Purpose of the registry

In September 2012, the Swiss National Implant Registry SIRIS was introduced to register hip and knee implants. Registration in SIRIS is compulsory for all Swiss hospitals that perform knee and hip arthroplasties , due to their participation in the ANQ's national quality agreement.

Clearly defining the aim of the national joint registry is essential to get all contributors and participants to pursue a common goal. This also influences which specific information is contained in the registry, since there will be different requirements for each of the partners involved. The fact that a multi-partner association was needed to get SIRIS off the ground meant that more than one point of view had to be taken into consideration in order for the registry to become successful and supported by all. Although each partner naturally tends to focus more on one particular aspect that reflects their particular interest, in the end there is one basic interest that is common to all partners: the long-term well-being of the patient after prosthetic joint replacement.

The patient's perspective. Patients expect joint replacement surgery to provide them with long-lasting, pain-free mobility. The operation needs to be adapted to their level of activity and should be tissue-sparing and complication-free, followed by rapid rehabilitation. The registry data should be presented in such a way as to be readily comprehensible, allowing patients to find information of interest despite the complex methodology behind the analysis. Not all patients will read the registry reports, but those who do might better understand and discuss their past or future surgery with their surgeon. The SIRIS registry should provide both parties with interesting topics and information to discuss.

The surgeon's perspective. Surgeons are seriously concerned with avoiding surgical complications and shortcomings for their patients. In fact, the desires of patients and surgeons are similar: the long-lasting, pain-free and full function of the prosthesis. However, by choosing a particular prosthesis, surgeons integrate the performance of the implant with their own expertise. The implants must be impeccably manufactured and versatile in order to avoid problems such as early loosening, wear particle disease, breakage, dislocation, infection, stiffness or chronic pain. A long, problem-free implant life with the minimum amount of wear on the bearing surfaces is the ultimate goal. Within a relatively short time frame, the registry should be able to identify problematic implants and provide valuable early warnings to surgeons. However, entering individual clinical results into the SIRIS data collection system is not a welcome addition to surgeons' already intense daily activities. Although surgeons certainly do appreciate benchmarking their own results, the controversial aspect remains the public availability of the information at the individual surgeon's level. This may lead to bias entering into the system and may as well modify patient recruitment practices.

The perspective of the industry. The industry's main activity is manufacturing and sales, driven by a legitimate profit-orientation motive. Designing and providing first-rate, problem-free implant systems is the mos long-lasting strategy, because a single implant that causes failures in a series of patients may lead to allegations of negligence that could ultimately destabilise the company. It is clear that economic viability coincides with the primary interest of the patients, i.e. the long-term well-being of the patient after prosthetic joint replacement. Progress and technical innovation are extremely important for an industry dedicated to providing safe high-performance implants.

The registry is also seen as an essential tool for post-market surveillance and clinical control that validates improvements in materials, designs and concepts in real-life clinical settings. If the industry accepts quality as being the principal market-regulating factor, then the registry is a welcome tool and motivates industry participation. The publication of two-year revision rates for registered implants in the SIRIS reports was met with great interest from involved providers (industry) and users (surgeons) of prosthetics replacements. It is not the purpose of the registry to regulate the market, but to define and provide quality assessment tools that are needed for market self-regulation.

The hospitals' perspective. Hospitals aim to provide high-quality and safe care to a large number of patients at reasonable cost. Hospitals are where surgeon/patient interaction takes place, with both parties sharing a common interest. After a prosthetic replacement, patients should feel so well that they forget their treated joint in daily life (the forgotten joint concept). However, hospitals or departments have an interest in ensuring that patients do not forget the institution where they were treated so successfully and that they return to the same hospital if necessary, including for reasons other than a prosthetic replacement. Personal recommendations from satisfied patients are the very best publicity. The registry is perceived as an instrument for quality control, not only for the implants used, but for the entire process, ranging from the preoperative consultation to the procedures in the operating room as well as the postoperative follow-up. As institutions providing healthcare in today's competitive environment, hospitals are also very keen to uphold their reputation and the registry is an invaluable tool for this purpose. Some Swiss cantons even require SIRIS reports in order to prove that the number of procedures are sufficient to place the hospital on contract lists. It appears that participating in the registry might be crucial for the survival of some hospitals. This is a strong motivation in an environment where hospital mergers and closures are frequently discussed. Since 2020, performance benchmarks containing the two-year revision rates of institutions registered in SIRIS have been published online (https://www.anq.ch/de/fachbereiche/akutsomatik/messergebnisse-akutsomatik/step2/measure/20/), and are updated with every new report.

The insurer's perspective. Insurers and third-party payers are concerned about healthcare costs, thus aiming for short hospitalisation times, no expensive re-admissions for complications and the patient's quick return to work. Insurers are very conscious of cost when it comes to implant pricing, medical honoraria and hospital bills. The insurer's desire is to provide equal benefits to all its clients within the budget available. The registry is therefore perceived as an instrument that can provide information regarding the performance of surgeons and institutions and function as a cost-quality tool. Since revisions cause massive additional and possibly avoidable costs, the focus of insurers remains the same as that of patients: long-lasting, pain-free function after prosthetic replacement.

The government's perspective. The government organises the healthcare system on behalf of all citizens. Therefore, the main challenge it faces is having to consider and bring together the needs and preferences of all players in the health economy. At the Swiss federal level, government may not have any inherent financial interest in the running of the system, but cantonal governments bear directly a major share of hospital costs and are very active participants in all debates on and around treatment in hospitals, outcomes and costs. Governments also have an interest in assessing an overall picture of the quality of healthcare provision. While

patients understandably tend to place their prime focus on receiving treatment that provides optimal and long-lasting results, the government certainly shares this aim but also has to focus on ensuring that high-quality treatment is cost-effective. Governments therefore need data on the overall surgical performance for public health purposes, for assessing needs and for planning the macroeconomic policies related to healthcare. Government health agencies are commissioned to ensure that the institutions under their supervision provide high-quality and complication-free healthcare to the general population. The agencies will also have an interest in benchmarking hospitals and in keeping insurance and third-party payer costs down to a reasonable minimum. One specific characteristic of the Swiss healthcare system is that cantons are independent and are the principal political and financial authorities for their healthcare systems. Furthermore, the healthcare system of the Principality of Lichtenstein (FL) interacts closely with the Swiss healthcare system and participates in SIRIS activities. Therefore, as of 2020, SIRIS is also presenting some cumulative data for Swiss cantons and FL. Although the fragmentation of the dataset down to cantonal level may sometimes preclude meaningful statistical analysis, the information can still be of interest to cantonal/FL governments and the public.

1.2 Strong commitment

The 2022 SIRIS report represents a collaborative data collection effort involving all the institutional partners of SIRIS and includes the surgeons and operating teams of 159 active orthopaedic or surgical units in 146 hospitals. Streamlining, improving and optimizing data collection is a work in progress involving expert groups and all members, including industrial partners.

Coverage is one important indicator for the commitment of all parties involved in SIRIS. However, it is difficult to assess because any registration system aiming to be a benchmark will have some specificities, strengths and drawbacks. For SIRIS, only performed arthroplasties submitted to the registry as closed cases can be used in the coverage analysis. As a benchmark, we use data from the hospital quality report published by the Swiss Federal Health Authorities (BAG) for the period 2017–2020 (data for 2021 is not yet available for inclusion in the SIRIS Report 2022). The data is available publicly and can be considered in relation to SIRIS data, although some details regarding coding and filtering definitions may differ. In 2020, the coverage of SIRIS was over 97% for primary hip and knee replacements (benchmark: for all reasons excluding trauma). High coverage rates confirm that the

commitment of all participating individuals and institutions remains strong. Further details about coverage can be found in Chapter 2 Methods, Part 2.3 Coverage.

Officially only started in 2012, the registry has achieved high coverage and continues to improve the content of reports that attract public attention. This demonstrates not only strong commitment to the project by the surgeons and their teams, both in public and private hospitals, but also the high quality of the organization, coaching and data collection by the SIRIS team. The SIRIS 2022 report provides information on the state of hip and knee replacements in Switzerland and presents a wealth of new information. The report also offers important and verifiable information that we hope the healthcare community, third-party payers, and healthcare regulators will find useful.

Table 1.1
Variables collected by the SIRIS registry

Factors	Variables
Patient related	Name
	Surname
	Date of birth
	Gender
	Height
	Weight
Surgery related	Main diagnosis
	Previous surgery
	Date and place of surgery
	Morbidity state
	Charnley class
	Intervention
	Approach
	Positioning
	Component fixation
	Cementing technique
Implant related	Type of implant
	Article number
	LOT number
	Company name
	Brand name

2. Methods

2.1 Maintenance and hosting of the registry

The Swiss National Implant Registry, SIRIS Hip and Knee is hosted and maintained by SwissRDL at the Institute for Social and Preventive Medicine (ISPM), University of Bern. A dedicated team consisting of a statistician/methodologist, data monitor, data management/IT specialists and support staff is responsible for the management and maintenance, technical support, analysis and reporting of the registry data. The data monitor supervises the data entries and supports and trains collaborators at the participating hospitals to ensure the correct and efficient running of the registry. Overall project management at SwissRDL is provided jointly by the data monitor and the statistician/methodologist. Both positions are also members in the SIRIS Scientific Advisory Board that directs and oversees the registry and, among other things, produces this annual report.

SIRIS data are collected on an online documentation IT platform (accessible at siris.memdoc.org). Clinical data on primary arthroplasties, reoperations and component revisions are recorded. Clinics may also register post-operative follow-up data at their own discretion. All individual implants used (including minor components) are registered alongside all relevant arthroplasties or revisions. The current versions of the SIRIS forms (v2021) for data entry can be downloaded from www.siris-implant.ch. Most participating surgical units use the online interface for documenting their operations, but some large centres send data exports from their hospital information systems to SwissRDL via a web service client. Alternative registration, based on paper forms that were sent to SwissRDL, was phased out in 2021.

Specific implant data are mostly entered into SIRIS by scanning the barcodes on the implant tags. Until 2019, it was also possible to enter the information manually via the web interface. However, this data entry mode was associated with considerably lower data quality, which led to time-intensive data revisions or to the exclusion of cases from analyses. Manual data entry of implants is therefore now restricted to multiple-choice drop-down menus containing only known implants. New implants may be registered by SwissRDL on demand by SIRIS users or upon notification by a producer. The clinical data of the SIRIS registry are stored on allocated servers at the University of Bern.

Information identifying the patient (e.g. medical record number, name and date of birth) is stored on a specific module server, physically separate from the clinical data of SIRIS. Identifying information is encrypted into a salted hash code, in order to allow linking of revisions performed at a different health facility to the corresponding primary arthroplasty. This is needed to calculate revision rates and for the continuous follow-up of implants.

In order to estimate the number of patients “at risk” of revision, all patients from SIRIS are cross-checked with the database of the Swiss Central Compensation Office (ZAS Geneva) and the Federal Statistical Office (FSO Neuchâtel). As of 2022, SIRIS can verify annually whether a patient has died or left Switzerland for the entire active reporting period. In previous years, this information was only available with a one-year time lag. Therefore, only patients confirmed alive and residing in Switzerland are considered “at risk” of revision. Patients who have died or left the country during the observation period are accounted for proportionally in terms of the number of days from operation to death or leaving Switzerland. Fewer than 5% had unknown status or were foreigners operated

on in Switzerland but not registered in ZAS. These patients are considered lost to follow-up after predetermined time intervals, unless actually revised in Switzerland, and are subsequently excluded from the analysis of (long-term) revision rates.

SwissRDL data protection complies with current standards. The methodology of separating the clinical from the patient-identifying information was reviewed and approved by data protection delegates (from the canton of Bern and from the Federal authority). Patients must provide written informed consent before data are entered into SIRIS, secured by participating surgeons and hospitals. Patients have the right to withdraw participation, check their data and to have their data completely deleted at any time.

2.2 Data quality and completeness

Data for this report were exported from the database in June 2022. The consistency and completeness of SIRIS data are checked in part through systematic software-generated validation tests of the received data and additionally every quarter by the registry's statistician/methodologist after running it through an automated analysis script for producing master files, which also produces lists of likely data errors. These are then fed back to the data monitoring team who analyses root causes of confirmed problems and provides feedback to hospitals. The latter procedure, established in its current form in 2019, has already shown great potential for improving data quality. In addition to the ongoing data-quality checking routines, several specific methodological decisions are taken in order to report figures as accurately as possible. For example, when information provided on a form and the registered implants contradict each other, and it has not yet been possible to verify the case (e.g. hemiarthroplasty is selected on the form but total hip components are registered). The implant registration information is given priority and the case is (provisionally) counted as a total hip arthroplasty. Where such decisions had to be made and likely impact results, it is indicated in the relevant tables or figures.

Three versions of case report forms (CRF) have been used in SIRIS. The first version was used from 2012 to 2014 and an updated version was in use between 2015 and 2020. Some changes in the definition of existing variables (particularly for the type of arthroplasty of the knee) were introduced as well as some new variables: notably the body mass index (BMI) and the morbidity state (according to the ASA classification). The latter allows the answer "unknown", which was inconsistently used among providers, including one reporting unknown ASA status in almost all cases, indicating issues with data collection. Other common problems are impossible or inconsistent responses, more frequently observed in some parts of the forms than in others: e.g. revisions relating to acetabular components in hemiarthroplasties. This could be due to systematic misunderstanding of the meaning of certain response categories (e.g. confusion between AC revision and conversion to THA after a hemiarthroplasty) or because of random data entry errors likely aggravated by design issues such as long drop-down lists. The hospitals are now being closely monitored to reduce missing and implausible values. A new case report form was introduced in 2021, to address a number of those problems and to update the content to changing practices. As the 2021 version is largely backwards compatible with the 2015 version, this report still – with a few exceptions – draws on the 2015 data format.

2.3 Coverage

Reliable reference data from other sources are needed to estimate the coverage of SIRIS. One option is to compare the annual number of cases reported in the registry with the numbers from quality indicators for Swiss acute care hospitals as published by the Federal Office of Public Health (FOPH/BAG). This encompasses a complete survey of all annual hospital discharges in Switzerland. Each entry represents the discharge from hospital of a person residing in Switzerland and includes information about the patient's socio-demographic characteristics, diagnosis and treatment. These figures are published online but only with a considerable time lag (link to www.bag.admin.ch). Detailed definitions may be found here (link to www.bag.admin.ch). Codes I.1.8.F, I.1.9.F, I.1.10.F can be used to identify primary hip prostheses of any kind and for any diagnosis, codes I.1.15.F, I.1.16.F for knee prostheses. At the time of writing the 2022 report, only figures up to 2020 are available.

We used the official Federal Office for Public Health (FOPH/BAG) figures to re-estimate the 2017 to 2020 figures. As can be seen in **Table 2.3,** primary coverage peaked at 97.9% in 2020.

SIRIS also accesses annual implant sales figures for Switzerland, specifically the number of femoral stems (indicator for hip arthroplasties) and tibia plateaus (indicator for knee arthroplasties) sold per year (data provided by the manufacturers). We consider this a generally reliable source of information, even though analysis strongly suggests that sales figures and implant use figures in hospitals do not always reliably agree within the same calendar year. In other words, hospitals can report more procedures per year than implant purchase suggests (i.e. coverage rates above 100%). We also became aware of the possibility that implants are imported directly from foreign suppliers and therefore not counted among official sales in Switzerland. However, it is reasonable to assume that such discrepancies tend to even out over time

Table 2.3
Retrospective coverage analysis 2017–2020 based on Federal Office of Public Health figures (FOPH/BAG)

	2017	2018	2019	2020
Primary hip prostheses				
BAG	22,970	23,160	23,619	23,310
SIRIS*	20,962	21,673	22,452	22,699
Primary coverage (%)	91.3	93.6	95.1	97.4
Primary knee prostheses				
BAG	18,558	18,325	19,181	18,837
SIRIS**	17,095	17,356	18,519	18,576
Primary coverage (%)	92.1	94.7	96.5	98.6
All primary hip and knee prostheses				
BAG	41,528	41,485	42,800	42,147
SIRIS	38,057	39,029	40,971	41,275
Primary coverage (%)	91.6	94.1	95.7	97.9

* I.1.8.F/I.1.9.F/I.1.10.F (all first hip prostheses, all diagnoses)
** I.1.15.F/I.1.16.F (all first knee prostheses, all diagnoses)

and across hospitals, or are relatively small. We therefore consider coverage rates between 90% and 110% as the "target zone" for hospitals for this type of analysis. In previous years, the two different ways of calculating coverage rates were mostly in agreement. For 2020, for example, we estimated overall coverage (primary plus revision procedures) to be between 96.5% and 98.3%. The now confirmed true value for primary coverage of 97.9% confirms the quality of the estimation procedure described in the annual report for 2021. For 2021, a total of 48,236 relevant implants were reportedly sold and 46,928 corresponding procedures were registered. This would suggest a nominally possible coverage rate of up to 97.3%. If correct, this would suggest a slight drop in coverage in 2021, which would seem improbable given the current state of data entry monitoring. Furthermore, both registration and sales figures indicate record increases in 2021 case numbers, but the 10% increase in sales figures appears to be surprisingly high. At the time of writing this report, however, we had been unable to finish scrutinizing several inconsistencies in the industry figures. We will therefore refrain from making an estimate for 2021 and wait for the official figures to be released.

We also rely on feedback from individual manufacturers in Swiss industry reporting (implant reports) and know that these high coverage rates are realistic. In specific implant reports, coverage rates tended to be as high as 99% for typical standard implants such as primary hip stems and as low as 60% for specific hemi-heads. The under-coverage of hemiarthroplasties is a well-known problem as they are frequently implanted in trauma units , not in orthopaedic departments where participation in SIRIS has more routine, and generally as emergencies. Thus, hip coverage tends to be slightly lower than knee coverage.

We have also seen clear progression at the hospital level since 2017. All eligible units are currently submitting cases to SIRIS. Last year, we had reasons to believe that the registry already had a higher, but not officially counted, coverage rate. Cases created in the SIRIS online system need to be completed, including at least one implant registered for most types of procedures, before they can be submitted and be included in the analysis. A certain number of incomplete and unsubmitted cases are left in the system every year. The improvements in coverage since 2017 are, to a certain extent, due to our collaboration with hospitals to help solve submission problems. Indeed, the number of registered cases keeps increasing after each reporting period. In recent years, however, at least part of the gap is to be explained by increasing difficulties in obtaining informed consent from patients. This is a topic to keep an eye on as unwillingness to give informed consent poses a direct threat to an implant registry that, in order to fulfil its function, does need very high – ideally complete – coverage of all primary and revision procedures.

2.4 Statistical precision and outlier detection

Figures in this report are, whenever appropriate, accompanied by 95% confidence intervals. This interval indicates the plausible range within which the "true" value should lie with 95% probability, considering random variation of samples of limited size. All confidence intervals are unadjusted for the various forms of clustering that may also affect precision, especially when results are depend on small numbers of surgeons or hospitals. The latter aspect is a particular challenge for a medical registry in a small yet diverse country like Switzerland and must be evaluated on a case-by-case basis (e.g. in outlier detection). In this report, we are introducing a simple metric that we call the "case concentration score". It is simply the share of a particular implant combination or system accounted for by the number one using hospital service. We provide this information in the interest of transparency as the performance of implants that are used in few places may not be an unbiased estimate of their true performance. As the number of knee systems included in this report has also been widened to include more complicated designs, as long as these designs were used for cases of primary osteoarthritis, we also provide mean age figures for each system. Again, this is done in the interest of transparency. As knee systems used in younger patients tend to have higher revision risks.

We detect statistical outliers – i.e. units or products that perform markedly worse than expected – by several means. For clinics and individual surgeons (not part of the scope of this report), we rely on risk-adjusted funnel plots and use the 99.8% limit as the relevant threshold. That is to say a clinic is deemed an "outlier" if the 2-year revision rate is higher than the range of plausible observations in which 99.8% of observations would fall if the result was due entirely to random variation. In other words, the likelihood of observing a value at least as extreme would be 1 in 500 if it were just pure chance.

For implants, we use a much simpler method, but also report the results with much more caveats and additional context. In this report, we are introducing a distinction between 2-year evaluation and long-term evaluation. The latter starts at 5 years follow-up and currently ends at 9 years follow-up. All implant combinations or systems with at least 500 cases and sufficient numbers at certain time points are subject to long-term evaluation. We identify three possible deviations from normal performance: (1) Implants with elevated revision risk, i.e. 50% more revisions at any point between 5 and 9 years follow-up; (2) Implants with long-term outlier status, i.e. 100% more revisions at any point between 5 and 9 years follow-up; (3) Implants with below average revision risk, i.e. having no more than 66% revision risk at 9 years follow-up. All of these boundaries are subject to further limitations on remaining numbers at risk and spread of confidence intervals as specified in the relevant chapters. In the 2-year evaluation, we determine that an implant is a "potential outlier" if the observed 2-year revision rate is more than twice that of the relevant group average. The relevant threshold for inclusion in the analysis was at least 50 cases in the current evaluation time frame (i.e. all primary operations between 1.1.2016 and 12.31.2019). In this report, we have refrained from ranking the implants by their 2-year revision rates and we have excluded any potential outliers with confidence intervals so large that they overlap with the 95% confidence interval of the actual group average.
We thus benchmark implants directly against the relatively narrow field of comparable products in their normal variety of uses. In other words, there

is no further risk adjustment as products of this kind are already meant to be used for a particular range of comparable patient characteristics and diagnoses. However, detailed outlier reports are produced for manufacturers and affected hospitals, and we also provide additional analytical information such as risk-adjusted hazard ratios there. We also benchmark implants within a moving time window (four years). This is to ensure that results are not affected by period effects and represent "current" performance, albeit with a necessary two-year time lag in order to allow for complete follow-up of at least two years. As implants come in hugely different group sizes, readers must pay attention to the reported 95% confidence intervals and any other contextual information – especially relating to the small numbers of clinics involved – stated on the outlier watch board in this report.

2.5 Evolving statistical methodology

The mainstay of statistical visualization and reporting in joint registries is the well-established Kaplan-Meier method (KM). Kaplan-Meier figures allow us to track visually the risk of revision of implants or groups of patients over time (failure curves). However, much debate has taken place regarding suitability in the presence of competing risks. In the context of joint registries, the one obvious competing risk is death of a patient. Deceased patients will not have their implant revised at any later time point. Risk of death is said to "compete" with the risk of revision. Within the constraints of the Kaplan-Meier method, we account for death by declaring patients who died during their observation time as censored on the day of death. This already provides an important correction to the model as we do not falsely assume that those implants are still at risk of revision and still unrevised. In statistical terminology, we remove them from the risk set. However, the implicit assumption of the method is that the occurrence of death is unrelated to the risk of revision. In other words, if the patient had not died, they would or would not have experienced a revision like any of the surviving patients, but it can no longer be observed. This assumption is basically not testable and will frequently be false. The patients who died can never experience a revision and probably had a lower likelihood to begin with, maybe because they were particularly frail and had low mobility. Competing risks regression, which comes in the form of a number of related but actually competing statistical approaches, is an attempt to correct for the implied overestimation of revision risks using KM in the presence of strong competing risks. In the 2021 report, we included a first special analysis in the chapter on hip fractures, where mortality rates are a special concern for every analysis even in the short term. We have only slightly expanded on the details of this analysis in this report, but keep it as an additional perspective on the performance of implants used in very elderly groups of patients. These results also formed the basis for our decision to refrain from performing the new long-term evaluation for implant combinations used for hip fractures.

Hip arthroplasty

Ten Years of Swiss Hip and Knee Registry

3. Hip arthroplasty

3.1 Introduction and summary

Overall volume of hip surgeries in relation to demography

Since its inception in 2012, SIRIS has registered 177,710 primary total hip arthroplasties (THA), 8,041 linked and 15,542 unlinked revisions **(Table 3.1a).** Linked revisions refer to revisions of primary implantations that have been recorded in SIRIS since 2012. Unlinked revisions are performed on hip replacements implanted before the start of SIRIS or implantations not registered in SIRIS for other reasons. During the same period, 19,997 hemiarthroplasties (HA), predominantly for the treatment of fractures of the proximal femur, were implanted, of which 753 were revised (linked revisions). With the growing age of the register, the number of unlinked revisions is declining.

The absolute number of hip procedures registered in SIRIS has been growing steadily, with the annual growth rates since 2013 averaging about 2.5% **(Figure 3.1c).** The increase in the total number of procedures is caused, at least partially, by increased coverage in the registry and needs to be considered in relation to demographic changes in the Swiss population. Between 2013 and 2020, it seems that this increase is broadly in line with the increase of the population particularly "at risk" of needing those procedures (50 to 89 years of age). Between 2020 and 2021, an increase of 7.5% was observed for THA. At the same time, a 1.2% decrease of HA was observed. The increase of THA may be explained by a backlog demand caused by the restricted availability of THA during the Covid-19 pandemic. This is supported by the loss of the seasonal pattern where, for 2021, a dip was only observed in Q3. The pre-Covid era showed a seasonal drop for Q2 and Q3 **(Table 3.1b and Figure 3.1d).** Also, there was an increasing preference for treating hip fractures with THA instead of HA, contributing 1.6% to the increase (derived from **Figure 3.6a**). This change in preference also explains the decrease of implanted HAs in 2021 to treat hip fractures.

Table 3.1a

Total and partial hip arthroplasty (THA & HA), primary and revisions/reoperations

All documented operations

Year	Primary THA	Primary HA	Primary others or type uncl.	Primary total	Linked Rev./Reop. of THA[2]	Linked Rev./Reop. of HA[2]	Unlinked Rev./Reop. can be of THA & HA	Rev./Reop. total[3]	% Linked Rev./Reop.
2012[1]	6,709	637	6	7,352	112	6	789	908	13.0
2013	16,917	1,933	10	18,860	401	39	1,854	2,298	19.1
2014	17,222	2,031	3	19,256	572	60	1,890	2,523	25.0
2015	17,653	1,975	6	19,634	718	63	1,804	2,586	30.2
2016	18,699	1,997	8	20,704	828	84	1,714	2,629	34.7
2017	18,880	2,075	7	20,962	862	77	1,674	2,616	35.9
2018	19,431	2,233	9	21,673	958	101	1,557	2,618	40.5
2019	20,099	2,343	10	22,452	1,101	105	1,503	2,712	44.5
2020	20,285	2,406	8	22,699	1,217	105	1,447	2,772	47.7
2021	21,815	2,367	13	24,195	1,272	113	1,310	2,700	51.3
All	**177,710**	**19,997**	**80**	**197,787**	**8,041**	**753**	**15,542**	**24,362**	**36.1**

[1] Does not represent a full year of data, as data collection in most hospitals started only in October 2012
[2] i.e. primaries already in SIRIS
[3] including linked revisions/reoperations of procedures that were classified as „primary others" or of unclear type

Comparing the incidence of implantation of hip prostheses with incidences in other healthcare systems can be difficult, and interpretations must be made cautiously. This comparison is usually presented as a fraction where the numerator shows the number of all prostheses implanted during a given period and the denominator defines the base against which the numerator is evaluated. Exact definitions used in such indicators may differ and readers are advised to pay attention to any technical appendices or small print provided in publications. This report presents two calculations with different denominators: overall population and population "at risk" (those who belong to the age group in which this procedure is usually performed) **(Figure 3.1c).** It should be noted, however, that these figures only include procedures registered in SIRIS and, because the registry's coverage is still incomplete (97.4%), the actual annual incidence rates for Switzerland could be approximately 1.7–3.5% higher, depending on the year under observation.

Figure 3.1a

Age distribution at surgery of primary total hip arthroplasty and hemiarthroplasty

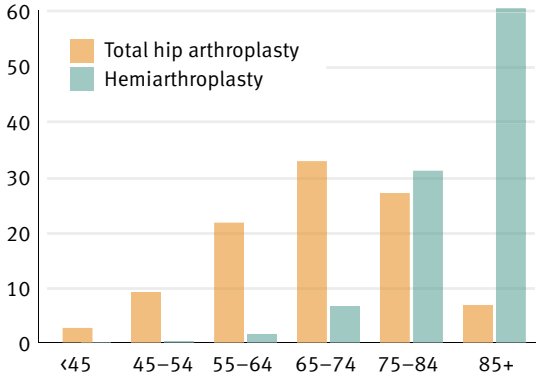


Figure 3.1b

Age distribution at surgery of revision/reoperation of total hip arthroplasty and hemiarthroplasty

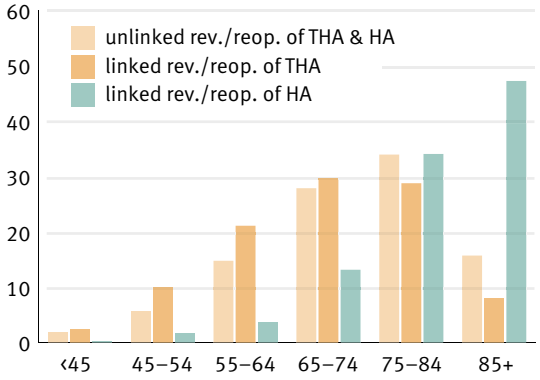
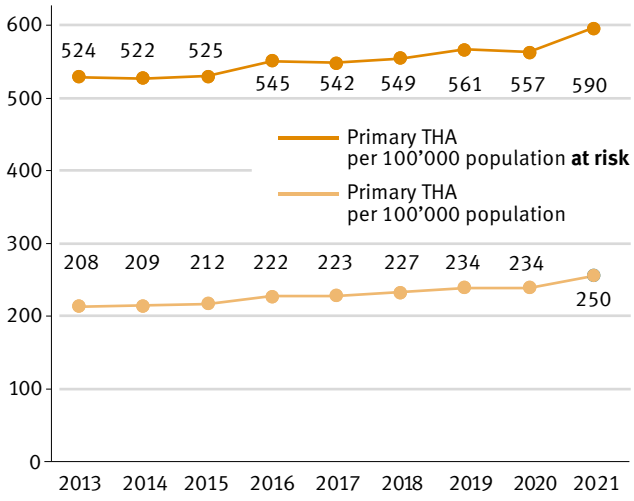


Figure 3.1c

Incidence of primary total hip arthroplasties registered in SIRIS

Per 100'000 residents and per 100'000 residents at risk*



*Age group 50–89 years accounts for 93% of all recipients of THA

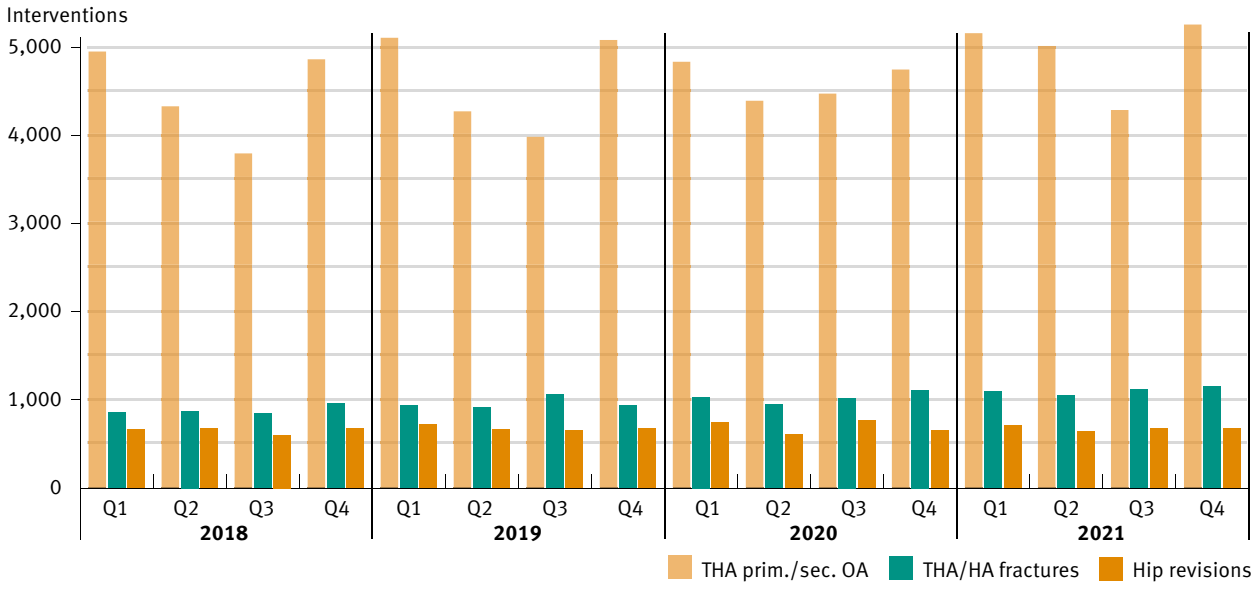
The Covid-19 pandemic impacted all sectors of public activity in 2020, and especially the Swiss health system. Looking at the hardly changing numbers of THAs in 2020 compared to 2019 **(Table 3.1b)**, the impact of the pandemic appears obvious in that the expected growth was cancelled. It did not result in major reductions in elective procedures. **Figure 3.1d** shows a distinctive seasonal pattern in THAs that was apparently distorted by the pandemic. Its effect was, however, limited to the following aspects:

1. There was a relatively moderate drop in cases in the first quarter (3–6%);
2. Cases were apparently shifted to the third quarter in particular;
3. The previously observable natural growth rate in elective procedures disappeared in 2020;
4. The drop in cases in the fourth quarter (relative to previous years) was slightly larger than in the first quarter;
5. It is likely that cases have been moved from Q4 2020 into the year 2021, responsible for a catch-up effect of about 4–5%

Table 3.1b
Seasonal pattern of SIRIS submissions 2018–2021
All documented operations

	2018				2019			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
THA primary/secondary OA	4,949	4,328	3,794	4,861	5,105	4,271	3,982	5,080
THA/HA fractures	853	873	850	956	939	913	1057	939
Hip revisions	659	677	602	680	717	660	655	680
	2020				2021			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
THA primary/secondary OA	4,833	4,391	4,472	4,745	5,157	5,012	4,286	5,255
THA/HA fractures	1,032	944	1,021	1,112	1,096	1,053	1,121	1,149
Hip revisions	742	607	768	655	708	640	677	675

Figure 3.1d
Seasonal pattern of SIRIS submissions 2018 – 2021



Prosthetic replacement of the hip

Of the 77,111 documented primary THAs, 64,416 implanted for primary OA were analysed for the four-year moving average, between 01.01.2016 and 31.12.2019, with complete two-year follow-up. Of these, 1,631 hips were revised, accounting for a two-year revision rate of 2.6% (CI 2.4–2.7). The risk of revision was higher in hips with secondary osteoarthritis (3.7%) and even higher in hips treated for fractures (4.8%) **(Table 3.4a).**

For primary OA, the male/female ratio has remained stable over the last five years. There was a slight increase in age at implantation of almost one year. Hip implantations were slightly more frequent in women (53.1%), and their mean age of 70.6 years was higher than that of men (66.9 years).

66.8% of THAs were performed in patients older than 65 years of age and 7.0% of implants were in patients aged over 85 years. Patients under 55 constituted 11.6% of the recipients. The distribution among the age groups has remained stable during the last six years.

The most frequent complication of primary THAs for primary OA was infection (0.65%), followed by periprosthetic fracture (0.49%), femoral loosening (0.47%) and dislocation (0.038%) (derived from **Table 3.4b).** About one tenth of all revisions (0.3% of all primary THAs) were performed for malpositioning of either acetabular or femoral components.

The mean BMI was 27.0 kg/m² for all patients with primary osteoarthritis (OA); 38.4% of THAs were performed in overweight patients (BMI 25–29.9) and 24.0% in obese patients **(Table 3.2a).** BMI has a clear impact on the risk of revision **(Table 3.4a and Figures 3.4e,f).** Revision rates rose with increasing BMI. The two-year revision rate for patients with BMI >40 was 6.8% (95% CI 5.3–8.6) **(Table 3.4a).** This is more than three times higher than in patients of normal weight.

The register covers a total of 22,369 fractures of the hip between 2016 and 2021, which is an increase of 8.1% compared to the previous period (2015–2020). However, because of a changed preference in favor of treating hip fractures with THA, the use of HA has decreased by 2% compared to the previous year. Between 2016 and 2021, the use of THAs to treat fractures of the hip increased from 38.7% to 47.6%. Parallel to that, the use of HA declined from 61.3% to 52.42%. Women were more often affected (68.3%). Patients older than 65 incurred 91.4% of the fractures. The age group above 85 accounted for 43.7% **(Table 3.6a).**

At two years, the average revision rate for all THA is 2.9% (CI 2.8–2.9) and 3.3% (CI 3.0–3.6) for HA. The nine-year revision rates are 5.0% (CI 4.8–5.2) and 7.5% (5.8–9.6), respectively **(Figure 3.1e).** The comparison of different time periods since 2015 shows surprisingly stable revision rates over time for THAs after a diagnosis of primary osteoarthritis **(Figure 3.1f).**

Implant-specific outcomes

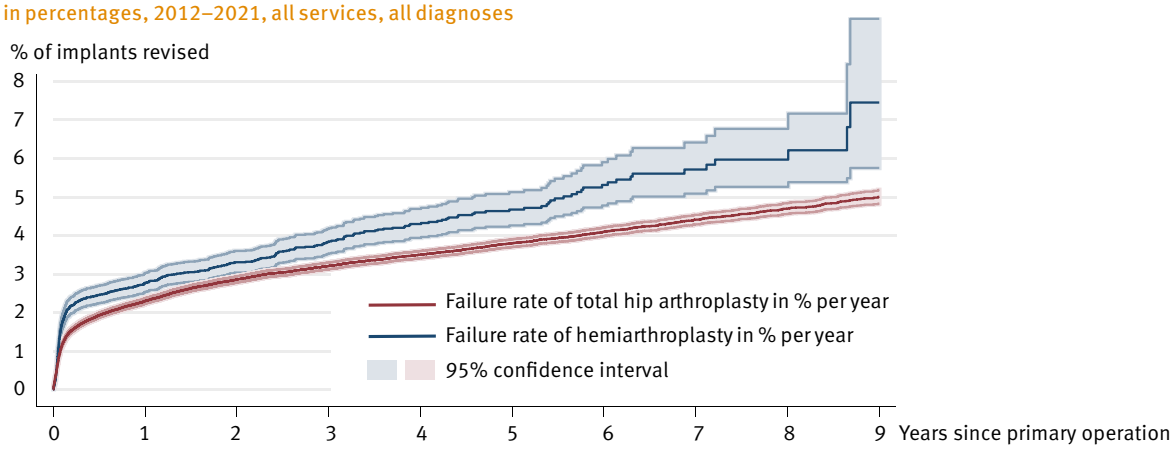
The annual report analyses early and long-term outcome after implantation of a THA. The two-year revision rates were calculated for a moving four-year window. This includes the last four years with full two-year follow-up. For this report, the data for implantations conducted between 1.1.2016 and 31.12.2019 were analysed with completed two-year follow-up until 31.12.2021. This practice has the advantage that the burden of the past will not influence the results of current practice of an implant, clinic or surgeon. It also offers the possibility of comparing different time periods, showing whether there is improvement or deterioration over time. For long-term outcome, Kaplan-Meier (KM) survival estimations and cumulative revision rates were calculated. The analysis included the detection of implants (minimal n≥ 50 cases at risk) with elevated revision rate or outlier implants any time between 5 and 9 years. An elevated revision rate was defined as a deviation of at least 50% above the group average at any time between year 5 and year 9 (and lower bounds of the 95% confidence interval exceeding the upper bound of the group average). Outlier status was defined as a revision rate of twice the group average at any time between year 5 and year 9. In the long term, there were no outliers. There were four implant combinations with an elevated revision rate **(Figure 3.5a),** of which two were also identified as outliers at two years **(Figure 3.5i).** However, the total number of these four implant combinations reaches only 2.7% (1,757 of 64,004 cases).

The 2-year revision rate is an important time point to gather initial results about the early performance of an implant, hospital or surgeon. Most complications occur within the first three months after implantation **(Figure 3.4a,b)** and loosening is not yet a problem **(Figure 3.4b).** Two years is a standard time

Figure 3.1e

Kaplan Meier estimate of cumulative postoperative revision risk after primary hip arthroplasty

in percentages, 2012–2021, all services, all diagnoses



Failure rate	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years
THA	**2.3**(2.2-2.4)	**2.9**(2.8-2.9)	**3.2**(3.1-3.3)	**3.5**(3.4-3.6)	**3.8**(3.7-3.9)	**4.1**(4.0-4.2)	**4.4**(4.3-4.5)	**4.7**(4.6-4.8)	**5.0**(4.8-5.2)
HA	**2.8**(2.5-3.0)	**3.3**(3.0-3.6)	**3.8**(3.5-4.2)	**4.3**(3.9-4.7)	**4.7**(4.3-5.1)	**5.3**(4.8-5.9)	**5.7**(5.1-6.4)	**6.0**(5.3-6.8)	**7.5**(5.8-9.6)

Number at risk	0 year	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years
THA	177,710	147,501	100,005	80,874	62,859	45,986	30,968	17,211	4,758	3,255
HA	19,997	12,085	8,664	5,542	3,679	2,338	1,432	812	388	71

period for outlier detection. An implant may be considered a "statistical outlier" if its revision rate deviates markedly from the relevant group average. The reference revision rate used in this report is the average revision rate of all corresponding implants (or combinations) in this registry over the observation period (primary THA for primary OA 2.6%). Seven uncemented stem/cup combinations have been identified as potential outliers at two years **(Figure 3.5i).** They are further analysed and presented in the outlier watchlist at the end of this report. The long-term analysis revealed no outliers.

Reporting of prostheses-related revision rates by hospitals

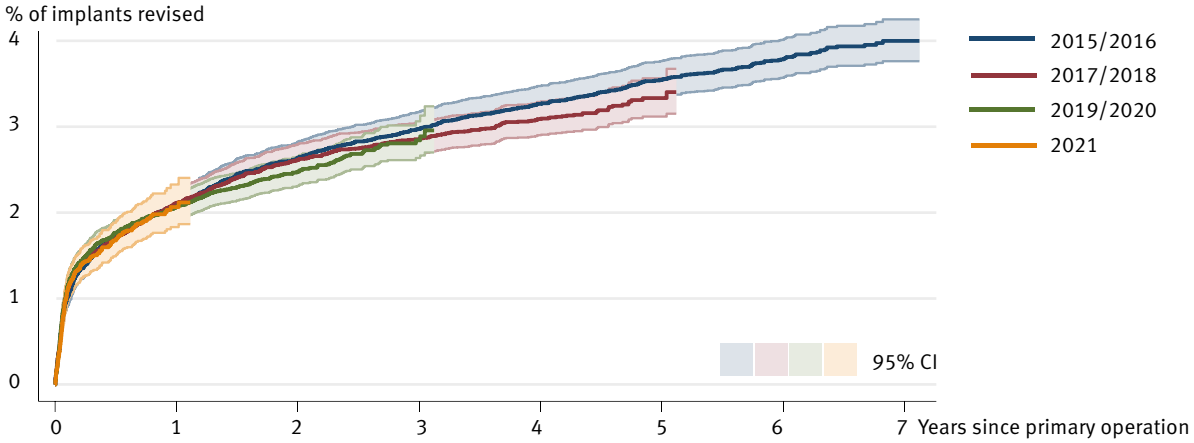
More than 150 hospital services in Switzerland provide hip and knee arthroplasty procedures and SIRIS has achieved 100% participation of institutions since 2018. There is a trend to fewer services, decreasing from 157 in 2016 to 149 in 2021 **(Table 3.1c).** The number of services performing less than 100 primary THAs per year decreased from 85 to 61. At the same time, services with volumes ›200 are increasing in numbers and cases. There is a case concentration in the large centres **(Table 3.1d).** A graphical overview of the distribution of THA, HA and revision surgeries is shown in **Figure 3.1g.** It is interesting that there are 10 services only performing HAs.

Figures 3.1h,i show funnel plots of risk-adjusted 2-year revision rates for THA and HA by hospital services. The results are restricted to patients with primary OA. The results are risk adjusted for age, sex, BMI, ASA and Charnley score, if available. On funnel plots, each dot represents a hospital service centered on the national average. The vertical axis indicates the outcome, with dots higher up the axis showing services with higher revision rates. The

Figure 3.1f

Kaplan Meier estimate of cumulative postoperative revision risk after THA by time period

in percentages, 2015–2021, all services, diagnoses primary OA



Failure rate	1 year	2 years	3 years	4 years	5 years	6 years	7 years
2015/2016	**2.1** (1.9-2.3)	**2.6** (2.5-2.8)	**3.0** (2.8-3.2)	**3.3** (3.1-3.5)	**3.5** (3.3-3.8)	**3.8** (3.6-4.0)	**4.0** (3.8-4.3)
2017/2018	**2.1** (2.0-2.3)	**2.6** (2.4-2.8)	**2.9** (2.7-3.0)	**3.1** (2.9-3.3)	**3.3** (3.1-3.6)		
2019/2020	**2.1** (1.9-2.2)	**2.5** (2.3-2.7)	**2.8** (2.6-3.1)				
2021	**2.1** (1.8-2.3)						

horizontal axis shows surgical activity with dots further to the right indicating the surgical units that performed more operations within the reported period.

Funnel plots include control limits to define the range within which outcomes are expected to be. Following convention, 99.8% control limits were used as the outer limit. It is unlikely for a hospital to fall beyond these limits solely because of random variation (a 1 in 500 chance). The main cause of variation within the control limits is likely to be random variation. As the plots show, the spread of outcomes in Switzerland was relatively homogeneous, but there were exceptions. For THA, there were four services detected as outliers and seven with an elevated revision risk. For HA, there was one outlier and two services with elevated revision risk.

Table 3.1c

Number of participating hospital services (N) and median procedures (M) per unit per year

		2016	2017	2018	2019	2020	2021
Primary total hip arthroplasty	N services	157	153	154	152	153	149
	M per service	86	87	86	87	94	117
Primary hemiarthroplasty of the hip	N services	143	136	125	126	125	105
	M per service	9	9	10	10	10	16
Revision arthroplasty (THA or HA)	N services	127	131	127	137	134	140
	M per service	9	9	9	10	12	12

Table 3.1d

Number of hospital services and number of primary THA according to hospital volume

Service volume		2016	2017	2018	2019	2020	2021
‹100	N procedures/%	3,599/**19.7**	3,190/**17.2**	3,040/**15.7**	2,236/**12.1**	2,829/**14.0**	2,355/**10.9**
	N services	85	79	74	64	73	61
100–199	N procedures/%	5,406/**29.6**	5,695/**30.6**	5,742/**29.7**	6,669/**33.3**	5,551/**27.5**	6,097/**27.9**
	N services	43	44	44	51	43	46
200–299	N procedures/%	3,630/**19.9**	4,499/**24.2**	4,242/**21.9**	4,424/**22.1**	4,995/**24.8**	5,185/**23.8**
	N services	16	19	19	20	22	24
›300	N procedures/%	5,628/**30.8**	5,213/**28.0**	6,303/**32.6**	6,522/**32.5**	6,800/**33.7**	8,178/**37.4**
	N services	13	11	15	15	15	18

Figure 3.1g

Cases per hospital sevice 2021: Total hip arthroplasty and hemiarthroplasty

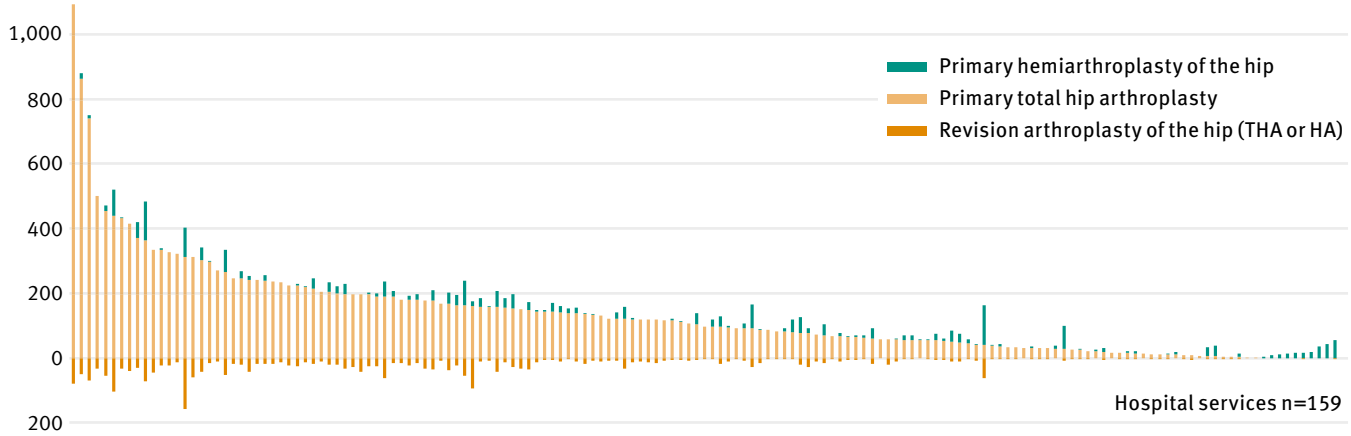


Figure 3.1h

2-year revision rate of primary total hip arthroplasty by service*

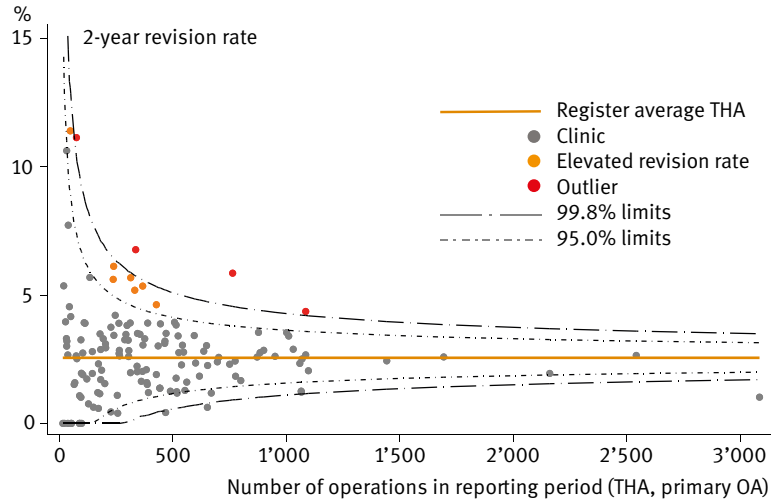
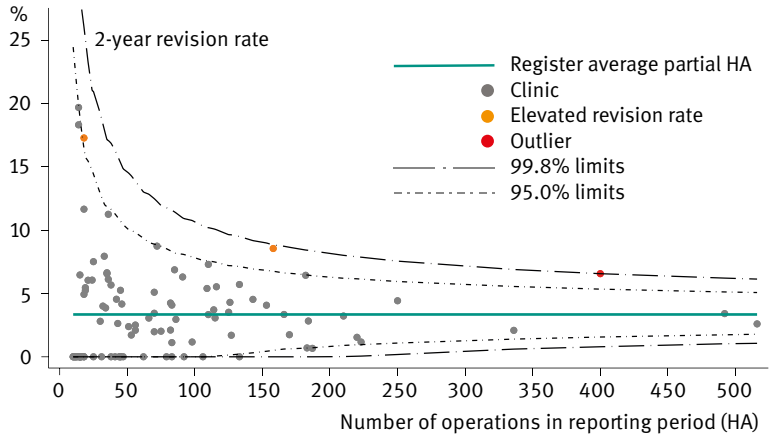


Figure 3.1i

2-year revision rate of primary hemiarthroplasty by service*



Interpretation of funnel plots

The yellow/green line denotes the Swiss average 2-year revision rate

Clinics that lie between the 95% limits (grey) have revision rates that are within the statistically expected range of observations given their operation volume

Clincs below the 95/99.8% limits are performing better than the average

Clinics above the 95% limit and below the 99.8% limit (orange) have elevated 2-year revision rates. This could be due to random variation, but we recommend that possible reasons are investigated, in particular if the position should be stable over time or worsen.

Clinics above the 99.8% limit (red dots) have 2-year revision rates that deviate markedly from the national average (unlikely to be due to random variation alone).

*Number of operations in the reporting period 01/2016–12/2019 (4-year moving average, follow-up to 12/2021). THA results restricted to patients with primary osteoarthritis (prim OA). Results are risk-adjusted for age, sex and BMI, ASA, Charnley Score if available.

3.2 Primary total hip arthroplasty

Since 2016, SIRIS has documented 119,209 primary total hip arthroplasties (THA) **(Table 3.2a).** The registry discriminates between THAs performed for primary osteoarthritis (OA) (83.2%) – the largest group – and implantations for treating secondary osteoarthrosis, including post-traumatic hip joint degeneration, inflammatory diseases, avascular necrosis and sequels of childhood diseases like dysplasia and Perthes' disease (8.9%). The third group includes THAs for fractures of the hip (7.9%). For primary OA, the male/female ratio has remained stable over the years. There was a slight increase in age at implantation of almost one year. Hip implants were slightly more frequent in women (53.1%) and their mean age of 70.6 years was higher than that of men (66.9 years).

Table 3.2a
Primary total hip arthroplasty: Baseline patient characteristics by year

		2016	2017	2018	2019	2020	2021	2016–2021
N		**18,699**	**18,880**	**19,431**	**20,099**	**20,285**	**21,815**	**119,209**
Diagnosis [%]*	Primary OA	84.3	84.6	84.3	83.5	82.1	81.0	83.2
	Secondary OA	9.0	8.6	8.5	8.6	9.1	9.4	8.9
	Fracture	6.7	6.8	7.2	7.9	8.8	9.6	7.9
Women [%]		52.9	53.2	53.4	53.1	52.4	53.8	53.1
Mean age (SD)	All	68.4 (11.6)	68.5 (11.5)	68.9 (11.5)	69.1 (11.5)	69.0 (11.6)	69.3 (11.7)	68.9 (11.6)
	Women	70.2 (11.2)	70.3 (11.2)	70.6 (11.2)	70.8 (11.1)	70.6 (11.4)	70.8 (11.5)	70.6 (11.3)
	Men	66.4 (11.6)	66.5 (11.5)	66.9 (11.5)	67.1 (11.6)	67.2 (11.6)	67.5 (11.7)	66.9 (11.6)
Age group [%]	<45	2.9	2.6	2.3	2.5	2.5	2.7	2.6
	45–54	9.5	9.5	9.3	8.6	8.9	8.5	9.0
	55–64	21.6	21.7	21.5	21.6	21.9	21.3	21.6
	65–74	34.1	33.6	32.8	32.3	31.5	30.9	32.5
	75–84	25.7	26.2	27.1	27.7	27.9	28.8	27.3
	85+	6.3	6.3	7.0	7.3	7.3	7.8	7.0
N unknown BMI (%)		3,710 (20)	3,299 (17)	3,048 (16)	2,924 (15)	2,506 (12)	1,942 (9)	17,429 (15)
N known BMI		14,989	15,581	16,383	17,175	17,779	19,873	101,780
Mean BMI (SD)		27.1 (5.4)	27.1 (5.1)	27.2 (5.5)	27.0 (5.1)	26.9 (5.3)	27.0 (5.6)	27.0 (5.3)
BMI [%]	<18.5	1.9	1.8	2.1	2.1	2.3	2.2	2.1
	18.5–24.9	35.1	35.4	35.0	35.6	36.4	36.2	35.6
	25–29.9	39.1	38.8	38.1	39.1	38.2	37.5	38.4
	30–34.9	17.3	17.0	17.5	16.6	16.6	17.3	17.1
	35–39.9	4.9	5.2	5.4	5.1	4.8	5.0	5.1
	40+	1.7	1.7	2.0	1.5	1.7	1.9	1.8
N unknown ASA (%)		2,137 (11)	1,919 (10)	1,700 (9)	1,497 (7)	1,237 (6)	731 (3)	9,221 (8)
N known ASA		16,562	16,961	17,731	18,602	19,048	21,084	109,988
Morbidity	ASA 1	14.8	13.3	12.0	12.1	11.6	11.2	12.4
state [%]	ASA 2	59.4	60.0	59.5	59.0	59.0	57.9	59.1
	ASA 3	25.1	26.0	27.6	28.0	28.3	29.7	27.6
	ASA 4/5	0.8	0.6	0.9	0.9	1.0	1.2	0.9

*A diagnostic category could not be determined in 663 cases (0.56%). Percentages shown are of n=118,546 THAs with valid diagnostic group.

66.8% of THAs were performed in patients older than 65 years of age and 7.0% of implants were in patients aged over 85 years. Patients under 55 constituted 11.6% of the recipients. The distribution among the age groups has remained stable during the last six years.

Data on BMI and the ASA score have been recorded since 2015. Data collection is still improving. In 2021, 9% of BMI data and 3% of ASA were missing. The mean BMI was 27.0 kg/m² for all patients with primary osteoarthritis (OA); 38.4% of THAs were performed in overweight patients (BMI 25–29.9) and 24.0% in obese patients **(Table 3.2a).** Younger patients were observed to have higher BMIs. This is true for both male and female patients **(Figure 3.2a).** The distribution of BMIs remained constant during the observation period.

Most procedures were performed on healthy individuals; 27.6% of the implants were performed in ASA class ≥3. The decrease in ASA 1 assessments continued. Concurrently, the number of patients with ASA 3 increased.

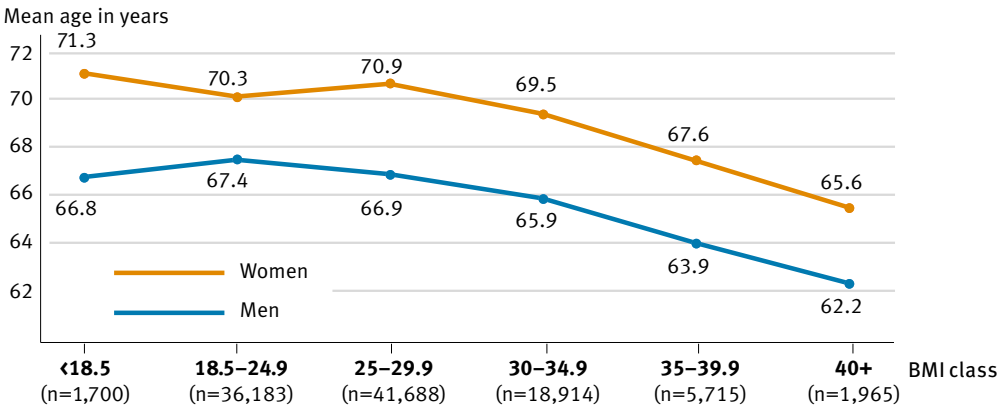
Patients treated for secondary OA were on average five years younger than those treated for primary OA. Hip dysplasia showed an increase from 20.5% in 2015 to 24.3% in 2021 among all secondary OA patients. 56.7% of the hips with secondary OA were treated for avascular necrosis. Compared to the other main diagnostic groups, there were increasingly more young patients treated for secondary OA (11.3% were younger than 45 years of age) **(Table 3.2b).**

Considerably more women were affected by fractures than men. They accounted for close to two-thirds (64.5%) of all patients sustaining hip fractures. The average age of women with fractures was 75.4 years compared to men at 72.6 years. More than 80% occur in patients over 65 and more than 50% in patients over 75. There was also a much higher proportion of patients in the fracture group belonging to ASA class ≥3. In chapter 3.6ff., we provide a detailed analysis of patients with hip fractures, comparing treatment with THA to treatment with hemiarthroplasty (HA).

Figure 3.2a

Primary total hip arthroplasty: Mean age at primary THA depending on BMI class

Primary and secondary osteoarthritis patients only. Please note that group sizes vary considerably.



Between 2016 and 2021, 119,209 THAs were implanted in 170 orthopedic units in Switzerland. 16,274 hips (13%) were implanted in units performing fewer than 100 procedures per year. In 2021, 37% of the primary THAs (40,334) were implanted in 18 services that see more than 300 cases per year. In those large units, more complex procedures (secondary OA) were performed and patients were slightly younger on average **(Table 3.2c).**

Resurfacing of the hip has been largely abandoned in Switzerland. Only 30 cases were treated this way in the past five years **(Table 3.2d)**. **Table 3.2d** com-

Table 3.2b

Primary total hip arthroplasty: Baseline patient characteristics by main diagnostic group

		Primary OA	Secondary OA	Fracture
N (2016–2021)*		**98,676**	**10,524**	**9,346**
Women [%]		51.6	57.3	64.5
Mean age (SD)	All	68.9 (10.9)	63.5 (15.4)	74.4 (10.9)
	Women	70.6 (10.5)	65.4 (15.3)	75.4 (10.4)
	Men	67.1 (11.0)	61.0 (15.2)	72.6 (11.5)
Age group [%]	‹45	1.8	11.3	0.8
	45–54	8.7	17.1	3.8
	55–64	22.3	21.9	13.7
	65–74	34.1	21.7	27.8
	75–84	27.3	20.6	35.5
	85+	5.9	7.4	18.4
Diagnosis [%]	Osteoarthritis	100.0	0.0	0.0
	Inflammatory arthritis	0.0	4.9	0.0
	Developmental dysplasia	0.0	24.3	0.0
	Osteonecrosis	0.0	56.7	0.0
	Miscellaneous	0.0	14.0	2.3
	Fracture	0.0	0.0	97.7
N unknown BMI (%)		14,162 (14)	1,248 (12)	1,948 (21)
N known BMI		84,514	9,276	7,398
Mean BMI (SD)		27.3 (5.3)	26.7 (5.6)	24.2 (4.5)
BMI [%]	‹18.5	1.5	2.7	7.4
	18.5–24.9	33.6	39	55.0
	25–29.9	39.6	35.6	28.0
	30–34.9	18.0	16.0	7.5
	35–39.9	5.4	4.6	1.5
	40+	1.8	2.2	0.5
N unknown ASA		7,858 (8)	651 (6)	657 (7)
N known ASA		90,818	9,873	8,689
Morbidity state	ASA 1	12.8	14.2	6.7
[%]	ASA 2	61.2	52.5	44.7
	ASA 3	25.4	31.9	44.8
	ASA 4/5	0.6	1.5	3.7

* Number of cases with clear diagnostic information (in 0.56% of cases we cannot determine the diagnosis)

pares previous surgeries, approaches and fixation techniques between the main diagnostic groups.

With minimal variations registered, the fixation methods have remained stable over the last five years **(Figure 3.2b)** for all three diagnostic groups. Relatively more acetabular reinforcement rings were used in the secondary OA group, reflecting more complex surgeries. For treatment of hip fractures, significantly more stems were cemented and more hybrid fixations were used.

For primary OA, the anterior approach was by far the most commonly used approach, followed by the anterolateral approach. Since the start of recording approaches in 2015, use of the anterior approach has gradually increased, reaching 55.6% in 2021, which is a 2.9% increase, while the use of ante-

Table 3.2c

Primary total hip arthroplasty: Baseline patient characteristics by hospital service volume

Calculations of hospital service volume based on primary hip surgeries in each included year (2016-2021).

Hospital service volume		<100	100–199	200–299	300+
N (2016–2021)		**16,274**	**35,130**	**27,471**	**40,334**
Women [%]		52.5	53.2	52.7	53.7
Mean age (SD)	All	69.8 (11.2)	69.4 (11.4)	69.0 (11.3)	68.0 (12.0)
	Women	71.5 (10.9)	71.1 (10.9)	70.6 (11.1)	69.7 (11.8)
	Men	67.9 (11.2)	67.4 (11.5)	67.1 (11.3)	66.0 (12.0)
Age group [%]	<45	1.7	2.2	2.2	3.4
	45–54	8.2	8.3	9.1	9.9
	55–64	20.3	21.1	21.6	22.5
	65–74	33.0	32.7	32.8	31.8
	75–84	28.6	28.2	27.4	25.9
	85+	8.1	7.4	6.9	6.4
Diagnosis [%]	Primary OA	82.6	82.3	85.8	82.5
	Secondary OA	7.8	7.7	7.4	11.3
	Fracture	9.6	9.9	6.7	6.2
N unknown BMI (%)		3,203 (20)	5,854 (17)	4,136 (15)	4,236 (11)
N known BMI		13,071	29,276	23,335	36,098
Mean BMI (SD)		27.1 (5.3)	27.2 (5.3)	27.1 (5.6)	26.8 (5.2)
BMI [%]	<18.5	2.1	2.0	2.0	2.1
	18.5–24.9	35.2	34.4	35.4	36.9
	25–29.9	38.5	38.5	38.2	38.4
	30–34.9	17.4	17.6	17.3	16.3
	35–39.9	4.9	5.5	5.3	4.6
	40+	1.8	1.9	1.8	1.6
N unknown ASA (%)		655 (4)	2,829 (8)	2,451 (9)	3,286 (8)
N known ASA		15,619	32,301	25,020	37,048
Morbidity state [%]	ASA 1	13.3	12.7	11.8	12.3
	ASA 2	59.5	59.0	60.6	58.0
	ASA 3	26.1	27.4	26.8	28.9
	ASA 4/5	1.1	1.0	0.8	0.8

ro-lateral, lateral and posterior approaches has been declining **(Table 3.2e).** The approach chosen depends on the experience and training of the surgeon. The distribution of the approaches shows a major regional variability. The distribution by Canton is shown in **Figure 3.2c.**

Bearing is one of the most important factors for wear and implant survival. The improvement of bearing materials has led to a decrease of osteolysis and loosening. Currently, the most frequently used bearing in Switzerland is CoXLPE. In 2021, this bearing was chosen in 56.6% of all primary hip implants for primary OA **(Table 3.2f).** Furthermore, the combination of ceramic head and standard PE (CoPE) has increased over the years and was used in 19.2% of implantations in 2021. The combinations of MoPE and MoXLPE steadily decreased between 2016 and 2021, while the use of CoC bearings has remained relatively stable **(Table 3.2f).** The share of unknown bearing surfaces is continually decreasing and fell to 2.2% in 2021.

Table 3.2d

Primary total hip arthroplasty: Surgery characteristics by main diagnostic group

Main diagnostic group		Primary OA		Secondary OA		Fracture	
N (2016–2021)		N	%	N	%	N	%
Previous surgery	None	95,173	96.4	8,874	84.3	8,370	89.6
	Internal fixation femur			583	5.5	702	7.5
	Osteotomy femur			432	4.1	41	0.4
	Internal fixation acetabulum			68	0.6	71	0.8
	Osteotomy pelvis			240	2.3	6	0.1
	Arthrodesis			4	0.0	3	0.0
	Other previous surgery	3,503	3.6	412	3.9	179	1.9
Intervention	Total hip replacement (as entered on SIRIS form)	98,368	99.7	10,459	99.4	9,248	99.0
	Full hip resurfacing	27	0.0	3	0.0	0	0.0
	Other (other categories and free text entries recognised as THAs)***	281	0.3	62	0.6	98	1.0
Approach	Anterior	49,475	50.1	4,526	43.0	4,851	51.9
	Anterolateral	30,717	31.1	3,618	34.4	2,427	26.0
	Posterior	13,204	13.4	1,491	14.2	1,207	12.9
	Lateral	47,19	4.8	684	6.5	673	7.2
	Other approach	561	0.6	205	1.9	188	2.0
Fixation	All uncemented	86,022	87.2	8,400	79.8	4,642	49.7
	Hybrid*	10,728	10.9	1,389	13.2	3,689	39.5
	All cemented	1,209	1.2	420	4.0	680	7.3
	Reverse hybrid**	479	0.5	175	1.7	184	2.0
	Reinforcement ring, femur uncemented	99	0.1	47	0.4	46	0.5
	Reinforcement ring, femur cemented	139	0.1	93	0.9	105	1.1

* acetabulum uncemented, femur cemented ** acetabulum cemented, femur uncemented

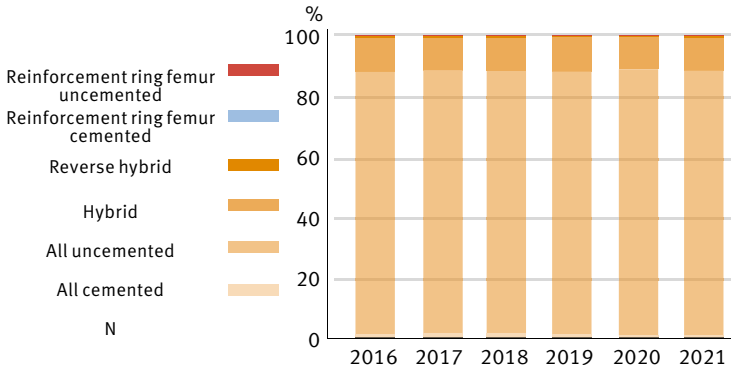
*** in case of inconsistencies between form entry and implant registration, we use the implant in determining the relevant category (e.g. entered „bipolar prosthesis“ but registered stem and dual mobility cup) . Such cases are routinely counted as THAs, but still retained in the „other“ category chosen by the user.

Figure 3.2b

Primary total hip arthroplasty: Component fixation methods by diagnostic group by year

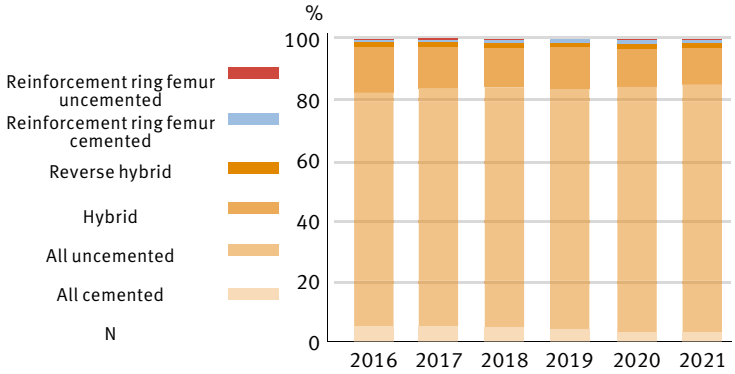
Primary osteoarthritis

2016	2017	2018	2019	2020	2021
0.2	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.2	0.1	0.2	0.2
0.5	0.6	0.5	0.4	0.4	0.5
11.2	10.6	10.9	11.3	10.4	10.8
86.8	87.0	86.8	86.8	88.0	87.6
1.3	1.6	1.5	1.2	0.8	0.9
15,565	**15,842**	**16,287**	**16,721**	**16,596**	**17,665**



Secondary osteoarthritis

2016	2017	2018	2019	2020	2021
0.4	0.4	0.6	0.3	0.4	0.5
0.7	0.9	0.7	1.0	1.2	0.8
1.7	1.4	1.9	1.6	1.7	1.6
14.9	13.6	12.8	13.7	12.4	12.1
77.2	78.9	79.5	79.4	81.2	81.9
5.0	4.9	4.5	4.0	2.9	3.0
1,656	**1,616**	**1,645**	**1,717**	**1,845**	**2,045**



Fracture

2016	2017	2018	2019	2020	2021
0.7	0.6	0.4	0.4	0.5	0.4
1.1	0.7	1.2	1.3	1.2	1.1
1.4	2.0	2.7	2.0	1.9	1.9
37.2	42.1	36.8	41.4	39.2	39.7
49.3	45.8	50.3	47.5	52.3	51.2
10.3	8.8	8.7	7.4	4.9	5.6
1,235	**1,265**	**1,384**	**1,586**	**1,774**	**2,102**

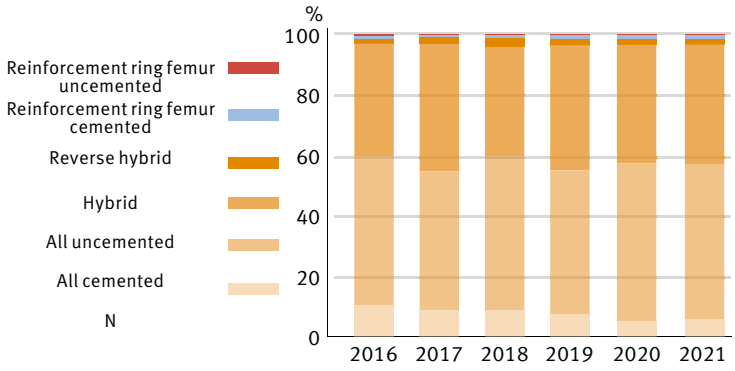


Table 3.2e

Surgical approach (since 2015) in total hip arthroplasty for primary osteoarthritis by year (in %)

	2016	2017	2018	2019	2020	2021	2016–2021
Anterior	44.2	48.0	49.1	50.3	52.7	55.6	50.1
Anterolateral	32.8	31.9	32.1	31.5	30.8	28.0	31.1
Lateral	7.1	5.8	4.9	4.6	3.7	2.9	4.8
Posterior	15.2	13.6	13.2	12.8	12.4	13.3	13.4
Other approach	0.7	0.6	0.6	0.7	0.5	0.3	0.6
Total [N]	**15,565**	**15,842**	**16,287**	**16,721**	**16,596**	**17,665**	**98,676**

The selection of the bearing surface depends, amongst other criteria, on the activity level and age of the patient. Bearings with favorable wear characteristics were most often used in younger patients, e.g. CoXLPE and CoC. Standard PE combined with a metal or ceramic head were more often used in older patients **(Table 3.2g).**

All uncemented fixations are standard for primary THAs in primary OA in this registry and account for 87.2% of all hips with primary OA. SIRIS shows that more than 90% of patients under the age of 75 received entirely cementless prostheses. As age increases, more and more THAs were cemented stems. Approximately 40% of stems in patients older than 85 years of age were cemented. Female patients received significantly more cemented stems than male patients **(Tables 3.2h,i).**

Figure 3.2c

Relative share of total hip arthroplasty procedures using different approaches by Swiss Canton and Principality of Liechtenstein (2016–2021)

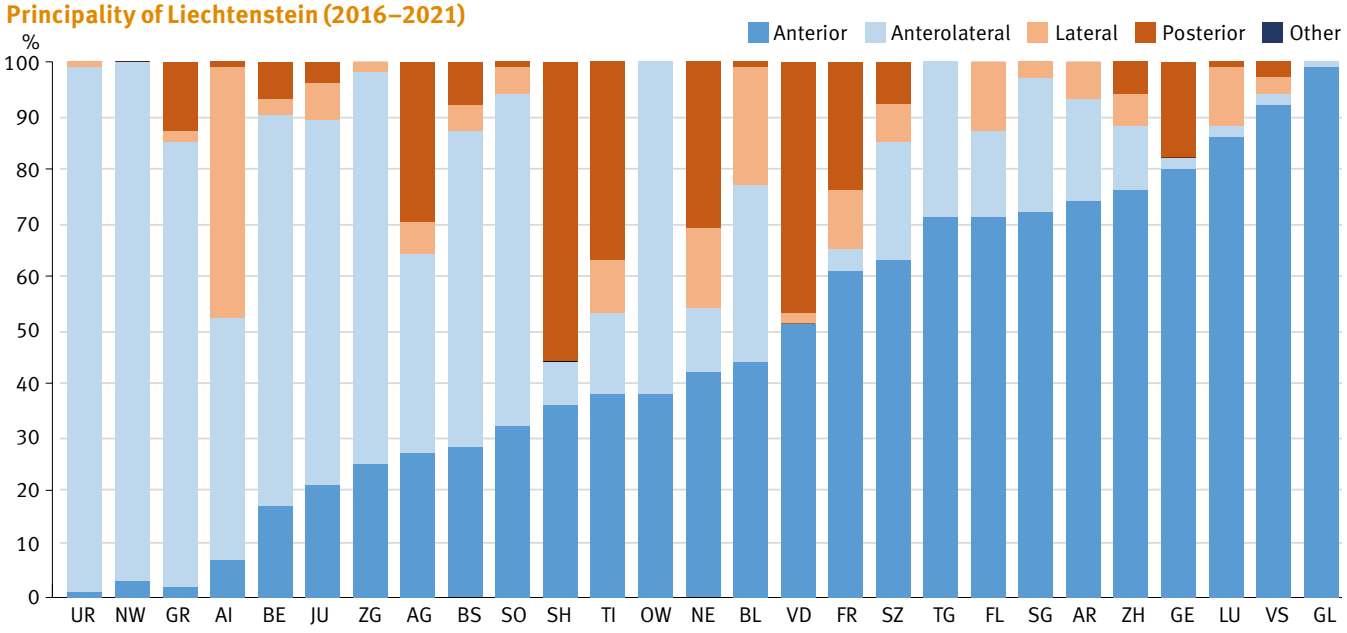


Table 3.2f

Primary total hip arthroplasty: Bearing surface* in primary osteoarthritis by year (in %)

Year	2016	2017	2018	2019	2020	2021	2016–2021
Metal on polyethylene (PE) (MoPE)	2.3	2.3	2.2	2.2	1.8	2.3	2.2
Ceramic on PE (CoPE)	13.2	13.5	14.5	15.1	16.8	19.2	15.5
Metal on cross-linked PE (MoXLPE)	13.1	11.5	11.6	10.8	9.3	8.3	10.7
Ceramic on cross-linked PE (CoXLPE)	55.4	57.4	57.0	56.6	57.2	56.0	56.6
Metal on metal (MoM)	0.04	0.05	0.00	0.00	0.00	0.00	0.01
Ceramic on ceramic (CoC)	16.0	15.1	14.8	15.3	14.9	14.1	15.0
Other	0.01	0.01	0.00	0.00	0.00	0.02	0.01
N (bearing surface known)	15,302	15,511	15,957	16,256	16,263	17,253	96,542
N (bearing surface unknown)	263	331	330	465	333	412	2,134

* Femoral heads and acetabular inserts/monobloc cups

Table 3.2g

Primary total hip arthroplasty: Bearing surface* in primary osteoarthritis by age (in %)

Age	<45	45–54	55–64	65–74	75–84	85+	All
Metal on polyethylene (PE) (MoPE)	0.2	0.5	0.5	1.2	4.0	9.2	2.2
Ceramic on PE (CoPE)	11.7	12.6	13.0	14.8	18.2	21.5	15.5
Metal on cross-linked PE (MoXLPE)	9.0	8.0	8.7	10.4	12.6	16.3	10.7
Ceramic on cross-linked PE (CoXLPE)	54.2	56.7	59.0	58.7	54.5	45.4	56.6
Metal on metal (MoM)	0.06	0.04	0.02	0.02	0.00	0.00	0.01
Ceramic on ceramic (CoC)	24.8	22.2	18.8	14.9	10.7	7.5	15.0
Other	0.00	0.00	0.01	0.00	0.01	0.00	0.01
N (bearing surface known)	1,737	8,410	21,627	32,902	26,234	5,626	96,536
N (bearing surface unknown)**	46	133	390	712	659	194	2,134

* Femoral heads and acetabular inserts/monobloc cups,
** Please note that age is missing in 9 cases

Table 3.2h

Primary total hip arthroplasty: Fixation methods in primary osteoarthritis by age* (in %)

Age	<45	45–54	55–64	65–74	75–84	85+	All
All cemented	0.3	0.3	0.3	0.7	2.1	5.5	1.2
All uncemented	96.6	97.1	96.0	91.0	77.8	57.6	87.2
Hybrid**	2.0	2.1	3.1	7.8	19.2	34.9	10.9
Reverse hybrid***	1.0	0.3	0.3	0.4	0.6	1.4	0.5
Reinforcement ring, femur cemented	0.00	0.09	0.09	0.10	0.19	0.43	0.14
Reinforcement ring, femur uncemented	0.1	0.1	0.1	0.1	0.1	0.2	0.1
N	1,783	8,543	22,017	33,614	26,893	5,820	98,670

* Please note that age is missing in 9 cases

Table 3.2i

Primary total hip arthroplasty: Fixation methods in primary osteoarthritis by gender (in %)

Gender	Women	Men	All
All cemented	1.7	0.7	1.2
All uncemented	82.3	92.3	87.2
Hybrid**	14.9	6.5	10.9
Reverse hybrid***	0.7	0.3	0.5
Reinforcement ring, femur cemented	0.20	0.08	0.14
Reinforcement ring, femur uncemented	0.1	0.1	0.1
N	50,931	47,745	98,676

** acetabulum uncemented, femur cemented
*** acetabulum cemented, femur uncemented

3.3 Revision of total hip arthroplasty

SIRIS has been recording all primary and revision hip procedures since 2012. Some of the revisions were carried out on hip prostheses implanted before 2012. These are so-called "unlinked revisions" because we cannot link the revision procedure to a registered primary procedure. Revisions of primary implantations registered in SIRIS are termed "linked revisions". These form the basis for calculations of survival and first revision rates (see chapter 3.4).

Table 3.3a shows the demographic data for all revisions performed since 2016, whether linked or unlinked. Revisions since 2016 constituted 12.8% of all hip procedures (the overall revision burden). Of the 15,290 THA revisions documented since 2016, 50.9% were performed on women **(Table 3.3a)** with the mean age at revision being 71.9 years. On av-

Table 3.3a
Revision* of total hip arthroplasty: Baseline patient characteristics by year

Year		2016	2017	2018	2019	2020	2021	2016–2021
N		**2,514**	**2,510**	**2,494**	**2,583**	**2,635**	**2,554**	**15,290**
Women [%]		52.2	49.6	51.0	51.5	48.6	52.5	50.9
Mean age (SD)	All	70.8 (11.9)	71.4 (11.9)	71.9 (11.8)	72.2 (11.5)	72.0 (12.2)	73.0 (12.0)	71.9 (11.9)
	Women	71.9 (11.9)	72.9 (12.0)	73.0 (12.1)	73.6 (11.3)	73.8 (11.9)	74.3 (11.9)	73.2 (11.9)
	Men	69.6 (11.9)	69.9 (11.7)	70.7 (11.5)	70.7 (11.5)	70.2 (12.2)	71.6 (12.0)	70.4 (11.8)
Age group [%]	<45	2.3	2.2	1.9	1.2	2.2	1.9	1.9
	45–55	8.0	7.8	7.6	6.3	7.0	6.2	7.1
	55–65	17.9	15.5	15.8	17.8	16.2	15.2	16.4
	65–75	30.7	30.4	29.4	28.3	26.7	25.2	28.4
	75–85	30.0	31.4	32.1	32.2	34.0	35.0	32.5
	85+	11.2	12.7	13.4	14.2	14.0	16.6	13.7
N unknown BMI (%)		508 (20)	495 (20)	483 (19)	485 (19)	435 (17)	288 (11)	2,694 (18)
N known BMI		2,006	2,015	2,011	2,098	2,200	2,266	12,596
Mean BMI (SD)		27.5 (5.7)	27.2 (5.5)	27.3 (5.6)	27.4 (7.1)	27.5 (6.8)	27.3 (5.7)	27.4 (6.1)
BMI [%]	<18.5	2.1	2.4	2.6	2.1	2.3	2.0	2.3
	18.5–24.9	33.1	36.1	34.3	36.9	33.9	36.8	35.2
	25–29.9	38.1	36.0	36.5	35.0	37.5	33.5	36.1
	30–34.9	17.7	17.6	17.9	16.6	16.7	18.2	17.4
	35–39.9	6.7	5.1	5.8	6.1	7.1	6.7	6.3
	40+	2.3	2.8	2.9	3.2	2.5	2.8	2.8
N unknown ASA (%)		303 (12)	339 (14)	255 (10)	246 (10)	225 (9)	113 (4)	1,481 (10)
N known ASA		2,211	2,171	2,239	2,337	2,410	2,441	13,809
Morbidity state	ASA 1	7.3	6.5	6.2	4.2	4.2	4.2	5.4
[%]	ASA 2	49.7	46.7	44.8	43.8	44.0	38.8	44.5
	ASA 3	40.8	44.5	46.2	48.2	48.1	52.6	46.9
	ASA 4/5	2.1	2.3	2.8	3.8	3.7	4.4	3.2

* includes a small proportion of reoperations that are not counted as component revisions in the evaluative parts of this report

erage, men were three years younger than women when revised. The mean age at revision was quite stable between 2016 and 2020. For 2021, an increase of approximately 1% was observed. The age group <45 years accounted for 1.8% and the age group between 45 and 54 for 7.1% of revisions. Of all revisions performed, approximatively 60% were in the group between 65 and 84 years of age.

Aseptic loosening of the femoral component was the most common cause for revision, followed by infection, aseptic loosening of the acetabular component, periprosthetic fracture and dislocation **(Table 3.3b).** Revision of both components was carried out in 18.6% of cases **(Table 3.3c).** Uncemented revision was preferred and accounted for 60%, followed by fully cemented revision in 20.0% **(Table 3.3d, Figure 3.3a).**

The most frequently used approach was the posterior approach in 33.8% of cases **(Table 3.3e).**

Since 2021, acetabular and femoral periprosthetic fractures have been recorded separately, using the Vancouver classification for periprosthetic femoral fractures **(Table 3.3f).** In 2021, 493 periprosthetic fractures were recorded, of which 102 were acetabular fractures **(3.3f).**

The implants used for revision are influenced by the age of the patient. The younger the patient the more likely the revision was performed with an unce-

Table 3.3b

Reason for revision* of total hip arthroplasty

Multiple responses possible (percentages do not sum to 100).
2016 – 2021

	N	%
Loosening femoral	3,244	21.2
Infection	3,200	20.9
Loosening acetabular	2,583	16.9
Periprosthetic fracture	2,647	17.3
Dislocation	1,850	12.1
Wear	1,053	6.9
Metallosis	774	5.1
Acetabular osteolysis	622	4.1
Position/Orientation of cup	715	4.7
Femoral osteolysis	574	3.8
Trochanter pathology	242	1.6
Status after spacer	331	2.2
Implant breakage	316	2.1
Blood ion level	239	1.6
Position/Orientation of stem	384	2.5
Impingement	210	1.4
Acetabular protrusion	173	1.1
Squeaking	90	0.6
Other	1,649	10.8
Total	**20,896**	

Table 3.3c

Type of revision* of total hip arthroplasty

2016 – 2021

	N	%
Exchange acetabular and femoral components	2,837	18.6
Exchange acetabular component and head	2,945	19.3
Exchange femoral component	2,248	14.7
Exchange head and inlay	1,551	10.1
Exchange acetabular component	806	5.3
Exchange femoral component and inlay	1,288	8.4
Component reimplantation (after spacer or Girdlestone)	870	5.7
Exchange head	727	4.8
Component removal, spacer implantation	550	3.6
Girdlestone	186	1.2
Exchange femoral component, inlay and osteosynthesis	239	1.6
Exchange inlay	149	1.0
Prosthesis preserving revision	175	1.1
Osteosynthesis	182	1.2
Other intervention	537	3.5
Total	**15,290**	**100.0**

* includes a small proportion of reoperations that are not counted as component revisions in the evaluative parts of this report.

Figure 3.3a

Revision of hip arthroplasty: Component fixation by year

Percentage per year

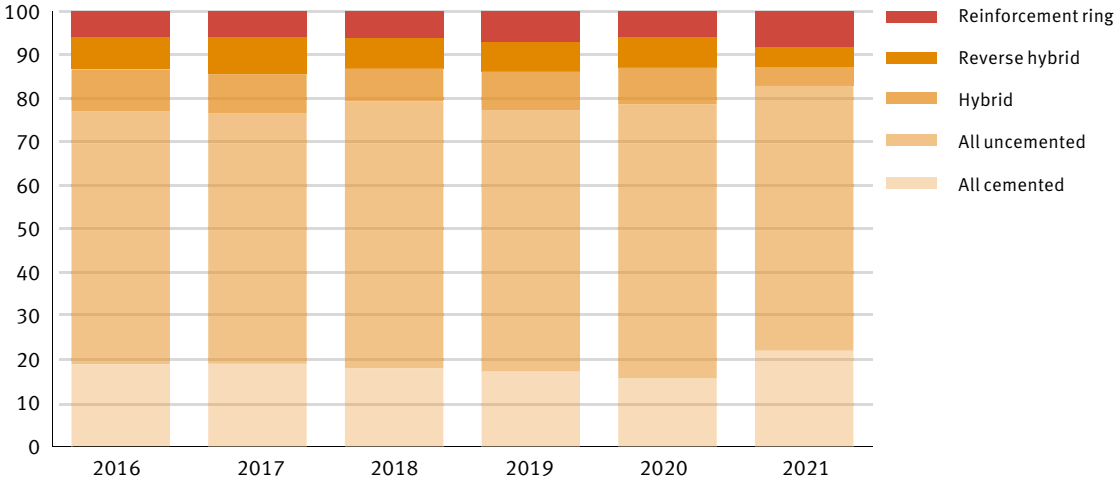


Table 3.3d

Revision of total hip arthroplasty: Component fixation by year

Year	2016	2017	2018	2019	2020	2021	2016–2021
All cemented	18.9	19.0	18.0	17.2	15.6	22.0	18.3
All uncemented	58.2	57.5	61.3	60.0	63.1	60.9	60.5
Hybrid**	9.6	9.1	7.6	9.0	8.4	4.3	7.7
Reverse hybrid*	7.3	8.4	7.0	6.8	6.9	4.6	6.8
Reinforcement ring	6.0	6.0	6.1	7.0	6.0	8.2	6.7
Total N	**2,017**	**1,975**	**1,923**	**1,993**	**1,980**	**1,810**	**9,681**

* acetabulum cemented, femur uncemented = Reverse hybrid
** acetabulum uncemented, femur cemented = Hybrid

Table 3.3e

Approach of revision of total hip arthroplasty

2016 – 2021

	N	%
Posterior	5,173	33.8
Lateral	3,040	19.9
Anterolateral	2,504	16.4
Anterior	2,977	19.5
Transfemoral	941	6.2
Other approach	655	4.3

Table 3.3f

Distribution of selected subtypes of reasons for revision

2021; new version of SIRIS proforma

	N	%
FE periprosthetic fract. Vancouver A	48	9.7
FE periprosthetic fract. Vancouver B	314	63.7
FE periprosthetic fract. Vancouver C	29	5.9
AC periprosthetic fracture	102	20.7
Total periprosthetic fracture	**493**	

	N	%
FE implant fracture	33	40.2
AC implant fracture	35	42.7
Femoral head prosthesis impl. fract.	14	17.1
Total implant breakage	**82**	

mented primary stem. Cemented stems were more often used in the elderly population **(Table 3.3g).** The selection most likely is influenced by bone quality. Short stems were used in approximately 2% of cases. In general, acetabular revisions were performed with uncemented primary cups. Surprisingly, revision cups are not very often used. Acetabular reinforcement rings or cages on the other hand are used quite frequently. **Table 3.3h** gives an overview of implants used for revisions.

Table 3.3g

Hip revision: main components used by age at type of revision

All registered component revisions of four main types 2016-2021 with at least one FE/AC revision component with a known e-class

	E-class category*	Age at revision						N
	of implant	<45	45-54	55-64	65-74	75-84	85+	
Type of revision of femoral components		%	%	%	%	%	%	
AC + FE revision	cem. primary stems	20.0	13.3	16.2	20.2	28.8	42.5	632
	uncem. primary stems	45.0	48.1	37.2	26.2	17.2	8.9	669
	short stems	10.0	1.0	3.5	2.1	1.4	1.0	55
	cem. revision stems	1.7	0.0	1.3	1.9	3.3	3.8	60
	uncem. revision stems	23.3	37.6	41.8	49.7	49.3	43.8	1,202
FE revision (with or without inlay)	cem. primary stems	22.8	22.1	25.6	25.3	28.7	35.1	954
	uncem. primary stems	47.4	43.2	35.3	23.0	13.4	3.8	674
	short stems	5.3	7.5	4.8	3.0	1.8	0.5	92
	cem. revision stems	0.0	1.0	1.2	1.1	2.6	3.1	66
	uncem. revision stems	24.6	26.1	33.1	47.6	53.6	57.5	1,616
Component reimplantation (after spacer)	cem. primary stems	8.7	10.0	15.1	14.0	25.1	25.9	149
	uncem. primary stems	34.8	32.9	30.2	25.1	20.5	10.3	208
	short stems	8.7	4.3	1.1	0.4	1.3	0.0	11
	cem. revision stems	4.3	0.0	0.6	1.1	1.3	0.0	8
	uncem. revision stems	43.5	52.9	53.1	59.4	51.9	63.8	464
Type of revison of acetabular components								
AC + FE revision	cem. primary cups	5.0	7.2	7.7	13.1	19.1	26.7	390
	uncem. primary cups	71.7	75.6	72.0	61.9	52.7	45.2	1,570
	revision cups	5.0	4.3	3.6	3.5	2.6	2.0	83
	AC roof ring or cage	18.3	12.9	16.6	21.5	25.5	26.1	565
AC revision (with or without head)	cem. primary cups	9.0	13.5	10.3	18.0	22.6	33.7	682
	uncem. primary cups	73.1	67.1	65.5	53.7	46.6	31.3	1,755
	revision cups	3.0	2.5	3.4	3.4	2.6	2.4	100
	AC roof ring or cage	14.9	16.9	20.8	24.9	28.1	32.6	875
Component reimplantation (after spacer)	cem. primary cups	4.2	8.8	9.4	8.7	15.5	15.8	93
	uncem. primary cups	70.8	67.6	68.3	65.7	59.0	50.9	530
	revision cups	4.2	0.0	2.8	1.5	2.5	0.0	16
	AC roof ring or cage	20.8	23.5	19.4	24.2	23.0	33.3	194

Table 3.3g and 3.3h: eclass categories used: 34-32-10-01, 34-32-10-02, 34-32-10-03, 34-32-10-05, 34-32-10-06, 34-32-10-08, 34-32-10-09, 34-32-10-10, 34-32-10-11. A small proportion of tumor systems such as MUTARS is excluded.

Table 3.3h

Hip revision: Main brands used

All registered component revisions of four main types 2016-2021 with at least one FE/AC revision component with a known e-class

E-class category* of implant	Main brands (50+)	N
Cem. primary stems (50+)	SPII Lubinus	367
	Weber	240
	Quadra-C	230
	Centris	211
	Amistem-C	163
	Twinsys	156
	Corail	134
	Avenir	81
	Exafit	51
Uncem. primary stems (50+)	Corail collared	295
	Quadra-H	271
	Polarstem	182
	CLS Spotorno	179
	Avenir	135
	Corail	130
	Stellaris	104
	Twinsys	75
	Quadra-P	50
Short stems (30+)	Optimys	119
	Fitmore*	41
Cem. rev. stems (50+)	Arcad L XL	115
Uncem. revision stems (50+)	Revitan	816
	Corail collared	699
	Mathys mod. revision	385
	Lima revision	383
	Wagner SL	355
	Quadra-R	184
	MRP-titan	162
	Alloclassic SLL	126
	Redapt	90
	Reclaim	89
	Reef	75
	Restoration modular	64
	MP reconstruction	60

E-class category of implant	Main brands (50+)	N
Cemented primary cups (50+)	DS evolution	273
	Polarcup	236
	Original Mueller	224
	Versacem	204
	Avantage	142
	Symbol DM	110
	Ades DM	55
Uncemented primary cups (50+)	Pinnacle	467
	RM pressfit vitamys	372
	Allofit	371
	Symbol DM	318
	Polarcup	301
	TM	268
	Versafitcup DM	261
	Versafitcup trio/ccl.	200
	Gyros	192
	Fitmore	165
	DS evolution	164
	Mpact	144
	Avantage	114
	Delta ONE-TT	114
	Mpact DM	95
	Bi-Mentum	82
	Liberty	78
	G7 hemispherical	67
	Delta TT	64
	R3	62
Revision cups (30+)	Pinnacle	103
	TMARS	45
	Delta revision TT	38
AC reinforcement ring or cage (30+)	ZB reinforcement (Ganz) ring	1,086
	Burch-Schneider cage	376
	Original mueller ring	136
	Medacta reinforc. cage	39
	CMK	34

* please note that the Fitmore stem is originally classified as a regular uncemented primary stem even though we consider it technically a short stem

3.4 First revision of primary total hip arthroplasty

First revisions are those that can be linked to a primary implantation registered in SIRIS and that occur for the first time (as opposed to a re-revision). We differentiate between early revisions within the first two years after implantation and revisions in the longer term, currently up to 9 years after implantation. For long-term outcomes, Kaplan-Meier (KM) survival estimations and cumulative revision rates were calculated.

The two-year revision rate of an implant, hospital or surgeon was calculated for primary THA for the treatment of primary osteoarthrosis (OA). This is an international standard and makes sense because hips with secondary OA often include hips with difficult anatomy, previous osteotomies or unfavorable conditions leading to increased revision rates. Revision rates were calculated for a moving four-year window. This includes the last four years with full two-year follow-up. For this report, the data of implantations between 1.1.2016 and 31.12.2019 were analysed with completed two-year follow-up

Table 3.4a

First revision of primary total hip arthroplasty within 24 months according to baseline characteristics

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

		Primary	Revised within 24 months			
			Revised		95% CI	
		N at risk*	N	%**	lower	upper
Overall (moving average)		77,111	2,146	2.8	2.7	2.9
Diagnosis	Primary OA	64,416	1,631	2.6	2.4	2.7
	Secondary OA	6,634	239	3.7	3.2	4.2
	Fracture	5,471	253	4.8	4.3	5.5
Overall Primary OA		64,416	1,631	2.6	2.4	2.7
Gender	Women	33,281	832	2.5	2.4	2.7
	Men	31,135	799	2.6	2.4	2.8
Age group	‹55	6,858	218	3.2	2.8	3.7
	55–64	14,347	349	2.5	2.2	2.7
	65–74	22,313	520	2.3	2.2	2.6
	75–84	17,173	444	2.6	2.4	2.9
	85+	3,720	100	2.7	2.2	3.3
BMI group	‹18.5	792	8	1.0	0.5	2.1
	18.5–24.9	17,890	362	2.0	1.8	2.3
	25–29.9	21,447	498	2.3	2.1	2.6
	30–34.9	9,639	302	3.2	2.8	3.5
	35–39.9	2,966	107	3.6	3.0	4.4
	40+	952	64	6.8	5.3	8.6
	Unknown	10,712	290	2.7	2.4	3.1
Morbidity state	ASA 1	7,768	142	1.8	1.6	2.2
	ASA 2	35,630	842	2.4	2.2	2.5
	ASA 3	14,428	457	3.2	2.9	3.5
	ASA 4/5	296	8	2.8	1.4	5.5
	Unknown	6,276	182	2.9	2.5	3.4

* Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

** Rates adjusted for effects of mortality and emigration.

until 31.12.2021. This practice has the advantage that the burden of the past will not influence the results of current practice of an implant, clinic or surgeon. It also offers the possibility of comparing different periods of time and showing whether there is improvement or deterioration over time. Kaplan-Meier survival estimates and cumulative revision rates cover the entire run of the registry since 2012. Dual information is therefore provided – the two-year revision rate in a four-year moving window – showing the performance of the last four years as well as the long-term results after 9 years.

A revision is defined as any removal, addition or exchange of any prosthetic component. Of the 77,111 documented primary THAs, 64,416 implanted for primary OA were analysed for the four-year moving average, between 01.01.2016 and 31.12.2019, with complete two-year follow-up. Of these, 1,631 hips were revised, accounting for a two-year revision rate of 2.6% (CI 2.4–2.7). The risk of revision was higher in hips with secondary osteoarthritis (3.7%) and even higher in hips treated for fractures (4.8%) **(Table 3.4a).**

The most frequent cause of revision of primary THA for primary OA was infection (25%), followed by periprosthetic fracture (18.9%), femoral loosening (18.3%) and dislocation (14.5%) **(Table 3.4b).** About one ninth of all revisions (11.3%) were undertaken for malpositioning of either acetabular or femoral components.

The majority of revisions occurred during the first three months postoperatively, including high and early peaks of periprosthetic fractures and dislocations. Although infection and aseptic loosing were

Table 3.4b

Reason for early first revision of primary total hip arthroplasty

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021). Early first revisions are those occurring within 2 years of the primary arthroplasty.

	N	%*
Infection	407	25.0
Periprosthetic fracture	308	18.9
Loosening femoral	299	18.3
Dislocation	236	14.5
Loosening acetabular	144	8.8
Position/orientation of cup	100	6.1
Position/orientation of stem	84	5.2
Impingement	21	1.3
Acetabular protrusion	19	1.2
Trochanter pathology	15	0.9
Spacer	13	0.8
Osteolysis FE	10	0.6
Implant failure	9	0.6
Wear	5	0.3
Osteolysis AC	5	0.3
Squeaking	5	0.3
Metalosis	2	0.1
Ion blood level	0	0.0
Other	172	10.5

* Multiple responses possible (percentages do not sum to 100)

more frequent complications, their curves were flatter but remained elevated over a longer period of time. **Figures 3.4a** show the cause and frequency distribution (Kernel density estimation) for cemented and uncemented femoral implants, respectively. In cemented stems, dislocation was an early complication, as was infection. Other complications occurred later and during a longer time period. The curves were therefore flatter. In uncemented stems periprosthetic fracture occured early and in a higher frequency.

Table 3.4c gives an overview of the revision rates depending on stem fixation, bearing and approach. The 2-year revision rate is on average 2.6% (1,631 of 64,416 primary OAs). Parameters that are above average include entirely cemented fixation techniques (3.6%), metal on PE (4.0%) and the use of a posterior approach (3.1%). The highest 2-year revision rate is observed in unspecified approaches not defined as one of the standard approaches (5.2%).

The two-year revision rate for the current 4-year moving window was lowest for the combination of ceramic heads with highly crosslinked polyethylene (CoXLPE) (2.5%), followed by normal polyethylene (CoPE) (2.4%) **(Table 3.4c).**

Cumulative incidence rates show the long-term behavior of implants. In this type of graphic, a line starts when the first relevant revision in the SIRIS dataset is observed and ends with the last recorded revision. **Figures 3.4b** present the cumulative

Table 3.4c

First revision of primary total hip arthroplasty within 24 months according to stem fixation, articulation and approach

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

		Revised		95% CI	
	N at risk*	N	%**	lower	upper
Overall (moving average)	64,416	1,631	2.6	2.4	2.7
Fixation					
All cemented	916	32	3.6	2.5	5.0
All uncemented	55,939	1,399	2.5	2.4	2.7
Hybrid	7,416	189	2.6	2.2	3.0
Articulation					
Metal on polyethylene (MoPE)	1,420	56	4.0	3.1	5.1
Ceramic on polyethylene (CoPE)	8,879	243	2.8	2.4	3.1
Metal on cross-linked polyethylene (MoXLPE)	7,391	199	2.7	2.4	3.1
Ceramic on cross-linked polyethylene (CoXLPE)	35,678	839	2.4	2.2	2.5
Ceramic on ceramic (CoC)	9,644	253	2.6	2.3	3.0
Approach					
Anterior	30,911	760	2.5	2.3	2.7
Anterolateral	20,664	506	2.5	2.3	2.7
Lateral	3,602	70	2.0	1.6	2.5
Posterior	8,808	273	3.1	2.8	3.5
Other approach	431	22	5.2	3.5	7.9

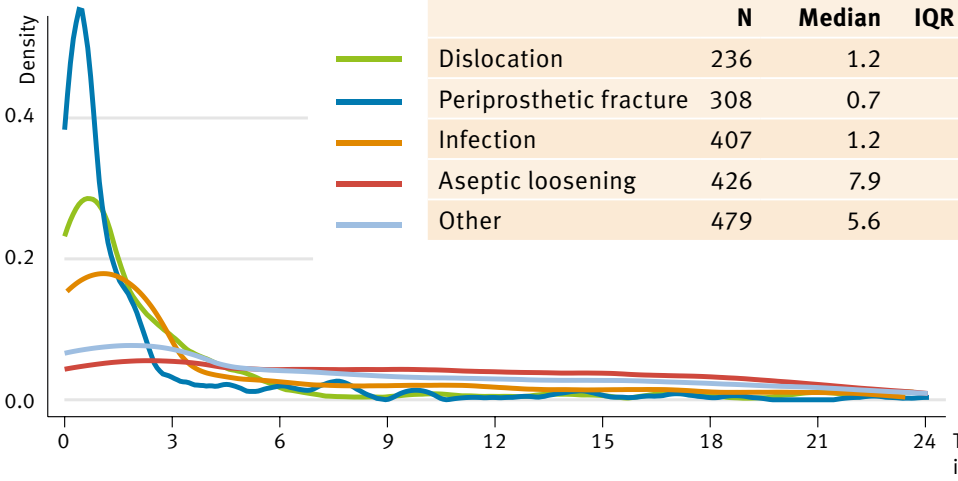
* Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).
** Rates adjusted for effects of mortality and emigration.

Figure 3.4a

Reason for early first revision by time interval since primary total hip arthroplasty

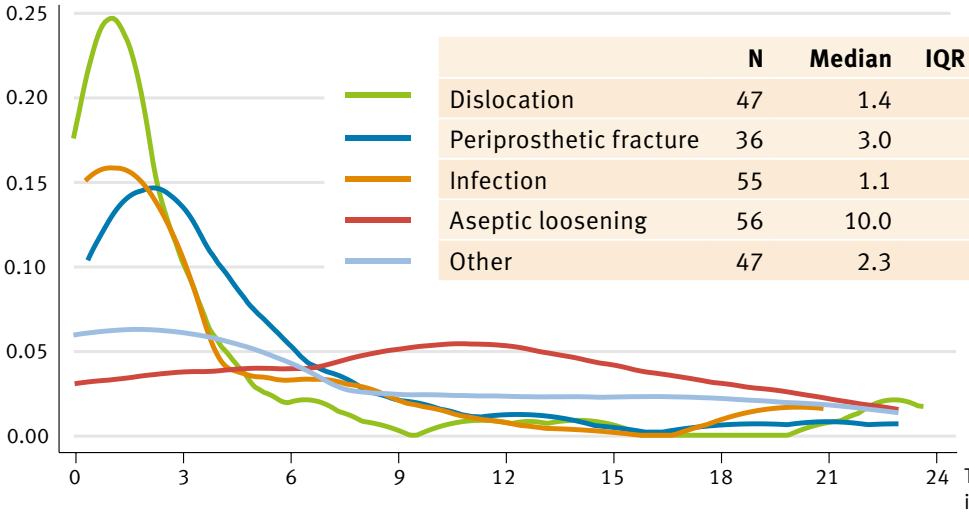
4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021).
Early first revisions are those occurring within 2 years of the primary arthroplasty

All revisions
(N= 1,631)



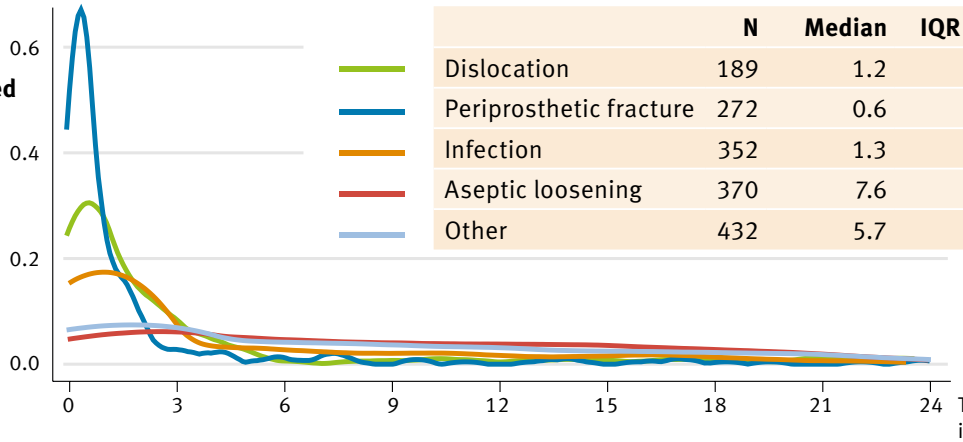
	N	Median	IQR 25%	IQR 75%
Dislocation	236	1.2	0.5	3.1
Periprosthetic fracture	308	0.7	0.3	1.8
Infection	407	1.2	0.7	6.3
Aseptic loosening	426	7.9	2.5	14.1
Other	479	5.6	0.8	12.7

Revisions femur cemented
(N= 210)



	N	Median	IQR 25%	IQR 75%
Dislocation	47	1.4	0.6	3.2
Periprosthetic fracture	36	3.0	1.2	5.4
Infection	55	1.1	0.7	5.5
Aseptic loosening	56	10.0	4.6	14.7
Other	47	2.3	0.5	12.6

Revisions femur uncemented
(N= 1,421)



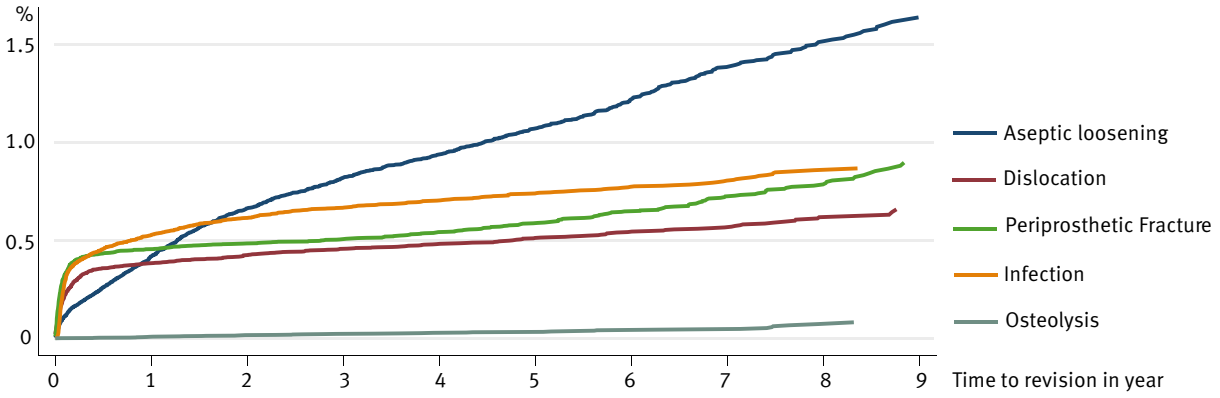
	N	Median	IQR 25%	IQR 75%
Dislocation	189	1.2	0.4	2.8
Periprosthetic fracture	272	0.6	0.2	1.5
Infection	352	1.3	0.7	6.4
Aseptic loosening	370	7.6	2.5	14.1
Other	432	5.7	0.9	12.7

Figure 3.4b

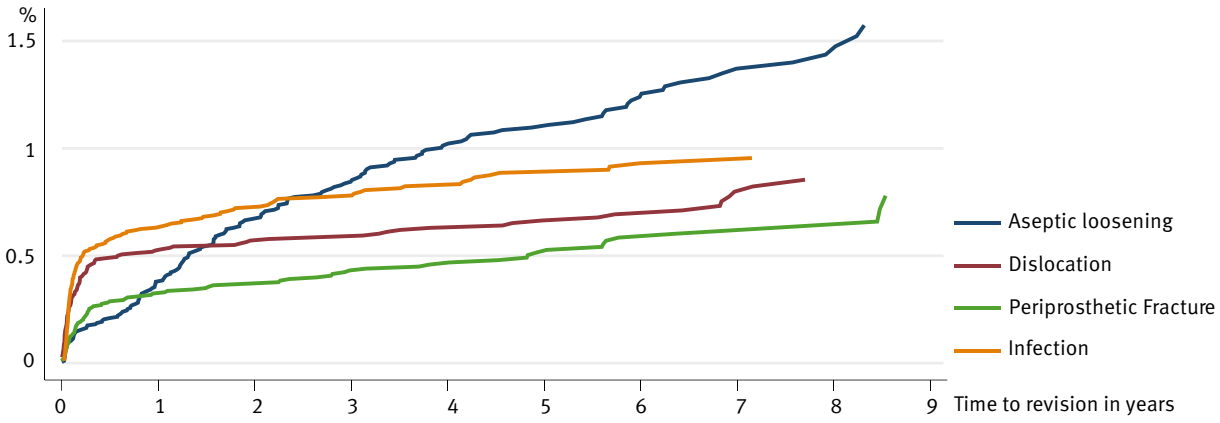
Cumulative incidence rates for different first revision diagnoses

Time since operation, 2012–2021, all services, % of implants revised

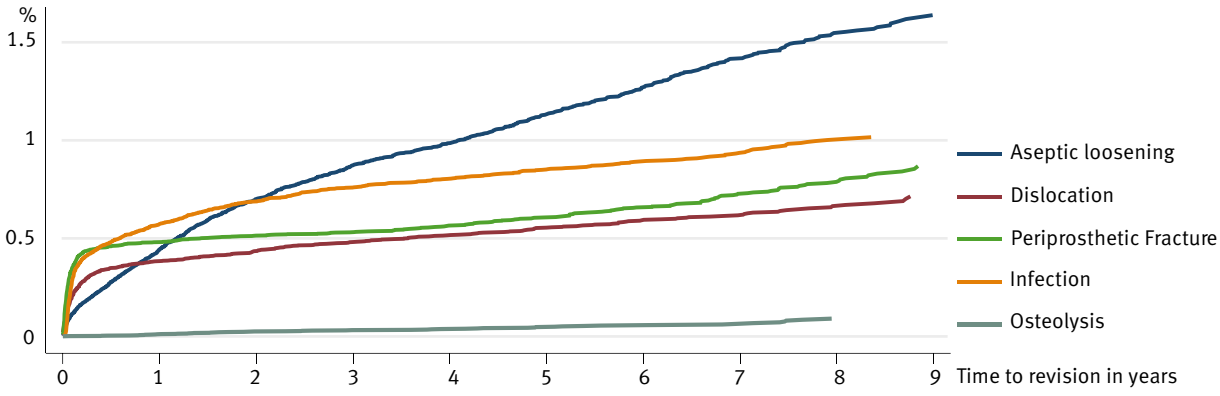
Primary osteoarthritis (OA) total hip arthroplasty



Primary osteoarthritis (OA) total hip arthroplasty – cemented femur



Primary osteoarthritis (OA) total hip arthroplasty – uncemented femur



incidence rates overall and for cemented and/or uncemented femoral components. They show the proportion of implants having experienced at least one revision due to a certain underlying reason (e.g. revision due to loosening of a component). As already seen in **Figures 3.4a,** it reveals that most reasons for revisions tend to show up rather early: a steep initial growth curve followed by very gradual growth in the long term. The exception is the loosening of components that is on a persistent and, in the long run, almost linear growth curve.

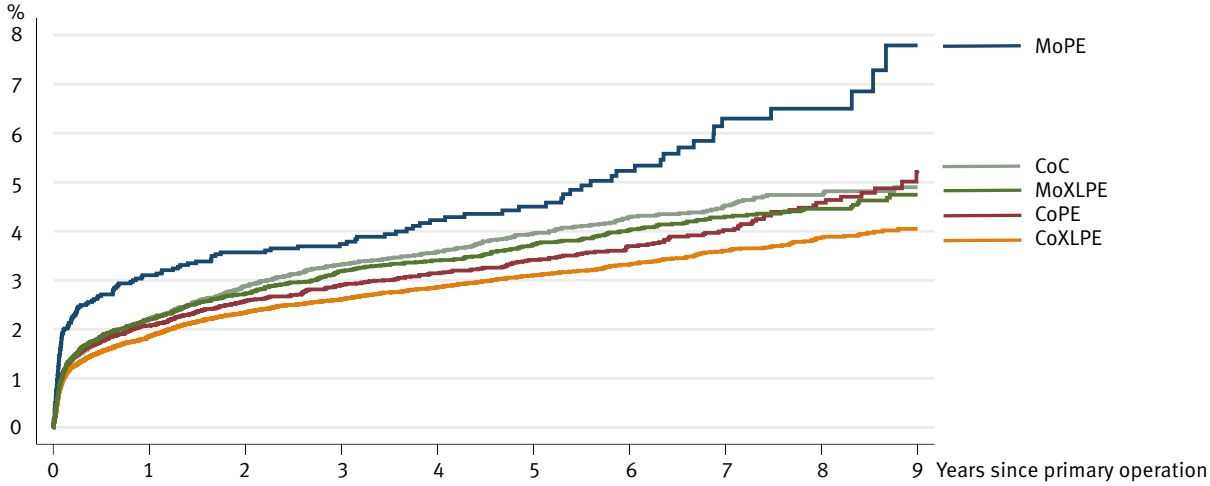
At nine years, the estimated cumulative revision rate for ceramic on highly crosslinked PE (CoXLPE) had the lowest revision rate of 4.0% (95% CI 3.7–4.2). The highest revision rate was found for metal on PE (MoPE) of 7.8% (95% CI 6.1–9.9). MoPE revisions showed an increase after 5 years, even though this result may not be fully generalisable due to relatively small numbers at risk (**Figure 3.4c).**

The fixation method had an impact on the revision rate **(Figures 3.4d)**. Hybrid fixation showed fewer revisions (4.3%, 95% CI 3.8–4.9) than uncemented (4.5%, 95% CI 4.3–4.7) or all cemented THA (5.0%, 95% CI 3.8–6.5) at nine years. However, direct comparison of hybrid and uncemented reveals that, in terms of statistical significance, the result at nine years is inconclusive, although the revision rates for hybrid fixation tends to run below the revision rates for uncemented fixation for much of the observation time.

Figure 3.4c

Estimated failure rates of primary total hip arthroplasty for different bearing surfaces

Time since operation, 2012–2021, all services, diagnosis primary OA



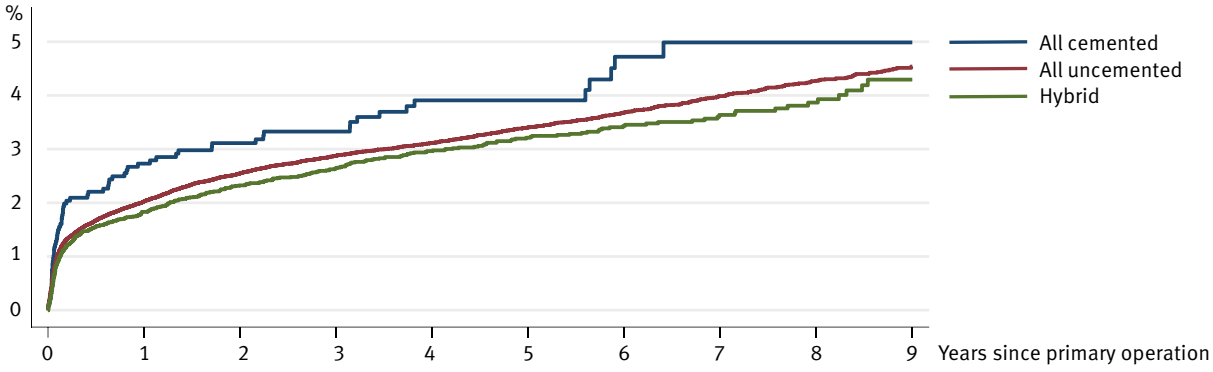
	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
MoPE	**3.1** (2.6-3.7)	**3.6** (3.0-4.3)	**3.7** (3.1-4.5)	**4.2** (3.6-5.0)	**4.5** (3.8-5.3)	**5.2** (4.4-6.2)	**6.3** (5.2-7.6)	**7.8** (6.1-9.9)
CoPE	**2.1** (1.9-2.3)	**2.6** (2.4-2.8)	**2.9** (2.7-3.2)	**3.1** (2.9-3.4)	**3.4** (3.1-3.7)	**3.7** (3.4-4.0)	**4.0** (3.7-4.4)	**5.2** (4.5-6.0)
MoXLPE	**2.2** (2.0-2.4)	**2.7** (2.5-3.0)	**3.2** (2.9-3.4)	**3.4** (3.1-3.7)	**3.7** (3.5-4.0)	**4.0** (3.7-4.4)	**4.3** (4.0-4.6)	**4.7** (4.3-5.2)
CoXLPE	**1.9** (1.8-2.0)	**2.3** (2.2-2.5)	**2.6** (2.5-2.7)	**2.9** (2.7-3.0)	**3.1** (3.0-3.2)	**3.3** (3.2-3.5)	**3.6** (3.4-3.8)	**4.0** (3.8-4.3)
CoC	**2.2** (2.0-2.4)	**2.9** (2.7-3.1)	**3.3** (3.1-3.6)	**3.6** (3.3-3.8)	**4.0** (3.7-4.3)	**4.3** (4.0-4.6)	**4.5** (4.2-4.9)	**4.9** (4.5-5.3)

BMI, on the other hand, has a very clear impact on the risk of revision **(Table 3.4a and Figures 3.4e and f).** Revision rates rose with increasing BMI. The two-year revision rate for patients with BMI >40 was 6.8% (95% CI 5.3–8.6) **(Table 3.4a).** This is more than three times higher than in patients of normal weight. The majority of complications occurred within the first two to three months. The most frequent complication in patients with high BMI is infection, accounting for up to one-third of all complications in this population. This is followed by periprosthetic fracture, femoral loosening and dislocation. Compared to the overall complication rate, only infections were clearly more frequent, periprosthetic fractures and dislocations were approximately the same and femoral and acetabular loosening less frequent.

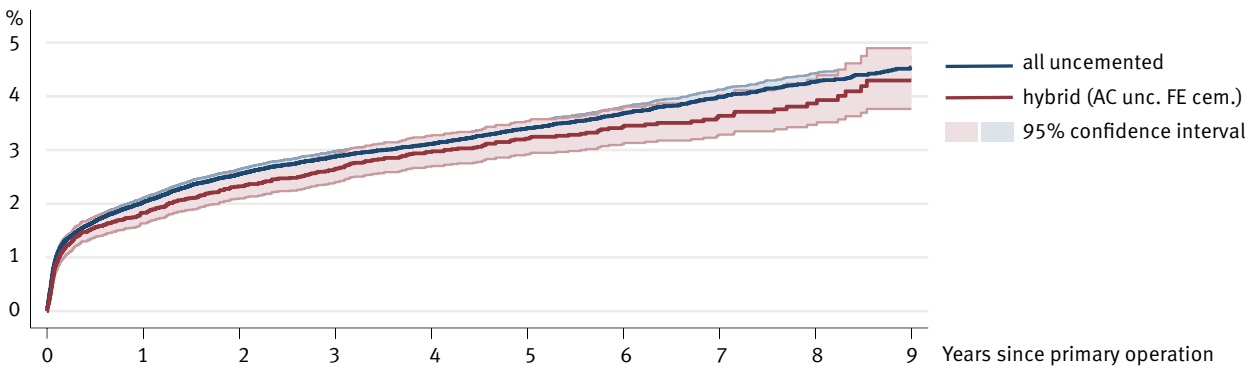
Figure 3.4d

Estimated failure rates of primary total hip arthroplasty for different fixation methods

Time since operation, 2012–2021, all services, diagnosis primary OA



	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
All cemented	**2.7** (2.1-3.6)	**3.1** (2.4-4.0)	**3.3** (2.6-4.3)	**3.9** (3.1-5.0)	**3.9** (3.1-5.0)	**4.7** (3.6-6.1)	**5.0** (3.8-6.5)	**5.0** (3.8-6.5)
All uncemented	**2.0** (2.0-2.1)	**2.5** (2.5-2.6)	**2.9** (2.8-3.0)	**3.1** (3.0-3.2)	**3.4** (3.3-3.5)	**3.7** (3.6-3.8)	**4.0** (3.9-4.1)	**4.5** (4.3-4.7)
Hybrid (AC unc. FE cem.)	**1.8** (1.6-2.1)	**2.3** (2.1-2.6)	**2.6** (2.4-2.9)	**3.0** (2.7-3.3)	**3.2** (2.9-3.5)	**3.4** (3.1-3.8)	**3.6** (3.3-4.0)	**4.3** (3.8-4.9)

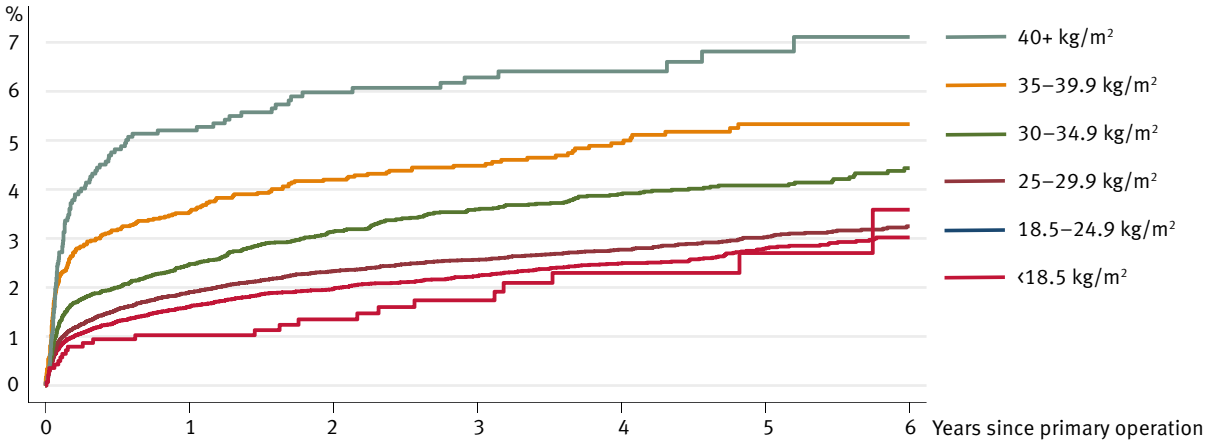


	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
All uncemented	**2.0** (2.0-2.1)	**2.5** (2.5-2.6)	**2.9** (2.8-3.0)	**3.1** (3.0-3.2)	**3.4** (3.3-3.5)	**3.7** (3.6-3.8)	**4.0** (3.9-4.1)	**4.5** (4.3-4.7)
Hybrid (AC unc. FE cem.)	**1.8** (1.6-2.1)	**2.3** (2.1-2.6)	**2.6** (2.4-2.9)	**3.0** (2.7-3.3)	**3.2** (2.9-3.5)	**3.4** (3.1-3.8)	**3.6** (3.3-4.0)	**4.3** (3.8-4.9)

Figure 3.4e

Estimated failure rates of primary total hip arthroplasty for different BMI

Time since operation, 2015–2021, all services, diagnosis primary OA

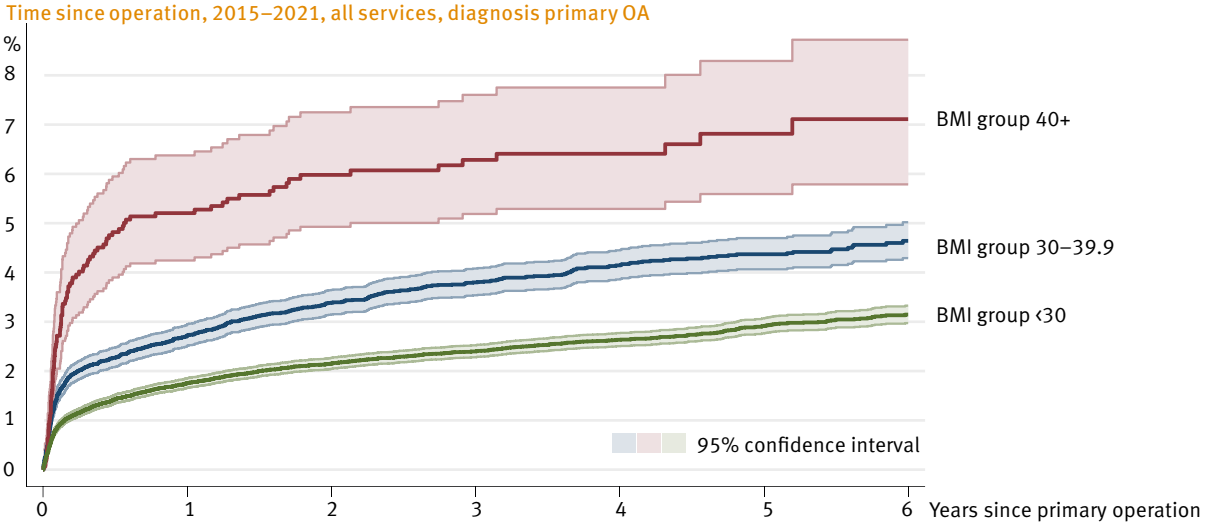


kg/m²	1 year	2 years	3 years	4 years	5 years	6 years
‹18.5	**1.0** (0.6-1.7)	**1.3** (0.8-2.2)	**1.7** (1.1-2.7)	**2.3** (1.5-3.5)	**2.7** (1.7-4.3)	**3.6** (2.0-6.5)
18.5–24.9	**1.6** (1.5-1.8)	**2.0** (1.8-2.1)	**2.2** (2.1-2.4)	**2.5** (2.3-2.7)	**2.8** (2.6-3.0)	**3.0** (2.8-3.3)
25–29.9	**1.9** (1.8-2.0)	**2.3** (2.2-2.5)	**2.6** (2.4-2.7)	**2.8** (2.6-3.0)	**3.0** (2.8-3.2)	**3.2** (3.0-3.5)
30–34.9	**2.5** (2.3-2.7)	**3.1** (2.9-3.4)	**3.6** (3.3-3.9)	**3.9** (3.6-4.2)	**4.1** (3.7-4.4)	**4.4** (4.0-4.9)
35–39.9	**3.5** (3.1-4.1)	**4.2** (3.7-4.8)	**4.5** (3.9-5.1)	**4.9** (4.3-5.6)	**5.3** (4.7-6.1)	**5.3** (4.7-6.1)
40+	**5.2** (4.2-6.4)	**6.0** (4.9-7.2)	**6.3** (5.2-7.6)	**6.4** (5.3-7.8)	**6.8** (5.6-8.3)	**7.1** (5.8-8.7)

Figure 3.4f

Estimated failure rates of primary total hip arthroplasty for different BMI

Time since operation, 2015–2021, all services, diagnosis primary OA



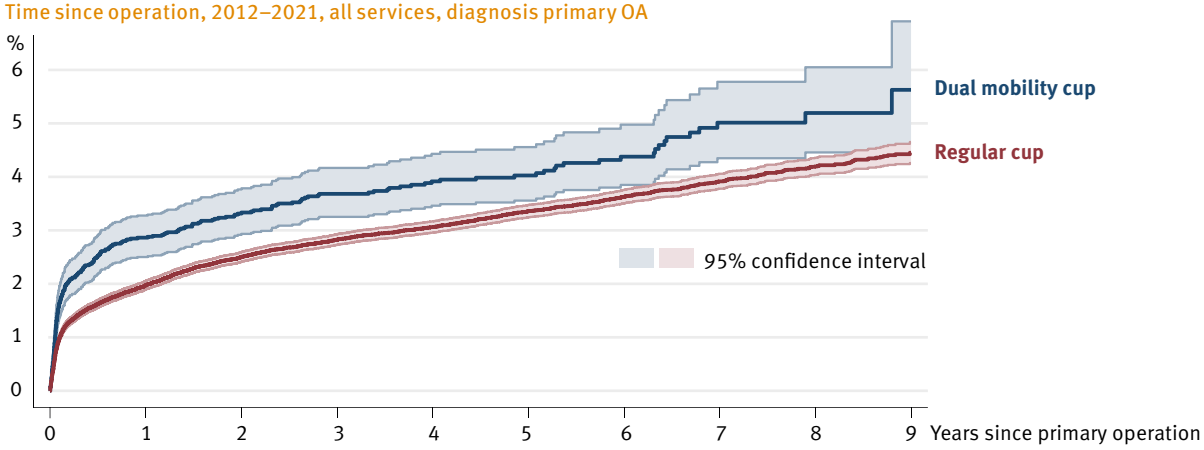
Dual mobility cups

Dual mobility or double mobility cups are increasingly being used for primary and revision THA. The exact role is still debated and several questions are not yet fully answered. Three design philosophies have an impact on stability and mobility: hemispherical, spherico-cylindrical and superior extended coverage. Compared to the average revision rate of regular cups, the average revision rate for all dual mobility cups is elevated for all time periods **(Figure 3.4g).** The revision rate for double mobility cups depends amongst other factors on the type of stem fixation. Hybrid fixation (cemented stem) is associated with a decreased revision rate for regu-

Figure 3.4g

Estimated failure rates of primary total hip arthroplasty for different types of cups (primary OA and all uncemented fixation)

Time since operation, 2012–2021, all services, diagnosis primary OA

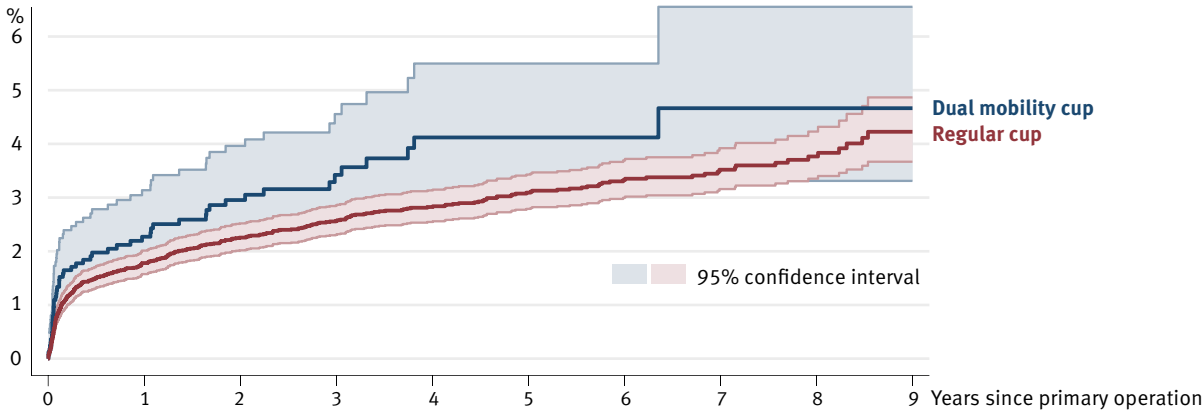


	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
Regular cup	**2.0** (1.9-2.1)	**2.5** (2.4-2.6)	**2.8** (2.7-2.9)	**3.1** (3.0-3.2)	**3.4** (3.2-3.5)	**3.6** (3.5-3.8)	**3.9** (3.8-4.1)	**4.5** (4.3-4.7)
Dual mobility cup	**2.9** (2.5-3.3)	**3.3** (2.9-3.8)	**3.7** (3.3-4.2)	**3.9** (3.5-4.4)	**4.0** (3.6-4.6)	**4.4** (3.8-5.0)	**5.0** (4.3-5.8)	**5.6** (4.6-6.9)

Figure 3.4h

Estimated failure rates of primary total hip arthroplasty for different types of cups (primary OA and hybrid fixation)

Time since operation, 2012–2021, all services, diagnosis primary OA



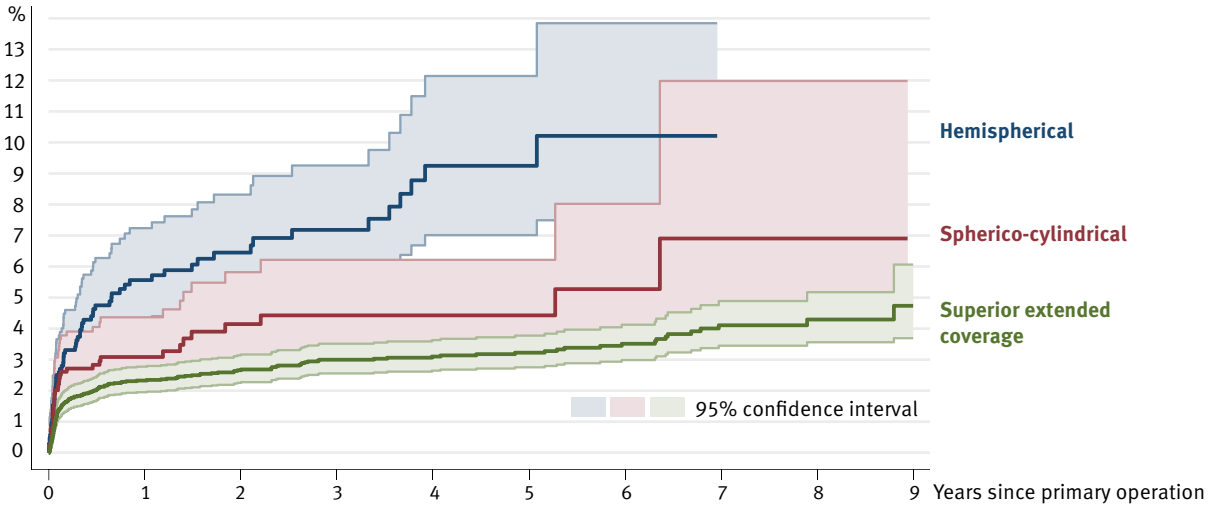
	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
Regular cup	**1.8** (1.6-2.0)	**2.3** (2.0-2.5)	**2.6** (2.3-2.9)	**2.8** (2.5-3.1)	**3.1** (2.8-3.4)	**3.3** (3.0-3.7)	**3.5** (3.2-3.9)	**4.2** (3.7-4.9)
Dual mobility cup	**2.3** (1.6-3.1)	**3.0** (2.2-4.0)	**3.4** (2.6-4.6)	**4.1** (3.1-5.5)	**4.1** (3.1-5.5)	**4.1** (3.1-5.5)	**4.7** (3.3-6.6)	**4.7** (3.3-6.6)

lar and dual mobility cups **(Figure 3.4h).** The design of the cup has a major impact on the revision rate. Uncemented dual mobility cups with superior extended coverage have the lowest revision rate at 9 years (4.7%, CI 3.7–6.1). Hemispherical cups have a 7-year revision rate of 10.2% (CI 7.5–13.8), which is almost twice as high as the revision rate for spherico-cylindrical and three times that for superior extended coverage **(Figure 3.4i). Table 3.4d** shows the currently used dual mobility cups in SIRIS.

Figure 3.4i

Estimated failure rates of primary total hip arthroplasty for different types of dual mobility cups (primary OA and all uncemented fixation)

Time since operation, 2012–2021, all services, diagnosis primary OA



	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
Hemispherical*	**5.6** (4.3-7.2)	**6.5** (5.0-8.3)	**7.2** (5.6-9.3)	**9.2** (7.0-12.1)	**9.2** (7.0-12.1)	**10.2** (7.5-13.8)		
Spherico-cylindrical	**3.1** (2.2-4.4)	**4.1** (2.9-5.8)	**4.4** (3.1-6.2)	**4.4** (3.1-6.2)	**4.4** (3.1-6.2)	**5.3** (3.4-8.0)	**6.9** (3.9-12.0)	
Superior extended coverage	**2.3** (1.9-2.8)	**2.7** (2.3-3.1)	**3.0** (2.6-3.5)	**3.1** (2.6-3.6)	**3.2** (2.8-3.8)	**3.5** (3.0-4.1)	**4.1** (3.4-4.9)	**4.7** (3.7-6.1)

* The hemispherical group is not well represented in SIRIS data. It comprises Symbol/DS evolution cups as well as the modular G7 cups

Table 3.4 d

Currently used dual mobility cups in Switzerland

Brand names	Design	Manufacturer Distributer
DS evolution	Hemispherical with flattened pole	Dedienne Santé (Mathys)
Symbol DM	Hemispherical with flattened pole	Dedienne Sante
G7 hemispherical	Modular (Hemispherical)	Zimmer Biomet
G7 bispherical	Modular (Hemispherical)	Zimmer Biomet
Liberty	Spherico-cylindrical	ATF Implants (Symbios)
Bi-Mentum	Spherico-cylindrical	SERF
Novae sunfit TH	Spherico-cylindrical	SERF
Serenity	Spherico-cylindrical	Symbios
Mobility	Spherico-cylindrical	X.NOV
X.Cup MOB (mobile bearing)	Spherico-cylindrical	X.NOV
Saturne II	Spherico-cylindrical	Amplitude
Corin DM	Spherico-cylindrical	Corin
Novae E TH	Spherico-cylindrical	SERF
Novae stick	Spherico-cylindrical	SERF
Polarcup	Superior extended coverage	S&N
Avantage	Superior extended coverage	Zimmer Biomet
Versafitcup DM	Superior extended coverage	Medacta
Gyros	Superior extended coverage	J&J Depuy Synthes
Ades DM	Superior extended coverage	Zimmer Biomet
Versacem	Superior extended coverage	Medacta
Mpact DM	Superior extended coverage	Medacta
Saturne	Superior extended coverage	Amplitude
Ecofit 2M	Superior extended coverage	Implantcast
Selexys DS	Superior extended coverage	Dedienne Santé (Mathys)
Bimobile CL	Superior extended coverage	LINK Implants
Stafit	Superior extended coverage	Zimmer Biomet
United dual mobility (UDM)	Superior extended coverage	United Orthopedic
Acorn DM	Superior extended coverage	Permedica Orthopaedics
Bimobile C	Superior extended coverage	LINK Implants

3.5 Results of implants in total hip arthroplasty

One of the key elements of an implant register is to analyse the performance of the implant with regard to complications, early revisions and, most importantly, long-term survival. While short-term results are more of a reflection of a surgeon's or a hospital's performance, long-term results depend more on the design and quality of the implants. A total hip replacement comprises at least three components, including stem, cup and head. Considering the modularity of the cup or a dual mobility system, it is sensible to focus investigations on combinations in current use and to compare those with each other. It may be that a cup works well with one stem but less well with another – and vice versa. For that reason, the following tables present frequently used implant combinations.

The analysis includes primary THA with the diagnosis of primary OA with a follow-up of at least two years within a moving four-year window. Only combinations with n>50 are presented. From a statistical point of view, n=50 may be considered the smallest "large" number useful for this type of analysis, but it is nevertheless a number that will imply very low statistical precision in the absence of a very high revision rate. This implies wide confidence intervals. One revision more or less may be enough to categorise an implant as an outlier. There is always a trade-off between statistical stability and the necessity to identify possible low-volume outliers.

Since the start of the registry, SIRIS has documented a total of 160 different brands of stem (including all currently identified sub-variants). 30 stems were implanted less than 10 times. Another 33 stems were used in 10 to 49 cases. There were 107 different brands of cup. 22 cups were implanted less than 10 times. Another 20 cups were used in 10 to 49 cases. There were 1,092 different stem cup combinations, of which 214 combinations were used in more than 50 cases. It is noteworthy that almost half of all recognised combinations were registered less than 5 times. Yet this remarkable diversity accounts for less than one percent of all registered THAs.

For the current report, only implantations from 2016 onwards were included for the two-year analysis. For this time period, there were 76 combinations with more than 50 cases implanted.

9-year revision rates

Uncemented combinations for primary OA

Sixteen stem/cup combinations cover 75% of the most frequently used uncemented combinations for primary OA **(Table 3.5a). Table 3.5b** shows the revision rates for the time period since 2012 for implantations carried out for primary OA. Only stem/cup combinations with n›500 are included. At nine years, the average revision rate for all uncemented stem/cup combinations was 4.5 (CI 4.3–4.7). Ten of the 33 combinations had a higher than average revision rate. Furthermore, the mean revision rate of the combination with less than 500 cases (other) was higher. For the 2022 report, a so-called case concentration score (CCS) was introduced. The CCS indicates the percentage of implantations performed by the main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of ›50% would suggest that reported results are likely dominated by data from one hospital service. A score of 100% indicates that the implant is used in one hospital only.

For the first time since the inception of SIRIS, the mid-term performance of implants has been assessed. The analysis included the detection of implants (minimal n≥50 cases at risk) with elevated revision rates or outlier implants anytime between 5 and 9 years. An elevated revision rate was defined as a deviation of at least 50% above the group average at any time between year 5 and year 9 (and lower bounds of the 95% confidence interval exceeding the upper bound of the group average). Outlier status was defined as a revision rate of twice the group average at any time between year 5 and year 9 (and lower bounds of the 95% confidence interval exceeding the upper bound of the group average). Below average was defined as

Table 3.5a

Top 75% of primary total hip arthroplasty uncemented combinations (primary OA)

2016–2021

Stem component	Cup component	2016	2017	2018	2019	2020	2021	2016–2021
Amistem-H	Versafitcup trio/ccl.	1,376	655	95	28	1	0	**2,155**
Amistem-H prox coating	Versafitcup trio/ccl.	190	840	1,260	853	49	27	**3,219**
Amistem-P	Versafitcup trio/ccl.	1	0	1	380	1,175	1,213	**2,770**
Avenir	Allofit	1,088	1,101	1,166	1,141	1,038	711	**6,245**
Avenir	Fitmore	353	323	302	286	256	185	**1,705**
CLS Spotorno	Fitmore	223	171	108	123	130	125	**880**
Corail	Pinnacle	1,261	1,112	1,142	1,148	1,234	1,250	**7,147**
Corail collared	Pinnacle	822	1,194	1,271	1,392	1,568	1,864	**8,111**
Fitmore	Allofit	657	550	507	527	561	617	**3,419**
Fitmore	Fitmore	416	432	593	619	623	576	**3,259**
Optimys	RM pressfit vitamys	1,464	1,676	1,756	1,831	2,103	2,474	**11,304**
Polarstem	Polarcup	217	203	216	189	209	173	**1,207**
Polarstem	R3	530	588	633	681	762	795	**3,989**
Quadra-H	Versafitcup trio/ccl.	895	943	1,046	935	725	454	**4,998**
SBG	R3	188	207	209	198	196	196	**1,194**
Twinsys	RM pressfit vitamys	389	405	399	407	394	408	**2,402**
other combinations		3,299	3,225	3,244	3,532	3,417	4,222	**20,939**
Total		**13,369**	**13,625**	**13,948**	**14,270**	**14,441**	**15,290**	**84,943**

Table 3.5b

Long term evaluation: Failure rates of primary total hip arthroplasty uncemented combinations (primary OA)

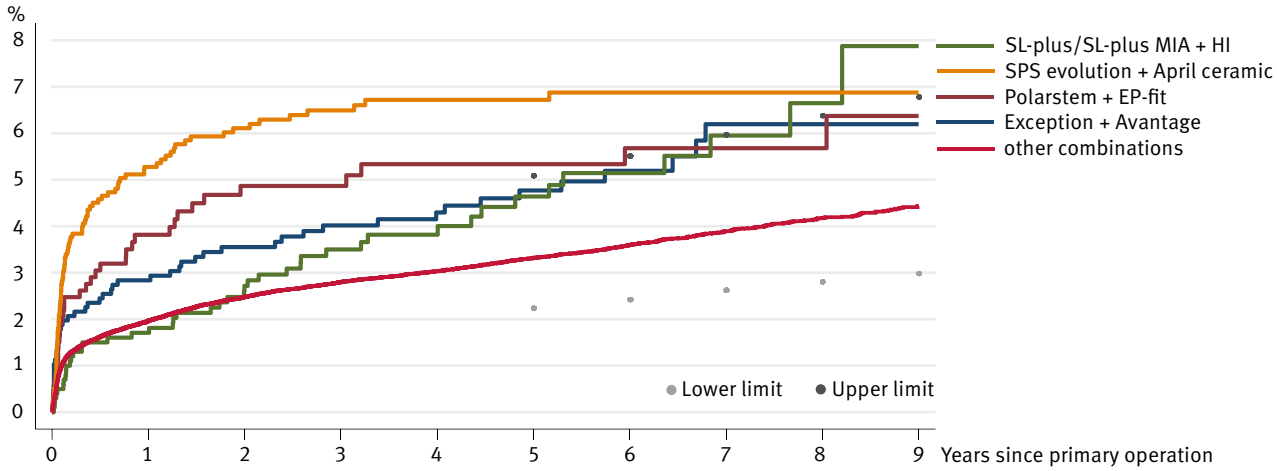
Stem component	Cup component	Total number	CCS*	1 year (95% CI)	3 years (95% CI)	5 years (95% CI)	7 years (95% CI)	9 years (95% CI)
Alloclassic	Fitmore	719	68	**2.1** (1.3-3.4)	**4.1** (2.9-5.8)	**5.0** (3.6-6.9)	**5.8** (4.2-7.9)	**5.8** (4.2-7.9)
Amistem-H	Versafitcup trio/ccl.	7,308	15	**1.9** (1.6-2.2)	**3.1** (2.7-3.5)	**4.3** (3.8-4.8)	**5.4** (4.9-6.0)	**6.4** (5.6-7.3)
Amistem-H collared	Versafitcup trio/ccl.	546	100	**0.9** (0.4-2.2)	**1.9** (1.0-3.5)	**1.9** (1.0-3.5)	**1.9** (1.0-3.5)	
Amistem-H prox coat.	Versafitcup trio/ccl.	3,220	12	**2.1** (1.6-2.6)	**2.8** (2.2-3.4)	**3.5** (2.7-4.7)		
Amistem-P	Versafitcup trio/ccl.	2,771	15	**2.5** (1.9-3.2)				
Avenir	Alloclassic	591	68	**1.9** (1.0-3.3)	**2.4** (1.4-4.0)	**2.8** (1.7-4.5)	**3.2** (1.9-5.1)	**3.7** (2.2-6.0)
Avenir	Allofit	9,651	12	**2.0** (1.7-2.3)	**2.6** (2.3-3.0)	**3.0** (2.7-3.4)	**3.5** (3.1-4.0)	**3.9** (3.3-4.5)
Avenir	Fitmore	2,564	16	**3.2** (2.5-3.9)	**4.0** (3.3-4.9)	**4.3** (3.5-5.2)	**4.7** (3.8-5.7)	**4.7** (3.8-5.7)
CLS Spotorno	Allofit	1,455	34	**2.6** (1.9-3.5)	**3.9** (3.0-5.0)	**4.3** (3.3-5.5)	**4.6** (3.5-5.9)	**5.1** (3.9-6.6)
CLS Spotorno	Fitmore	1,719	22	**1.7** (1.1-2.4)	**2.3** (1.7-3.2)	**3.0** (2.2-4.0)	**3.1** (2.3-4.2)	**3.3** (2.5-4.5)
Corail	Pinnacle	11,106	12	**2.1** (1.8-2.4)	**3.1** (2.8-3.4)	**3.8** (3.4-4.2)	**4.5** (4.0-5.0)	**5.3** (4.7-6.1)
Corail collared	Gyros	953	65	**2.0** (1.3-3.1)	**2.6** (1.8-3.9)	**2.6** (1.8-3.9)	**3.7** (2.3-6.0)	**3.7** (2.3-6.0)
Corail collared	Novae TH/Bi-Mentum	510	36	**1.6** (0.8-3.4)	**2.4** (1.1-5.2)			
Corail collared	Pinnacle	9,574	25	**1.4** (1.2-1.7)	**2.1** (1.8-2.4)	**2.3** (2.0-2.7)	**2.7** (2.3-3.3)	**2.7** (2.3-3.3)
Exception	Avantage	1,068	78	**2.8** (2.0-4.0)	**4.0** (3.0-5.4)	**4.8** (3.6-6.3)	**6.2** (4.6-8.3)	**6.2** (4.6-8.3)
Fitmore	Allofit	6,100	65	**2.0** (1.6-2.4)	**3.0** (2.6-3.5)	**3.4** (2.9-3.9)	**3.8** (3.3-4.4)	**4.1** (3.5-4.8)
Fitmore	Fitmore	4,803	23	**1.9** (1.6-2.3)	**3.0** (2.5-3.5)	**3.5** (3.0-4.2)	**3.6** (3.0-4.3)	**4.1** (3.2-5.2)
Fitmore	RM pressfit vitamys	1,257	80	**1.4** (0.9-2.2)	**2.3** (1.6-3.4)	**2.6** (1.8-3.8)	**2.6** (1.8-3.8)	
Individual/custom hip	April ceramic	882	16	**1.9** (1.2-3.1)	**2.7** (1.8-4.1)	**3.7** (2.4-5.6)	**4.1** (2.7-6.4)	**4.1** (2.7-6.4)
Optimys	RM pressfit	590	23	**2.2** (1.3-3.8)	**2.5** (1.5-4.1)	**3.0** (1.7-5.0)	**3.6** (2.1-6.4)	
Optimys	RM pressfit vitamys	14,229	11	**1.8** (1.5-2.0)	**2.2** (2.0-2.5)	**2.4** (2.2-2.7)	**2.6** (2.3-3.0)	**2.6** (2.3-3.0)
Polarstem	EP-fit	731	47	**3.8** (2.6-5.5)	**4.9** (3.5-6.8)	**5.3** (3.8-7.4)	**5.7** (4.1-7.9)	**6.4** (4.4-9.1)
Polarstem	Polarcup	1,893	78	**2.0** (1.5-2.7)	**2.2** (1.6-3.0)	**2.2** (1.6-3.0)	**2.5** (1.8-3.5)	**2.5** (1.8-3.5)
Polarstem	R3	5,730	64	**1.2** (0.9-1.5)	**1.7** (1.4-2.1)	**1.8** (1.4-2.2)	**2.2** (1.7-2.7)	**2.5** (1.9-3.2)
Quadra-H	Versafitcup trio/ccl.	6,898	19	**2.0** (1.7-2.4)	**2.9** (2.5-3.4)	**3.5** (3.1-4.1)	**4.8** (4.1-5.6)	**6.5** (5.3-8.0)
Quadra-P	Versafitcup trio/ccl.	817	35	**0.8** (0.3-1.7)				
SBG	R3	1,71	43	**1.3** (0.8-2.0)	**1.8** (1.2-2.7)	**2.4** (1.7-3.5)	**3.0** (1.8-4.8)	
SL-plus/SL-plus MIA	EP-fit	1,156	32	**2.0** (1.3-3.0)	**2.2** (1.5-3.2)	**2.6** (1.8-3.7)	**2.6** (1.8-3.7)	**3.8** (1.9-7.3)
SL-plus/SL-plus MIA	HI	1,008	38	**1.7** (1.1-2.7)	**3.5** (2.5-4.9)	**4.6** (3.4-6.4)	**6.0** (4.3-8.3)	**7.9** (5.1-12.0)
SL-plus/SL-plus MIA	R3	1,806	64	**0.8** (0.5-1.4)	**1.2** (0.7-1.8)	**1.3** (0.9-2.0)	**1.4** (0.9-2.1)	**1.7** (1.0-2.7)
SPS evolution	April ceramic	1,395	36	**5.3** (4.2-6.6)	**6.5** (5.3-8.0)	**6.7** (5.5-8.2)	**6.9**(5.6-8.4)	**6.9** (5.6-8.4)
Tri-Lock	Pinnacle	763	65	**1.2** (0.6-2.3)	**2.8** (1.8-4.3)	**3.2** (2.1-4.9)	**3.9** (2.5-5.9)	**3.9** (2.5-5.9)
Twinsys	RM pressfit vitamys	3,649	17	**2.2** (1.8-2.7)	**2.8** (2.3-3.4)	**3.1** (2.6-3.8)	**3.6** (3.0-4.4)	**4.0** (3.2-5.0)
other combinations		17,908		**2.6** (2.4-2.8)	**3.7** (3.4-4.0)	**4.3** (4.0-4.7)	**5.0** (4.6-5.4)	**5.5** (5.1-6.1)
CH average for group				**2.0** (1.9-2.1)	**2.9** (2.8-3.0)	**3.4** (3.3-3.5)	**4.0** (3.8-4.1)	**4.5** (4.3-4.7)

* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

a revision rate of up to 66% of the group average throughout the entire time between 5 and 9 years (and upper bounds of the 95% confidence interval staying below the lower bound of the group average). The Kaplan-Meier estimate for implants with an elevated revision rate is shown in **Figure 3.5a.** Four implant combinations with an elevated revision rate were detected, showing two different failure patterns. There is a high early revision rate up to three years after which the curve flattens, showing almost no further revisions. This was observed in two implant combinations (Polarstem/EP Fit, SPS Evolution/April ceramic), both being also outliers at two years. The flattening of the curve left them still with an elevated revision rate that remained high with an above-average revision rate. The other pattern shows a low revision rate from the beginning, but then an almost linear increase over the entire time period. At two years, the revision rate was still inconspicuous but, instead of flattening,

Figure 3.5a

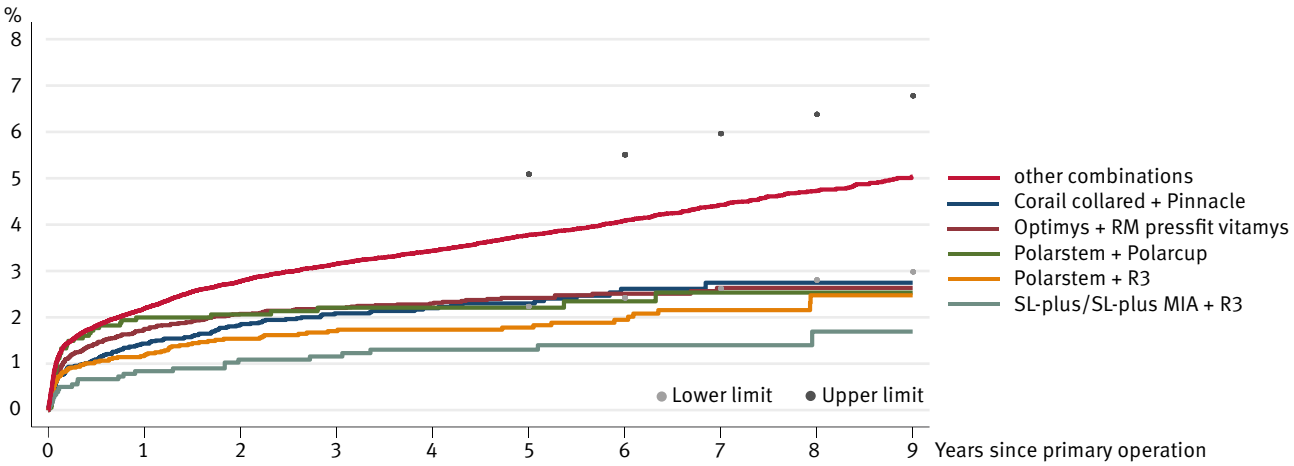
Implant combinations with elevated long-term revision rates (primary OA, uncemented THA)



An elevated revision rate was defined as a deviation of at least 50% above the group average at any time between year 5 and year 9 (and lower bounds of the 95% confidence interval exceeding the upper bound of the group average; and at least 50 cases at risk at 5 years). The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).

Figure 3.5b

Implant combinations with below-average long-term revision rates (primary OA, uncemented THA)

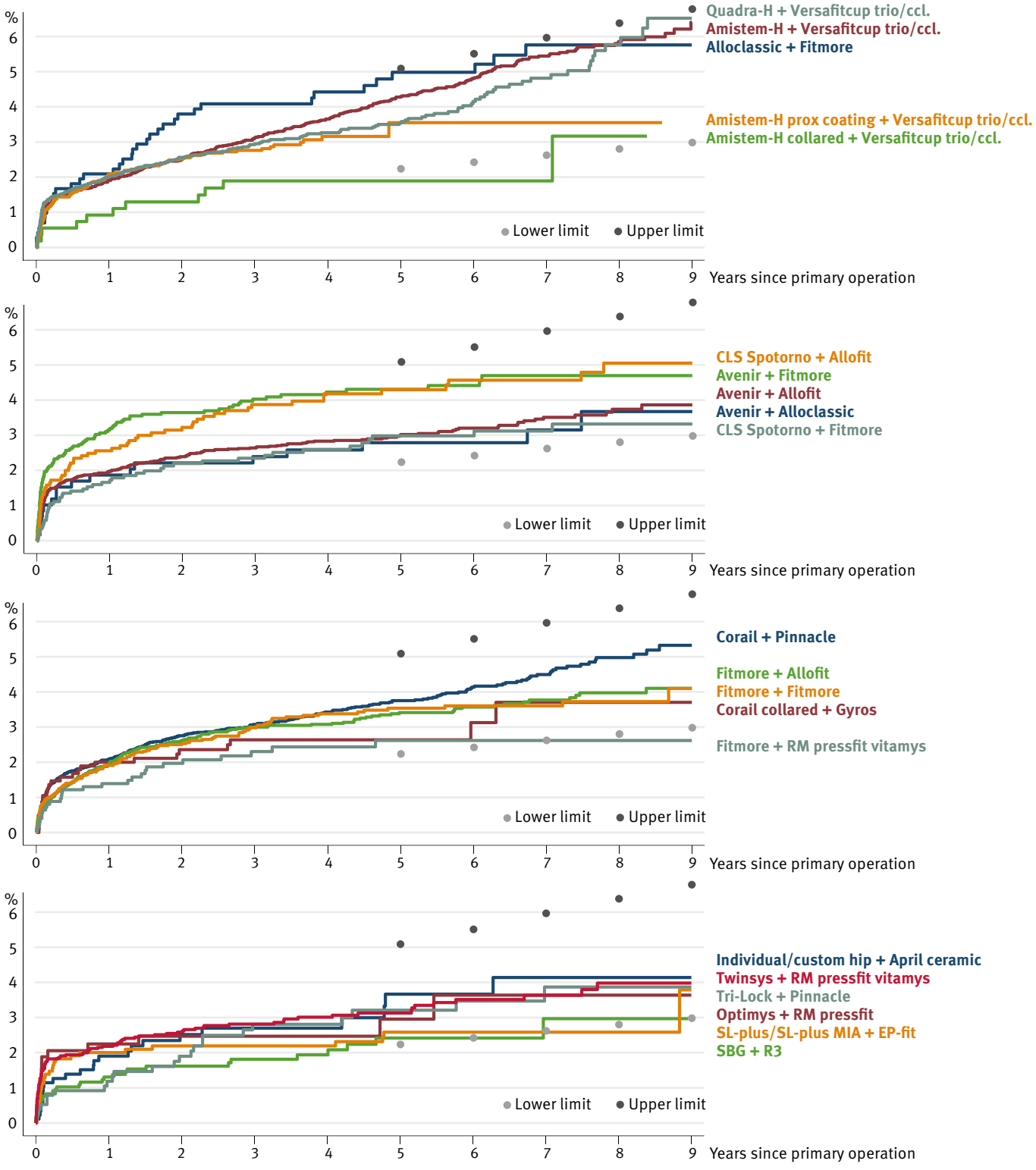


Below-average was defined as a 9-year revision rate of up to 66% of the group average (and upper bounds of the 95% confidence interval staying below the lower bound of the group average; and at least 25 cases at risk at 9 years). The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).

Figure 3.5c

All remaining implant combinations with average revision risks (prim OA, uncemented THA)

The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively). Only showing combinations with at least 100 cases still at risk at 5 years follow-up.



the curves show a steady increase over time until they reach a higher than expected revision rate (Exception/Avantage, SL-plus/SL-plus MIA + HI). For both patterns, longer observation periods are necessary to determine the performance of these implants. However, the total number of these four implant combinations reaches only 2.1% (1,757 of 84,943 cases). **Figure 3.5b** shows the implant combinations with a below-average revision rate. The pattern of these well-performing implant combinations has an initial rise and a flat ascending curve. The KM estimate of cumulative revision risk for all other uncemented implant combinations from **Table 3.5b** are shown in **Figures 3.5c.** There were no outliers between years 5 and 9.

Hybrid combinations for primary OA

Table 3.5c shows the eighteen implant combinations that cover 75% of all implantations. **Table 3.5d** shows the revision rates for the time period since 2012 for hybrid implantations carried out for primary OA. Only stem/cup combinations with n›500 are included. At nine years, the average revision rate for all uncemented stem/cup combinations was 4.3 (CI 3.7–4.9). There were no outliers at nine years, nor combinations with elevated mid-term revision rates. One implant combination (Corail (cem)/Pinnacle) had a below-average long-term revision rate **(Figure 3.5d).** As shown in **Figure 3.5e,** all implants were within the upper and lower limits. However, both curve patterns as described above were present.

Table 3.5c

Top 75% of primary total hip arthroplasty hybrid combinations (primary OA)

2016–2021

Stem component	Cup component	2016	2017	2018	2019	2020	2021	2016–2021
Amistem-C	Mpact	5	15	26	27	31	15	**119**
Amistem-C	Versafitcup DM	5	14	22	27	29	26	**123**
Amistem-C	Versafitcup trio/ccl.	289	207	187	208	161	181	**1,233**
Arcad	April ceramic	36	29	26	5	15	6	**117**
Avenir (cem)	Allofit	62	62	131	96	94	93	**538**
Avenir (cem)	Fitmore	6	13	30	53	54	75	**231**
Centris	RM pressfit vitamys	45	77	50	31	55	64	**322**
Corail (cem)	Pinnacle	152	129	121	130	148	167	**847**
Harmony (cem)	Liberty	13	24	24	24	14	22	**121**
MS-30	Allofit	45	29	43	48	43	68	**276**
MS-30	Fitmore	120	90	90	70	54	16	**440**
Original Mueller	Allofit	31	26	16	22	22	21	**138**
Original Mueller	Fitmore	32	44	37	30	20	19	**182**
Quadra-C	Versafitcup trio/ccl.	94	188	176	206	155	80	**899**
Twinsys (cem)	RM pressfit	33	29	3	15	19	34	**133**
Twinsys (cem)	RM pressfit vitamys	76	80	157	198	196	284	**991**
Weber	Allofit	103	95	76	48	38	31	**391**
Weber	Fitmore	257	244	195	180	162	148	**1,186**
other combinations	-	382	351	435	498	428	586	**2,680**
Total		**1,786**	**1,746**	**1,845**	**1,916**	**1,738**	**1,936**	**10,967**

9-year revision rates

Uncemented combinations for secondary OA

Table 3.5e shows the nineteen implant combinations that cover 75% of all implantations. Three combinations have been used less than 100 times since 2016. The revision rates for the time period since 2012 for uncemented implantations for secondary OA are presented in **Table 3.5f.** Only stem/cup combinations with n>500 are included. At nine years, the average revision rate for all uncemented stem/cup combinations was 6.0 (CI 5.4–6.7). There were no outliers at nine years. One combination (Quadra-H/Versafitcup Trio/ccl.) had an elevated long-term revision rate. One implant combination

Table 3.5d

Long term evaluation: Failure rates of primary total hip arthroplasty hybrid combinations (primary OA)

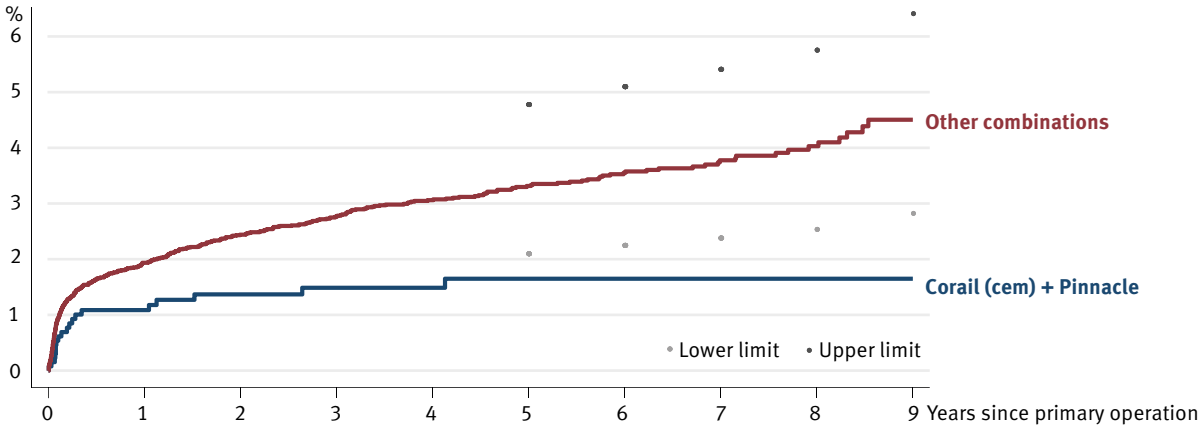
Time since surgery, 2012–2021

Stem component	Cup component	Total number	CCS*	1 year (95% CI)	3 years (95% CI)	5 years (95% CI)	7 years (95% CI)	9 years (95% CI)
Amistem-C	Versafitcup trio/ccl.	1,981	27	**2.3** (1.7-3.1)	**3.0** (2.3-3.9)	**3.4** (2.7-4.4)	**3.6** (2.8-4.6)	**5.1** (3.2-8.0)
Avenir (cem)	Allofit	580	19	**2.0** (1.1-3.7)	**2.5** (1.5-4.4)	**2.5** (1.5-4.4)	**2.5** (1.5-4.4)	
Corail (cem)	Pinnacle	1,323	24	**1.1** (0.6-1.8)	**1.5** (0.9-2.4)	**1.6** (1.0-2.6)	**1.6** (1.0-2.6)	**1.6** (1.0-2.6)
MS-30	Fitmore	778	58	**1.0** (0.5-2.1)	**1.5** (0.8-2.7)	**1.5** (0.8-2.7)	**1.5** (0.8-2.7)	**2.1** (1.0-4.2)
Quadra-C	Versafitcup trio/ccl.	1,021	33	**2.1** (1.4-3.2)	**2.9** (1.9-4.2)	**3.6** (2.4-5.4)	**3.6** (2.4-5.4)	
Twinsys (cem)	RM pressfit vitamys	1,095	21	**0.9** (0.5-1.8)	**1.1** (0.6-2.1)	**3.0** (1.6-5.8)	**4.1** (2.0-8.2)	
Weber	Allofit	717	29	**1.9** (1.1-3.2)	**2.7** (1.7-4.2)	**2.9** (1.8-4.5)	**3.8** (2.4-6.2)	**3.8** (2.4-6.2)
Weber	Fitmore	2,241	27	**1.6** (1.2-2.2)	**2.5** (1.9-3.3)	**3.5** (2.7-4.5)	**4.3** (3.4-5.6)	**5.1** (3.8-6.8)
other combinations		6,890		**2.2** (1.8-2.5)	**3.2** (2.8-3.6)	**3.7** (3.2-4.2)	**4.1** (3.5-4.7)	**4.7** (4.0-5.7)
CH average for group				**1.9** (1.7-2.1)	**2.7** (2.4-2.9)	**3.2** (2.9-3.5)	**3.6** (3.3-4.0)	**4.3** (3.7-4.9)

* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.
Please note that if reported stem-cup combinations involve multiple sub-variants, it is possible that the long-term performance of these sub-variants may be significantly different from their combined performance.

Figure 3.5d

Implant combinations with below-average long-term revision rates (primary OA, hybrid THA)



Below-average was defined as a 9-year revision rate of up to 66% of the group average (and upper bounds of the 95% confidence interval staying below the lower bound of the group average; and at least 25 cases at risk at 9 years). The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).

(Fitmore/Allofit) had a below-average long-term revision rate **(Figures 3.5f and g).** All other implant combinations were within the upper and lower limits **(Figure 3.5h).** Data for all cemented and hybrid fixations for secondary OA are not presented, because of small numbers implanted. The results for THA used to treat fractures are presented in chapter 3.8.

Figure 3.5e

All remaining implant combinations with average revision risks (primary OA, hybrid fixation THA)

The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively). Only showing combinations with at least 100 cases still at risk at 5 years follow-up.

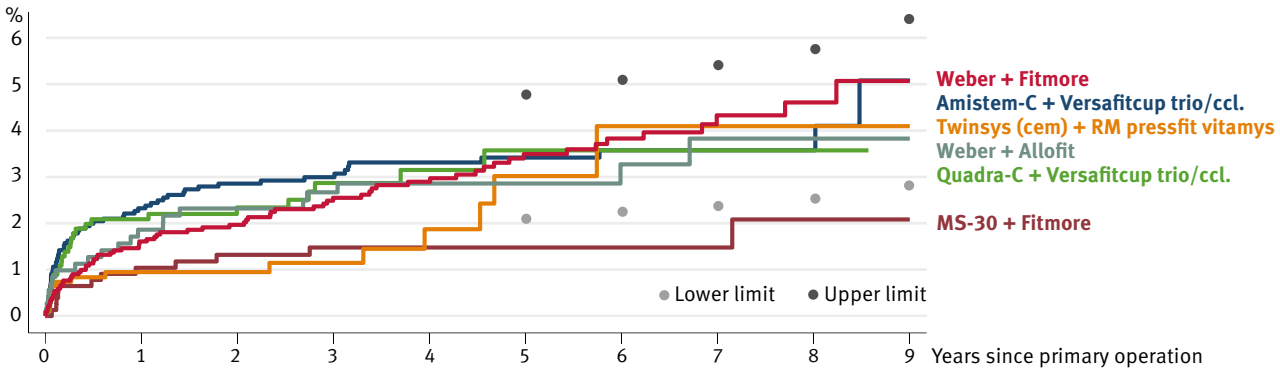


Table 3.5e

Top 75% of primary total hip arthroplasty uncemented combinations (secondary OA) 2016–2021

Stem component	Cup component	2016	2017	2018	2019	2020	2021	2016–2021
Amistem-H	Versafitcup trio/ccl.	82	53	8	1	0	0	**144**
Amistem-H prox coating	Versafitcup trio/ccl.	18	102	114	57	3	3	**297**
Amistem-P	Versafitcup trio/ccl.	0	0	1	41	112	118	**272**
Avenir	Allofit	70	71	90	92	102	54	**479**
Avenir	Fitmore	39	25	18	20	21	24	**147**
CLS Spotorno	Allofit	22	30	30	35	23	9	**149**
Corail	Pinnacle	124	96	66	76	80	110	**552**
Corail collared	Pinnacle	95	106	104	108	122	196	**731**
Fitmore	Allofit	129	134	121	123	131	173	**811**
Fitmore	Fitmore	51	31	32	58	52	37	**261**
Fitmore	RM pressfit vitamys	7	5	6	11	33	23	**85**
Individual/custom hip	April ceramic	11	14	18	20	10	27	**100**
Optimys	RM pressfit vitamys	118	107	147	144	179	218	**913**
Polarstem	Polarcup	3	1	2	19	30	29	**84**
Polarstem	R3	36	43	61	73	89	87	**389**
Quadra-H	Versafitcup trio/ccl.	76	80	79	69	52	42	**398**
SBG	R3	12	14	22	22	33	18	**121**
SL-plus/SL-plus MIA	HI	18	19	14	17	10	5	**83**
Twinsys	RM pressfit vitamys	46	45	33	26	33	40	**223**
other combinations		304	281	313	335	363	439	**2,035**
Total		**1,261**	**1,257**	**1,279**	**1,347**	**1,478**	**1,652**	**8,274**

Table 3.5f

Long term evaluation: Failure rates of primary total hip arthroplasty uncemented combinations (secondary OA)

Time since operation, 2012–2021

Stem component	Cup component	Total number	CCS*	1 year (95% CI)	3 years (95% CI)	5 years (95% CI)	7 years (95% CI)	9 years (95% CI)
Amistem-H	Versafitcup trio/ccl.	553	14	**1.8** (1.0-3.4)	**2.6** (1.5-4.3)	**3.9** (2.5-6.0)	**5.0** (3.4-7.4)	**5.5** (3.7-8.3)
Avenir	Allofit	684	16	**3.6** (2.4-5.3)	**4.3** (3.0-6.3)	**5.0** (3.4-7.1)	**6.0** (4.1-8.8)	**6.0** (4.1-8.8)
Corail	Pinnacle	824	10	**2.9** (1.9-4.3)	**4.1** (2.9-5.8)	**4.8** (3.4-6.8)	**5.7** (4.0-8.2)	**6.7**(4.4-10.1)
Corail collared	Pinnacle	911	33	**1.8** (1.1-3.0)	**2.8** (1.9-4.3)	**3.3** (2.2-5.0)	**3.3** (2.2-5.0)	**3.3** (2.2-5.0)
Fitmore	Allofit	1,161	88	**1.6** (1.0-2.6)	**3.0** (2.1-4.3)	**3.2** (2.2-4.5)	**3.5** (2.4-5.0)	**3.5** (2.4-5.0)
Optimys	RM pressfit vitamys	1,126	19	**3.0** (2.2-4.3)	**3.4** (2.5-4.7)	**3.4** (2.5-4.7)	**4.4** (3.0-6.6)	
Polarstem	R3	608	80	**2.4** (1.4-3.9)	**3.4** (2.1-5.3)	**3.8** (2.4-6.0)	**4.2** (2.7-6.7)	**4.2** (2.7-6.7)
Quadra-H	Versafitcup trio/ccl.	588	27	**2.9** (1.8-4.7)	**5.0** (3.4-7.2)	**7.6**(5.4-10.7)	**9.8**(6.8-14.2)	**9.8**(6.8-14.2)
other combinations		5,419		**3.6** (3.2-4.2)	**4.7** (4.1-5.3)	**5.4** (4.8-6.1)	**6.3** (5.5-7.2)	**6.8** (5.9-7.9)
CH average for group				**3.0** (2.7-3.3)	**4.1** (3.7-4.5)	**4.8** (4.4-5.3)	**5.6** (5.1-6.2)	**6.0** (5.4-6.7)

* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.
Please note that if reported stem-cup combinations involve multiple sub-variants, it is possible that the long-term performance of these sub-variants may be significantly different from their combined performance.

Figure 3.5f

Implant combinations with below-average long-term revision rates (secondary OA, uncemented THA)

Below-average was defined as a 9-year revision rate of up to 66% of the group average (and upper bounds of the 95% confidence interval staying below the lower bound of the group average; and at least 25 cases at risk at 9 years). The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).

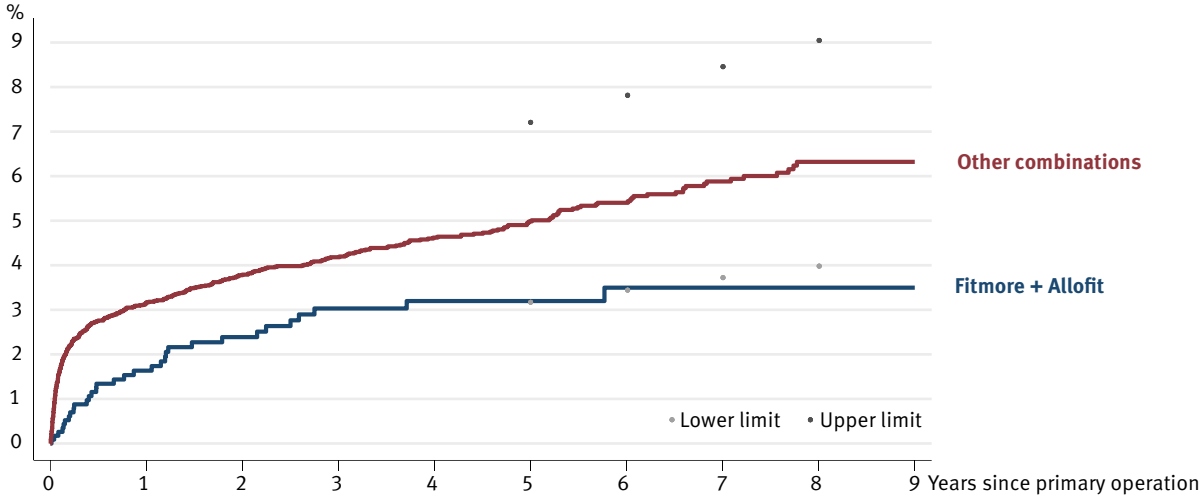


Figure 3.5g

Implant combinations with elevated long-term revision rates (secondary OA, uncemented THA)

An elevated revision rate was defined as a deviation of at least 50% above the group average at any time between year 5 and year 9 (and lower bounds of the 95% confidence interval exceeding the upper bound of the group average; and at least 50 cases at risk at 5 years).
The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively)

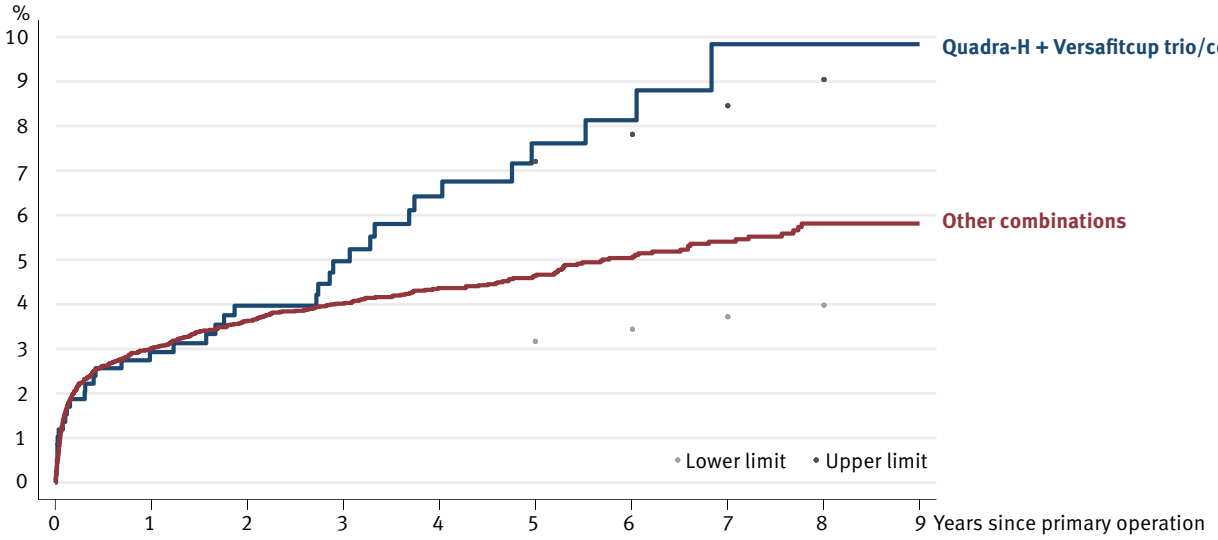
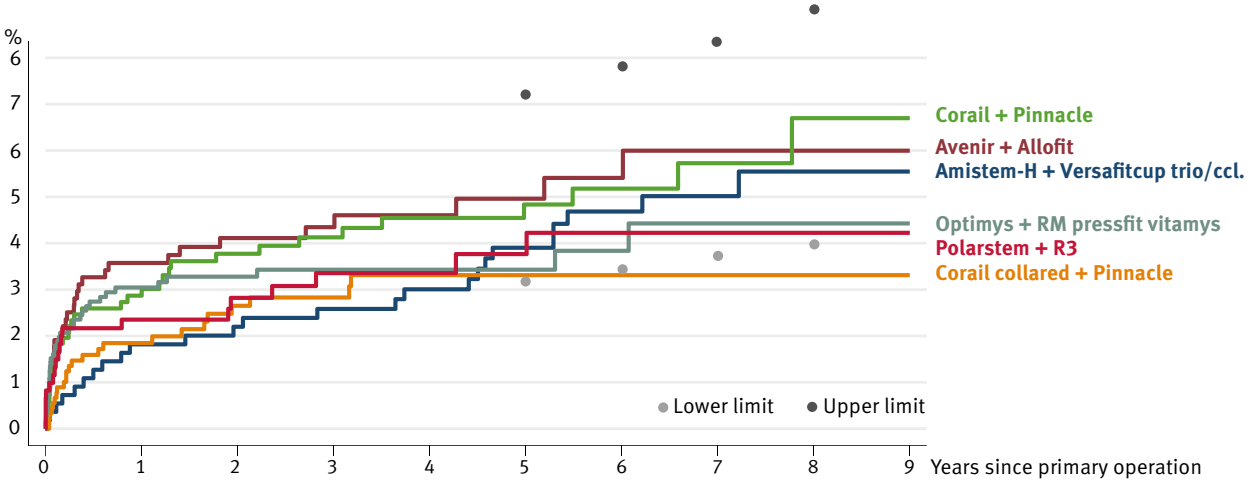


Figure 3.5h

All remaining implant combinations with average revision risks (secondary OA, uncemented THA)

The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively). Only showing combinations with at least 100 cases still at risk at 5 years follow-up.



2-year revision rates

Uncemented combinations for primary OA

The 2-year revision rate is an important time point for gathering initial results about the early performance of an implant. Most complications occur within the first three months after implantation **(Figure 3.4a),** when loosening is not yet a problem **(Figure 3.4b).** At two years, therefore, the initial phase has passed and the long-term effects have not yet started. This is a good time point to observe and describe the performance of an implant.

The time period observed is a 4-year period with a full 2 years of follow-up. This 4-year period moves one year further every year. The use of a moving time window leads to results reflecting current trends and currently used implants more reliably and also eliminates the burden of the past. It gives the possibility to compare time periods with each other and monitor the evolution of revision rates, newer implants and surgical results. This also facilitates the registry's function of being an early warning system for hospitals and surgeons. Two years is also a standard time period for reporting of early clinical results.

As in other registries, the following definition for a potential outlier was adopted: an implant may be considered a "statistical outlier" if its revision rate deviates markedly from the relevant group average. The reference revision rate used in this report is the average revision rate of all corresponding implants (or combinations) in this registry over the observation period (e.g. uncemented stem/cup combinations used in THAs with a diagnosis of primary osteoarthritis). The outlier alert boundary is set at twice that reference revision rate. An implant is regarded as a potential outlier when its two-year revision rate is higher than the outlier alert boundary, regardless of the extent of the statistical confidence interval. The outlier status comes with varying degrees of statistical probability. The outlier status is considered "highly likely" when both the estimated revision rate and the complete confidence interval exceed the outlier alert boundary. For an implant combination with high numbers, the confidence interval is usually narrow. As numbers get smaller, the statistical precision decreases, which results in wider confidence intervals. The confidence interval describes the range in which the true mean of a population is expected with the stated probability (typically 95%). For practical purposes, any position within the confidence interval should be seen as a plausible value. If confidence intervals overlap, they should be regarded as statistically not different. For that reason, implants for which the revision rate exceeds the double of the mean revision rate , but the confidence inervals overlap, are defined as potential outliers. If the lower confidence interval exceeds twice the mean revision rate, it is considered a definitive outlier.

Some components that perform well in one combination do not necessarily perform as well in another.

The average revision rate is calculated for all primary implants for primary OA per fixation group. For the moving four-year window time period from 1.1.2016 to 31.12.2019, covering a total of 64,004 implantations, the average revision rate for uncemented THAs was 2.5% (CI 2.4–2.7) and 2.5% (CI 2.2–2.9) for hybrid fixation. Because of infrequent use and small numbers, the analysis for all cemented THAs was skipped. Due to the four-year moving window for the analysis of the two-year revision rates, the results of some of the implant combinations may be different to those reported in 2021.

Table 3.5g shows the two-year revision rates of all uncemented implant combinations for primary OA with n›50. 96% of all combinations are covered within this list. 2,157 implantations are attributed to combinations not reaching the minimum of 50 cases in the 4-year time period. The revision rates were adjusted for effects of mortality and emigration from Switzerland. Seven stem/cup combinations have been identified as potential outliers. They are further analysed following the protocol described above and presented in the outlier watchlist at the end of this report.

Figure 3.5i shows the alphabetical list of stem/cup combinations with respect to the group average and outlier boundary, being twice the value of the group average.

Hybrid combinations for primary OA

The average two-year revision rate for hybrid implantation for primary OA was 2.5% (CI 2.2–2.9) **(Figure 3.5j).** The revision rates were adjusted for the effects of mortality and departure from Switzerland. Combinations of implants outside the outlier boundary (revision rate twice the revision rate of the group) are potential outliers. None of the implant combinations were considered to be outliers.

Uncemented combinations for secondary OA

The two-year revision rate for uncemented implantations for secondary OA was 3.3% (CI 2.9–3.9) **(Figure 3.5k).** None of the implants were considered to have outlier status.

Important information on the use of the implant performance tables below

- Estimated revision rate exceeds the alert boundary, but we do not identify this implant combination as an outlier because the 95% confidence interval overlaps the confidence zone of the reference group.
- Identified as potential outliers. Please note the statistical confidence intervals. The outlier status comes with varying degrees of statistical probability. We consider the potential outlier status „highly likely“ when both the estimated revision rate and the complete confidence interval exceed the outlier alert boundary.

Please be aware that relatively rare implant combinations are frequently used in only a small number or indeed only in one hospital in Switzerland. Observed revision rates may be determined by local factors and performance may differ significantly between locations. Manufacturers of detected outlier implants and the hospitals where they were used (and revisions occurred) have been informed by SIRIS.

Table 3.5g (Part 1)

2-year evaluation: Revision rates of uncemented primary total hip arthroplasty combinations within 24 months (primary OA)

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

Stem component	Cup component	CSS*	at risk N**	Revised N	Revised % (95% CI)***
Actis	Pinnacle	40	124	1	0.8 (0.1-5.6)
Alloclassic	Alloclassic	98	158	4	2.5 (1.0-6.6)
Alloclassic	Allofit	88	167	2	1.2 (0.3-4.7)
Alloclassic	Fitmore	85	231	13	5.7 (3.3-9.6)
Amistem-H	Mpact	74	95	4	4.2 (1.6-10.9)
Amistem-H	Versafitcup trio/ccl.	12	2,154	56	2.6 (2.0-3.4)
Amistem-H collared	Versafitcup trio/ccl.	100	341	4	1.2 (0.4-3.1)
Amistem-H prox coat.	Mpact	26	352	5	1.4 (0.6-3.4)
Amistem-H prox coat.	Versafitcup DM	67	66	5	7.7 (3.3-17.5)
Amistem-H prox coat.	Versafitcup trio/ccl.	13	3,143	79	2.5 (2.0-3.2)
Amistem-P	Versafitcup trio/ccl.	24	382	9	2.4 (1.2-4.5)
Ana.Nova alpha proxy	Ana.Nova alpha	99	128	0	0.0 (.-.)
Avenir	Ades DM	89	89	1	1.1 (0.2-7.7)
Avenir	Alloclassic	62	165	5	3.0 (1.3-7.1)
Avenir	Allofit	12	4,483	97	2.2 (1.8-2.7)
Avenir	Avantage	30	50	2	4.0 (1.0-15.1)
Avenir	Fitmore	21	1,257	54	4.3 (3.3-5.6)
Brexis	Xentrax	100	51	2	3.9 (1.0-14.8)
CLS Spotorno	Allofit	48	538	13	2.4 (1.4-4.2)
CLS Spotorno	Fitmore	30	625	8	1.3 (0.6-2.6)
Corail	Allofit	97	67	1	1.6 (0.2-10.6)
Corail	Fitmore	90	150	4	2.7 (1.0-7.0)
Corail	Pinnacle	12	4,654	137	3.0 (2.5-3.5)
Corail collared	Delta motion	60	78	0	. (.-.)
Corail collared	Gyros	57	573	12	2.1 (1.2-3.7)
Corail collared	Novae TH/Bi-Mentum	47	90	2	2.3 (0.6-9.0)
Corail collared	Pinnacle	31	4,679	80	1.7 (1.4-2.1)
Corehip	Plasmafit	77	82	0	0.0 (.-.)
Exacta	Jump system/JS traser	71	62	1	1.6 (0.2-10.9)
Exacta S	Jump system/JS traser	57	104	1	1.0 (0.1-6.6)
Exception	Allofit	50	107	2	1.9 (0.5-7.3)
Exception	Avantage	77	495	23	4.7 (3.1-6.9)
Exception	Exceed	80	74	4	5.4 (2.1-13.8)
Fitmore	Allofit	72	2,241	57	2.6 (2.0-3.3)
Fitmore	Fitmore	33	2,060	45	2.2 (1.7-2.9)
Fitmore	RM pressfit vitamys	84	585	10	1.7 (0.9-3.2)
GTS	G7 bispherical	96	101	13	13.0 (7.8-21.3)
H-Max S	Delta PF	48	127	2	1.6 (0.4-6.1)

* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

*** Rates adjusted for effects of mortality and emigration.

Table 3.5g (Part 2)

Stem component	Cup component	CSS*	at risk N**	Revised N	Revised % (95% CI)***
H-Max S	Delta TT	37	209	3	1.4 (0.5-4.4)
H-Max S	Symbol DM/DS evol.	58	62	0	0.0 (.-.)
Harmony	April ceramic	83	54	0	0.0 (.-.)
Harmony	April poly	53	57	1	1.8 (0.3-12.0)
Harmony	Symbol DM/DS evol.	100	87	8	9.3 (4.8-17.7)
Individual/custom hip	April ceramic	21	348	4	1.2 (0.4-3.1)
Individual/custom hip	Pinnacle	53	59	1	1.7 (0.2-11.4)
Minimax	Versafitcup trio/ccl.	29	87	2	2.3 (0.6-9.0)
Nanos	R3	42	113	6	5.3 (2.4-11.4)
Optimys	Allofit	76	59	1	1.7 (0.2-11.4)
Optimys	Anexys	38	307	5	1.7 (0.7-3.9)
Optimys	RM pressfit	37	304	6	2.0 (0.9-4.4)
Optimys	RM pressfit vitamys	12	6727	144	2.2 (1.8-2.5)
Polarstem	EP-fit	83	196	12	6.1 (3.5-10.5)
Polarstem	HI	85	72	1	1.4 (0.2-9.6)
Polarstem	Polarcup	79	823	20	2.4 (1.6-3.8)
Polarstem	R3	57	2432	39	1.6 (1.2-2.2)
Quadra-H	Mpact	61	267	8	3.0 (1.5-6.0)
Quadra-H	Versafitcup DM	46	120	4	3.3 (1.3-8.7)
Quadra-H	Versafitcup trio/ccl.	18	3819	99	2.6 (2.2-3.2)
SBG	HI	43	65	2	3.2 (0.8-12.0)
SBG	R3	43	802	13	1.6 (0.9-2.8)
SBG	Xentrax	100	107	3	2.8 (0.9-8.6)
SL-plus/SL-plus MIA	EP-fit	32	411	6	1.5 (0.7-3.2)
SL-plus/SL-plus MIA	HI	40	515	19	3.8 (2.4-5.8)
SL-plus/SL-plus MIA	R3	73	678	9	1.3 (0.7-2.6)
SMS	Versafitcup trio/ccl.	100	64	4	6.3 (2.4-15.9)
SPS HA	April ceramic	52	64	5	7.8 (3.3-17.8)
SPS evolution	April ceramic	36	551	33	6.0 (4.3-8.4)
SPS evolution	April poly	34	121	3	2.5 (0.8-7.5)
SPS evolution	Liberty	49	81	4	5.0 (1.9-12.9)
Stelia-Stem	Ana.Nova hybrid	100	136	5	3.7 (1.6-8.7)
Stelia-Stem	BSC pressfit	100	71	1	1.4 (0.2-9.8)
Trendhip	Plasmafit	66	50	0	0.0 (.-.)
Tri-Lock	Pinnacle	82	320	3	1.0 (0.3-2.9)
Twinsys	Anexys	34	88	3	3.5 (1.2-10.6)
Twinsys	RM pressfit	62	97	4	4.1 (1.6-10.6)
Twinsys	RM pressfit vitamys	15	1595	44	2.8 (2.1-3.7)
other combinations			2157	97	4.6 (3.7-5.5)
CH average for group					**2.5 (2.4-2.7)**

Figure 3.5i

Stem component	Cup component
Actis	Pinnacle
Alloclassic	Alloclassic
Alloclassic	Allofit
Alloclassic	Fitmore
Amistem-H	Mpact
Amistem-H	Versafitcup trio/ccl.
Amistem-H collared	Versafitcup trio/ccl.
Amistem-H prox coating	Mpact
Amistem-H prox coating	Versafitcup DM
Amistem-H prox coating	Versafitcup trio/ccl.
Amistem-P	Versafitcup trio/ccl.
Ana.Nova alpha proxy	Ana.Nova alpha
Avenir	Ades DM
Avenir	Alloclassic
Avenir	Allofit
Avenir	Avantage
Avenir	Fitmore
Brexis	Xentrax
CLS Spotorno	Allofit
CLS Spotorno	Fitmore
Corail	Allofit
Corail	Fitmore
Corail	Pinnacle
Corail collared	Delta motion
Corail collared	Gyros
Corail collared	Novae TH/Bi-Mentum
Corail collared	Pinnacle
Corehip	Plasmafit
Exacta	Jump system/JS traser
Exacta S	Jump system/JS traser
Exception	Allofit
Exception	Avantage
Exception	Exceed
Fitmore	Allofit
Fitmore	Fitmore
Fitmore	RM pressfit vitamys
GTS	G7 bispherical
H-Max S	Delta PF
H-Max S	Delta TT
H-Max S	Symbol DM/DS evol.
Harmony	April ceramic
Harmony	April poly
Harmony	Symbol DM/DS evol.
Individual/custom hip	April ceramic
Individual/custom hip	Pinnacle
Minimax	Versafitcup trio/ccl.
Nanos	R3
Optimys	Allofit
Optimys	Anexys
Optimys	RM pressfit
Optimys	RM pressfit vitamys
Polarstem	EP-fit
Polarstem	HI
Polarstem	Polarcup
Polarstem	R3
Quadra-H	Mpact
Quadra-H	Versafitcup DM
Quadra-H	Versafitcup trio/ccl.
SBG	HI
SBG	R3
SBG	Xentrax
SL-plus/SL-plus MIA	EP-fit
SL-plus/SL-plus MIA	HI
SL-plus/SL-plus MIA	R3
SMS	Versafitcup trio/ccl.
SPS HA	April ceramic
SPS evolution	April ceramic
SPS evolution	April poly
SPS evolution	Liberty
Stelia-Stem	Ana.Nova hybrid
Stelia-Stem	BSC pressfit
Trendhip	Plasmafit
Tri-Lock	Pinnacle
Twinsys	Anexys
Twinsys	RM pressfit
Twinsys	RM pressfit vitamys
other combinations	-

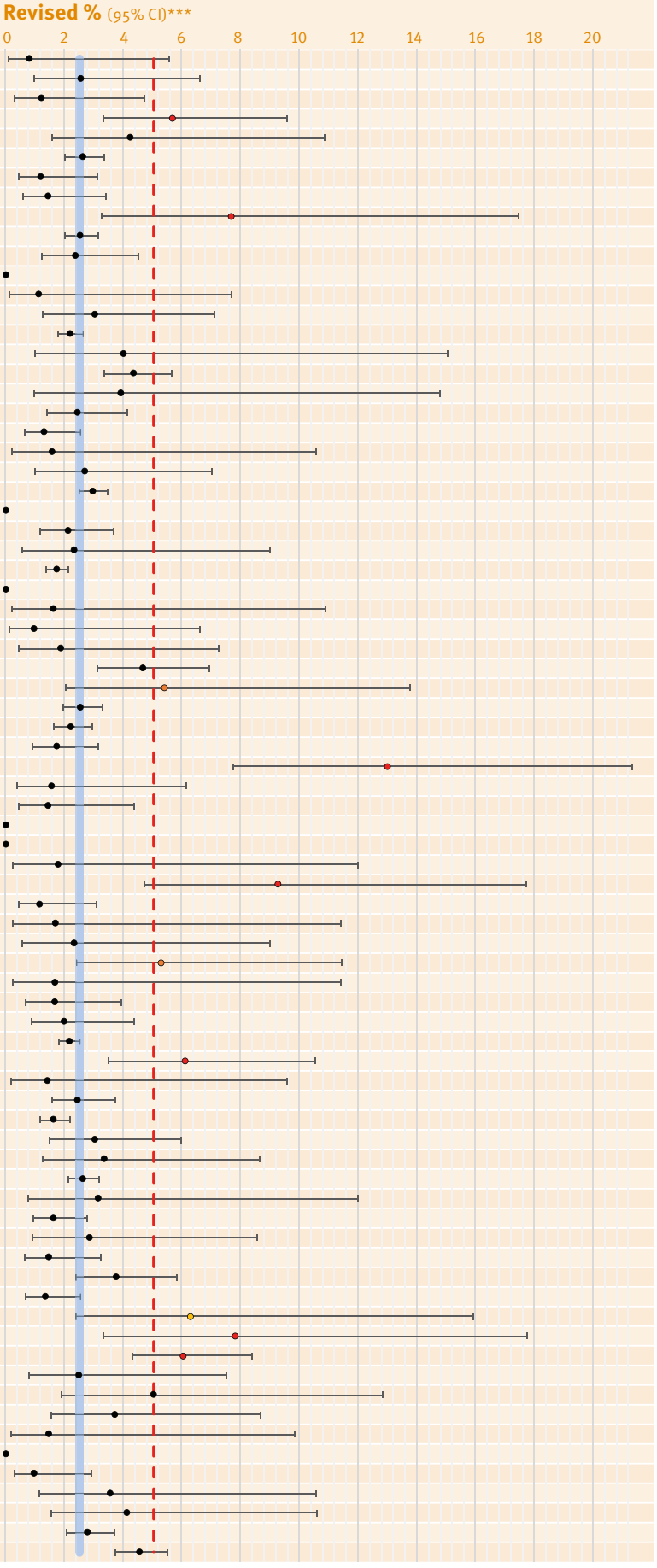
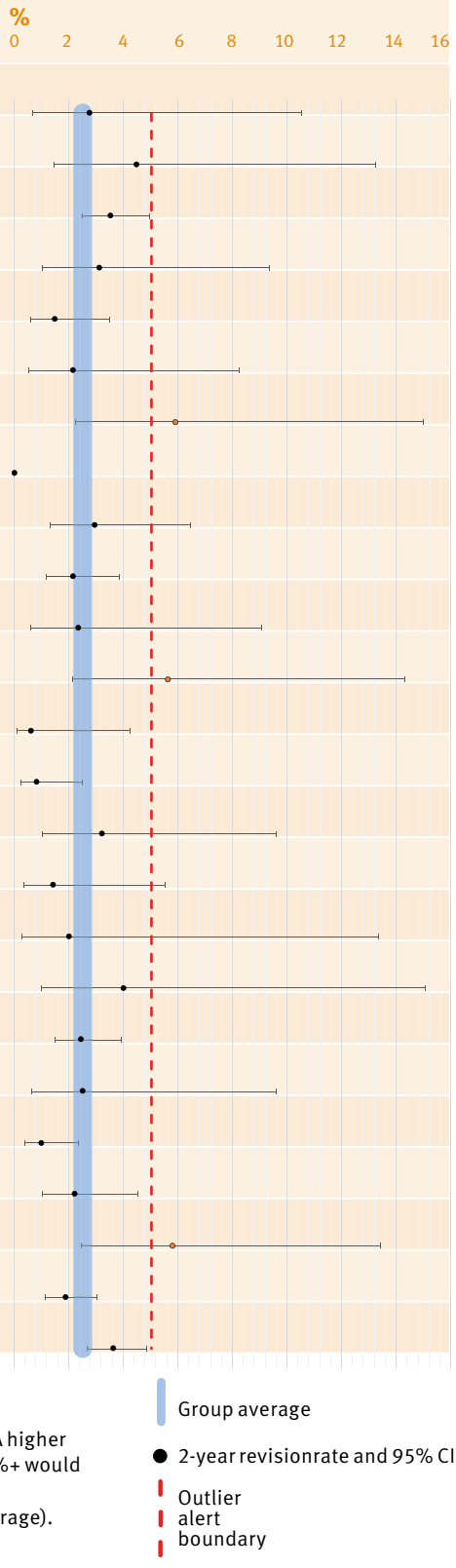


Figure 3.5j

2-year evaluation: Revision rates of hybrid primary total hip arthroplasty combinations within 24 months (primary OA)

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

Stem component	Cup component	CCS*	at risk N**	Revised N	Revised % (95% CI)***
Amistem-C	Mpact	30	73	2	2.7 (0.7-10.5)
Amistem-C	Versafitcup DM	31	68	3	4.5 (1.5-13.2)
Amistem-C	Versafitcup trio/ccl.	26	891	31	3.5 (2.5-5.0)
Arcad	April ceramic	45	96	3	3.1 (1.0-9.4)
Avenir (cem)	Allofit	22	347	5	1.5 (0.6-3.5)
Avenir (cem)	Fitmore	44	98	2	2.1 (0.5-8.3)
CCA	RM pressfit vitamys	72	71	4	5.9 (2.3-15.0)
Centris	RM pressfit	40	68	0	0.0 (.-)
Centris	RM pressfit vitamys	55	203	6	3.0 (1.3-6.5)
Corail (cem)	Pinnacle	30	525	11	2.2 (1.2-3.9)
Harmony (cem)	Liberty	84	85	2	2.4 (0.6-9.1)
Harmony (cem)	Symbol DM/DS evol.	100	72	4	5.6 (2.2-14.3)
MS-30	Allofit	98	165	1	0.6 (0.1-4.2)
MS-30	Fitmore	55	370	3	0.8 (0.3-2.5)
Original Mueller	Allofit	38	95	3	3.2 (1.0-9.6)
Original Mueller	Fitmore	44	143	2	1.4 (0.4-5.5)
Quadra-C	Mpact DM	78	50	1	2.0 (0.3-13.4)
Quadra-C	Versafitcup DM	30	50	2	4.0 (1.0-15.1)
Quadra-C	Versafitcup trio/ccl.	32	664	16	2.4 (1.5-3.9)
Twinsys (cem)	RM pressfit	41	80	2	2.5 (0.6-9.6)
Twinsys (cem)	RM pressfit vitamys	23	507	5	1.0 (0.4-2.4)
Weber	Allofit	31	322	7	2.2 (1.1-4.6)
Weber	Avantage	99	87	5	5.8 (2.5-13.4)
Weber	Fitmore	25	876	16	1.9 (1.1-3.0)
other combinations			1,207	43	3.6 (2.7-4.9)
CH average for group					2.5 (2.2-2.9)



* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

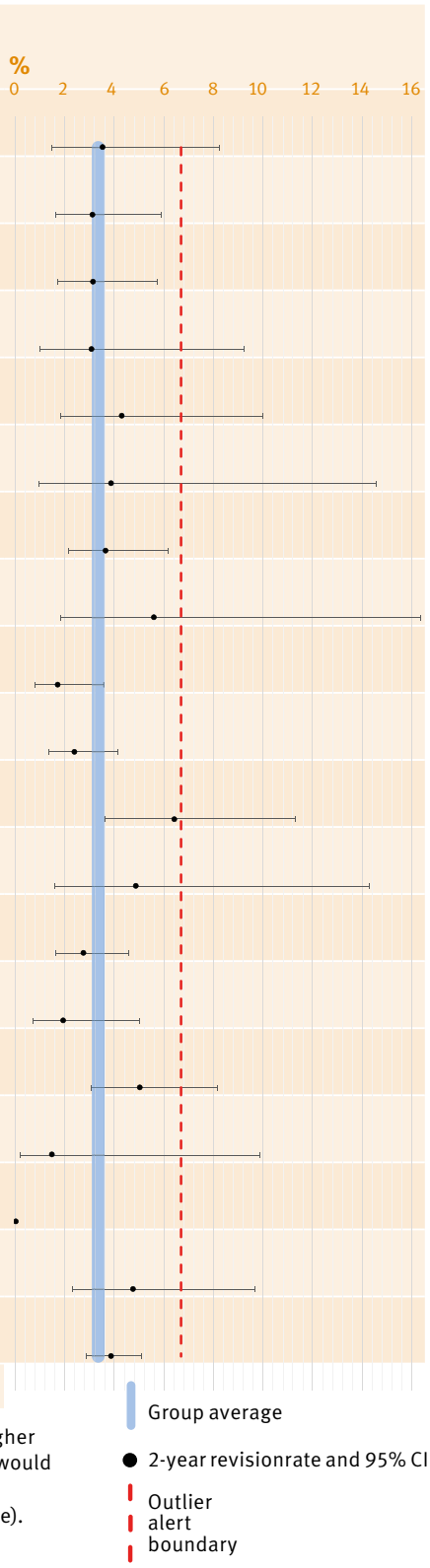
*** Rates adjusted for effects of mortality and emigration.

Figure 3.5k

2-year evaluation: Revision rates of uncemented primary total hip arthroplasty combinations within 24 months (secondary OA)

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

Stem component	Cup component	CSS*	at risk N**	Revised N	Revised % (95% CI)***
Amistem-H	Versafitcup trio/ccl.	11	144	5	3.5 (1.5-8.2)
Amistem-H prox coat.	Versafitcup trio/ccl.	19	291	9	3.1 (1.6-5.9)
Avenir	Allofit	14	322	10	3.1 (1.7-5.7)
Avenir	Fitmore	19	102	3	3.1 (1.0-9.2)
CLS Spotorno	Allofit	49	117	5	4.3 (1.8-10.0)
CLS Spotorno	Fitmore	44	54	2	3.9 (1.0-14.6)
Corail	Pinnacle	12	360	13	3.6 (2.1-6.2)
Corail collared	Gyros	53	57	3	5.6 (1.8-16.4)
Corail collared	Pinnacle	40	413	7	1.7 (0.8-3.6)
Fitmore	Allofit	93	507	12	2.4 (1.4-4.1)
Fitmore	Fitmore	26	172	11	6.4 (3.6-11.3)
Individual/custom hip	April ceramic	29	62	3	4.8 (1.6-14.3)
Optimys	RM pressfit vitamys	19	516	14	2.7 (1.6-4.6)
Polarstem	R3	76	213	4	1.9 (0.7-5.0)
Quadra-H	Versafitcup trio/ccl.	27	304	15	5.0 (3.1-8.2)
SBG	R3	44	70	1	1.4 (0.2-9.8)
SL-plus/SL-plus MIA	HI	53	68	0	0.0 (.-)
Twinsys	RM pressfit vitamys	21	150	7	4.7 (2.3-9.7)
other combinations	-		1211	46	3.8 (2.9-5.1)
CH average for group					3.3 (2.9-3.9)

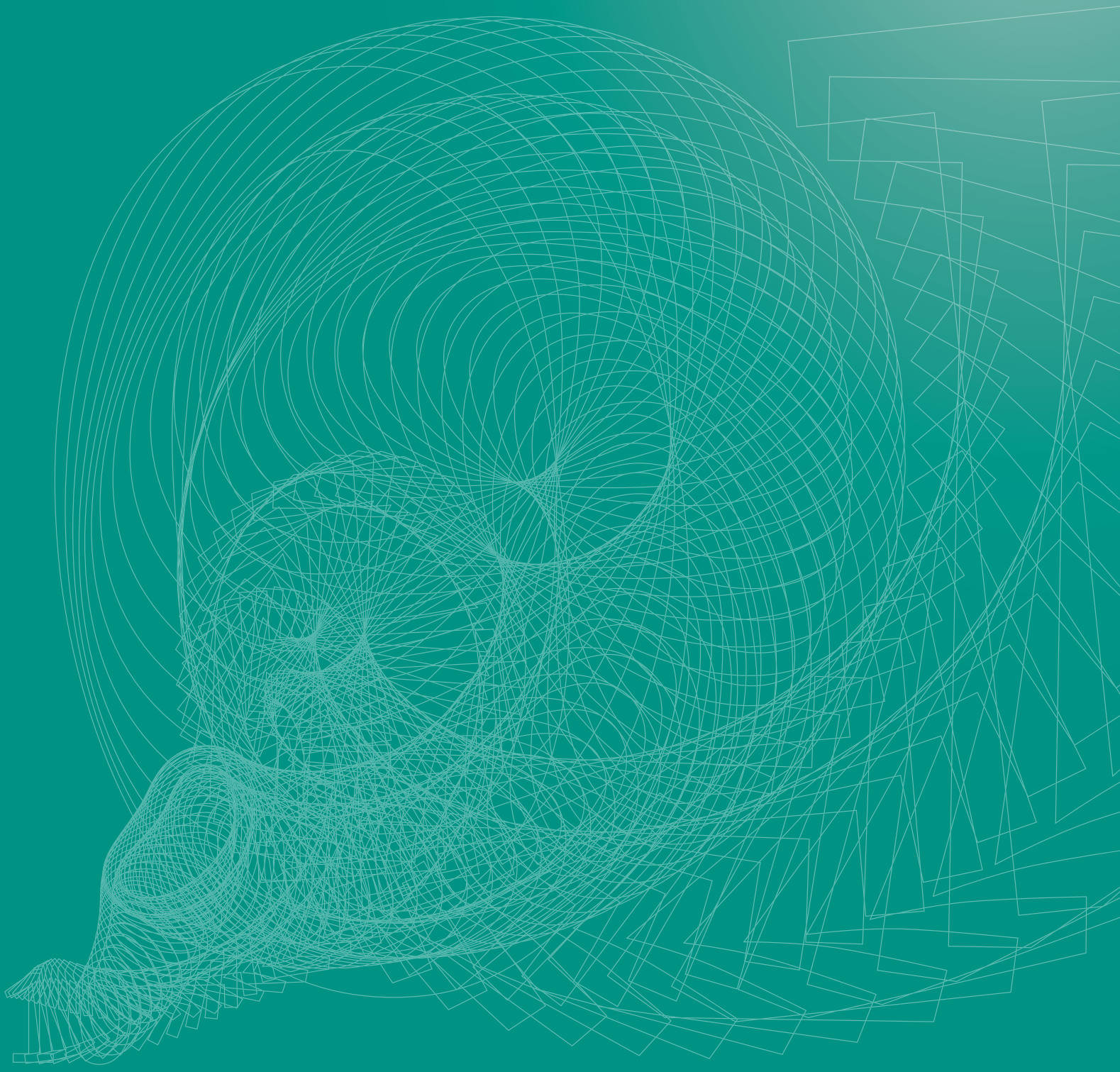


* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

*** Rates adjusted for effects of mortality and emigration.

Fracture of the hip



Ten Years of Swiss Hip and Knee Registry

3.6 Treatment of hip fractures

Fractures of the hip include femoral neck fractures, other fractures of the proximal femur and fractures of the acetabulum. Hip fractures occur more frequently in the elderly but also in younger age groups, in the latter group often due to rather severe accidents. The treatment varies from internal fixation of the femur or of the acetabulum to prosthetic replacement with either hemiarthroplasty (HA) or total hip arthroplasty (THA), depending on the pathology, feasibility and experience of the surgeon. Age, activity level and comorbidities also influence the choice of treatment.

In general, patients with hip fractures are of advanced age. This injury affects a special group of patients with substantial comorbidities and low remaining life expectancy. The mortality rate is therefore

Table 3.6a
Fracture of the hip: Baseline patient characteristics by year

		2016	2017	2018	2019	2020	2021	2016–2021
N		**3,188**	**3,273**	**3,532**	**3,848**	**4,109**	**4,419**	**22,369**
Treatment with THA* [%]		38.7	38.6	39.2	41.2	43.2	47.6	41.8
Treatment with HA** [%]		61.3	61.4	60.8	58.8	56.8	52.4	58.2
Women [%]		69.6	69.6	68.1	69.1	67.1	67.0	68.3
Mean age (SD)	All	80.6 (10.8)	80.8 (10.8)	81.0 (10.5)	81.0 (10.7)	81.1 (10.7)	80.9 (10.7)	80.9 (10.7)
	Women	81.3 (10.2)	81.9 (10.0)	82.1 (10.0)	81.7 (10.1)	82.3 (10.0)	81.8 (10.3)	81.9 (10.1)
	Men	78.9 (12.0)	78.5 (12.0)	78.7 (11.2)	79.4 (11.7)	78.8 (11.6)	79.2 (11.4)	78.9 (11.6)
Age group [%]	<45	0.6	0.4	0.3	0.4	0.1	0.4	0.4
	45–54	1.9	1.8	1.7	1.8	1.9	1.6	1.8
	55–64	5.9	6.7	6.3	6.2	6.9	6.9	6.5
	65–74	16.4	15.3	14.5	15.3	14.7	14.6	15.1
	75–84	33.4	31.3	33.5	32.2	32.1	32.8	32.5
	85+	41.8	44.5	43.8	44.2	44.2	43.7	43.7
N unknown BMI (%)		953 (30)	941 (29)	930 (26)	891 (23)	773 (19)	714 (16)	5,202 (23)
N known BMI		2,235	2,332	2,602	2,957	3,336	3,705	17,167
Mean BMI (SD)		23.9 (4.5)	23.8 (4.3)	23.8 (4.4)	23.7 (4.3)	23.7 (4.4)	23.8 (4.3)	23.8 (4.4)
BMI [%]	<18.5	8.9	9.3	9.0	9.0	10.0	8.7	9.2
	18.5–24.9	55.0	56.5	57.6	57.4	56.7	56.7	56.7
	25–29.9	27.1	27.1	25.6	26.3	26.0	26.7	26.5
	30–34.9	7.0	5.2	6.5	5.5	5.6	6.4	6.0
	35–39.9	1.6	1.5	0.8	1.5	1.3	1.2	1.3
	40+	0.4	0.3	0.5	0.3	0.3	0.4	0.3
N unknown ASA (%)		247 (8)	279 (9)	220 (6)	276 (7)	246 (6)	200 (5)	1,468 (7)
N known ASA		2,941	2,994	3,312	3,572	3,863	4,219	20,901
Morbidity state	ASA 1	3.2	3.4	3.1	3.3	3.8	3.0	3.3
[%]	ASA 2	33.5	32.6	31.7	30.7	28.9	28.0	30.6
	ASA 3	56.0	57.1	58.8	58.4	60.0	60.3	58.6
	ASA 4/5	7.3	6.8	6.5	7.5	7.4	8.7	7.4

*THA= Total Hip Arthroplasty. **HA= Hemi Hip Arthroplasty

high. One-year mortality rates between 15% to 35% are reported after index surgery. In Europe, recent work has shown that, on average, about 22% of patients die within the first year after a fracture of the proximal femur. While HA treatment is preferred in fragile, low-demand patients, THA is commonly performed in healthier and more active patients.

As in the other chapters of the SIRIS annual report, a four-year moving window was used for analysis and reporting. The rationale behind it can be found in the introduction to chapter 3. The report covers the period between 1.1.2016 and 31.12.2019 with a complete 2-year follow-up until 31.12.2021. Since 2016, the registry has recorded a total of 22,369 fractures of the hip. On average, approximately 40% were treated with THA and 60% with HA, but there is a clear trend towards treatment with THA, increasing from 38.7% in 2016 to 47.6% in 2021. The documented cases have increased by 1,682 cases since the 2020 report, representing an in-

Table 3.6b

Fracture of the hip: Baseline patient characteristics by type of treatment

		THA	HA
N (2016–2021)		**9,345**	**13,024**
Women [%]		64.5	71.1
Mean age (SD)	All	74.4 (10.9)	85.6 (7.7)
	Women	75.4 (10.4)	86.0 (7.3)
	Men	72.6 (11.5)	84.5 (8.5)
Age group [%]	‹45	0.8	0.1
	45–54	3.8	0.3
	55–64	13.7	1.4
	65–74	27.8	6.0
	75–84	35.5	30.4
	85+	18.4	61.9
N unknown BMI (%)		1,949 (21)	3,253 (25)
N known BMI		7,396	9,771
Mean BMI (SD)		24.3 (4.5)	23.4 (4.2)
BMI [%]	‹18.5	7.3	10.5
	18.5–24.9	55.0	58
	25–29.9	28.1	25.2
	30–34.9	7.5	4.9
	35–39.9	1.5	1.1
	40+	0.5	0.2
N unknown ASA (%)		657 (7)	811 (6)
N known ASA		8,688	12,213
Morbidity state [%]	ASA 1	6.7	0.9
	ASA 2	44.7	20.6
	ASA 3	44.8	68.4
	ASA 4/5	3.7	10.1

crease of approximately 8%. Age distributions hase remained constant. Women were more frequently affected, at 69% of cases. 91.3% of the patients were 65 years of age or older. The age group above 85 accounted for 43.7% **(Table 3.6a).** 2.2% were younger than 55 years and 66.5% between 55 and 64. The majority of patients had a normal BMI. Patients treated with HA are on average 11.2 years older than those treated with THA **(Table 3.6b).** Younger patients were more likely to receive a THA. 61.9% of HAs were implanted in patients aged 85 years and older. 482 patients younger than 55 years of age sustained hip fractures. Of these, 89% (n=430) were treated with THA. Of the patients over 85 years of age, 18% received THA and 82% were treated with HA (derived from **Table 3.6b**).

Table 3.6c

Fracture of the hip: Baseline patient characteristics by hospital service volume*

Calculations of hospital service volume based om primary hip surgeries in each included year (2016-2021).

		<100	100–199	200–299	300+
N (2016–2021)		**5,340**	**7,498**	**4,412**	**5,119**
Treatment with THA [%]		29.1	46.4	41.8	48.2
Treatment HA [%]		70.9	53.6	58.2	51.8
Women [%]		69.8	68.1	67.8	67.6
Mean age (SD)	All	81.9 (9.9)	80.5 (10.9)	80.6 (10.9)	80.8 (11.0)
	Women	82.8 (9.4)	81.4 (10.3)	81.6 (10.3)	81.8 (10.3)
	Men	80.0 (10.7)	78.5 (11.7)	78.7 (11.9)	78.7 (12.2)
Age group [%]	<45	0.1	0.3	0.5	0.5
	45–54	1.3	1.8	2.0	2.1
	55–64	5.1	7.3	6.6	6.7
	65–74	14.0	16.4	15.2	14.3
	75–84	32.9	32.6	32.9	31.6
	85+	46.6	41.6	42.7	44.7
N unknown BMI (%)		1,660 (31)	1,877 (25)	946 (21)	719 (14)
N known BMI		3,680	5,21	3,466	4,400
Mean BMI (SD)		23.9 (4.3)	23.8 (4.5)	23.9 (4.4)	23.6 (4.3)
BMI [%]	<18.5	9.0	8.9	8.6	10.0
	18.5–24.9	55.0	57.3	57.0	57.2
	25–29.9	28.1	26.4	26.6	25.0
	30–34.9	6.4	5.3	6.2	6.4
	35–39.9	1.3	1.5	1.1	1.1
	40+	0.2	0.5	0.5	0.2
N unknown ASA (%)		255 (5)	810 (11)	274 (6)	129 (3)
N known ASA		5,085	6,688	4,138	4,990
Morbidity state [%]	ASA 1	3.6	3.4	3.2	2.9
	ASA 2	30.1	32.2	30.4	29.2
	ASA 3	58.3	57.3	58.8	60.6
	ASA 4/5	7.9	7.1	7.6	7.3

* Note that service volume is defined as the sum of primary procedures per year

One-third (33.5%) of all patients with a fracture were treated in a hospital with a volume of 100–199 primary hips per year **(Table 3.6c).** 23.9% were treated in institutions that performed fewer than 100 primary hips/year. The average age distribution in the four categories (‹100cases /year, 100–199, 200–299, ›300) was comparable, with an average age between 80.5 and 81.9 years. Hospitals with smaller numbers (‹100 per year) treated more octogenarians. It is interesting to note that the percentage of patients treated by HA in the low-volume institutions was significantly higher, with 70.9% compared to the average of 54.4% **(Table 3.6c)** and may indicate undertreatment. The reason for this is unclear. One explanation may be that general surgeons not trained to perform THA participated in the treatment of hip fractures in these smaller institutions.

Of the patients diagnosed with fractures, 5.9% in the THA group and 1.3% in the HA group have had previous internal fixation. However, the time lapse between internal fixation and implantation of THA or HA is unknown. Most HA stems were cemented (85.9%) compared to 48.9% of stems in the THA group **(Tables 3.6d and e and Figure 3.6a).**

The most common approaches for both procedures were a direct anterior or an anterolateral approach **(Tables 3.6d and f and Figures 3.6b).** In both HA and THA, the share of the anterior approach was the highest, being used distinctly more for THAs.

Table 3.6d

Fracture of the hip: Surgery characteristics by main treatment group

		THA		HA	
N (2016–2021)		**N**	**%**	**N**	**%**
Previous surgery	None	8,370	89.6	12,641	97.1
	Internal fixation femur	702	5.4	165	1.3
	Osteotomy femur	41	0.3	14	0.1
	Internal fixation acetabulum	71	0.5	1	0.0
	Osteotomy pelvis	6	0.0	0	0.0
	Arthrodesis	3	0.0	0	0.0
	Other previous surgery	179	1.4	204	1.6
Approach	Anterior	4,851	51.9	5,248	40.3
	Anterolateral	2,427	26.0	3,854	29.6
	Posterior	1,207	12.9	1,845	14.2
	Lateral	673	7.2	1868	14.3
	Other approach	188	2.0	208	1.6
Fixation	All uncemented / uncemented stem	4642	49.7	1806	13.9
	Hybrid*	3,689	39.5		
	All cemented / cemented stem	680	7.3	11,138	85.5
	Reverse hybrid**	184	2.0		
	Reinforcement ring, femur uncemented	46	0.5		
	Reinforcement ring, femur cemented	105	1.1		

* acetabulum uncemented, femur cemented
** acetabulum cemented, femur uncemented

Figure 3.6a

Fracture of the hip: Component fixation methods by type of treatment by year

Relative distribution per year in %

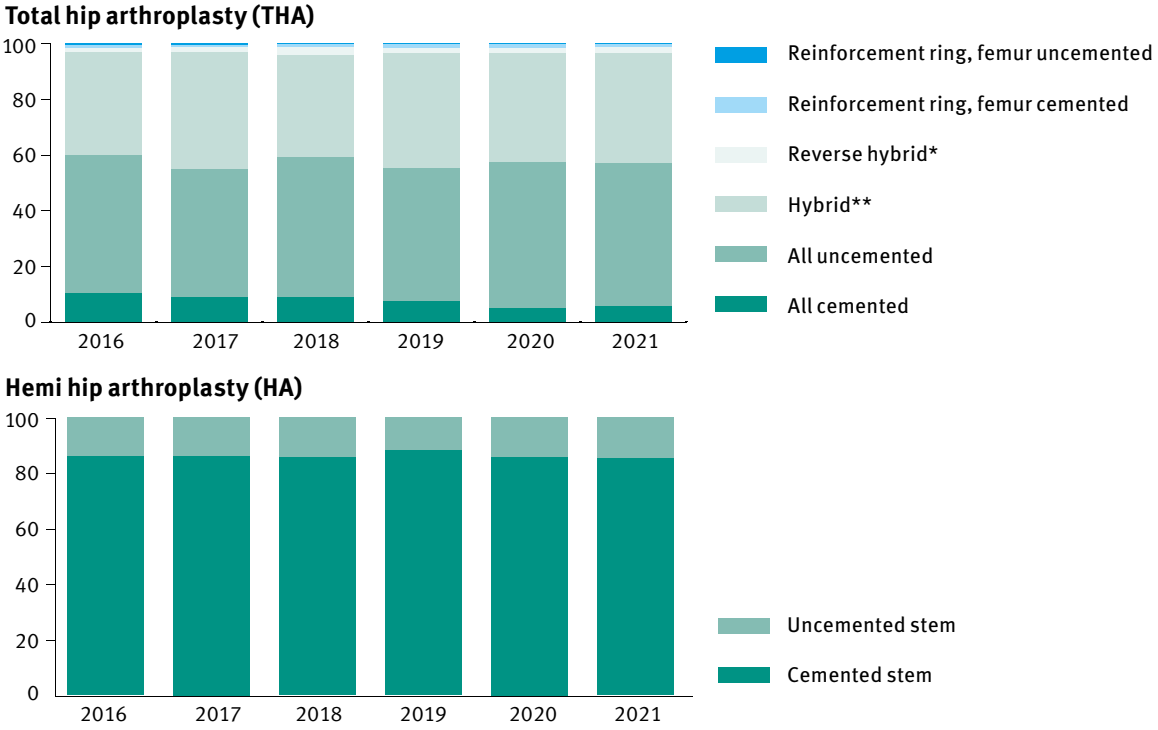


Table 3.6e

Fracture of the hip: Component fixation methods by type of treatment by year

Relative distribution per year in %

Total hip arthroplasty (THA)	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Reinforcement ring, femur uncemented	0.7	0.6	0.4	0.4	0.5	0.4
Reinforcement ring, femur cemented	1.1	0.7	1.2	1.3	1.2	1.1
Reverse hybrid*	1.4	2.0	2.7	2.0	1.9	1.9
Hybrid**	37.2	42.1	36.8	41.4	39.2	39.7
All uncemented	49.3	45.8	50.3	47.5	52.3	51.2
All cemented	10.3	8.8	8.7	7.4	4.9	5.6
Total [N]	**1,235**	**1,265**	**1,384**	**1,586**	**1,774**	**2,102**

Hemi hip arthroplasty (HA)	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Uncemented stem	14.1	14.0	14.5	12.0	14.4	14.8
Cemented stem	85.9	86.0	85.5	88.0	85.6	85.2
Total [N]	**1,946**	**1,998**	**2,137**	**2,255**	**2,322**	**2,286**

* acetabulum cemented, femur uncemented = Reverse hybrid
** acetabulum uncemented, femur cemented = Hybrid

Figure 3.6b

Fracture of the hip: Surgical approach by year

Relative distribution per year in %

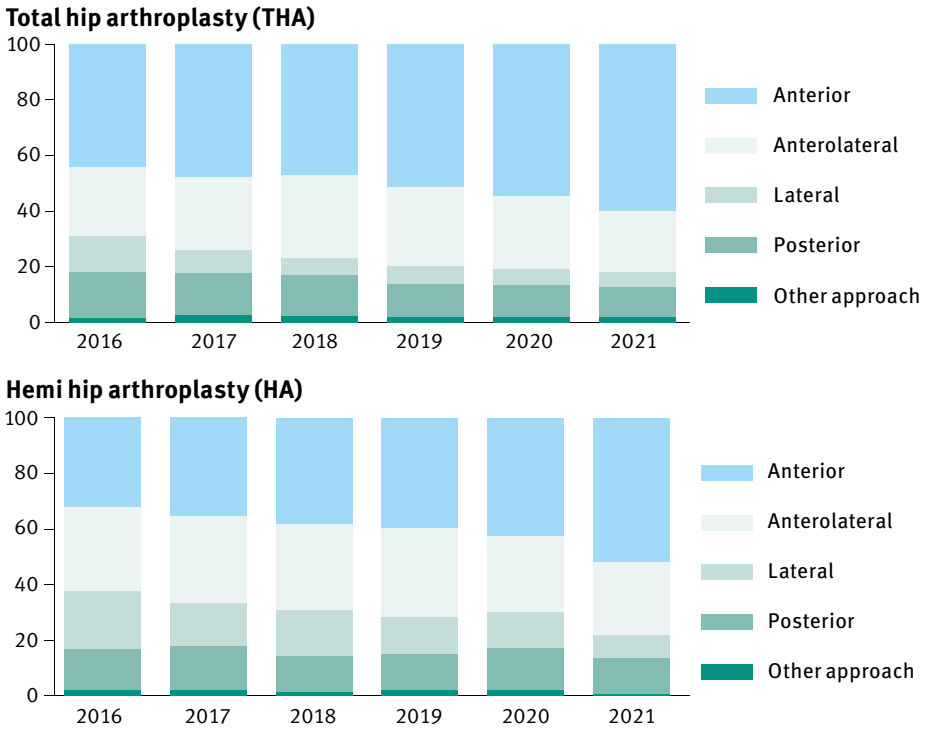


Table 3.6f

Fracture of the hip: Surgical approach by year

Relative distribution per year in %

Total hip arthroplasty (THA)	2016	2017	2018	2019	2020	2021
Anterior	44.1	47.7	47.3	51.5	54.7	59.9
Anterolateral	24.9	26.2	29.6	28.5	26.1	22.1
Lateral	13.2	8.6	6.1	6.2	5.9	5.4
Posterior	16.2	14.9	14.7	11.9	11.4	10.7
Other approach	1.6	2.6	2.3	2.0	1.9	1.8
Total [N]	**1,235**	**1,265**	**1,384**	**1,586**	**1,774**	**2,102**

Hemi hip arthroplasty (HA)	2016	2017	2018	2019	2020	2021
Anterior	32.1	35.3	38.1	39.6	42.7	51.8
Anterolateral	30.2	31.3	30.9	32.2	27.1	26.3
Lateral	21.0	15.5	16.7	13.0	12.9	8.2
Posterior	14.9	16.0	12.9	13.1	15.4	12.9
Other approach	1.8	1.9	1.3	2.0	1.9	0.7
Total [N]	**1,953**	**2,008**	**2,148**	**2,262**	**2,335**	**2,317**

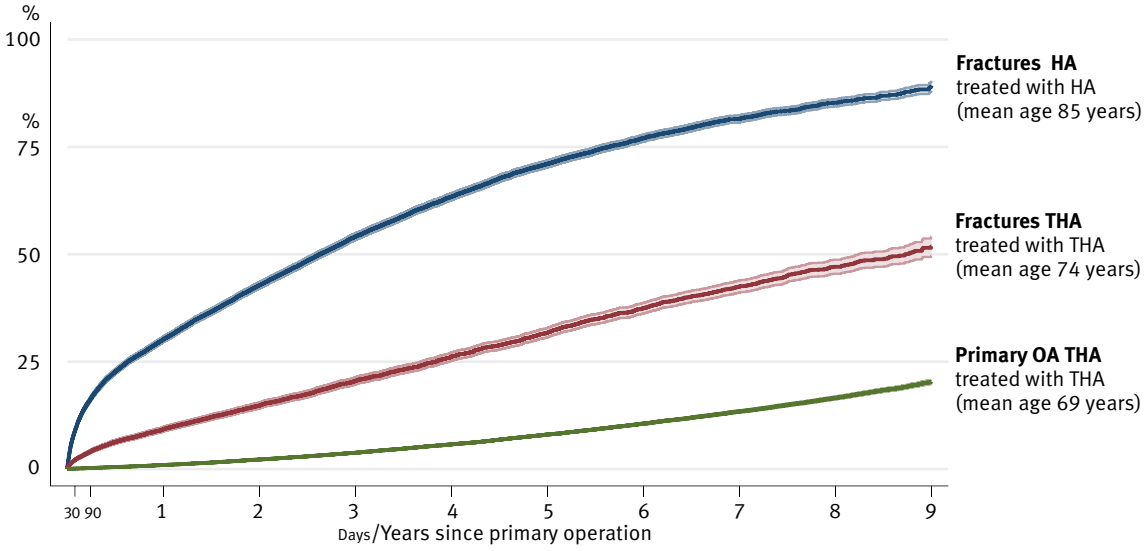
Mortality

For obvious reasons, the estimated mortality rates were different between the HA and THA groups and substantially higher compared to patients treated for primary osteoarthritis of the hip **(Figure 3.6c).** The one-year mortality rate for patients treated with HA was 30.2% (29.5–30.8) and 9.2% (8.7–9.8) in patients with THA fracture treatment. For the same one-year period, the mortality rate for a primary THA was 0.9% (0.9–1.0) **(Figure 3.6c).** This is explained by the older age of the patients with HA, which was 85 years at the time of surgery. Patients selected for a THA were, on average, 11 years younger. Certainly, there is a selection bias, in that more active and healthier patients were treated with THA. The 30-day mortality rate is an indicator for the effectiveness of the perioperative treatment of fractures of the proximal femur. Mortality rate was estimated by linking the SIRIS database with the Swiss CCO (Central Compensation Office, Geneva). In the literature, reported rates vary between 3% and 12%. Advances in recent treatment modalities, including treatment within the first 24 hours, preoperative medical optimisation and specialised medical care (geriatric traumatology), have led to decreasing 30-day mortality rates. This report analyses the mortality rate of a subgroup of fractures of the proximal femur, specifically femoral neck fractures treated with HA. The distribution of the 30-day mortality rate was quite narrow between most cantons, as shown by the overlapping 95% confidence intervals **(Table 3.6g and Figure 3.6d).**

Figure 3.6c

Mortality rates after treatment for fractures of the hip: total hip arthroplasty (THA) versus hemiarthroplasty (HA) and for comparison versus THA with primary OA

Time since operation, 2012–2021, all services. Cumulative mortality rates in percent (30 days= postoperative mortality)



Fractures	30 days	90 days	1 year	3 years	5 years	7 years	9 years
Treated with THA (mean age 74 years)	**2.1** (1.9-2.4)	**4.1** (3.7-4.4)	**9.2** (8.7-9.8)	**20.5** (19.7-21.3)	**31.7** (30.6-32.8)	**42.5** (41.1-43.9)	**51.8** (49.6-54.1)
Treated with HA (mean age 85 years)	**8.9** (8.5-9.3)	**16.4** (15.9-16.9)	**30.2** (29.5-30.8)	**54.1** (53.3-54.9)	**71.0** (70.2-71.9)	**81.5** (80.7-82.3)	**89.2** (88.0-90.4)
Primary OA							
Treated with THA (mean age 69 years)	**0.1** (0.1-0.1)	**0.2** (0.2-0.3)	**0.9** (0.9-1.0)	**3.8** (3.7-3.9)	**8.0** (7.9-8.2)	**13.4** (13.1-13.7)	**20.2** (19.8-20.7)

The average 30-day mortality rate in Switzerland is 8.9% (CI 8.5–9.3). It ranged from 4.2% to 15.4%. The hospital-based analysis indicates a clear distinction between the centres with the highest 30-day mortality rates and those with the lowest **(Figure 3.6e and Table 3.6i).** Four clinics had an increased 30-day mortality rate. These figures were unadjusted but additional regression analyses have been conducted to test the reliability. In order to verify that the observed differences between major centres were not due to known differences in the risk structure, a simple logistic regression model was performed using the most likely confounders and binary predictors for the three centres with the highest 30-day mortality rates. The model shows that the risk of death increased with each year of age

Table 3.6g

Estimated postoperative mortality rates after treatment for fractures of the hip (HA): by canton

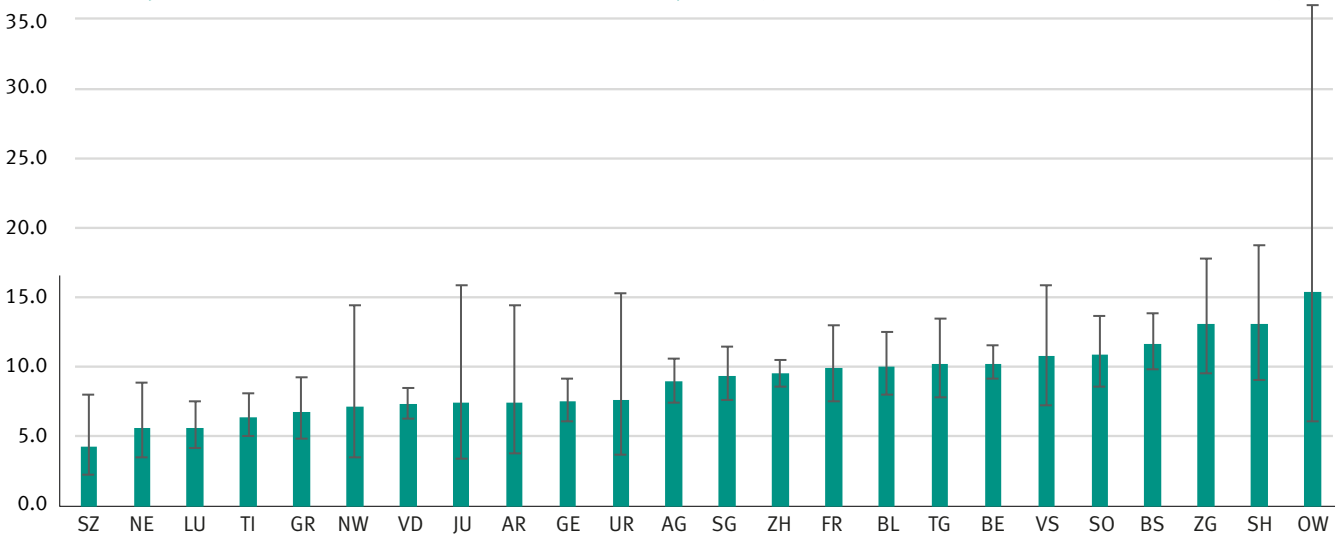
2012–2019, Kaplan-Meier estimates with 95% confidence intervals, only showing cantons with sufficient numbers (25 HAs annual average)

	30 days	90 days		30 days	90 days
AG	**8.9** (7.5-10.6)	**16.2** (14.3-18.4)	OW	**15.4** (6.1-36.0)	**26.9** (13.8-48.3)
AR	**7.5** (3.8-14.4)	**14.0** (8.7-22.2)	SG	**9.4** (7.6-11.5)	**15.5** (13.2-18.0)
BE	**10.3** (9.1-11.5)	**17.7** (16.2-19.2)	SH	**13.1** (9.0-18.7)	**21.5** (16.3-28.0)
BL	**10.0** (8.0-12.5)	**20.9** (18.1-24.1)	SO	**10.9** (8.6-13.7)	**20.3** (17.3-23.9)
BS	**11.6** (9.8-13.8)	**20.1** (17.7-22.8)	SZ	**4.2** (2.2-8.0)	**13.7** (9.7-19.0)
FR	**9.9** (7.6-13.0)	**16.4** (13.3-20.0)	TG	**10.2** (7.8-13.4)	**17.2** (14.0-21.0)
GE	**7.5** (6.1-9.2)	**16.4** (14.4-18.7)	TI	**6.4** (5.1-8.1)	**12.2** (10.3-14.4)
GR	**6.7** (4.9-9.2)	**14.9** (12.1-18.3)	UR	**7.6** (3.7-15.3)	**15.2** (9.3-24.4)
JU	**7.5** (3.4-15.8)	**13.8** (7.9-23.6)	VD	**7.3** (6.3-8.5)	**14.1** (12.7-15.7)
LU	**5.6** (4.2-7.5)	**12.8** (10.6-15.4)	VS	**10.8** (7.2-15.9)	**15.9** (11.5-21.7)
NE	**5.6** (3.5-8.8)	**11.3** (8.2-15.5)	ZG	**13.1** (9.6-17.7)	**21.0** (16.6-26.4)
NW	**7.1** (3.5-14.4)	**14.4** (8.8-23.1)	ZH	**9.5** (8.6-10.5)	**16.8** (15.6-18.1)

Figure 3.6d

30-day postoperative mortality rates (2012-2021) with 95% confidence intervals

2012–2019, Kaplan-Meier estimates with 95% confidence intervals, only showing cantons with sufficient numbers (25 HAs annual average)



at operation (approx. 5%). Men were more likely to die than women and patients rated as having a life-threatening condition were considerably more likely to die within 30 days of surgery **(Table 3.6h).** After controlling for these known risk factors, four clinics featured statistically significant odds ratios, indicating that the risk of dying there after hemiarthroplasties is considerably elevated. However, it must be kept in mind that this analysis only covers a subgroup of fractures of the proximal femur and the mortality rate after internal fixation of proximal femur fractures is not the topic of SIRIS registry.

Figure 3.6e

30-day postoperative mortality rates of HA per hospital

2012–2021, with 95% confidence intervals, only showing hospitals with sufficient numbers (25 HAs annual average – x-axis is showing numbers of operations included in analysis). The average mortality rate in Switzerland is 8.9% (CI 8.5-9.3)

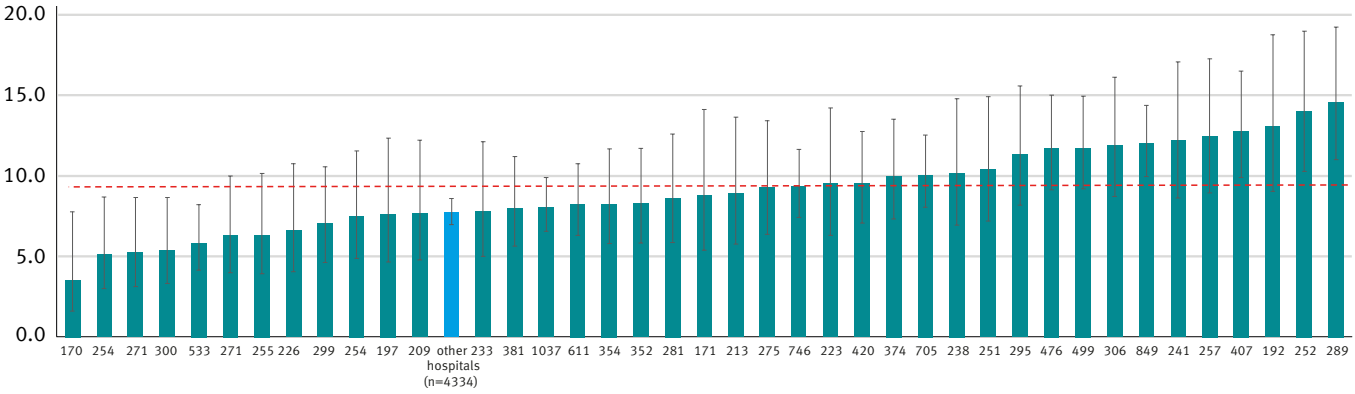


Table 3.6h

Results of logistic regression model predicting 30-day post-operative mortality after hemi-arthroplasty for fractures and testing effects of top 4 centres

N=13,289, using only cases with valid ASA

Predictor	Odds ratio	Sig	95% CI
Age at operation	1.06	‹0.001	1.05-1.07
Male	1.59	‹0.001	1.41-1.80
ASA 2	1.16	0.799	0.36-3.74
ASA 3	3.29	0.042	1.04-10.42
ASA 4/5	8.01	0.001	2.52-25.49
Centre with high rate No. 1	1.39	0.070	0.97-1.98
Centre with high rate No. 2	1.66	0.009	1.14-2.42
Centre with high rate No. 3	1.64	0.022	1.08-2.51
Centre with high rate No. 4	1.45	0.003	1.13-1.87

Table 3.6i

Estimated postoperative mortality rates after treatment for fractures of the hip (HA) per hospital

2012–2021, with 95% confidence intervals, only showing hospitals with sufficient numbers (25 HAs annual average). N= 18,501

Volume by service	30 days*	90 days
170	**3.6** (1.6-7.8)	**9.0** (5.5-14.4)
254	**5.1** (3.0-8.7)	**11.5** (8.2-16.2)
271	**5.2** (3.1-8.7)	**12.8** (9.3-17.5)
300	**5.4** (3.3-8.7)	**10.9** (7.9-15.1)
533	**5.8** (4.1-8.2)	**13.8** (11.1-17.0)
271	**6.3** (4.0-10.0)	**15.9** (12.0-20.9)
255	**6.3** (3.9-10.2)	**11.2** (7.8-15.8)
226	**6.6** (4.1-10.8)	**16.9** (12.6-22.5)
299	**7.0** (4.6-10.6)	**14.9** (11.3-19.5)
254	**7.5** (4.9-11.5)	**15.3** (11.4-20.4)
197	**7.6** (4.7-12.3)	**13.3** (9.2-18.9)
209	**7.7** (4.8-12.2)	**12.1** (8.3-17.3)
4,334 (other hospitals)	**7.7** (7.0-8.6)	**14.9** (13.9-16.0)
233	**7.8** (5.0-12.1)	**17.5** (13.1-23.1)
381	**8.0** (5.6-11.2)	**15.2** (12.0-19.3)
1,037	**8.1** (6.6-9.9)	**17.0** (14.8-19.4)
611	**8.3** (6.3-10.7)	**14.3** (11.7-17.3)
354	**8.3** (5.8-11.7)	**15.2** (11.8-19.4)
352	**8.3** (5.8-11.7)	**17.1** (13.5-21.5)
281	**8.6** (5.9-12.6)	**16.3** (12.4-21.2)

Volume by service	30 days*	90 days
171	**8.8** (5.4-14.1)	**14.6** (10.1-20.9)
213	**8.9** (5.8-13.6)	**15.1** (10.9-20.6)
275	**9.3** (6.4-13.4)	**17.9** (13.8-23.1)
746	**9.3** (7.4-11.6)	**16.0** (13.5-18.8)
223	**9.5** (6.3-14.2)	**11.8** (8.2-16.8)
420	**9.5** (7.1-12.8)	**16.2** (13.0-20.1)
374	**10.0** (7.3-13.5)	**16.8** (13.4-21.1)
705	**10.1** (8.0-12.5)	**21.0** (18.1-24.2)
238	**10.2** (6.9-14.8)	**17.4** (13.1-22.9)
251	**10.4** (7.2-14.9)	**18.5** (14.2-23.9)
295	**11.3** (8.2-15.6)	**20.1** (15.9-25.2)
476	**11.7** (9.1-15.0)	**18.5** (15.3-22.4)
499	**11.8** (9.2-14.9)	**18.9** (15.7-22.7)
306	**11.9** (8.7-16.1)	**19.0** (15.0-23.9)
849	**12.0** (10.0-14.4)	**20.5** (17.9-23.4)
241	**12.2** (8.6-17.1)	**20.6** (16.0-26.3)
257	**12.5** (8.9-17.3)	**23.2** (18.4-29.0)
407	**12.8** (9.9-16.5)	**18.9** (15.4-23.1)
192	**13.1** (9.0-18.7)	**21.5** (16.3-28.0)
252	**14.0** (10.3-19.0)	**21.7** (17.1-27.4)
289	**14.6** (11.0-19.2)	**21.2** (16.9-26.4)

* Postoperative mortality

3.7 First revision (within two years) after fracture of the hip

The two-year revision rate after THA was 4.8% (95%CI 4.3–5.5) and higher than in HA patients with 3.3% (95% CI 2.9–3.7). Higher BMI and ASA scores were risk factors for revision **(Table 3.7a).** However, the number of patients with BMI ›30 and ASA 4/5 were small, and statistical precision may be low.

In both groups, uncemented stems had an increased risk for revision caused by a periprosthetic fracture. A posterior approach bore a higher risk of revision for both THA and HA. For THA, the effect was significantly higher **(Table 3.7b).**

There are some limitations related to the terminology describing the pathology for the revision. Protrusion of an acetabular shell can have a different meaning than protrusion of a HA. While the first implies a loose cup that protrudes into the small pelvis, the latter indicates severe wear of the acetabular cartilage with or without defect of the medial

Table 3.7a

Fracture of the hip: First revisions within 24 months overall and according to baseline characteristics

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

		Total hip arthroplasty					Hemi hip arthroplasty				
		At risk*	Revised		95% CI		At risk*	Revised		95% CI	
		N	N	%**	lower	upper	N	N	%**	lower	upper
Overall (moving average)		5,470	253	4.8	4.3	5.5	8,377	238	3.3	2.9	3.7
Gender	Women	3,578	157	4.5	3.9	5.3	5,988	174	3.3	2.8	3.8
	Men	1,892	96	5.4	4.4	6.6	2,389	64	3.4	2.6	4.3
Age group	‹55	277	11	4.0	2.3	7.2	29	2	7.6	1.9	27.0
	55–64	752	36	5.0	3.6	6.8	117	9	8.5	4.5	15.8
	65–74	1,573	86	5.6	4.6	6.9	552	27	5.8	4.0	8.3
	75–84	1,942	82	4.4	3.5	5.4	2,567	87	3.8	3.1	4.7
	85+	926	38	4.5	3.3	6.1	5,112	113	2.5	2.1	3.0
BMI group	‹18.5	297	13	4.7	2.7	7.9	625	13	2.5	1.4	4.3
	18.5–24.9	2,310	87	3.9	3.2	4.8	3,436	73	2.4	1.9	3.1
	25–29.9	1,155	54	4.8	3.7	6.2	1,528	60	4.6	3.6	5.9
	30–34.9	329	26	8.3	5.7	11.9	281	17	6.6	4.1	10.4
	35–39.9	64	5	8.3	3.5	18.9	71	3	4.4	1.4	13.1
	40+	23	4	18.3	7.3	41.8	14	1	8.3	1.2	46.1
	Unknown	1,292	64	5.2	4.1	6.6	2,422	71	3.4	2.7	4.3
Morbidity state	ASA 1	342	8	2.4	1.2	4.7	77	5	6.8	2.9	15.5
	ASA 2	2,380	90	3.9	3.1	4.7	1,730	43	2.7	2.0	3.6
	ASA 3	2,146	123	6.1	5.1	7.3	5,245	159	3.5	3.0	4.1
	ASA 4/5	160	6	4.3	2.0	9.4	743	14	2.7	1.5	4.6
	Unknown	442	26	6.3	4.3	9.1	582	17	3.4	2.1	5.5

* Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).
** Rates adjusted for effects of mortality and emigration.

wall. Similar ambiguities are present for the type of revisions. In about 12% of HA cases, response categories related to revision of an acetabular implant were chosen. These were interpreted and analysed as conversions.

Periprosthetic fractures, dislocations and infections were the three most common complications in both THA and HA **(Table 3.7c).** Infections were the most important cause of revision in the HA group representing 35,3%. Interestingly, the revision rate for dislocations in HA was similar to THA, with 24.5% in THA and 21.8% for HA. The conversion of HA to THA with/without stem exchange accounted for 36.5% of all revisions **(Table 3.7e).**

The revision rates of unipolar and bipolar heads in the presence of only cemented stems shows that bipolar heads had a higher revision rate in the first two years. After three years, the revision rate of unipolar heads and bipolar heads remained identical **(Figure 3.7a).** There was a trend for an increased re-

Table 3.7b

Fracture of the hip: First revisions according to stem fixation and approach

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

	Total hip arthroplasty					Hemi hip arthroplasty				
	At risk*	Revised		95% CI		At risk*	Revised		95% CI	
	N	N	%**	lower	upper	N	N	%**	lower	upper
Overall (moving average)	5,470	253	4.8	4.3	5.5	8,377	238	3.3	2.9	3.7
All cemented / cemented stem	473	19	4.5	2.9	7.0	7,208	182	3.0	2.6	3.4
All uncemented / uncemented stem	2,638	135	5.3	4.5	6.2	1,134	56	5.6	4.3	7.2
Hybrid	2,160	89	4.3	3.5	5.3					
Anterior	2,619	103	4.1	3.4	5.0	3,052	87	3.3	2.7	4.1
Anterolateral	1,501	66	4.6	3.6	5.8	2,611	54	2.4	1.8	3.1
Lateral	457	20	4.6	3.0	7.1	1,376	42	3.6	2.7	4.9
Posterior	777	53	7.0	5.4	9.1	1,188	53	5.0	3.9	6.5
Other approach	116	11	10.4	5.9	18.0	150	2	1.9	0.5	7.6

* Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).
** Rates adjusted for effects of mortality and emigration.

vision rate for unipolar heads after nine years. However, the difference was not significant as shown by the overlapping confidence intervals (CI). The higher early revision rate of bipolar heads was due to the rate of dislocation that was significantly higher and also occurred earlier **(Table 3.7d).** Periprosthetic fractures were more frequent in unipolar heads.

An additional perspective on the progression of reasons for revision shows the cumulative incidence figures **(Figures 3.7b).** This perspective shows what proportion of implants have experienced at least one revision due to certain specific reasons (e.g. revision due to loosening of a component). In this type of graph, a line starts when the first relevant revision in the SIRIS dataset was observed and ends with the last recorded revision.

Table 3.7c

Fracture of the hip: Reasons for early first revisions

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021). Early first revisions are those occurring within 2 years of the primary arthroplasty. Multiple responses possible (percentages do not sum to 100).

	Total hip arthroplasty		Hemi hip arthroplasty	
	N	%	N	%
Dislocation	62	24.5	52	21.8
Periprosthetic fracture	59	23.3	53	22.3
Infection	58	22.9	84	35.3
Loosening femoral	33	13.0	21	8.8
Loosening acetabular	22	8.7		
Position/Orientation of cup	11	4.3		
Position/Orientation of stem	8	3.2	3	1.3
Acetabular protrusion	7	2.8	3	1.3
Trochanter pathology	3	1.2	1	0.4
Wear	1	0.4	4	1.7
Metallosis	1	0.4	0	0.0
Femoral osteolysis	1	0.4	0	0.0
Implant breakage	1	0.4	1	0.4
Impingement	1	0.4	0	0.0
Squeaking	1	0.4	0	0.0
Acetabular osteolysis	0	0.0	1	0.4
Status after spacer	0	0.0	0	0.0
Blood ion level	0	0.0	0	0.0
Other	25	9.9	28	11.8
Total	**294**		**253**	

Table 3.7d

Fracture of the hip: Reasons for early first revisions (unipolar vs. bipolar hemi heads)

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021). Early first revisions are those occurring within 2 years of the primary arthroplasty. Multiple responses possible (percentages do not sum to 100).
Cemented stems only.

	Unipolar heads		Bipolar heads	
	N	%	N	%
Loosening femoral	7	6.9	7	10.9
Infection	43	42.2	25	39.1
Periprosthetic fracture	16	15.7	7	10.9
Dislocation	19	18.6	18	28.1
Wear	0	0.0	0	0.0
Acetabular osteolysis	0	0.0	1	1.6
Femoral osteolysis	0	0.0	0	0.0
Trochanter pathology	0	0.0	0	0.0
Status after spacer	0	0.0	0	0.0
Implant breakage	0	0.0	0	0.0
Blood ion level	0	0.0	0	0.0
Position/Orientation of stem	0	0.0	0	0.0
Impingement	2	2.0	1	1.6
Acetabular protrusion	0	0.0	0	0.0
Other	15	14.7	8	12.5
Total	**102**		**67**	

Table 3.7e

Fracture of the hip: Type of revisions by primary treatment modality, THA versus HA

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021).

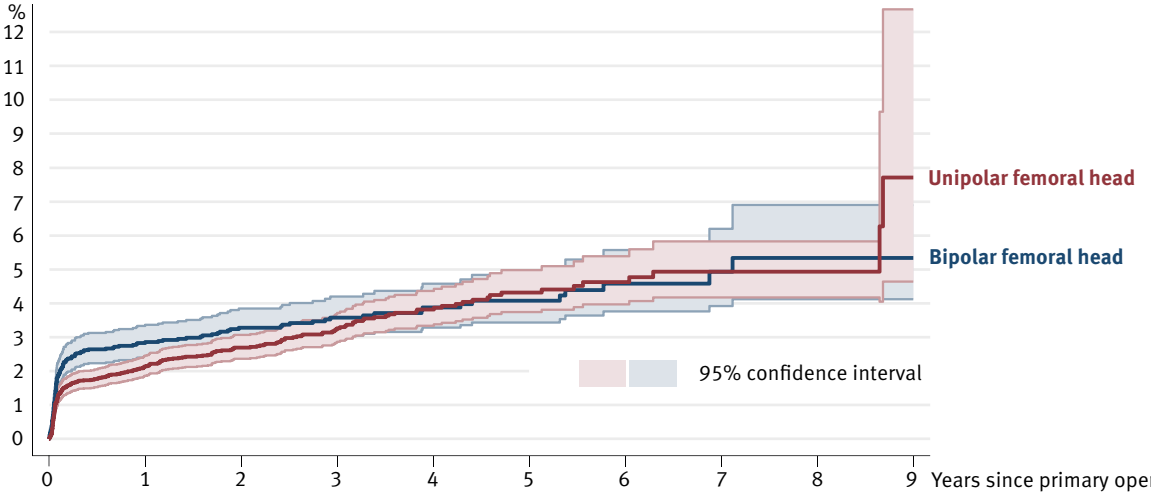
HA: in approx. 11% of cases response categories involving acetabular components were chosen.These were recoded to conversions.

	Total hip arthroplasty		Hemi hip arthroplasty	
	N	%	N	%
Exchange acetabular and femoral components	37	14.6		
Exchange acetabular component	13	5.1		
Exchange acetabular component and head	48	19.0		
Exchange femoral component	51	20.2	42	17.6
Exchange femoral component and inlay	14	5.5	6	2.5
Exchange head	20	7.9	56	23.5
Exchange inlay	0	0.0	2	0.8
Exchange head and inlay	39	15.4	21	8.8
Conversion of hemi-prosthesis to THA without stem exchange	-		50	21.0
Conversion of hemi-prosthesis to THA with stem exchange	-		37	15.5
Component removal, spacer implantation	8	3.2	3	1.3
Component reimplantation (after spacer or Girdlestone)	2	0.8	2	0.8
Girdlestone	4	1.6	3	1.3
Exchange femoral component, inlay and osteosynthesis	8	3.2	6	2.5
Other intervention	9	3.6	10	4.2
Total	**253**	**100.0**	**238**	**100.0**

Figure 3.7a

Fracture of the hip: Failure rates of hemiarthroplasty of the hip: unipolar heads versus bipolar heads

Time since operation, 2012–2021, only cemented stems. % of implants revised.



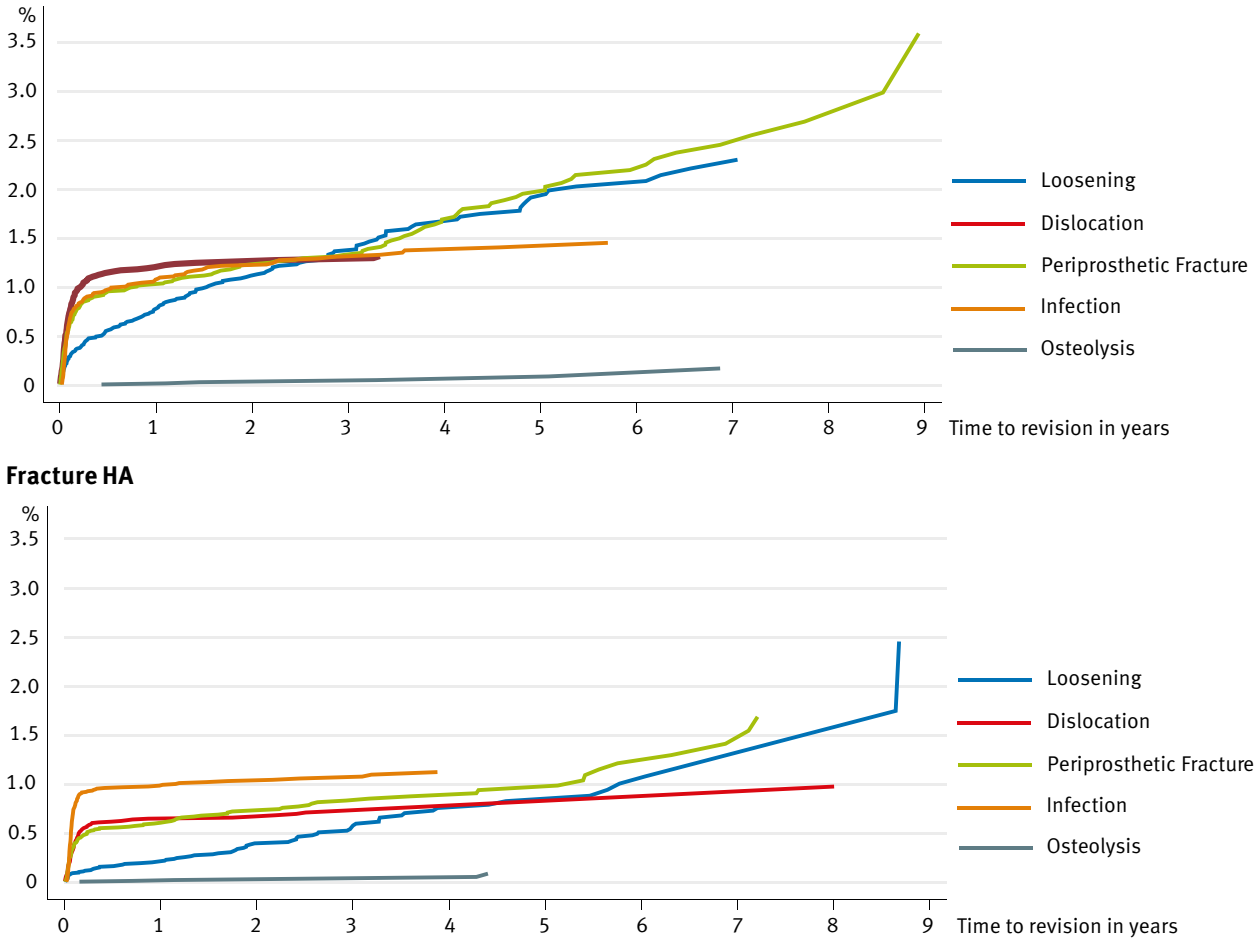
	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
Unipolar femoral head	**2.1** (1.9-2.5)	**2.7** (2.4-3.1)	**3.2** (2.8-3.7)	**3.8** (3.3-4.4)	**4.3** (3.7-5.0)	**4.6** (4.0-5.4)	**4.9** (4.2-5.8)	**7.7** (4.6-12.7)
Bipolar femoral head	**2.8** (2.4-3.3)	**3.3** (2.8-3.8)	**3.6** (3.0-4.2)	**3.9** (3.3-4.6)	**4.1** (3.4-4.8)	**4.6** (3.8-5.6)	**4.9** (3.9-6.2)	**5.3** (4.1-6.9)

It highlights that infection and dislocation events tend to occur rather early on – a steep initial spike followed by very gradual long-term growth. Incidents of loosening and periprosthetic fractures, on the other hand, were the drivers of long-term revision rates in both THA and HA.

Figure 3.7b

Fracture of the hip: Cumulative incidence rates for different first revision diagnoses

Time since operation, 2012–2021, all services, % of implants revised



3.8 Results of implants after hip fracture

The demographics of THA after fracture are shown in chapter 3.2. There are 22 uncemented stem/cup combinations, accounting for 75% of all cases **(Table 3.8a).** Some of these combinations were used fewer than 50 times during the period 2016–2021. The average two-year revision rate (four-year moving average) was 5.2% (95% CI 4.4–6.2). Only implant combinations with n at risk › 50 were included in the analysis. The revision rates for combinations with n at risk › 50 are shown in **Figure 3.8a.** Two of

Table 3.8a

Top 75% of primary total hip arthroplasty uncemented combinations to treat fractures

2016–2021

Stem component	Cup component	2016	2017	2018	2019	2020	2021	2016–2021
Alloclassic	Fitmore	5	4	12	14	5	13	**53**
Amistem-H	Versafitcup trio/ccl.	66	53	6	1	0	0	**126**
Amistem-H prox coating	Versafitcup trio/ccl.	3	44	76	63	5	9	**200**
Amistem-P	Versafitcup trio/ccl.	0	0	2	15	83	87	**187**
Avenir	Allofit	50	51	69	70	78	69	**387**
Avenir	Fitmore	10	11	12	9	7	13	**62**
CLS Spotorno	Allofit	8	13	18	15	11	10	**75**
Corail	Pinnacle	70	43	35	63	68	77	**356**
Corail collared	Gyros	8	13	18	13	19	1	**72**
Corail collared	Liberty	0	0	1	0	13	53	**67**
Corail collared	Novae TH/Bi-Mentum	0	4	3	5	26	58	**96**
Corail collared	Pinnacle	11	37	46	48	63	103	**308**
Fitmore	Allofit	19	12	15	18	15	26	**105**
Fitmore	Fitmore	6	10	14	15	21	14	**80**
Fitmore	RM pressfit vitamys	7	4	3	4	10	12	**40**
Optimys	RM pressfit	14	6	13	12	9	9	**63**
Optimys	RM pressfit vitamys	71	70	90	90	115	156	**592**
Optimys	Symbol DM/DS evol.	1	3	5	5	11	19	**44**
Polarstem	R3	13	9	14	13	16	10	**75**
Quadra-H	Versafitcup trio/ccl.	51	25	33	28	31	19	**187**
SBG	R3	10	0	1	13	8	9	**41**
Twinsys	RM pressfit vitamys	39	43	29	24	26	35	**196**
other combinations		142	118	159	183	246	259	**1,107**
Total		**604**	**573**	**674**	**721**	**886**	**1,061**	**4,519**

Important information on the use of the implant performance tables below

- Estimated revision rate exceeds the alert boundary, but we do not identify this implant combination as an outlier because the 95% confidence interval overlaps the confidence zone of the reference group.
- Identified as potential outliers. Please note the statistical confidence intervals. The outlier status comes with varying degrees of statistical probability. We consider the potential outlier status „highly likely“ when both the estimated revision rate and the complete confidence interval exceed the outlier alert boundary.

Please be aware that relatively rare implant combinations are frequently used in only a small number or indeed only in one hospital in Switzerland. Observed revision rates may be determined by local factors and performance may differ significantly between locations. Manufacturers of detected outlier implants and the hospitals where they were used (and revisions occurred) have been informed by SIRIS.

the combinations had revision rates that exceeded the outlier boundary (set at twice the average revision rate of the group), indicating possible outlier status. However, the numbers at risk are small with wide confidence intervals.

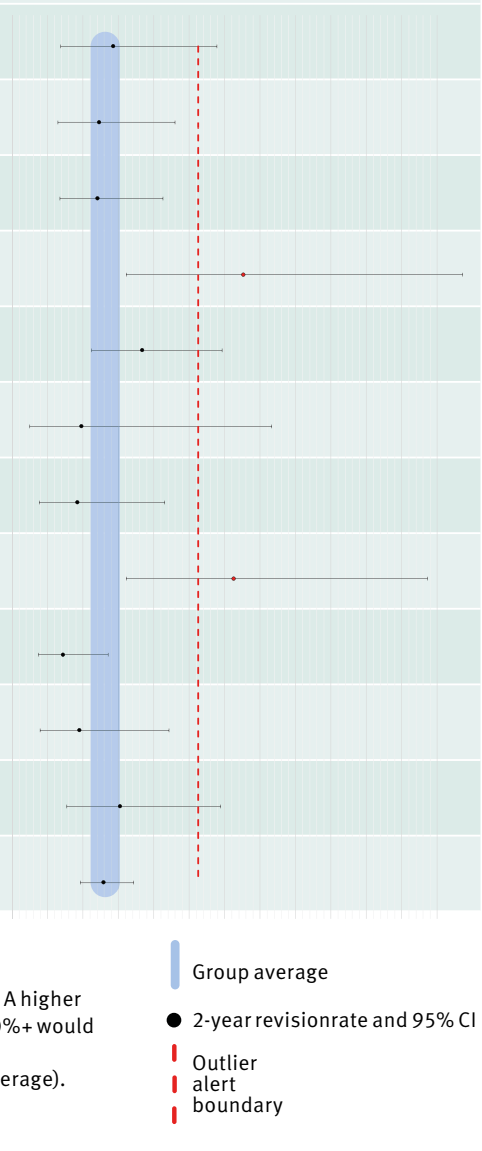
17 stem/cup combinations covered 75% of hip fractures treated with hybrid fixation. Eight of these combinations were used fewer than 100 times in the observed period between 2016 and 2021 **(Table 3.8b).** The revision rates for combinations

Figure 3.8a

2-year evaluation: Revision rates within 24 months of uncemented primary total hip arthroplasty combinations to treat fractures

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

Stem component	Cup component	CCS*	at risk N**	Revised N	Revised % (95% CI)***
Amistem-H	Versafitcup trio/ccl.	24	126	7	5.7 (2.8-11.6)
Amistem-H prox coating	Versafitcup trio/ccl.	19	187	9	4.9 (2.6-9.2)
Avenir	Allofit	24	239	11	4.8 (2.7-8.5)
CLS Spotorno	Allofit	56	54	7	13.0 (6.4-25.4)
Corail	Pinnacle	11	210	15	7.3 (4.5-11.9)
Corail collared	Gyros	33	52	2	3.9 (1.0-14.7)
Corail collared	Pinnacle	15	142	5	3.7 (1.5-8.6)
Fitmore	Allofit	72	64	8	12.5 (6.5-23.4)
Optimys	RM pressfit vitamys	13	320	9	2.9 (1.5-5.4)
Quadra-H	Versafitcup trio/ccl.	28	137	5	3.8 (1.6-8.9)
Twinsys	RM pressfit vitamys	21	135	8	6.1 (3.1-11.8)
other combinations			886	44	5.1 (3.9-6.9)
CH average for group					5.2 (4.4-6.2)



* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

*** Rates adjusted for effects of mortality and emigration

with n at risk › 50 are shown in **Figure 3.8b.** None of the implants reached potential outlier status. The choice of implant combination for the treatment of hip fractures with HA is less variable than for THA. There are only 10 stem/head combinations accounting for 75% of all implantations **(Table 3.8c).** Neither combination was used fewer than 300 times in the last 5 years. The revision rates for combinations with n at risk › 50 are shown in **Figure 3.8c.** None of the implants reached potential outlier status.

Table 3.8b

Top 75% of primary total hip arthroplasty hybrid combinations to treat fractures

2016–2021

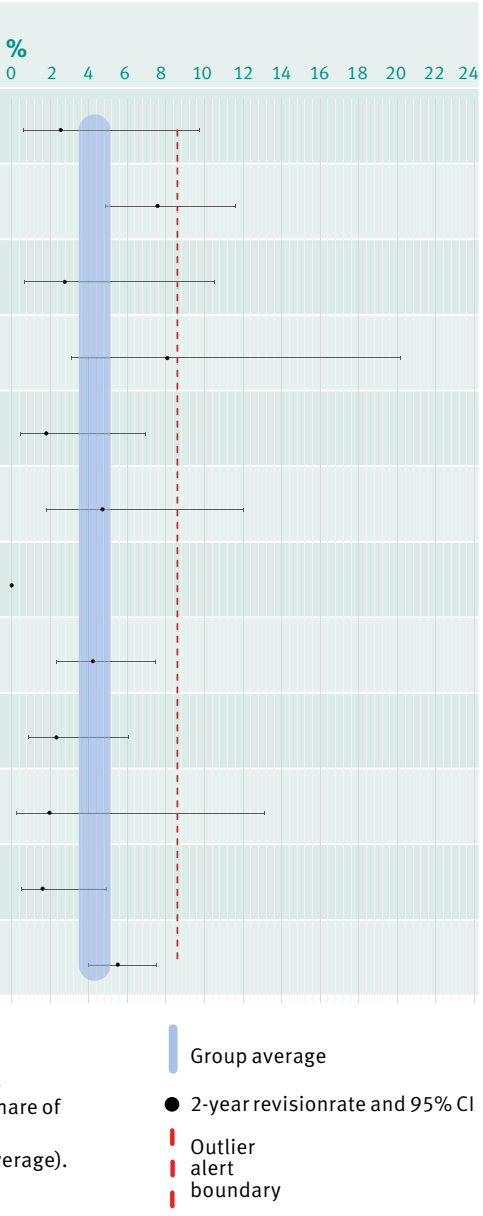
Stem component	Cup component	2016	2017	2018	2019	2020	2021	2016–2021
Amistem-C	Versafitcup DM	21	21	25	16	11	8	**102**
Amistem-C	Versafitcup trio/ccl.	51	71	53	86	93	103	**457**
Avenir (cem)	Allofit	7	19	16	30	33	41	**146**
Avenir (cem)	Fitmore	0	5	19	26	37	65	**152**
CCA	RM pressfit vitamys	2	5	10	19	9	10	**55**
Centris	RM pressfit	9	21	10	12	6	10	**68**
Centris	RM pressfit vitamys	18	34	35	30	32	49	**198**
Corail	Pinnacle	14	22	13	37	39	74	**199**
MS-30	Fitmore	24	24	21	9	10	1	**89**
Quadra-C	Mpact	0	0	1	25	18	16	**60**
Quadra-C	Mpact DM	0	1	3	11	32	34	**81**
Quadra-C	Versafitcup DM	13	10	6	9	12	3	**53**
Quadra-C	Versafitcup trio/ccl.	59	78	63	73	64	35	**372**
Twinsys	RM pressfit	13	13	6	5	6	6	**49**
Twinsys	RM pressfit vitamys	28	43	43	70	69	75	**328**
Weber	Allofit	20	14	9	9	10	2	**64**
Weber	Fitmore	51	49	38	51	45	37	**271**
other combinations		128	117	147	149	183	268	**992**
Total		**458**	**547**	**518**	**667**	**709**	**837**	**3,736**

Figure 3.8b

2-year evaluation: Revision rates within 24 months of hybrid primary total hip arthroplasty combinations to treat fractures

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

Stem component	Cup component	CCS*	at risk N**	Revised N	Revised % (95% CI)***
Amistem-C	Versafitcup DM	73	83	2	2.5 (0.6-9.7)
Amistem-C	Versafitcup trio/ccl.	28	261	19	7.6 (4.9-11.6)
Avenir (cem)	Allofit	50	74	2	2.7 (0.7-10.5)
Centris	RM pressfit	42	52	4	8.1 (3.1-20.1)
Centris	RM pressfit vitamys	44	117	2	1.8 (0.4-7.0)
Corail	Pinnacle	28	86	4	4.7 (1.8-12.0)
MS-30	Fitmore	71	78	0	0.0 (.-.)
Quadra-C	Versafitcup trio/ccl.	53	273	11	4.2 (2.3-7.5)
Twinsys	RM pressfit vitamys	26	183	4	2.3 (0.9-6.1)
Weber	Allofit	37	52	1	2.0 (0.3-13.1)
Weber	Fitmore	40	189	3	1.6 (0.5-4.9)
other combinations			717	37	5.5 (4.0-7.5)
CH average for group					4.3 (3.5-5.3)



* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

*** Rates adjusted for effects of mortality and emigration

Table 3.8c

Top 75% stem/head combinations used in hemi hip arthroplasty (HA)

2016–2021

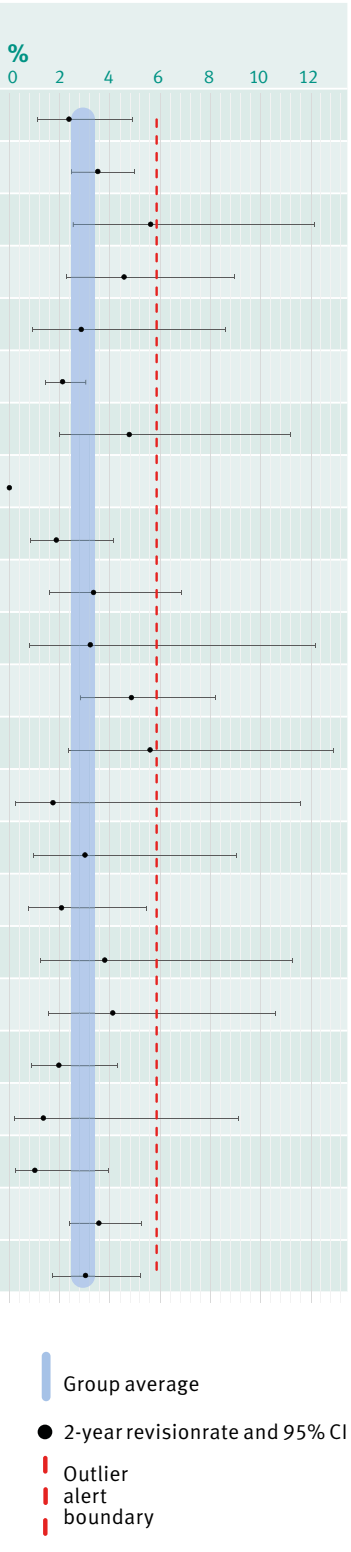
Stem component	Cup component	2016	2017	2018	2019	2020	2021	2016–2021
Amistem-C	Medacta bipolar head	61	69	94	92	113	143	**572**
Amistem-C	Medacta endohead	208	295	290	279	323	369	**1,764**
Avenir (cem)	ZB bipolar head	17	51	61	79	98	69	**375**
CCA	Hemihead SS	350	339	412	429	395	342	**2,267**
Centris	Hemihead SS	90	96	112	109	103	113	**623**
Corail	J&J modular head carthcart	40	63	43	87	105	172	**510**
Harmony	Symbios bibop	76	87	84	50	4	0	**301**
Twinsys	Hemihead SS	88	100	72	97	123	118	**598**
Weber	ZB bipolar head	61	48	45	57	57	52	**320**
Weber	ZB unipolar head	192	158	253	225	168	138	**1,134**
other combinations	-	491	417	368	498	505	435	**2,714**
Total		**1,674**	**1,723**	**1834**	**2,002**	**1,994**	**1,951**	**11,178**

Figure 3.8c

2-year evaluation: Revision rates of cemented primary HA components within 24 months

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

Stem component	Cup component	CCS*	at risk N**	Revised N	Revised % (95% CI)***
Amistem-C	Medacta bipolar head	28	317	7	2.4 (1.1-4.9)
Amistem-C	Medacta endohead	40	1073	31	3.5 (2.5-5.0)
Arcad	Symbios bibop	73	128	6	5.6 (2.5-12.1)
Avenir (cem)	ZB bipolar head	25	206	8	4.6 (2.3-9.0)
Avenir (cem)	ZB unipolar head	36	117	3	2.9 (0.9-8.6)
CCA	Hemihead SS	33	1530	27	2.1 (1.4-3.0)
CCA	Mathys bipolar steel head	34	134	5	4.8 (2.0-11.2)
CS-Plus	S&N bipolar ballhead	93	55	0	0.0 (.-)
Centris	Hemihead SS	40	407	6	1.9 (0.8-4.1)
Corail	J&J modular head carthcart	28	232	7	3.3 (1.6-6.8)
Corail	S&N bipolar ballhead	100	64	2	3.2 (0.8-12.2)
Harmony	Symbios bibop	100	297	13	4.8 (2.8-8.2)
MS-30	ZB bipolar head	50	96	5	5.6 (2.4-12.9)
MS-30	ZB unipolar head	91	67	1	1.7 (0.2-11.6)
Original Mueller	ZB bipolar head	34	138	3	3.0 (1.0-9.0)
Original Mueller	ZB unipolar head	32	228	4	2.1 (0.8-5.4)
Quadra-C	Medacta bipolar head	85	82	3	3.8 (1.2-11.3)
Quadra-C	Medacta endohead	58	117	4	4.1 (1.6-10.6)
Twinsys	Hemihead SS	36	352	6	2.0 (0.9-4.3)
Twinsys	Mathys bipolar steel head	36	86	1	1.3 (0.2-9.1)
Weber	ZB bipolar head	38	212	2	1.0 (0.2-3.9)
Weber	ZB unipolar head	25	828	24	3.6 (2.4-5.3)
other combinations			442	12	3.0 (1.7-5.2)
CH average for group					2.9 (2.5-3.4)



* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

*** Rates adjusted for effects of mortality and emigration

3.9 Competing risk

As has been outlined in the methods chapter of this report, the omnipresent Kaplan-Meier method has known limitations when the risk of revision is in competition with other risks. In the context of joint registries, the one obvious competing risk is the death of a patient and, as has been shown in this chapter, no other group of patients in this report was as affected by this as the recipients of prostheses after hip fractures. This is particularly true for recipients of THA or HA after hip fracture. A patient who dies will not have their implant revised at any later point in time. Risk of death is said to "compete" with the risk of revision. Within the constraints of the Kaplan-Meier method, we account for death by declaring patients who died during their observation time as "censored" from the day of death. This approach is not wrong, but it may be based on the unrealistic assumption that death is an event that occurs entirely independently of revision.

As a first step towards quantifying the potential bias of the Kaplan-Meier method in the presence of the strong competing risk of death in SIRIS data, we have produced a simple competing risks regression model. It includes component revision as the primary endpoint, death as the competing risk and the type of the arthroplasty as well as age and sex as covariates of interest. The results are shown in **Table 3.9a.** SHR stands for subhazard ratio. It is the coefficient that tells us here that fracture THAs are more likely to be revised than primary OA THAs by a factor of 1.96. For fracture HAs, that factor is 1.24. Also, the likelihood of revision is reduced by a factor of 0.99 for each year of age. It should be kept in mind that the cumulative effect of this covariate can be considerable. These three factors were statistically highly significant. Results in terms of what the now accounted for competing risk of death means for our interpretation are best shown by comparing standard KM results against the cumulative revision risk derived from the predicted values of this model. As has been shown before, primary OA

Table 3.9a

Results of competing risk regression* comparing primary OA THA, fracture THA and fracture HA

all cases 2012-2021, competing risk = death of patient, n=197,787, n failed=5,910, n competing=24,975

Primary OA THA (reference category)	SHR	robust std. error	sig.	95% confidence intervall	
Fracture THA	1.96	0.08	<0.001	1.80	2.12
Fracture HA	1.24	0.06	<0.001	1.13	1.37
Age at operation	0.99	0.001	<0.001	0.99	0.99
Female	1.02	0.03	0.37	0.97	1.08

* Fine and Gray's proportional subhazards model

THA carried the lowest overall revision risk, whilst fracture THA had the highest. Fracture HA lay somewhere in the middle **(Figure 3.9a).** The predicted results of the competing risks regression model, here expressed specifically for the "typical" or average patient in those groups, showed little difference for the THAs **(Figure 3.9b).** Primary OA THA is hardly changed by the adjustment for competing risks. This is to be expected as the relatively low mortality of this group, even after nine years of follow-up, did not have the weight to influence the results much. Fracture THA actually moved one percentage point downwards. But the impact on fracture HA, the group with the highest mortality rates, is most impressive. After adjustment, the model suggests that this group probably did not face a higher revision risk than the primary OA THA group. The KM curve is misleading in the sense that it shows us what happens if we only look at the survivors after each loss to the risk set (i.e. after a patient undergoes revision or dies). The regression model, on the other hand, shows us what is predicted to happen to a typical fracture HA patient who is 85 years old and has a high risk of dying during the observation time spanning nine years.

Figure 3.9a

Comparison of cumulative revision risk for generic groups with Kaplan-Meier method

% of implants revised

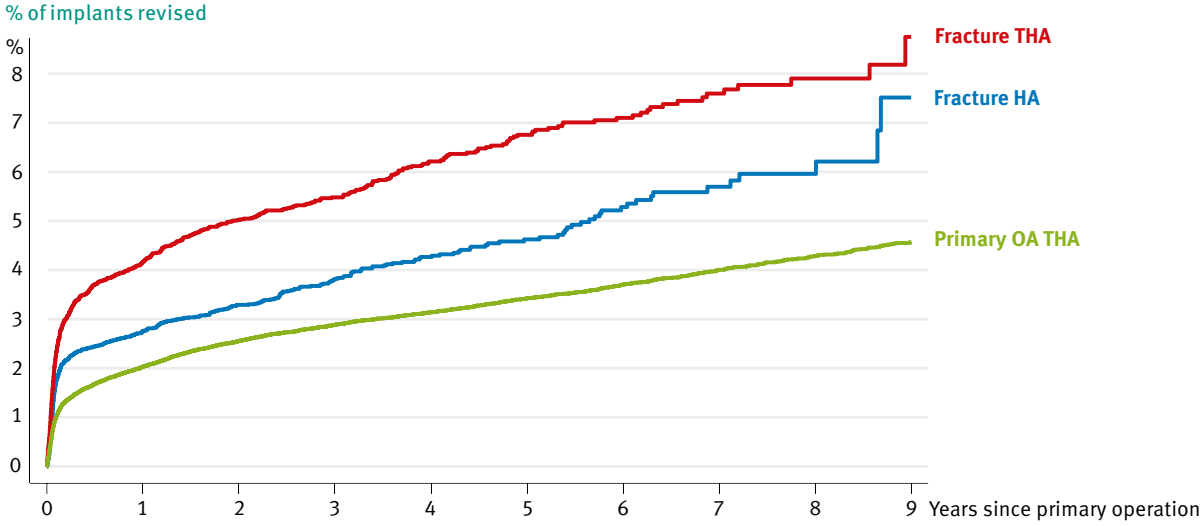
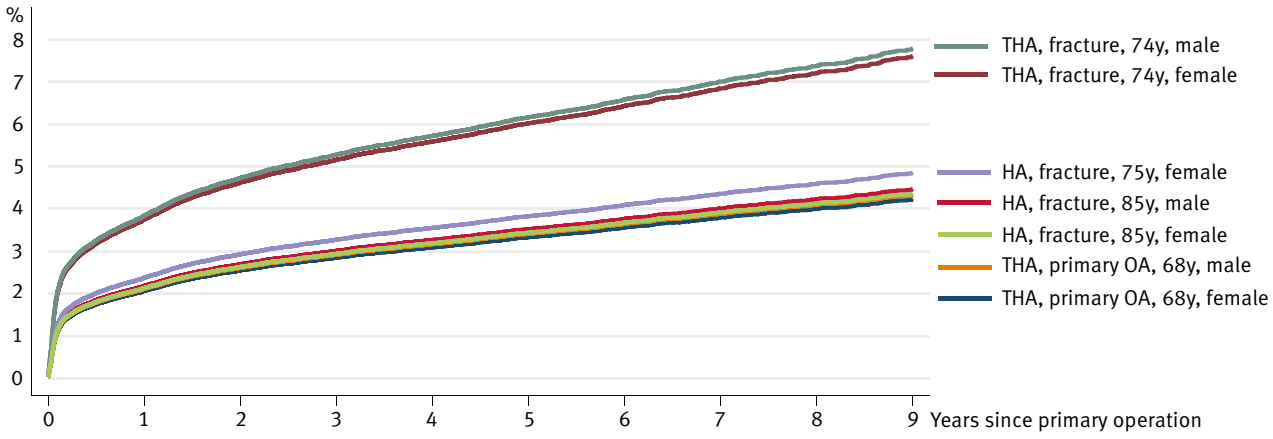


Figure 3.9b

Comparison of cumulative revision risk for typical patients under presence of competing risk of dying

% of implants revised (cumulative incidence function)



Knee arthroplasty

Ten Years of Swiss Hip and Knee Registry

4. Knee arthroplasty

4.1 Introduction and summary

One problem of continuing data collection is that the outdated data have the same weight as new data, and past or current problems may be over- or underestimated. To overcome the problem of antiquated data, it was decided that some analyses would be carried out within a four-year moving window, including the last four years with a completed two-year follow-up. For this report, the data of implantations from January 1, 2016 to December 31, 2019 with a completed two-year follow-up before December 31, 2021 were analysed (the scope of this report). However, for Kaplan-Meier survival estimates and the calculation of cumulative revision rates, the entire period from 2012 onwards was used to extend the follow-up to its maximum.

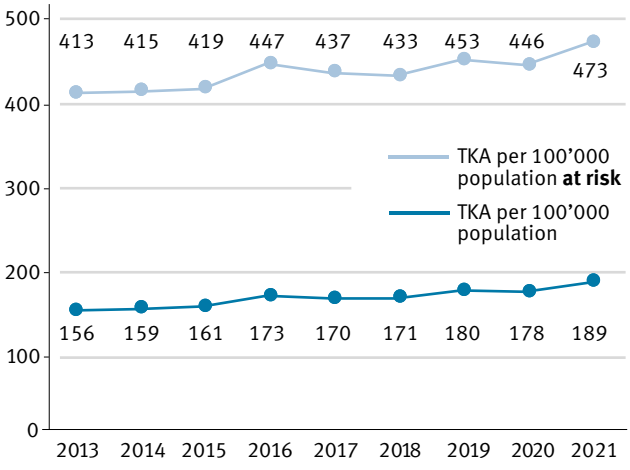
The number of implantations of total knee arthroplasties (TKA) and partial knee arthroplasties (PKA) has increased steadily over the past years. In the beginning, this increase could be explained by the improving coverage rate over time as participating services increasingly completed their data and respected yearly deadlines. The annual increase reached 7.3%, whereas the population at risk rose only 1.3% in 2021. The increase in numbers between 2020 and 2021 cannot be attributed to better coverage alone **(Figure 4.1a).** One explanation is that some centres may have caught up on missed operations in 2020 due to the COVID-19 pandemic. Another may be that the fear of a next partial lockdown could lead patients to have their symptomatic knees operated on sooner than planned. Finally, the increase may signal a real progression of TKA and PKA in Switzerland. Some of the patients operated on were not Swiss residents, but this effect was estimated to be rather small, although the exact number is unknown.

Since 2012, 160,250 primary knee arthroplasties have been registered in Switzerland. Of these, 134,923 were total, and 25,207 were partial knee arthroplasties. The share of PKA was 15.7 in the mean for the past nine years. In 2021, 16,555 TKAs and 3,166 PKAs were performed, resulting in a share of PKA of 16%. Age at surgery was lower for PKA, with the biggest peak in the age group 55–64

Figure 4.1a

Incidence of primary total knee arthroplasties registered in SIRIS

Per 100,000 residents and per 100,000 residents at-risk*



*Age group 50–89 years accounts for 97% of all recipients of TKA

years, whereas the peak for TKA was in the group 65–74 years **(Figure 4.1a).** The cumulative revision rate for PKA was higher than for TKA from the beginning on and reached 12.2% (range 11.4–13.0) and 7.3% (7.1–7.6), respectively, at nine years after primary surgery **(Figure 4.1d).** When the revision rates were calculated in different periods (2012/13, 2014/15, 2016/17, 2018/19, 2020/21), the lower revision rate for the very early years can be explained by the fact that not all the revisions were registered in the beginning, and some could not be linked correctly to the primary intervention. The rates for 2019/2020 and 2021 tend to be lower than for the previous time periods, demonstrating an improvement for the first time. This pattern represents one of the main goals of a implant registry: improving quality over time **(Figure 4.1e).**

Table 4.1a

Total and partial knee arthroplasty (TKA, PKA)

All documented operations

Year	Primary TKA	Primary PKA	Primary others or type uncl.	Primary Total	Linked Rev./Reop. of TKA[2]	Linked Rev./Reop. of PKA[2]	Unlinked Rev./Reop. can be of TKA or PKA	Rev./Reop. Total[3]	% Linked Rev./Reop.
2012[1]	4662	938	5	5,605	20	2	507	529	4.2
2013	12,674	2,404	17	15,095	171	50	1,248	1,470	15.0
2014	13,062	2,339	13	15,414	390	106	1,116	1,612	30.8
2015	13,396	2,392	10	15,798	583	119	1,068	1,772	39.6
2016	14,595	2,458	11	17,064	829	192	1,136	2,162	47.2
2017	14,460	2,616	19	17,095	935	259	1,094	2,292	52.1
2018	146,33	2,704	19	17,356	1,021	280	1,069	2,374	54.8
2019	15,463	3,045	11	18,519	1,177	296	1,045	2,521	58.4
2020	15,423	3,145	8	18,576	1,296	390	1,056	2,744	61.4
2021	16,555	3,166	7	19,728	1,323	399	1,028	2,756	62.5
All	**134,923**	**25,207**	**120**	**160,250**	**7,745**	**2,093**	**10,367**	**20,232**	**48.6**

[1] Does not represent a full year of data, as data collection in most hospitals started only in October 2012

[2] i.e. primaries already in SIRIS

[3] including linked revisions/reoperations of procedures that were classified as „primary others“ or of unclear type

Figure 4.1b

Age distribution at surgery of primary total and partial knee arthroplasty

All documented operations

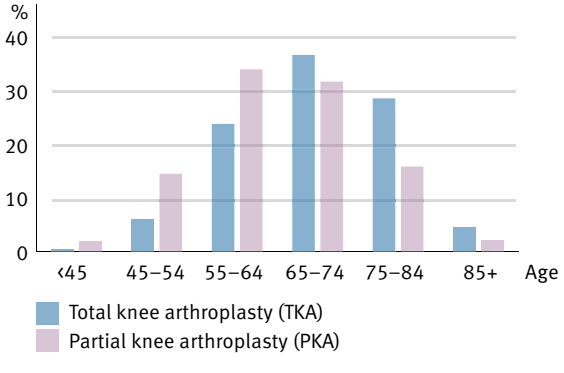


Figure 4.1c

Age distribution at surgery of revision/reoperation of total and partial knee arthroplasty

All documented operations

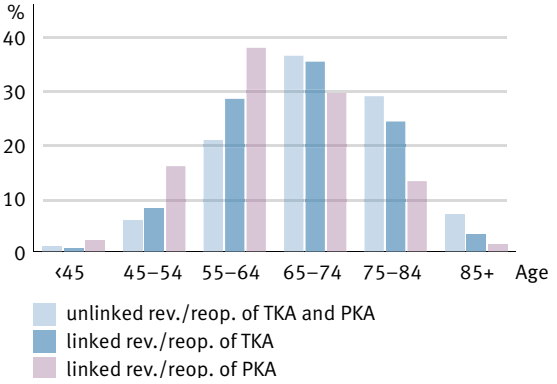
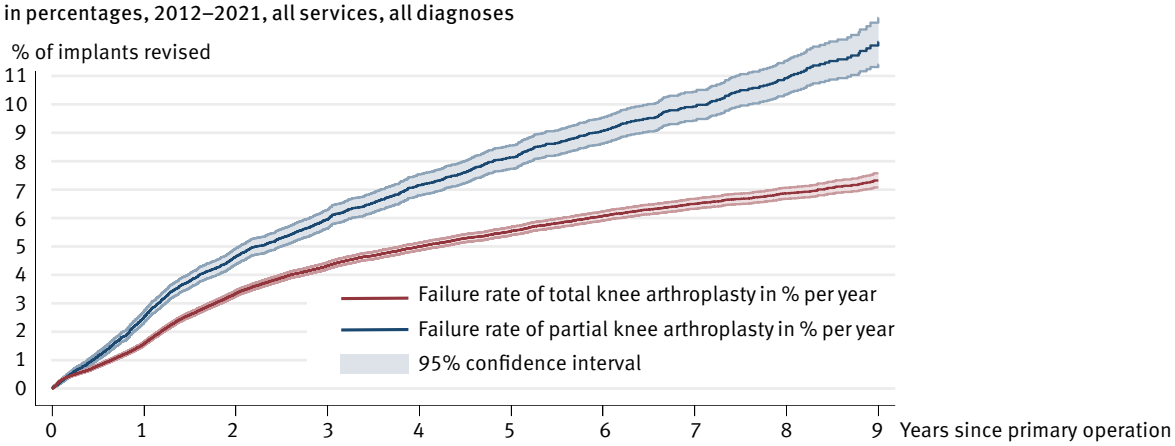


Figure 4.1d

Kaplan Meier estimate of cumulative postoperative revision risk after primary knee arthroplasty

in percentages, 2012–2021, all services, all diagnoses



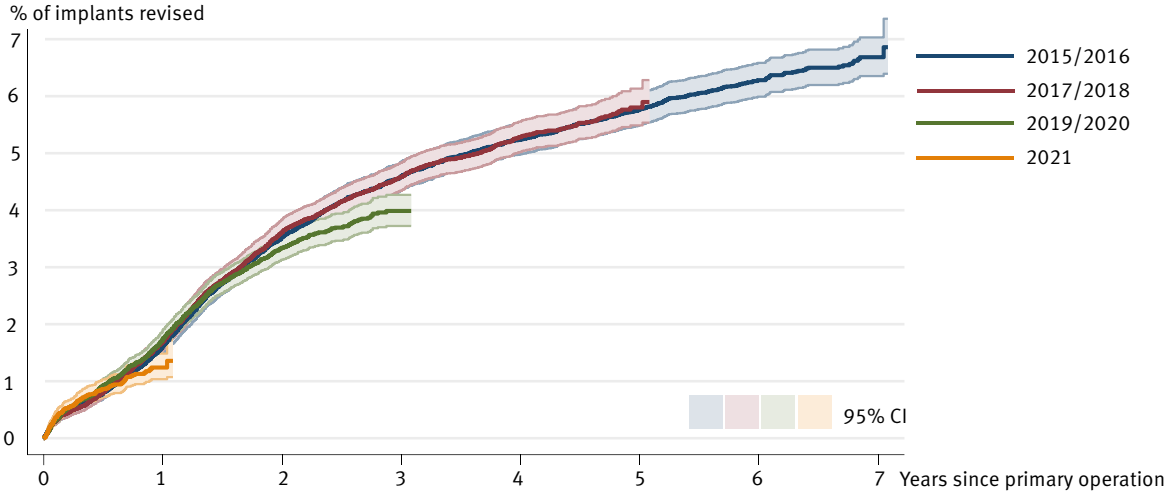
Failure rate	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years
TKA	**1.6** (1.5-1.7)	**3.3** (3.2-3.5)	**4.3** (4.2-4.4)	**5.0** (4.9-5.1)	**5.5** (5.4-5.7)	**6.1** (5.9-6.2)	**6.5** (6.3-6.7)	**6.9** (6.7-7.1)	**7.3** (7.1-7.6)
PKA	**2.5** (2.3-2.7)	**4.6** (4.4-4.9)	**6.0** (5.6-6.3)	**7.2** (6.8-7.5)	**8.1** (7.6-8.6)	**9.1** (8.6-9.5)	**9.9** (9.4-10.4)	**10.9** (10.3-11.5)	**12.2** (11.4-13.0)

Number at risk	0 year	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years
TKA	134,923	113,444	95,552	75,899	61,435	47,765	34,577	23,090	12,667	3,255
PKA	25,207	21,043	17,476	13,780	11,153	8,741	6,530	4,466	2,526	674

Figure 4.1e

Kaplan Meier estimate of cumulative postoperative revision risk after total knee arthroplasty by time period

in percentages, 2015–2021, all services, all diagnoses



Failure rate	1 year	2 years	3 years	4 years	5 years	6 years	7 years
2015/2016	**1.6** (1.5-1.8)	**3.5** (3.3-3.8)	**4.6** (4.4-4.9)	**5.2** (5.0-5.5)	**5.8** (5.5-6.0)	**6.3** (6.0-6.6)	**6.7** (6.4-7.0)
2017/2018	**1.7** (1.6-1.9)	**3.6** (3.4-3.8)	**4.6** (4.3-4.8)	**5.3** (5.0-5.6)	**5.8** (5.5-6.1)		
2019/2020	**1.8** (1.6-1.9)	**3.3** (3.1-3.6)	**4.0** (3.7-4.3)				
2021	**1.2** (1.0-1.5)						

Comparing the numbers of knee arthroplasties performed in different services in Switzerland characterised by their volume (‹100, 100–199, 200–300, ›300 procedures), a concentration in bigger centres can be detected over the past five years, but the effect is smaller than for hips **(Table4.1c).** In all hospitals, TKA was the most common knee replacement, whereas PKA and revision TKA were performed less frequently, with quite a high variation between the institutions. High-volume services tend to perform more PKAs and revision TKAs than smaller units, but some centres seem to focus on PKA and/or revision TKA, perhaps reflecting a sort of sub-specialisation. **(Figure 4.1f).**

Table 4.1b

Number of participating hospital services (N) and median procedures (M) per unit per year

		2016	2017	2018	2019	2020	2021
Primary arthroplasty of the knee (TKA)	N services	149	149	151	147	146	145
	M per service	75	72	78	79	77	86
Primary partial arthroplasty of the knee	N services	128	127	129	127	128	127
	M per service	10	10	11	12	12	13
Revision arthroplasty of the knee (TKA or partial)	N services	131	130	134	133	130	134
	M per service	8	9	9	9	13	12

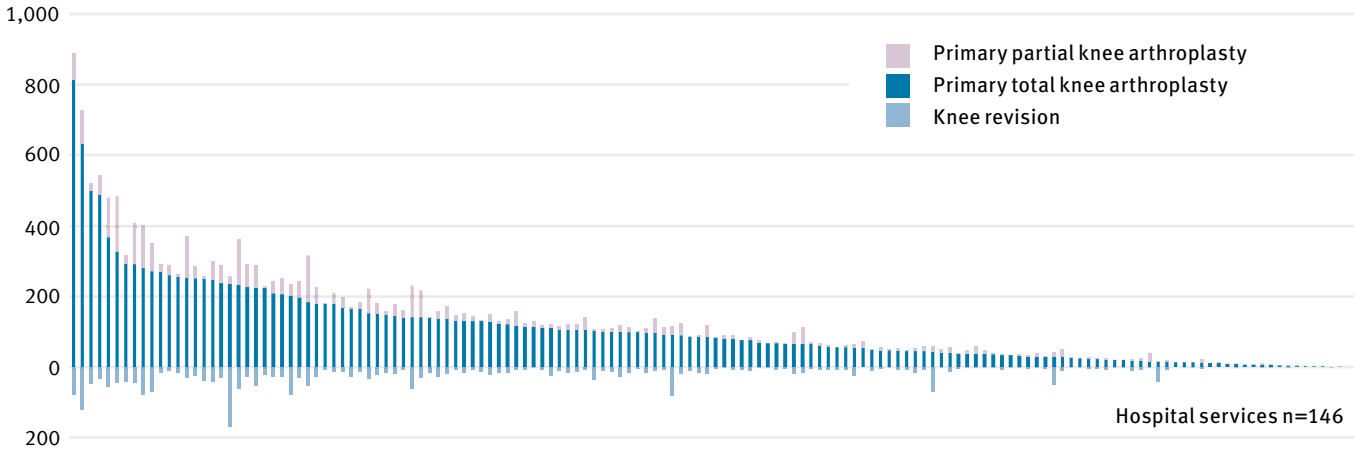
Table 4.1c

Number of hospital services and number of primary total knee arthroplasties according to hospital volume

Service volume		2016	2017	2018	2019	2020	2021
‹100	N procedures/%	3,838/**26.5**	3,086/**21.5**	3,590/**24.5**	3,184/**20.5**	2,721/**17.7**	2,551/**15.4**
	N services	94	86	90	81	78	72
100–199	N procedures/%	3,622/**25.0**	4,810/**33.5**	4,327/**29.5**	4,523/**29.1**	4,698/**30.5**	4,778/**28.9**
	N services	29	39	35	37	39	40
200–299	N procedures/%	2,640/**18.2**	2,940/**20.5**	3,273/**22.3**	3,461/**22.3**	3,240/**21.0**	4,041/**24.4**
	N services	13	14	16	17	16	19
›300	N procedures/%	4,375/**30.2**	3,528/**24.6**	3,480/**23.7**	4,352/**28.0**	4,754/**30.8**	5,185/**31.3**
	N services	12	9	9	12	13	14

Figure 4.1f

Cases per hospital service 2021: Total and partial knee arthroplasty

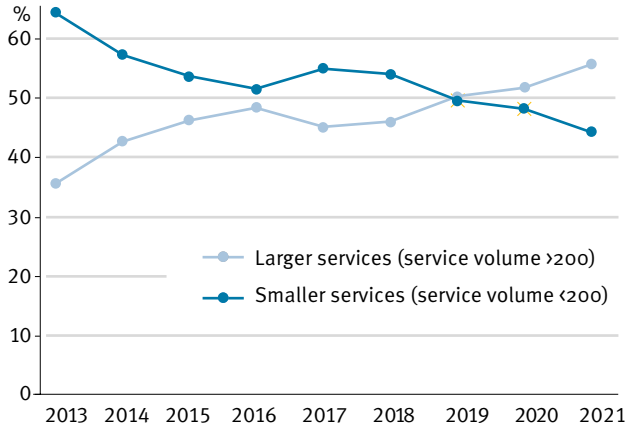


Figures 4.1g

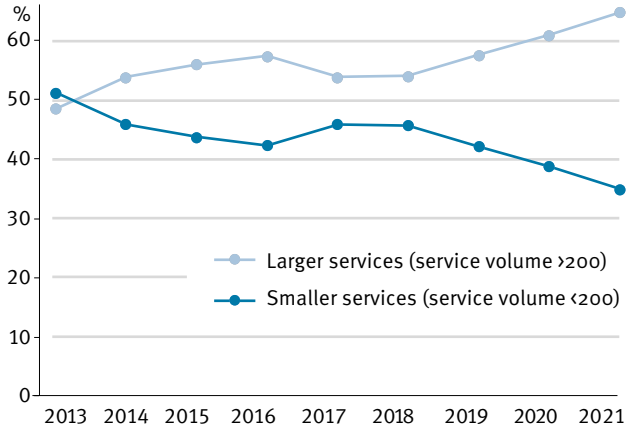
What share of selected procedures is performed in hospital services with different service volumes?

Service volume is defined as the sum of primary procedures per year

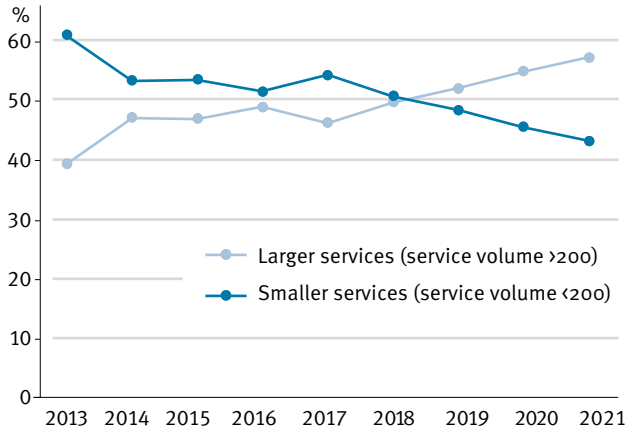
Total knee arthroplasty



Partial knee arthroplasty



Knee revision



Almost 150 hospital services in Switzerland (orthopedic or trauma departments) performed knee arthroplasty procedures, and SIRIS has achieved 100% participation of institutions since 2018. In 2021, 145 hospitals registered TKA, 127 PKA and 134 revision of TKA and/or PKA. Median procedure figures per hospital **(Table 4.1b)** reveal a stable picture over time, with only minimal fluctuation since 2016. **Figures 4.1g** highlight the distribution of case numbers for knee surgeries within service size categories. Since 2013, a concentration of TKA and PKA procedures in bigger service units can be recognised **(Figures 4.1g)**. The number of 200 procedures per year is artificial and can lead to the effect that a hospital moves between large (200+) and small (‹200). While a real increase in numbers in some services is possible, the concentration may also be an effect of uniting two or more smaller services into a bigger centre. The tendency toward larger services is also true for revisions though the effect seems less pronounced **(Figures 4.1g)**.

Figures 4.1h shows funnel plots of risk-adjusted revision rates (age and sex, BMI, ASA and Charnley scores, if available) for TKA and PKA and revision TKA without isolated patella resurfacing. On the funnel plots, each dot represents a hospital service and is centered on the national average. The vertical axis indicates the outcome, with dots higher up the axis showing services with higher revision rates. The horizontal axis shows surgical activity with dots further to the right indicating the surgical units which performed more operations within the reported period. Funnel plots include control limits to define the range within which outcomes are expected to be. Following convention, 99.8% control limits were used as the outer limit. It is unlikely for a hospital to fall beyond these limits solely because of random variation (a 1 in 500 chance). The main cause of variation within the control limits is likely to be random variation. As

Figure 4.1h

2-year revision rate of primary total knee arthroplasty by service*

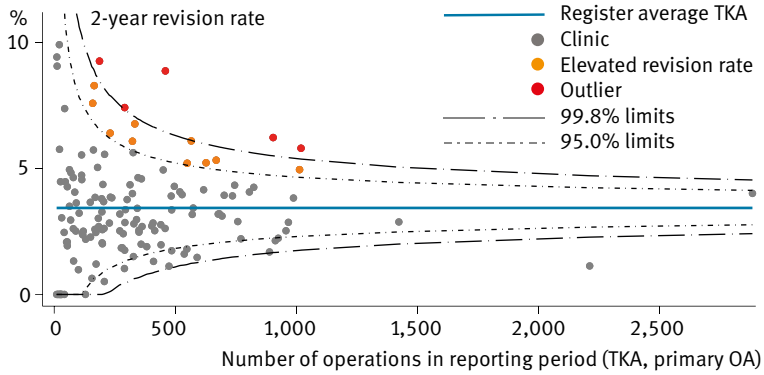
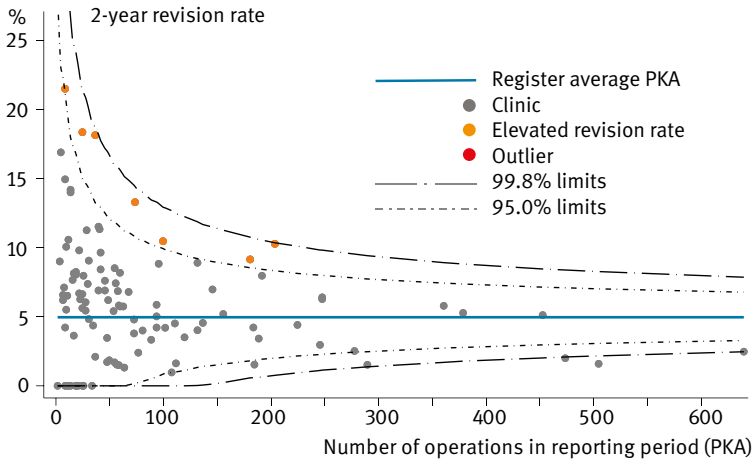


Figure 4.1i

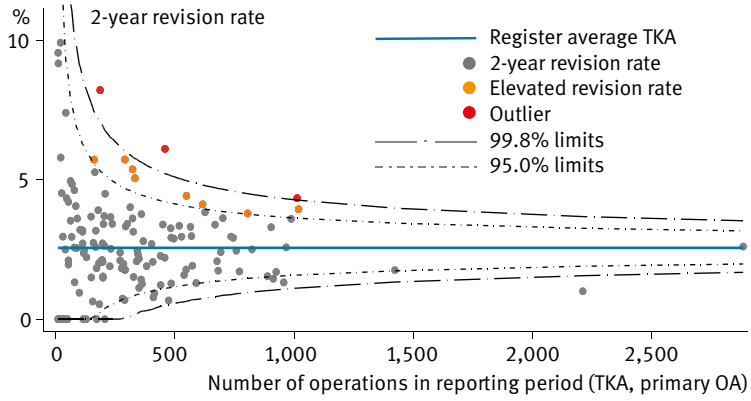
2-year revision rate of partial knee arthroplasty by service*



*Number of operations in the reporting period 01/2016–12/2019 (4-year moving average, follow-up to 12/2021)
TKA results restricted to patients with primary osteoarthritis (prim OA). Results are risk-adjusted for age, sex and BMI, ASA, Charnley Score if available

Figure 4.1j

Total knee arthroplasty without isolated secondary PAT resurfacing



Interpretation of funnel plots

The blue line denotes the Swiss average 2-year revision rate

Clinics that lie between the 95% limits (grey) have revision rates that are within the statistically expected range of observations given their operation volume

Clincs below the 95/99.8% limits are performing better than the average

Clinics above the 95% limit and below the 99.8% limit (orange) have elevated 2-year revision rates. This could be due to random variation, but we recommend that possible reasons are investigated, in particular if the position should be stable over time or worsen.

Clinics above the 99.8% limit (red) have 2-year revision rates that deviate markedly from the national average (unlikely to be due to random variation alone).

the plots show, the spread of outcomes in Switzerland was relatively homogeneous, but there were exceptions, and there appears to be more variation with knee than with hip procedures.

Revision rates for TKAs reveal more outliers than those for PKAs. When isolated secondary patella resurfacing is ignored as a type of revision then we see that the spread of results is actually becoming less pronounced. This implies that secondary patella resurfacing plays a prominent role in determining clinical performance at two years **(Figure 4.1h).**

In 2021, the total number of registered primary TKAs in the Swiss Joint Registry reached 134,923 cases **(Table 4.1a).** The share of women (60.1%) and mean age (69.5 years) remained constant throughout the entire period. The share of younger patients (younger than 45: 0.5%; and 45–54 years old: 6.1%) and patients older than 85 years old (4.5%) did not change significantly over the past years **(Table 4.2a).** Gender, mean age, age groups, and BMI did not differ in low or high-volume hospitals, whereas hospitals with more than 200 TKAs per year seemed to treat more patients classified as ASA 3 **(Table 4.1d).** Most reasons for TKAs were classified as primary OA (88.5% in 2021), although additional reasons (such as ligament lesions or infection) were introduced in 2015 as a possible underlying diagnosis for secondary OA, and the knowledge about factors causing a knee OA has steadily increased over the past decades.

Younger patients tended to be more obese. On average, women were older than men when a TKA was performed in all BMI groups, although the difference decreased with age and when BMI exceeded 30 kg/m². Mean age at surgery was about 70 years for BMI under 30 kg/m²; surgery had to be performed 5–6 years earlier when BMI was more than 40 kg/m² **(Figure 4.2a).** The difference in younger patients was mainly men's higher share of post-traumatic OA.

Differences in patient demographics, including BMI and ASA status, were very small and insignificant between hospitals with low or high-volume hospitals **(Table 4.1d and 4.6b).**

One must note that the knee systems used in Switzerland varied significantly between different cantons, regions and hospitals in Switzerland. Traditionally, posterior stabilised (PS) knees were more used in the western part of Switzerland, whereas in the German-speaking cantons, cruciate retaining (CR) and sacrificing (CS), including ultracongruent (UC) knees, were favored. Medial pivot knees did not seem to follow a particular regional pattern in Switzerland but seemed to be preferred in specific hospitals. **Figure 4.2c** shows the high variability of the different types of knee prostheses (posterior-stabilised PS, cruciate-sacrificing CS/UCOR, cruciate-retaining BCR/PCR and medial-pivot MP) used in Switzerland and adaptions between the periods 2015–2018 and 2019–2021, respectively. The share of medial pivot implants seems to increase and replace more traditional designs such as PS, CR and CS/UCOR in some hospitals/cantons.

Mostly, TKAs were fully cemented in Switzerland; the share in the past six years was 79.2%. Hybrid fixation of the components was used constantly and reached a mean of 15.5%. Interestingly, cementless fixation represented only 4.9% of the TKAs in 2016, but the share doubled in three years to 8% in 2021 **(Table and Figure 4.2d).**

Between 2016 and 2021, 70.6% of the TKAs in Switzerland were performed conventionally. The share of computer navigation was 9.4% and continuously decreased from 12.2% in 2016 to 9.8% in 2021. Patient-specific instrumentation (PSI) increased from 12.4% in 2016 to 18.6% in 2021. Robotic-assisted TKAs (imageless and image-based) were classified as "other" and accounted for 2.7% for the whole period, increasing from 1.2% in 2016 to 5.5% in 2021 **(Table 4.2c, Table 4.2g and**

Table 4.1d

Baseline patient characteristics of primary total knee arthroplasty by hospital service volume

Calculations of hospital service volume based on primary knee surgeries in each included year (2016–2021).

Hospital service volume		<100	100–199	200–299	300+
N (2016–2021)		**18,232**	**26,881**	**19,347**	**26,669**
Women [%]		60.5	59.6	60.5	59.9
Mean age (SD)	All	69.9 (9.7)	69.7 (9.5)	69.5 (9.4)	69.1 (9.5)
	Women	70.5 (9.7)	70.3 (9.6)	70.0 (9.5)	69.7 (9.6)
	Men	69.0 (9.6)	68.8 (9.4)	68.8 (9.2)	68.1 (9.2)
Age group [%]	<45	0.5	0.5	0.5	0.5
	45–54	6.1	5.8	5.7	6.6
	55–64	22.8	23.8	24.2	24.7
	65–74	35.6	36.1	37.1	37.2
	75–84	29.8	29.2	28.0	27.2
	85+	5.2	4.6	4.6	3.9
Diagnosis [%]	Primary OA	88.8	89.5	88.4	87.3
	Secondary OA	11.2	10.5	11.6	12.7
N unknown BMI (%)		3,176 (17)	3,649 (14)	2,205 (11)	4,395 (16)
N known BMI		15,056	23,232	17,142	22,274
Mean BMI (SD)		29.4 (5.6)	29.7 (6.0)	29.6 (6.0)	29.0 (5.7)
BMI [%]	<18.5	0.5	0.5	0.6	0.5
	18.5–24.9	21.0	20.2	20.6	23.4
	25–29.9	38.4	37.7	37.8	39.7
	30–34.9	25.2	25.8	25.4	23.1
	35–39.9	10.4	11.0	10.6	9.2
	40+	4.5	4.9	4.9	4.1
N unknown ASA (%)		1,140 (6)	1,594 (6)	1,599 (8)	2,520 (9)
N known ASA		17,092	25,287	17,748	24,149
ASA state [%]	ASA 1	9.0	8.3	7.2	8.3
	ASA 2	61.8	64.2	62.2	60.8
	ASA 3	28.7	27.0	30.2	30.7
	ASA 4/5	0.5	0.4	0.4	0.3

Figure 4.1k

Seasonal pattern of SIRIS submissions 2018–2021

All documented operations

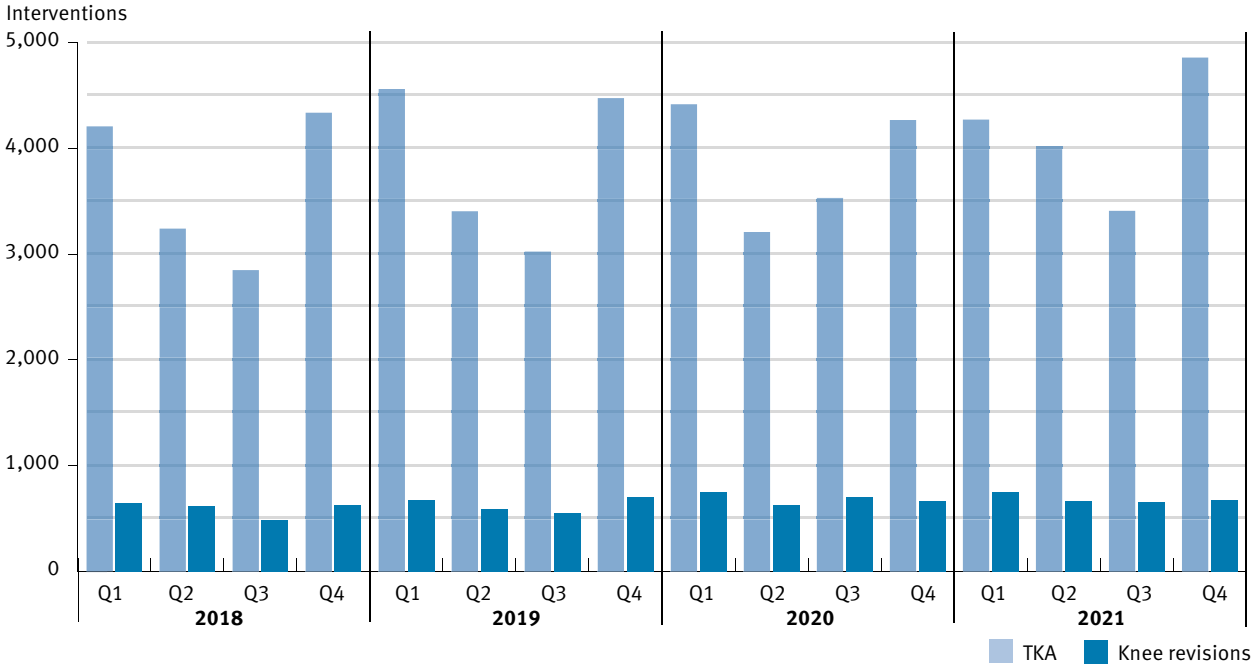


Table 4.1e

Seasonal pattern of SIRIS submissions 2018–2021

All documented operations

	2018				2019			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TKA	4,207	3,241	2,849	4,336	4,560	3,405	3,024	4,474
Knee revisions	645	615	489	625	673	591	557	700

	2020				2021			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TKA	4,416	3,209	3,531	4,267	4,271	4,018	3,409	4,857
Knee revisions	749	628	701	666	750	670	660	676

Figure 4.2i). In summary, surgeons used technical support in 26.8% of total knee arthroplasties over the past six years.

In 69.2% of primary TKA cases between 2016 and 2021, the patella was not resurfaced **(Table 4.e and Figure 4.2f).** The resurfacing rate increased continuously since 2016 from 26.8% to 34.9% in 2021. However, there were considerable differences between the cantons **(Figure 4.2g).** Some of these differences can be explained using posterior stabilised knees, where resurfacing of the patella is recommended more than in other TKA models, being more popular in the western part of Switzerland and in some centres. The continuous increase for primary patella resurfacing is not homogenous but underlies regional differences in the knee system used. In some cantons, such as TG and GE, the resurfacing rate increased significantly from 2015–2018 and 2019–2021, respectively; in others, such as OW or SH, the resurfacing rate even decreased in the same period **(Figure 4.2g).**

The rate of mobile-bearing polyethylene (PE) did rapidly decrease over the past six years, from 42.5% in 2016 to 25.1% in 2021 **(Table 4.2e and Figure 4.2f).** One must note, however, that the bearing type choice showed a high variation in the different cantons of Switzerland, along with the Principality of Liechtenstein **(Figure 4.2j).** The reduction of the mobile-bearing system is not a general effect but is more because some hospitals in certain cantons, such as OW, AR, SH, LU and FR, changed their knee systems. In some other cantons, such as UR and JU, the share of mobile-bearing PE even increased in the same period **(Figure 4.2j).**

Complete revision TKA was performed in 36.3% of the cases; in 16.4%, only the PE was exchanged. Secondary resurfacing of the patella alone was performed in 15.0% **(Table 4.3c).** A combined exchange of the PE with secondary patella resurfacing was conducted in 5.3% of the cases.

Posterior CR TKAs were used in 4.3% of the revisions, 20.7% were stabilised posteriorly, 8.4% were classified as cruciate sacrificing or ultracongruent implants, and in 27.5%, a hinge-type prosthesis was used. Unlinked semi-constrained or CCK implants formed, with 34.6% the biggest group, whereas medial pivot was used only in 1.7% of the revisions **(Table 4.3c).**

The vast majority of the implants were fully cemented (92.5% in mean from 2016 to 2021), reaching 93.4% in 2021 **(Figure 4.3a and Table 4.3d).** Revision TKA was associated with patella resurfacing with a mean of 65.6% and 66.6% in 2021 **(Figure 4.3b and Table 4.3e).**

Compared to hip prostheses, the numbers of "unlinked" knee revisions and reoperations are falling faster. Overall, the share of linked revisions is 48.6%, steadily increasing with time and reaching 62.5% in 2021, including linked revisions of total and partial knee arthroplasties **(Figure 4.1b).** An explantation for this difference between hips and knees could be that the latter are revised more often and earlier than hips. Between 2016 and 2021, 17,134 partial knee replacements (PKA) were implanted, accounting for 15.8% of all knee arthroplasties **(Tables 4.2a and 4.6a).** This proportion remained constant over the past five years and is among the highest in the western world. In 2021, the total number of partial knee replacements was 3,166. 46.8% of recipients were women, and the overall mean age at surgery was approximately 64.5 years, significantly younger than in the group with total knee arthroplasty **(Tables 4.2a and 4.6a).** Partial knee arthroplasty was more often implanted in younger patients (peak in the age group 55–64 years), whereas the peak for total knee arthroplasty was in the age group 65–74 years **(Figure 4.1c).** Hospitals with more than 100 interventions per year performed only 25.4% of the partial knee replacements **(Table 4.6b).** Medial uni-compartmental replacement was performed in

83.7% of cases, lateral in 6.0% and patellofemoral replacement in 6.4% **(Table 4.6c).** Technical support in PKA is still rare in Switzerland even though robotics was introduced in 2018 and patient-specific instruments (PSI) have been available for years **(Figure 4.1l).**

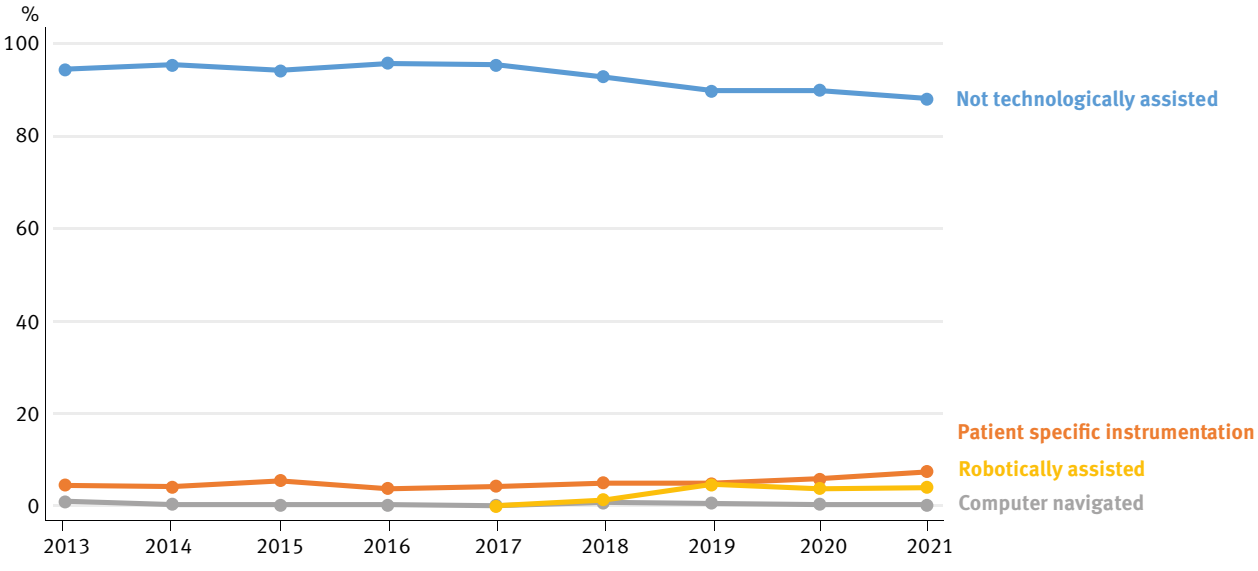
Of the 25,207 documented partial knee arthroplasties (PKA) implanted since 2012, 10,823 were at risk as they fell within the four-year moving average time window for primary surgery between January 1, 2016, and December 31, 2019 and had at least two years of follow-up by December 31, 2021. Of the implants at risk, 532 knees were revised, accounting for a two-year revision rate of 5.0% (CI 95% 4.6 –5.4%). Younger patients were much more at risk (e.g. 7.1% in the age group under 55 years) than older patients (e.g. 3.0% in the age group 75–84 years) **(Table 4.7a).** Compared to the 2021 report, PKA's revision rate has also increased **(Figure 4.1d).** The reason for this is likely the improved linkage rate, leading to the detection of formerly unrecognised revisions.

67.1% of the failed PKAs were converted to total knee arthroplasty **(Table 4.7d).** This share is far more than the reported 40.8% published in the 2021 SIRIS report. The reason is that in the meantime, many of the linked revision TKAs could be identified as a follow-on from a primary PKA instead of TKA by implant detection, which is sometimes more precise than the filled registry forms. Additionally, many locally-entered "complete revisions" were re-coded as conversion to TKA. Polyethylene was exchanged in 16.2% of revisions, followed by tibial revision in 5.8%.

Figure 4.1l

Partial knee arthroplasty: technology assistance over time (%)

NB: robotically assisted cases before v2021 were derived from free text entries.
„Other" responses were coded as „Not tech. assisted" unless they specifically mentioned robotic, PSI oder navigation".



4.2 Primary total knee arthroplasty

Since 2012, 134,923 total knee arthroplasties (TKA) have been registered in the Swiss national joint registry SIRIS, including morbidity state (ASA classification) and the Body Mass Index (BMI) since 2015. Baseline figures in **Table 4.2a** highlight that most variables showed little change in recent years. Namely, the share of operations performed on women, 60.1%, and the mean age at surgery of 69.5 years were constant during the whole period, as was the share of TKAs for primary OA (88.5%). The share of TKAs in younger patients (younger than 45: 0.5%; and 45–54 years old: 6.1%) and patients older than 85 years (4.5%) have remained consistently low since 2012, which is an indirect sign that indications for TKA were not expanding, although numbers of TKA increased by more than 7% in 2021 and the Swiss health care system features ample supply of hospitals and orthopedic surgeons.

The proportion of missing BMIs steadily decreased over the past years to 15% overall and fell to 9% in 2021. From the data available, we can calculate that the mean BMI was 29.4 kg/m2 and that the distribution of values over time has remained steady. Obese patients (BMI ≥ 30 kg/m2) made up 39.7% of the total knee arthroplasty patients in Switzerland. The BMI correlated inversely with increasing age. Younger patients tended to be more obese **(Figure 4.2a).** On average, women were older than men when a TKA was performed in all BMI groups, although the difference decreased when BMI exceeded 30 kg/m2. While the mean age at surgery was about 70 years for BMI under 30 kg/m2, surgery had to be performed 5–6 years earlier when BMI was more than 40 kg/m2 **(Figure 4.2a).**

The rate of unrecorded ASA classification was 8% on average over the period and continued to decrease and was 3% only in 2021. The better coverage of BMI and ASA over the past years demonstrates that most services and surgeons have realised that these two parameters markedly influence outcomes after TKA, PKA and revision TKA.

Generally, women were older than men when receiving a TKA, with the difference steadily decreasing with age **(Figure 4.2a).** The difference in younger patients was mainly men's higher share of post-traumatic OA.

Figure 4.2a

Primary total knee arthroplasty: Mean age at primary arthroplasty depending on BMI class

All diagnoses. Please note that group sizes vary considerably.

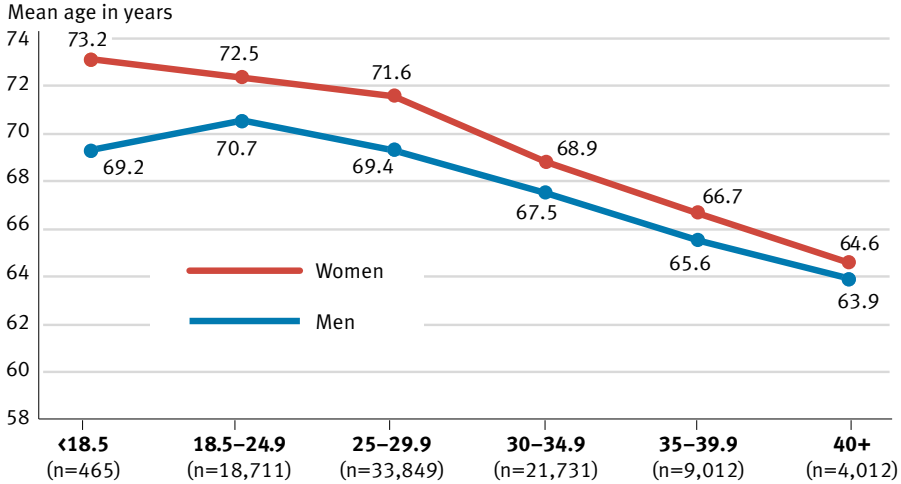


Table 4.2a

Primary total knee arthroplasty: Baseline patient characteristics by year

		2016	2017	2018	2019	2020	2021	2016–2021
N		**14,595**	**14,460**	**14,633**	**15,463**	**15,423**	**16,555**	**91,129**
Diagnosis [%]	Primary OA*	88.8	88.6	89.3	88.9	88.5	87.0	88.5
	Secondary OA	11.2	11.4	10.7	11.1	11.5	13.0	11.5
	Inflammatory origin	1.2	0.8	0.9	0.9	0.9	1.0	1.0
	Fracture	2.0	2.2	2.1	2.1	2.2	2.3	2.2
	Lesion of ligament	5.1	5.4	4.8	5.2	5.7	5.9	5.4
	Infection	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Osteonecrosis	1.7	1.7	1.7	1.5	1.4	1.9	1.7
	Other**	1.4	1.6	1.3	1.4	1.3	1.8	1.5
Women [%]		61.3	60.7	60.5	59.7	58.4	60.0	60.1
Mean age (SD)	All	69.4 (9.6)	69.4 (9.4)	69.4 (9.7)	69.8 (9.5)	69.5 (9.4)	69.6 (9.5)	69.5 (9.5)
	Women	70.0 (9.5)	70.0 (9.5)	69.9 (9.7)	70.5 (9.6)	70.1 (9.6)	70.1 (9.7)	70.1 (9.6)
	Men	68.4 (9.5)	68.4 (9.3)	68.6 (9.6)	68.9 (9.3)	68.7 (9.2)	68.8 (9.3)	68.7 (9.4)
Age group [%]	‹45	0.5	0.5	0.5	0.4	0.5	0.5	0.5
	45–54	6.6	6.2	6.3	5.9	5.7	5.7	6.1
	55–64	23.3	23.7	24.3	23.1	24.6	24.6	24.0
	65–74	37.7	37.9	36.3	36.2	36.0	35.3	36.5
	75–84	27.7	27.3	27.8	29.3	28.9	29.5	28.5
	85+	4.2	4.4	4.8	5.1	4.2	4.4	4.5
N unknown BMI (%)			2,567 (18)	2,256 (15)	2,291 (15)	1,917 (12)	1,502 (9)	13,425 (15)
N known BMI			11,893	12,377	13,172	13,506	15,053	77,704
Mean BMI (SD)		29.5 (5.6)	29.5 (5.7)	29.5 (5.9)	29.5 (5.8)	29.3 (5.7)	29.3 (6.1)	29.4 (5.8)
BMI [%]	‹18.5	0.4	0.5	0.5	0.5	0.6	0.6	0.5
	18.5–24.9	21.2	20.9	20.6	20.8	22.2	22.0	21.3
	25–29.9	38.8	38.4	38.5	38.8	38.2	38.0	38.4
	30–34.9	24.6	24.9	25.4	24.8	24.6	24.8	24.8
	35–39.9	10.5	10.6	10.6	10.2	10.1	9.9	10.3
	40+	4.5	4.7	4.5	4.8	4.3	4.6	4.6
N unknown ASA (%)		1,517 (10)	1,408 (10)	1,183 (8)	1,160 (8)	1,018 (7)	567 (3)	6,853 (8)
N known ASA		13,078	13,052	13,450	14,303	14,405	15,988	84,276
Morbidity state [%]	ASA 1	9.8	8.7	8.2	8.2	7.9	6.9	8.2
	ASA 2	62.4	63.2	63.1	61.5	62.0	61.9	62.3
	ASA 3	27.5	27.7	28.3	29.9	29.6	30.9	29.0
	ASA 4/5	0.3	0.4	0.4	0.5	0.4	0.4	0.4

* As of SIRIS version 2021, and pending further review, this category includes the newly introduced category „secondary arthritis after meniscus surgery“. This category accounts for more than 6% of current entries, but shows large variability between hospitals.

** A small number of newly added cases with „secondary OA caused by patellar instability“ were added to this category.

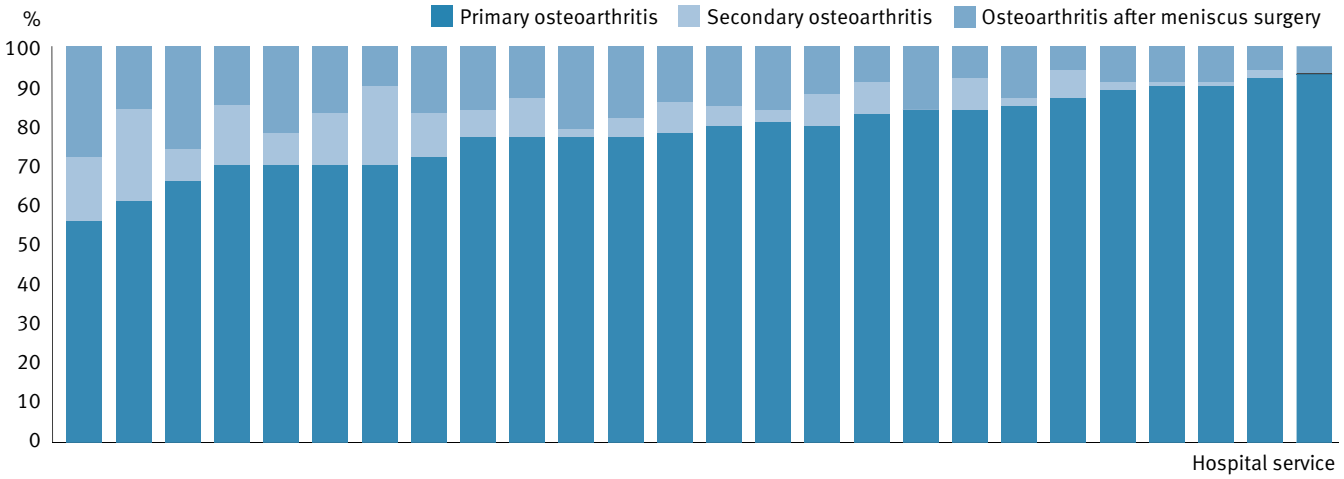
Differences in patient demographics, including BMI and ASA status, were small and not significant between hospitals with low or high-volume hospitals **(Figure 4.1d).**

The most frequent reasons for TKAs were classified as primary osteoarthritis (OA) (88.5% in the period from 2016 to 2021), even though more pathologies (such as ligament lesions or infections) were introduced in 2015 as possible underlying causes for secondary osteoarthritis **(Table 4.2a).** In 2021, a new SIRIS proforma introduced the category "secondary arthritis after meniscus surgery", which for the time being is still counted as a form of de-facto primary osteoarthritis due to a very inconsistent reporting pattern. Significant differences in the proportion of secondary arthritis could be observed in hospitals performing more than 200 knee arthroplasties per year, which may not reflect real differences in patient demographics as all other parameters were comparable **(Figure 4.2b).** For instance, a bias towards primary osteoarthritis (OA) is probable, as this reason ranges on top in the selection menu and thus possibly prevents thinking about other diagnoses and alternatives mentioned below. On the other hand, selecting more secondary arthritis may influence early revision rates as only primary arthritis cases are included for SIRIS performance evaluation in certain circumstances.

Since 2016, 13.0% (16,555 cases) were classified as secondary OA. The mean age at surgery was significantly lower, at 64.8 years, compared to TKA in primary OA at 70.2 years **(Table 4.2b).** The share of women was 47.1% for secondary and 61.8% for primary OA. In contrast, the rate in young patients was only 0.5% in the <45y group, 4.9% in the 45–54y group and 22.7% in the 55–64y group for primary OA, more young patients needed TKA for secondary OA (2.2% in the <45y group, 15.0 % in the 45–54y group and 33.9% in the 55–64y group). Patients older than 65 years had fewer cases of OA classified as secondary. Younger age and age distribution were the main difference between primary and secondary OA responsible for pretended discrepancies in revision TKA (see Chapters 4.3 and 4.4). Other factors like BMI and ASA classification did not differ in the two groups.

Figure 4.2b

Distributions of different diagnoses in hospitals >200 cases (2021)



66.9% of the knees were never operated on before TKA. Previous operations were mostly arthroscopies (16.3%) and meniscectomy (17.3%), ACL reconstruction (4.6%) and osteotomies of the tibia (2.8%). Arthroscopies and meniscectomies were performed independently, but in 49.3% of the cases, they were registered as combined, which may lead to the conclusion that previously half of the meniscectomies were performed by arthroscopy and the other half by open resection. Post-traumatic cases after tibial or femoral fractures close to the knee were responsible for only 1.8% of the TKA cases. Other surgeries before TKA were rare **(Table 4.2c).**

The classification of the TKA type was adapted with the revision of the registration forms in 2021 because of confusing terms. The share of cruciate-sacrificing ultracongruent systems (CS/UCOR) between 2016 and 2021 was 27.4%, the one for posterior stabilised (PS) 28.7% and posterior cruciate-retaining (PCR or CR) 25.8%. In primary TKA, a medial pivot was used in 12.8% of the knees, whereas constrained condylar knees or hinged implants were used only in 1.5% and 1.8%, respectively. As well Bicruciate-retaining knees (BCR) were rarely used (1.1%).

Table 4.2b

Primary total knee arthroplasty: Baseline patient characteristics by main diagnostic group

Number of cases with clear diagnostic information (in 0.3% of cases we cannot determine the diagnosis)

		Primary OA*	Secondary OA
N (2016–2021)		**80,443**	**10,480**
Women [%]		61.8	47.1
Mean age (SD)	All	70.2 (9.2)	64.8 (10.7)
	Women	70.5 (9.3)	66.4 (11.4)
	Men	69.6 (8.9)	63.3 (9.9)
Age group [%]	‹45	0.3	2.2
	45–54	4.9	15.0
	55–64	22.7	33.9
	65–74	37.6	28.6
	75–84	29.9	17.3
	85+	4.7	2.9
N unknown BMI (%)		12,071 (15)	1,320 (13)
N known BMI		68,372	9,160
Mean BMI (SD)		29.6 (5.9)	28.3 (5.4)
BMI [%]	‹18.5	0.5	0.9
	18.5–24.9	20.6	27
	25–29.9	38.1	40.7
	30–34.9	25.1	22.7
	35–39.9	10.8	6.8
	40+	4.9	2.4
N unknown ASA (%)		6,277 (8)	551 (5)
N known ASA		74,166	9,929
ASA state [%]	ASA 1	7.6	12.8
	ASA 2	62.4	62.0
	ASA 3	29.6	24.7
	ASA 4/5	0.4	0.5

* Including „arthritis after meniscus surgery“

Table 4.2c

Primary total knee arthroplasty: Surgery characteristics

all diagnoses

N (2016–2021)	**N**	**%**
Previous surgery		
None	60,976	66.9
Knee arthroscopy	14,821	16.3
Meniscectomy	15,729	17.3
ACL reconstruction	4,160	4.6
Osteotomy tibia close to knee	2,591	2.8
Osteosynthesis tibia close to knee	1,214	1.3
Surgery for patella stabilization	1,100	1.2
Synovectomy	720	0.8
Osteotomy femur close to knee	439	0.5
Osteosynthesis femur close to knee	456	0.5
Surgery for treating infection	159	0.2
Surgery for tumor	39	0.0
Other	2,498	2.7
Intervention		
CS (cruciate sacrificing) / UCOR	24,967	27.4
PS (posterior stabilised)	26,171	28.7
PCR (posterior cruciate retaining)	23,504	25.8
BCR (bicruciate retaining)	996	1.1
Hinge type	1,601	1.8
SC / CCK (semi-constrained / constrained)	1,341	1.5
Medial-Pivot*	11,679	12.8
Other	762	0.8
Technology		
Conventional	64,299	70.6
Computer assisted	8,610	9.4
Patient specific instrumentation	13,085	14.4
Minimally invasive	4,244	4.7
Computer navigation (v2021)	1,584	1.7
Robotic-assisted (v2021)	766	0.8
Other	1,677	1.8

*Medial pivot was not available as a response category before SIRIS v2021. In the annual report 2020, only free text „other“ responses were identified as and recoded to medial pivot. However, this missed a number of GMK Sphere total knee systems that were incorrectly registered as other types, mainly CS/UCOR. In this report, all GMK Sphere knee systems are counted as medial pivot, regardless of the type chosen locally at data entry.

One must note that the knee systems used in Switzerland varied significantly between different cantons, regions and hospitals. Traditionally, posterior stabilised (PS) knees were more present in the western part of Switzerland, whereas in the German-speaking cantons, cruciate-retaining (CR) and sacrificing (CS), including ultracongruent (UC) knees were still favored. Medial pivot knees did not seem to follow a particular regional pattern but seemed preferred in specific hospitals. **Figure 4.2c** shows the high variability of the different types of knee prostheses (posterior-stabilised PS, cruciate-sacrificing CS/UCOR, cruciate-retaining BCR/PCR and medial-pivot MP) used in Switzerland and adaptions between the periods 2015–2018 and 2019–2021, respectively. The share of medial pivot implants seems to increase and replace more traditional designs such as PS, CR and CS/UCOR in some hospitals/cantons.

Most TKAs were fully cemented in Switzerland; the share in the past six years was 79.2%. Hybrid fixation of the components was used constantly and reached a mean of 15.5%. Interestingly, cementless fixation has been only 4.9% of the TKA since 2016, but the share doubled in three years to 8% in 2021 **(Table and Figure 4.2d).** In primary TKA, 2.5% of the femoral components were stemmed (30% uncemented); in 5.8%, tibial stems were used (18.4% uncemented).

Between 2016 and 2021, 70.6% of the TKAs in Switzerland were performed conventionally. The share of computer navigation was 9.4% and continuously decreased from 12.2% in 2016 to 9.8% in 2021. Patient-specific instrumentation (PSI) has increased from 12.4% in 2016 to 18.6% in 2021. Robotic-assisted TKA (imageless and image-based) were classified as "other" and accounted for 2.7% for the whole period, increasing from 1.2% in 2016 to 5.5% in 2021 **(Table 4.2c, Table 4.2g and Figure 4.2i).** In summary, surgeons did use technical support in 26.8% of total knee arthroplasties over the past six years. Compared to Australia, the share of technical support is rather small in Switzerland and

Figures 4.2c

Relative share of TKA procedures using CR, CS, PS, MP by Swiss Canton and Principality of Liechtenstein: comparing 2015-2018 with 2019-2021

NB: Medial pivot was not available as a response category before SIRIS v2021. In the annual report 2020, only free text „other" responses were identified as and recoded to medial pivot. However, this missed a number of GMK Sphere total knee systems that were incorrectly registered as other types, mainly CS/UCOR. In this report, all GMK Sphere knee systems are counted as medial pivot, regardless of the type chosen locally at data entry.

has increased in the past four years due to more PSI TKA and the introduction of robotics in 2018 **(Figure 4.2e).** Minimally invasive surgery is no longer a topic in Switzerland: it was only used in 4.7% of operations and was removed from the SIRIS forms in 2021, which explains the reported 0%.

In 69.2% of primary TKA cases, the patella was not resurfaced between 2016 and 2021 **(Table and Figure 4.2e).** The resurfacing rate had increased continuously since 2016 from 26.8% to 34.9% in 2021. However, there were considerable differences between the cantons **(Figure 4.2g).** Parts of these differences can be explained using posterior stabilised knees, where resurfacing of the patella is recommended more than in other TKA models, being more popular in the western part of Switzerland and in some centres. The continuous increase for primary patella resurfacing was not homogenous, did not depend on the TKA type only, and underlies regional differences. In some cantons, such as TG and GE, the resurfacing rate significantly increased from 2015–2018 to 2019–2021. In others, such as OW or SH, the resurfacing rate decreased in the same period **(Figure 4.2g).**

Table 4.2d

Primary total knee arthroplasty: Component fixation

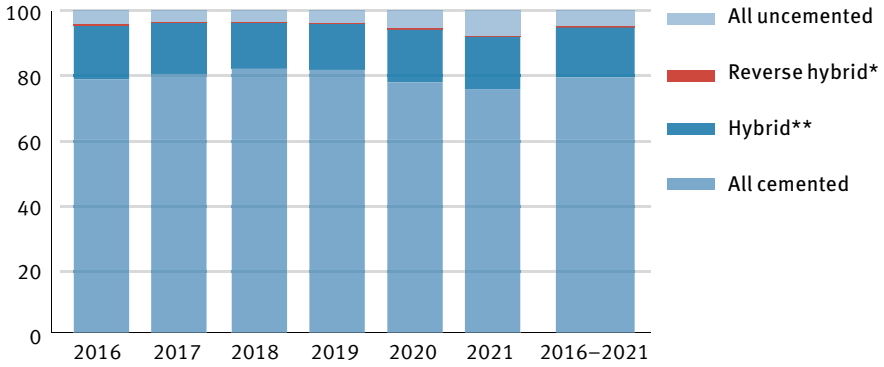
Percentage per year, all diagnoses

Year	2016	2017	2018	2019	2020	2021	2016–20210
N	14,569	14,442	14,623	15,456	15,421	16,552	91,063
All uncemented	4.3	3.7	3.5	4.0	5.5	8.0	4.9
Reverse hybrid*	0.5	0.4	0.3	0.4	0.5	0.2	0.4
Hybrid**	16.6	15.6	14.2	14.0	16.3	16.2	15.5
All cemented	78.6	80.3	82.0	81.6	77.7	75.6	79.2

Figure 4.2d

Primary total knee arthroplasty: Component fixation by year

Percentage per year



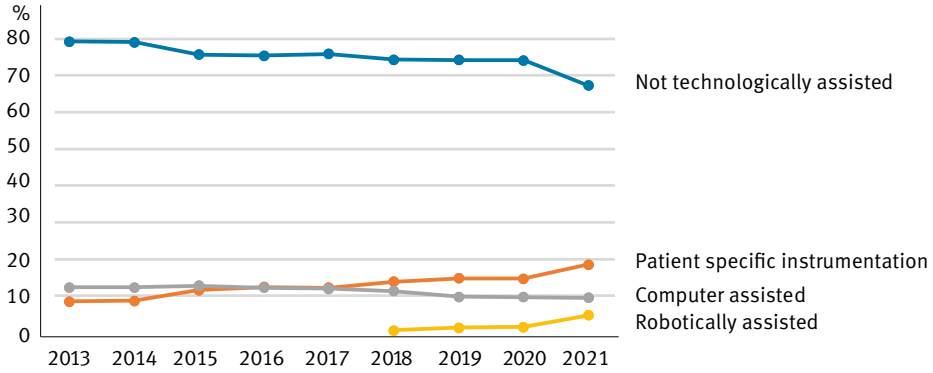
* femur cemented, tibia uncemented
** femur uncemented, tibia cemented

We refer to the 2021 SIRIS report, where it could be demonstrated that whether the primary patella is resurfaced or not is more dependent on the surgeon's personal preference than on knee type or geographic region. The observed trend toward primary patella resurfacing in the past years might be explained by the surgeon's attempt to prevent early revision surgery and improve the outcome for himself and the hospital. The same effect can be observed in Australia over the past 10 years.

The rate of mobile-bearing polyethylene (PE) did rapidly decrease over the past six years, from 42.5% in 2016 to 25.1% in 2021 **(Table 4.2f and Figure 4.2h).** However, one must note that the bearing

Figure 4.2e

Primary total knee arthroplasty: technology assistance over time (%)



NB: robotically assisted cases before v2021 were derived from free text entries. „Other" responses were coded as „Not tech. assisted" unless they specifically mentioned robotic, PSI oder navigation".

Table 4.2e

Primary total knee arthroplasty: Patellar component

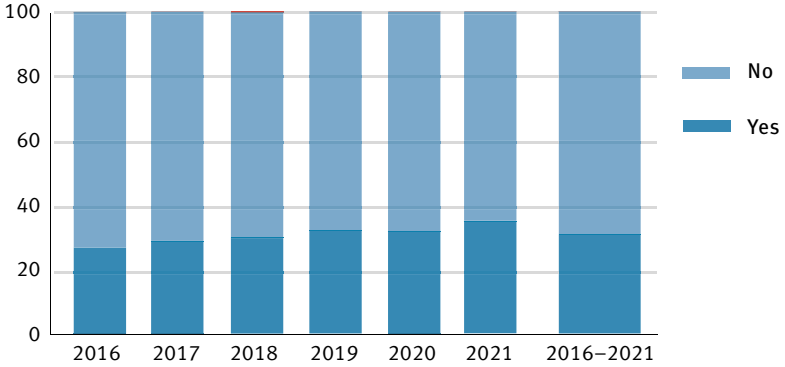
Percentage per year, all diagnoses

Year	2016	2017	2018	2019	2020	2021	2016–2021
N	14,569	14,442	14,623	15,456	15,421	16552	91,063
No	73.1	71.2	70.2	67.9	68.2	65.1	69.2
Yes	26.8	28.8	29.7	32.1	31.8	34.9	30.8
Status after patellectomy	0.0	0.0	0.1	0.0	0.0	0.0	0.0

Figure 4.2f

Primary total knee arthroplasty: Patellar component

Percentage per year, all diagnoses



type choice showed a high variation in the different cantons of Switzerland, including the Principality of Liechtenstein **(Figure 4.2j),** as do the knee systems used and the rate of primary patella resurfacing. The reduction of the mobile-bearing system is not a general effect but is more because some hospitals in certain cantons, such as OW, AR, SH, LU and FR, changed their knee systems. In other cantons, such as UR and JU, the share of mobile-bearing even increased in the same period **(Figure 4.2j).**

Figures 4.2g

Share of TKA procedures with patella resurfacing by Swiss Canton and Principality of Liechtenstein: comparing 2015-2018 with 2019-2021

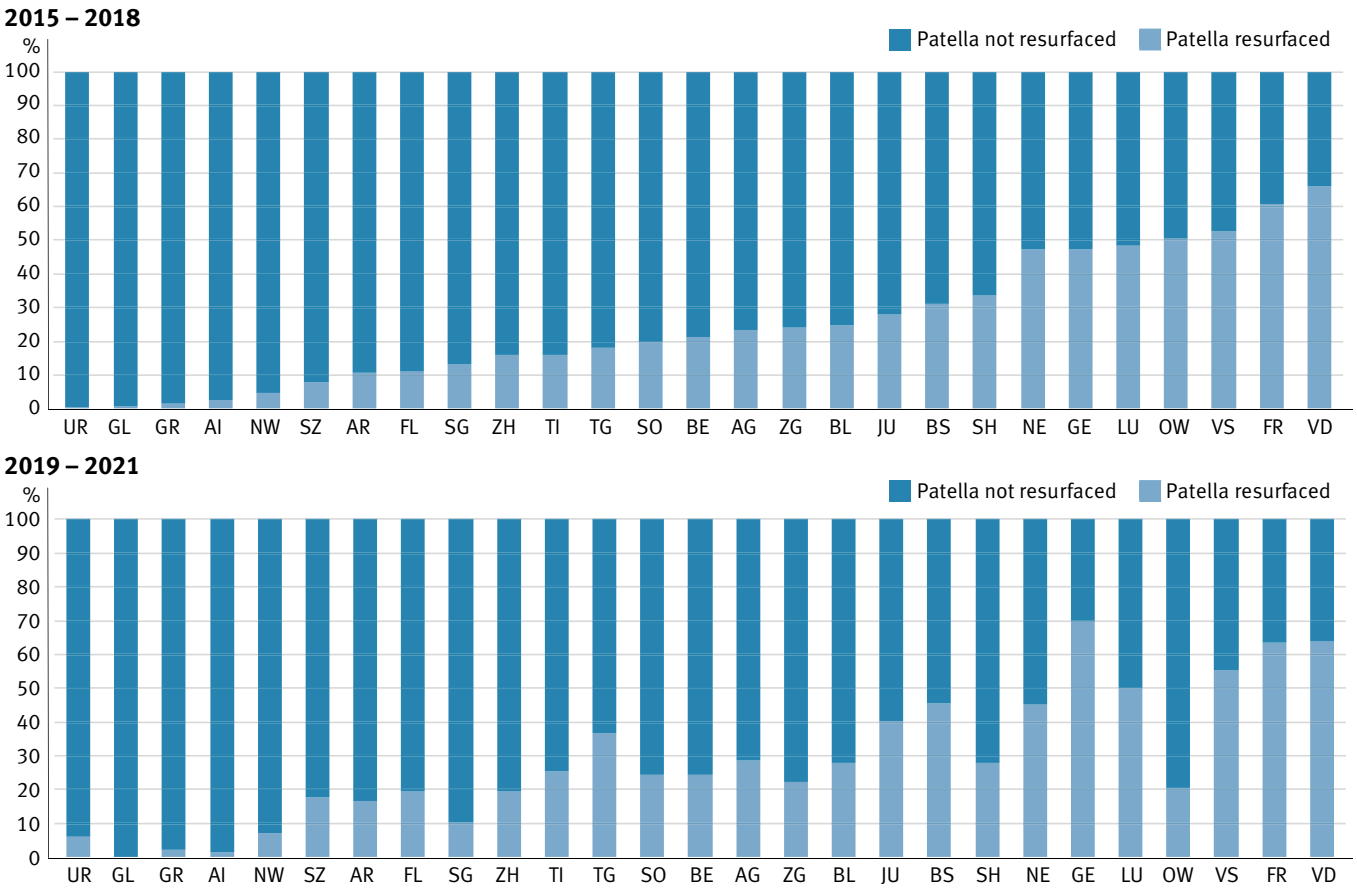


Table 4.2f

Primary total knee arthroplasty: Type of bearing

Percentage per year, all diagnoses

Year	2016	2017	2018	2019	2020	2021	2016–2021
N	13,599	13,234	13,061	13,674	13,485	16,083	83,136
Fixed bearing	57.5	58.8	60.7	63.5	66.0	74.9	63.9
Mobile bearing	42.5	41.2	39.3	36.5	34.0	25.1	36.1

Table 4.2g

Primary total knee arthroplasty: technologies used

All diagnoses. Multiple responses possible (percentages do not sum to 100)

	2016	2017	2018	2019	2020	2021	2016–2021
N	14,595	14,460	14,633	15,463	15,423	16,555	91,129
Conventional	72.0	72.5	70.9	71.1	70.6	66.9	70.6
Computer navigation	12.2	12.0	11.8	10.8	10.8	9.8	9.4
PSI	12.4	12.2	13.5	14.4	14.5	18.6	14.4
Minimally invasive	6.5	6.4	5.7	4.9	5.0	0.0	4.7
Other technologies/robotic	1.2	1.0	1.9	2.9	3.1	5.5	2.7

Figure 4.2h

Primary total knee arthroplasty: Type of bearing

Percentage per year

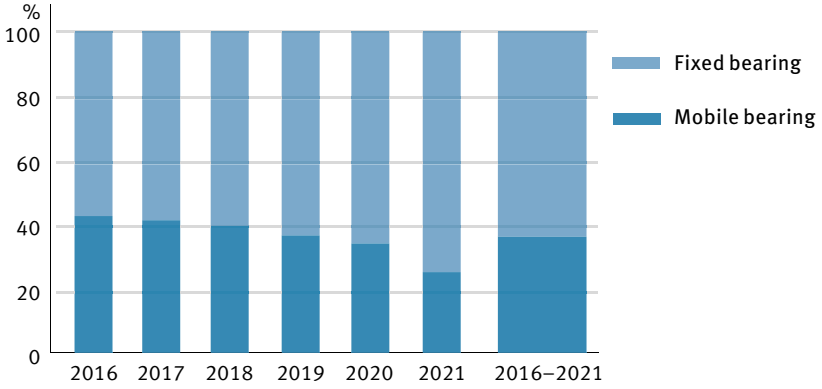
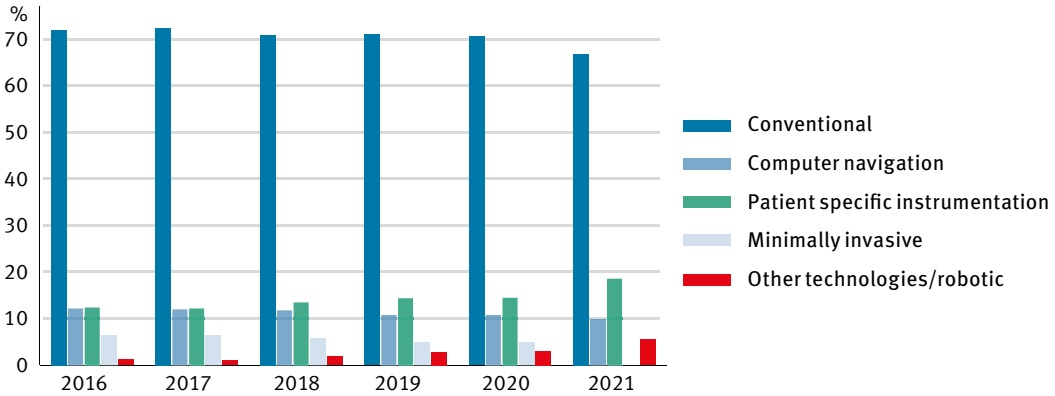


Figure 4.2i

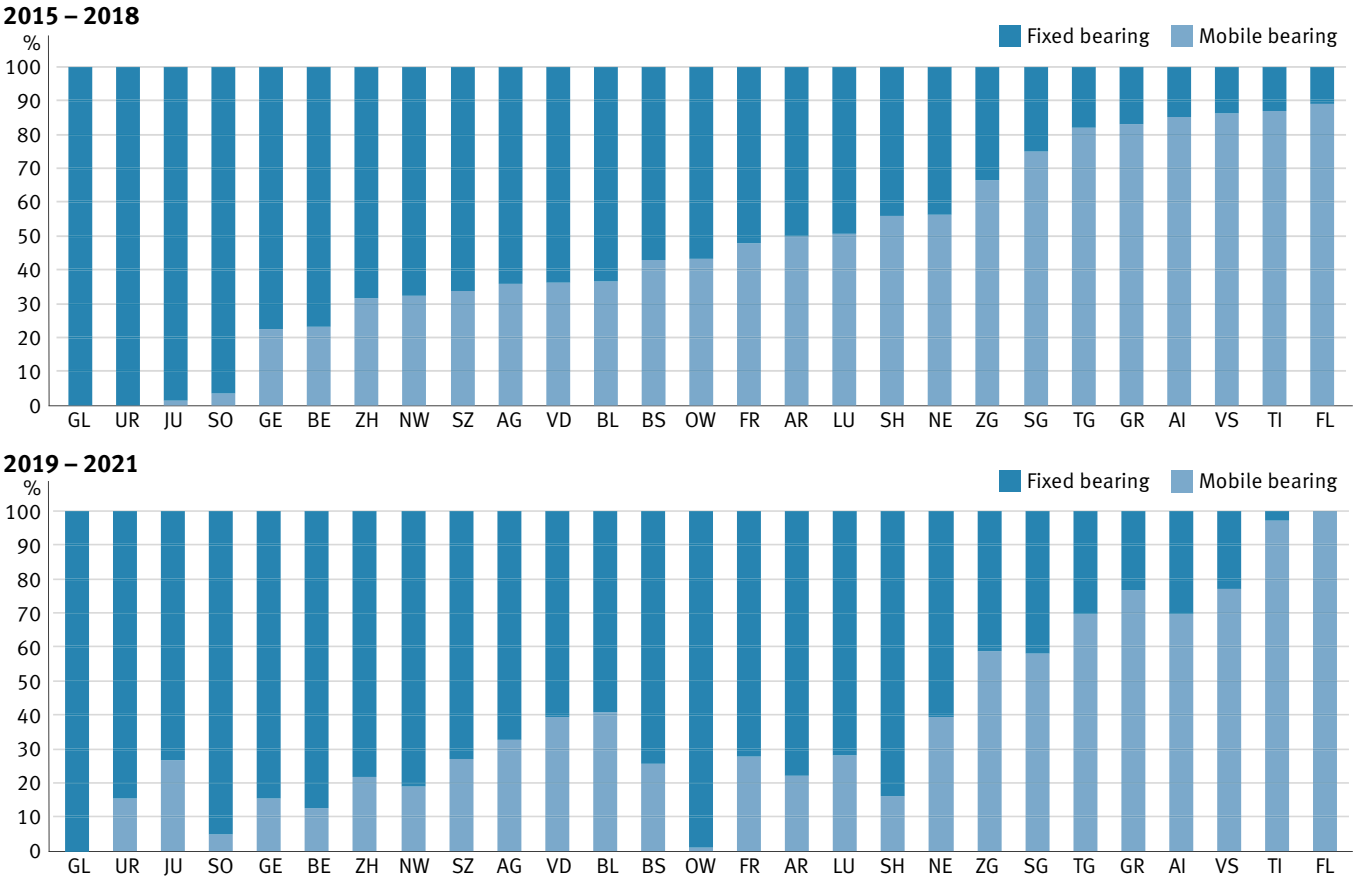
Primary total knee arthroplasty: Technologies used

Percentage per year



Figures 4.2j

Share of TKA procedures with mobile bearing by Swiss Canton and Principality of Liechtenstein: comparing 2015-2018 with 2019-2021



4.3 Revision of primary total knee arthroplasty

SIRIS has been recording all primary and revision knee procedures since 2012, irrespective of whether the procedure was the first or any subsequent revision defined as the exchange of any implant component, including secondary patella resurfacing. Some of the revisions were carried out on knee arthroplasties implanted before 2012. These are so-called "unlinked revisions" because without registred primary arthroplasty the linkage of a revision is not possible. Revisions of primary implantations registered in SIRIS are termed "linked revisions". The latter form the basis for calculations of survival and first revision rates (see Chapter 4.4). As explained above, a four-year moving window was used to analyse current data with implants starting on January 1, 2016 and ending on December 31, 2019.

Table 4.3a
Revision* of total knee arthroplasty: Baseline patient characteristics by year

		2016	2017	2087	2019	2020	2021	2016–2021
N		**1,842**	**1,940**	**1,962**	**2,108**	**2,236**	**2,221**	**12,309**
Women [%]		59.9	60.0	59.7	57.8	56.9	58.3	58.7
Mean age (SD)	All	69.0 (10.3)	69.1 (10.0)	69.3 (10.1)	69.6 (10.0)	69.4 (9.6)	70.2 (9.9)	69.5 (10.0)
	Women	69.8 (10.4)	69.7 (10.1)	70.0 (10.2)	70.4 (10.1)	69.9 (9.8)	70.8 (10.1)	70.1 (10.1)
	Men	67.7 (10.1)	68.3 (9.8)	68.3 (10.0)	68.6 (9.7)	68.8 (9.4)	69.3 (9.6)	68.5 (9.7)
Age group [%]	‹45	1.0	0.6	1.0	0.3	0.6	0.7	0.7
	45–54	7.3	7.9	6.6	6.9	5.5	4.5	6.4
	55–64	24.3	22.6	24.4	24.1	25.1	24.9	24.3
	65–74	36.6	38.3	36.2	35.4	36.7	33.5	36.1
	75–84	24.9	25.5	26.6	27.8	26.9	29.1	26.9
	85+	5.9	5.1	5.3	5.6	5.3	7.2	5.7
N unknown BMI (%)		484 (26)	449 (23)	423 (22)	399 (19)	386 (17)	253 (11)	2,394 (19)
N known BMI		1358	1491	1539	1709	1850	1968	9915
Mean BMI (SD)		30.0 (7.4)	29.8 (5.9)	29.8 (5.8)	29.6 (5.7)	30.0 (6.0)	29.8 (6.2)	29.8 (6.2)
BMI [%]	‹18.5	0.9	0.5	0.6	0.6	0.8	0.5	0.6
	18.5–24.9	18.3	19.2	20.5	20.3	18.6	20.0	19.5
	25–29.9	37.5	36.7	35.5	36.6	35.6	35.8	36.2
	30–34.9	26.7	26.0	26.4	26.2	27.5	27.0	26.7
	35–39.9	11.6	13.2	12.1	12.2	11.6	11.3	12.0
	40+	5.1	4.4	4.9	4.1	6.0	5.4	5.0
N unknown ASA (%)		225 (12)	198 (10)	167 (9)	195 (9)	191 (9)	94 (4)	1,070 (9)
N known ASA		1,617	1,742	1,795	1,913	2,045	2,127	11,239
Morbidity state	ASA 1	7.6	6.8	6.1	5.3	4.1	4.1	5.6
[%]	ASA 2	52.2	52.6	51.7	51.6	52.7	50.7	51.9
	ASA 3	38.6	39.6	40.9	41.5	41.6	43.0	41.0
	ASA 4/5	1.6	1.0	1.3	1.6	1.6	2.2	1.6

* includes a small proportion of reoperations that are not counted as component revisions in the evaluative parts of this report

58.7% of the patients were women. A total of 57.5% were classified as ASA 1 or 2; the morbidity status was not recorded in 9% of cases in the whole period but only 4% in 2021. The mean BMI was 29.8 kg/m2, with BMI not recorded in 19% of cases between 2016 and 2021 but only in 11% of cases in 2021 **(Table 4.3a).**

To understand **Table 4.3b** concerning the reasons for TKA revisions, it is important to note that several reasons can be combined. Therefore, the percentage does not add up to 100%. Patella problems were the main cause for revision (27.0%), followed by infection in 20.5% and then loosening of the tibia in 18.1% of cases. Adding together loosening of the tibial (18.1%), femoral (11.4%) and patellar component (2.2%), loosening takes the lead, being responsible for 31.7% of all revisions. By contrast, wear of inlay was responsible for only 5.5% of the revision TKAs. Femoro-tibial instability was the cause for revision in 18.1%. In 10.1%, unclear pain was claimed as the cause alone or in combination with other reasons for revision. Almost 11% (10.8%) of the causes were classified as "other" **(Table 4.3b).**

Table 4.3b

Reason for revision* of primary total knee arthroplasty

Multiple responses possible (percentages do not sum to 100). The reasons for revisions categories as listed below are only available from 2015 onwards

	N	%
Patella problems	3,319	27.0
Loosening tibia	2,234	18.1
Infection	2,529	20.5
Femorotibial instability	2,222	18.1
Pain (of unclear origin)**	1,249	10.1
Loosening femur	1,408	11.4
Wear of inlay	676	5.5
Joint stiffness/arthrofibrosis	735	6.0
Component malposition femur	547	4.4
Component malposition tibia	484	3.9
Loosening patella	266	2.2
Patellar instability	300	2.4
Periprosthetic fracture femur	256	2.1
Sizing femoral component	177	1.4
Periprosthetic fracture tibia	94	0.8
Sizing tibial component	61	0.5
Periprosthetic fracture patella	52	0.4
Other	1,333	10.8
Total 2016–2021	**17,942**	

* includes a small proportion of reoperations that are not counted as component revisions in the evaluative parts of this report

** Pain was frequently reported alongside other reasons. The proportion of „isolated pain" was 1.9% up to 2020. In the new v2021 SIRIS proforma the wording was changed to „pain of unclear origin". It was thus reported less frequently (dropping from approx. 12% to approx. 5%)

Table 4.3c

Revision of total knee arthroplasty: Surgery characteristics

2016 to 2021

Intervention type*	N	%
complete revision	4,465	36.3
exchange of PE	2,015	16.4
subsequent patella prosthesis	1,842	15.0
tibial revision	656	5.3
reimplantation of prosthesis	743	6.0
subsequent patella prosthesis with exchange of PE	656	5.3
patella revision	489	4.0
component removal with spacer implantation	477	3.9
femoral revision	339	2.8
prosthesis preserving revision	181	1.5
osteosynthesis	38	0.3
arthrodesis	40	0.3
component removal without spacer implantation	24	0.2
reconstruction after injury of extensor mechanism	27	0.2
plastic reconstruction	8	0.1
other	309	2.5
Type of arthroplasty		
SC / CCK (semi-constrained / constrained)	2,145	34.6
Hinge type	1,705	27.5
PS (posterior stabilised)	1,286	20.7
CS (cruciate sacrificing) / UCOR	524	8.4
PCR (posterior cruciate retaining)	269	4.3
Medial-Pivot**	103	1.7
BCR (bicruciate retaining)	27	0.4
Other	149	2.4
Technology		
Conventional	10,643	95.0
Computer assisted / navigation	197	1.8
Patient specific instrumentation	86	0.8
Minimally invasive (up to 2020)	236	2.1
Robotic assisted (from 2021)	4	0.0
Other	100	0.9

* includes a small proportion of reoperations that are not counted as component revisions in the evaluative parts of this report.

** Entered as „other“ intervention and then recoded before 2021. As of form version 2021, SIRIS lists Medial Pivot as a separate main category.

Complete revision was performed in 36.3% of the cases. In 16.4%, only the polyethylene (PE) was exchanged. Secondary resurfacing of the patella alone was performed in 15.0% **(Table 4.3c).** A combined exchange of the PE with secondary patella resurfacing was conducted in 5.3%. Osteosynthesis due to periprosthetic fractures on any level around the knee was reported only in 0.3% of cases, which seems to be underreported, as periprosthetic fractures are increasing in all western societies because of demographic changes and rising activ-

ity levels. SIRIS systematically records major revisions which implicate an exchange of at least one component. Therefore, many surgeons probably did not record open reduction and internal fixation of a periprosthetic fracture, as these were not taken for a knee revision by definition.

Posterior cruciate-retaining TKAs were used in 4.3% of the revisions, 20.7% were stabilised posteriorly, 8.4% were classified as cruciate-sacrificing or ultracongruent implants, and in 27.5% a hinge-type prosthesis was used. At 34.6%, unlinked semi-constrained or CCK implants formed the biggest group, whereas a medial pivot was used only in 1.7% of the revisions **(Table 4.3c).** An arthrodesis was necessary for only 0.3% (n=40) of revisions in the past six years. In revision surgery, computer navigation, PSI, robotics, and minimally invasive techniques did not play a significant role.

The vast majority of the implants were fully cemented (92.5% in mean from 2016 to 2021), reaching 93.4% in 2021 **(Figure 4.3a and Table 4.3d).**

Figure 4.3a

Revision of total knee arthroplasty: Component fixation

Component fixation only applicable when new components were implanted

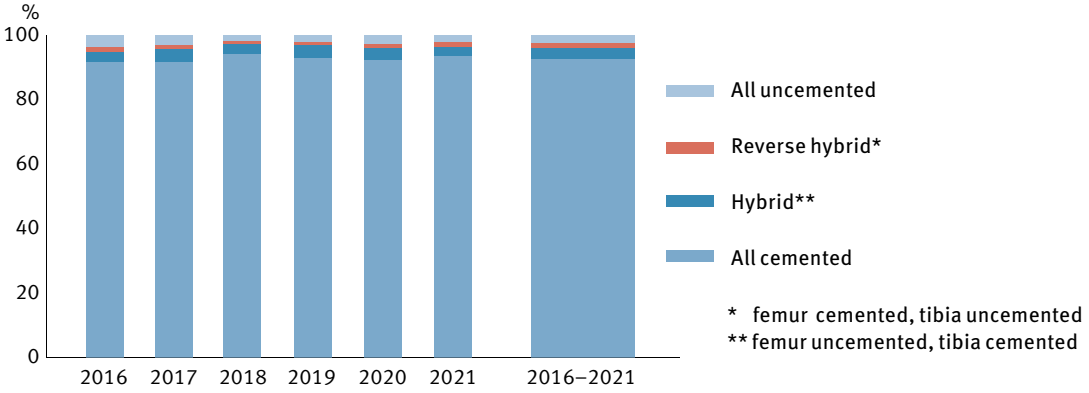


Table 4.3d

Revision of primary total knee arthroplasty: Component fixation

Component fixation only applicable when new components were implanted. Percentage per year.

Year	2016	2017	2018	2019	2020	2021	2016–2021
N	920	1,019	1,057	1,055	1,110	1,042	6,203
All uncemented	3.7	3.2	1.9	2.1	2.9	2.2	2.6
Reverse hybrid*	1.4	1.3	0.9	1.1	1.2	1.5	1.2
Hybrid**	3.4	4.1	3.3	4.0	3.9	2.9	3.6
All cemented	91.5	91.4	93.9	92.8	92.1	93.4	92.5

In the case of revision TKA, 55.1% of the femoral components used had stems, and 31.8% of those were uncemented. In 63.4% of tibial stems were used, 28.3% of them uncemented. The share of additional components (augments, stems, cones) seems to increase with time. This topic will be analysed more closely in 2023. Revision-TKA was associated with patella resurfacing in 65.6% on average and 66.6% in 2021 **(Figure 4.3b and Table 4.3e).**

One must notice that the number leaving a patella button in place deriving from the primary TKA is unknown but may explain the deep rate of patella resurfacing in revision TKA.

Re-revision after conversion of PKA to TKA and after TKA revision will be a topic for the report in 2023. Without further analysing reasons, implants and more factors, the rate of re-revision after TKA seemed to be quite high, reaching 11% two and over 17% five years after revision TKA on average.

Figure 4.3b

Revision of total knee arthroplasty: Patellar component

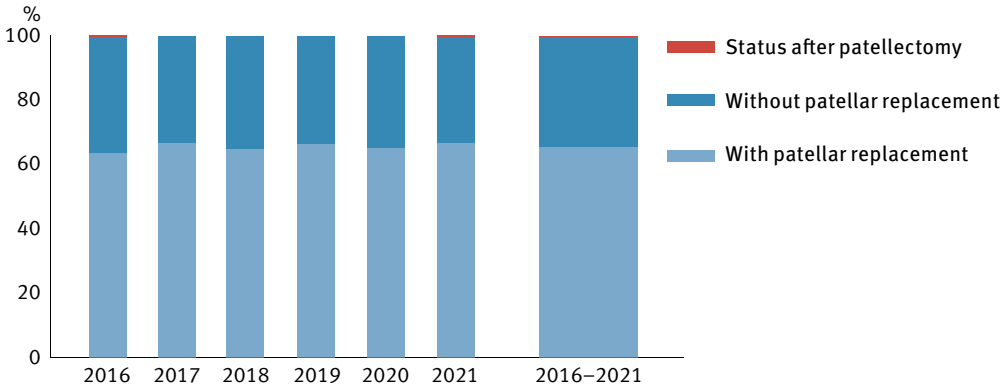


Table 4.3e

Revision of primary total knee arthroplasty: Patellar component

Percentage per year.

Year	2016	2017	2018	2019	2020	2021	2016–2021
N	1,338	1,521	1,546	1,584	1,628	1,573	9,190
Without patellar replacement	35.9	33.0	35.1	33.3	34.6	33.0	34.1
With patellar replacement	63.7	66.7	64.7	66.4	65.2	66.6	65.6
Status after patellectomy	0.4	0.3	0.2	0.3	0.2	0.4	0.3

4.4 First revision of a primary total knee arthroplasty

First revisions cover all revisions linked to primary implantations registered in SIRIS and that occur for the first time. Re-revisions were therefore not included here but are integrated into Chapter 4.3. Overall, the share of linked revisions is 48.6%, steadily increasing with time and reaching 62.5% in 2021 (including linked revisions of total and partial knee arthroplasties).

We distinguish between early revisions within the first two years after implantation and revisions in the longer term, currently up to 9 years after implantation. Kaplan-Meier (KM) survival estimations and cumulative revision rates were calculated for long-term outcomes. For benchmarking, the two-year revision rate of an implant, hospital, or surgeon was calculated for primary TKA to treat primary osteoarthritis (OA), including all cases after meniscus surgery. Other causes of secondary OA as those after ligament injury, fracture, osteotomy and inflam-

Table 4.4a

First revision of primary total knee arthroplasty within 24 months: Baseline patient characteristics

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

		Primary	Revised within 24 months			
			Revised		95% CI	
		N at risk*	N	%**	lower	upper
Overall (moving average)		59,152	2,049	3.5	3.4	3.7
Diagnosis	Primary OA	52,419	1,764	3.4	3.3	3.6
	Secondary OA	6,553	282	4.4	3.9	5.0
Overall Primary OA		52,419	1,764	3.4	3.3	3.6
Gender	Women	32,665	1,069	3.3	3.1	3.5
	Men	19,754	695	3.6	3.4	3.9
Age group [%]	<55	2,768	145	5.3	4.5	6.2
	55–64	11,696	540	4.7	4.3	5.1
	65–74	19,950	633	3.2	3.0	3.5
	75–84	15,466	398	2.6	2.4	2.9
	85+	2,528	48	1.9	1.5	2.6
BMI group	<18.5	191	9	4.9	2.6	9.2
	18.5–24.9	8,759	271	3.2	2.8	3.5
	25–29.9	16,594	499	3.1	2.8	3.3
	30–34.9	10,946	407	3.8	3.4	4.2
	35–39.9	4,737	186	4.0	3.5	4.6
	40+	2,152	88	4.2	3.4	5.1
	BMI unknown	9,040	304	3.4	3.1	3.8
Morbidity state	ASA 1	3,849	144	3.8	3.2	4.5
	ASA 2	29,762	949	3.2	3.0	3.5
	ASA 3	13,769	513	3.8	3.5	4.2
	ASA 4/5	195	7	3.8	1.8	7.8
	ASA unknown	4,844	151	3.2	2.7	3.7

* Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

** Rates adjusted for effects of mortality and emigration.

matory arthritis, etc., were excluded as they might have increased revision rates. Early revision rates were calculated for a moving four-year window. This group includes the last four years with a completed two-year follow-up. This report used the data pertaining to the period between January 1, 2016, and December 31, 2019. Using a moving time window leads to results reflecting current trends and currently used implants more reliably and eliminates the less credible early years of the registry (before 2015) from the analyses. In general, the lower coverage rates of early years, in the beginning, were associated with underestimates of revision rates, biasing "early" implants against more recent implants. The moving window also facilitates the registry's function as a learning system for hospitals and surgeons and eliminates older systems that are not used anymore. It also allows hospitals and surgeons to improve their outcomes and revision rates by not considering the burden of older implants.

Table 4.4b

First revision of primary total knee arthroplasty within 24 months overall and according to component fixation

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

	Primary TKA	Revised within 24 months			
		Revised		95% CI	
	N at risk[1]	N	%[2]	lower	upper
Overall (moving average)	59,152	2,049	3.5	3.4	3.7
Component fixation					
All cemented	47,656	1,655	3.5	3.4	3.7
All uncemented	2,290	111	4.9	4.1	5.9
Hybrid*	8,912	276	3.2	2.8	3.5
Reverse hybrid**	233	6	2.6	1.2	5.7
Patellar replacement					
With patellar replacement	17,375	554	3.3	3.0	3.5
Without patellar replacem.	41,693	1,491	3.6	3.5	3.8
Status after patellectomy	23	3	13.0	4.4	35.2

[1] Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).
[2] Rates adjusted for effects of mortality and emigration.

* femur uncemented, tibia cemented
** femur cemented, tibia uncemented

Table 4.4c

Reason for early first revision of primary total knee arthroplasty

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021). Early first revisions are those occurring within 2 years of the primary arthroplasty. Multiple responses possible (percentages do not sum to 100). All diagnoses.

	N	%
Patella problems	689	33.6
Femorotibial instability	376	18.4
Infection	372	18.2
Loosening tibia	227	11.1
Pain (of unclear origin)*	196	9.6
Joint stiffness/arthrofibrosis	173	8.4
Component malposition femur	95	4.6
Component malposition tibia	81	4.0
Loosening femur	72	3.5
Patellar instability	71	3.5
Wear of inlay	22	1.1
Loosening patella	34	1.7
Periprosthetic fracture femur	22	1.1
Sizing femoral component	25	1.2
Periprosthetic fracture tibia	14	0.7
Sizing tibial component	7	0.3
Periprosthetic fracture patella	12	0.6
Other	239	11.7
Total	**2,727**	

* Pain was frequently reported alongside other reasons. The proportion of „isolated pain" was 3.2%. The wording was adapted in v2021 and the share dropped accordingly in 2021

Inspired by procedures used in other joint registries, the following definition for a potential outlier was adopted: An implant may be considered a statistical outlier if its revision rate deviates markedly from the relevant group average. The reference revision rate used in this report is the average revision rate of all implants or implant combinations in this registry over the observation period. The outlier alert boundary was set at twice that national reference revision rate. An implant was regarded as a potential outlier when its two-year revision rate was higher than the outlier alert boundary, regardless of the extent of the statistical confidence interval. The outlier status comes with varying statistical probability depending on implanted arthroplasties. The outlier status was considered highly likely when the estimated revision rate and the complete confidence interval (CI) exceeded the outlier alert boundary. For implant combinations with high numbers, the confidence interval usually is narrow. When numbers get smaller, the statistical precision decreases, resulting in wider confi-

Figure 4.4a

Time interval between primary total knee arthroplasty and first revision by reason

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021).
Early first revisions are those occurring within 2 years of the primary arthroplasty.

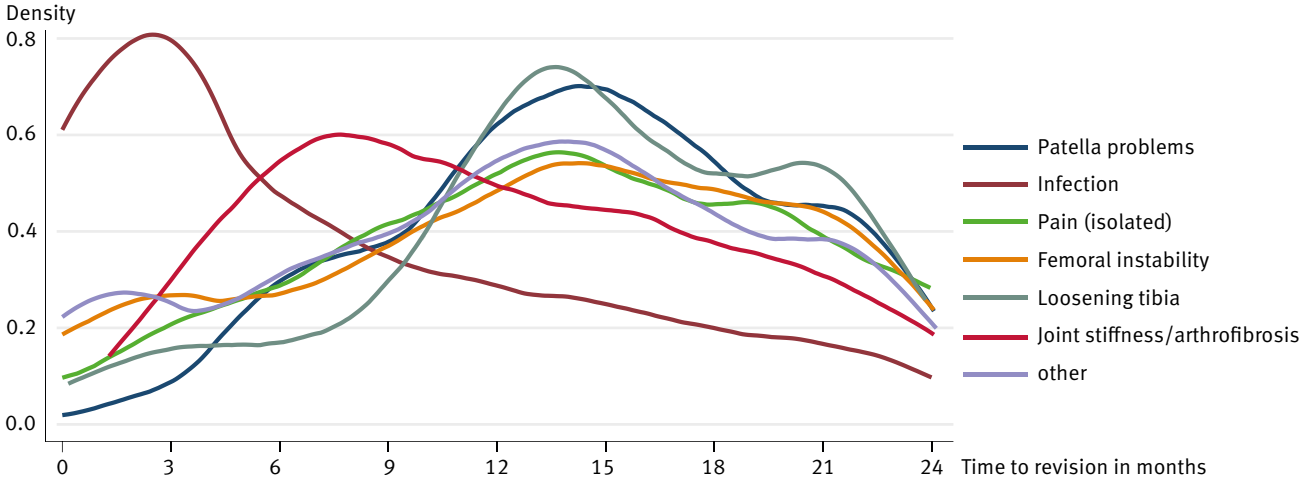


Table 4.4d

Median time interval between primary total knee arthroplasty and early first revision (in months) according to reason

all diagnoses

	N	Median	IQR 25%	IQR 75%
Patella problems	689	14.6	10.9	18.5
Infection	372	5.4	1.6	12.4
Pain (isolated)	57	14.8	9.7	18.1
Femoral instability	376	13.9	8.3	18.8
Loosening tibia	227	14.5	11.8	19.6
Joint stiffness/arthrofibrosis	173	11.1	7.2	16.7
Other	1,152	13.2	7.9	17.7

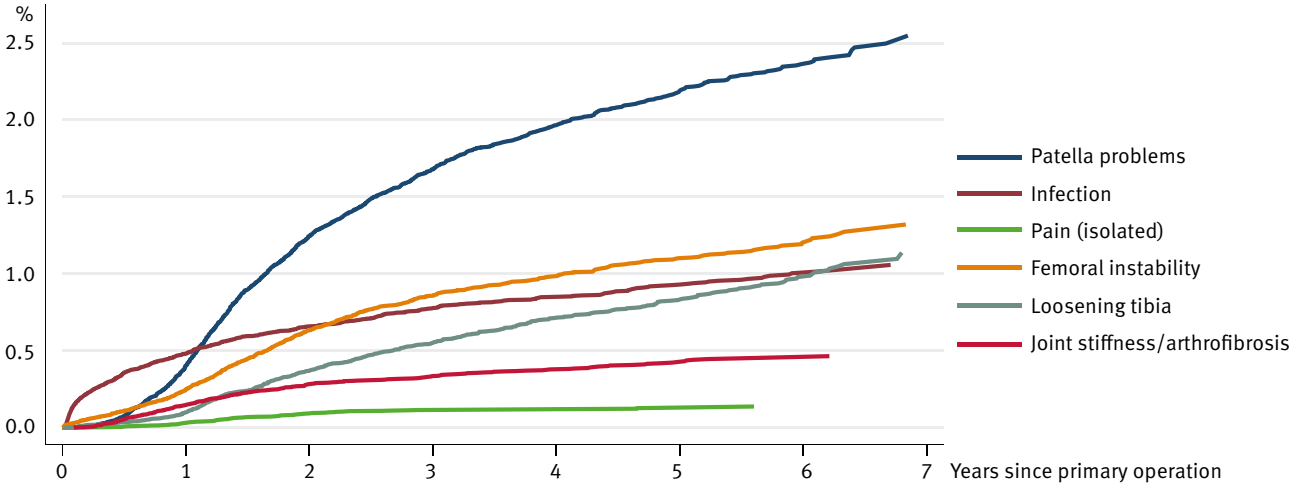
dence intervals. The confidence interval describes the range in which the true mean of a population is expected with the stated probability (typically 95% and 99.8%). For practical purposes, any position within the confidence interval should be considered a plausible value. If confidence intervals overlap, they should be regarded as statistically not different. For this reason, implants in which the revision rate exceeds double the mean revision rate are defined as potential outliers as long as the lower confidence interval remains within the boundaries. If the lower confidence interval exceeds twice the mean revision rate, it is considered a definitive outlier.

Of the documented primary TKAs implanted between January 1, 2016 and Decmeber 31, 2019 with a completed two-year follow up were at risk for the first revision. Of these, 2,049 knees were revised, accounting for the two-year revision rate of 3.5% (CI 95% 3.4–3.7%). The revision rate was higher for secondary (4.4%, CI 95% 3.9–5.0%) than for primary arthritis (3.4%, CI 95% 3.3–3.6%). This pattern seems mainly due to the younger age at surgery for secondary arthritis (mean age 64.8 years for secondary compared to 70.2 years for TKA in so-called primary arthritis). Younger patients were predominantly at risk of early revision (5.3% for the age group under 55 and 4.7% for the age group 55–64 years). Increasing BMI did raise the early revision rate from 3.2% for the BMI group 18.5–24.9 kg/m2 to 4.2% in the ›40 kg/m2 group (staying within the 95% confidence interval). Only nine revisions were performed in patients with BMI less than 18.5kg/m2. The calculated revision rate in this group was 4.9%; the small number is reflected in the considerable variation from 2.6 to 9.2%. ASA classification did not play an important role **(Table 4.4a).**

Figure 4.4b

Cumulative incidence rates for different revision diagnosis of primary total knee arthroplasty

Time since operation, 2012–2021, all services, % of implants revised. Detailed reasons for revisions available since 2015



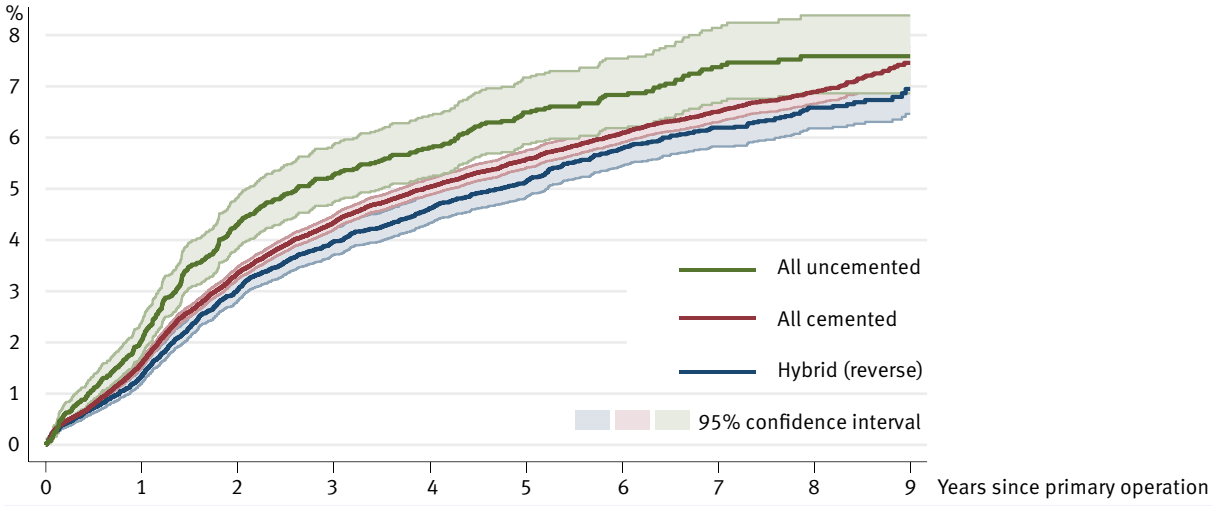
Completely cementless TKA were revised more often (4.9%, CI 95% 3.4–3.7%) than fully cemented TKA (3.5%, CI 95% 4.1–5.9%) in the first two years after index surgery, being significant for the first time in the Swiss joint registry. Ignoring the statistically inconclusive reverse hybrid fixations, hybrid fixation with cemented tibial and uncemented femoral components seemed to perform best (3.2%, CI 95% 2.8–3.5%), but the difference was not significant **(Table 4.4b).** With increasing time after primary TKA, cementless implants had a continuously higher revision rate than fully cemented or hybrid fixed implants but the difference became statistically insignificant from the sixth year after index surgery onward. At nine years after surgery, the revision rate for cemented TKA equaled that for uncemented ones. Hybrid fixation remained best, though the difference was not significant **(Figure 4.4c).** Again, in the cemented and cementless groups, younger age (‹ 60 years) seemed to play an important role in early revision. One could assume that unsatisfactory results after primary TKA were better accepted by patients older at the time of surgery due to less functional demands and possibly more acceptance for inferior results.

When considering TKA without and with primary patella resurfacing, early revision differed from 3.6% (CI 95% 3.5–3.8%) to 3.3% (CI 95% 3.0–3.5%), respectively, the difference not being statistically significant two years after index surgery. From the second year onwards, primary resurfacing of the patella had a lower revision risk **(Figure 4.4e).** The gaping occurred between the first and third year after surgery which is the typical delay for secondary patella resurfacing **(Figure 4.4a).** Between 3 and 9 years after TKA, the revision rate developed parallel for TKA with unresurfaced and resurfaced patella's **(Figure 4.4e).** It seems that secondary resurfacing had only a narrow time window between one and three years after index surgery for the common complaint of anterior knee pain after primary TKA.

Figure 4.4c

Estimated failure rates of primary total knee arthroplasty for different fixation methods

All diagnoses



	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
All cemented	**1.6** (1.5-1.7)	**3.4** (3.2-3.5)	**4.3** (4.2-4.5)	**5.0** (4.9-5.2)	**5.6** (5.4-5.7)	**6.1** (5.9-6.3)	**6.5** (6.3-6.7)	**7.5** (7.1-7.8)
All uncemented	**2.1** (1.7-2.4)	**4.3** (3.8-4.8)	**5.3** (4.7-5.9)	**5.8** (5.2-6.4)	**6.5** (5.9-7.2)	**6.8** (6.2-7.5)	**7.4** (6.7-8.1)	**7.6** (6.9-8.4)
(reverse) hybrid	**1.4** (1.2-1.5)	**3.0** (2.8-3.3)	**4.0** (3.7-4.2)	**4.6** (4.3-4.9)	**5.1** (4.8-5.5)	**5.8** (5.5-6.2)	**6.2** (5.8-6.6)	**6.9** (6.5-7.5)

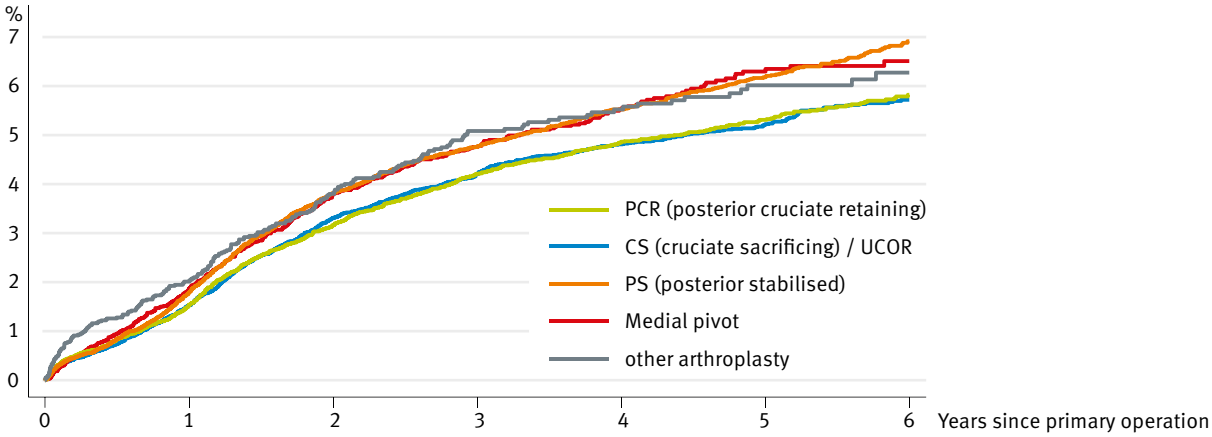
The main reasons for early revision were patella problems in 33.6%, followed by femorotibial instability (18.4%) and infection (18.2%) **(Table 4.4c).** When infection and periprosthetic fractures are excluded, surgical technical problems appear responsible for most early TKA revisions in Switzerland. Exact ratios are not available as multiple reasons could be selected per patient. In addition, 11.7% of the reasons were classified as "other". To a large extent, this diverse group contains the same reasons as listed above, but with added details, and includes numerous wound healing problems and more special reasons, such as inlay dislocations. Periprosthetic fractures of the femur, tibia and/or patella were rarely responsible for early revisions with the exchange of one or more components, and probably most cases with internal fixation were not registered.

A deeper understanding of the TKA revisions over time can be gained by looking at cumulative incidence rates **(Figure 4.4b).** In this type of graphic, a line starts when the first relevant revision in the SIRIS dataset is observed, and it ends with the last recorded revision and covers the observation period since 2016. This perspective shows what proportion of implanted TKAs have experienced at least one revision and for which underlying reasons (e.g. revision due to loosening of a component). **Figure 4.4a** is a Kernel density estimation used to estimate the probability density function of a random variable (frequency at a given time). It shows the temporal ordering of various underlying reasons for early revisions (≤ 2 years), as it is limited to revisions occurring during the moving average timeframe.

Figure 4.4d

Estimated failure rates of primary total knee arthroplasty for different implant types

All diagnoses



	1 year	2 years	3 years	4 years	5 years	6 years
PCR (posterior cruciate retaining)	**1.5** (1.4-1.7)	**3.2** (2.9-3.4)	**4.2** (3.9-4.5)	**4.9** (4.6-5.2)	**5.3** (5.0-5.7)	**5.8** (5.4-6.2)
CS (cruciate sacrificing) / UCOR	**1.5** (1.4-1.7)	**3.3** (3.1-3.5)	**4.2** (4.0-4.5)	**4.8** (4.5-5.1)	**5.2** (4.9-5.5)	**5.7** (5.4-6.1)
PS (posterior stabilised)	**1.8** (1.6-2.0)	**3.8** (3.6-4.1)	**4.8** (4.5-5.0)	**5.5** (5.2-5.8)	**6.2** (5.8-6.5)	**6.9** (6.5-7.4)
Medial Pivot	**1.9** (1.6-2.1)	**3.8** (3.4-4.2)	**4.8** (4.3-5.2)	**5.5** (5.0-6.1)	**6.3** (5.7-6.9)	**6.5** (5.9-7.2)
other arthroplasty	**2.0** (1.7-2.4)	**3.8** (3.3-4.4)	**5.1** (4.4-5.8)	**5.5** (4.8-6.3)	**6.0** (5.2-6.9)	**6.3** (5.4-7.2)

*Medial pivot was not available as a response category before SIRIS v2021. In the annual report 2020, only free text „other" responses were identified as and recoded to medial pivot. However, this missed a number of GMK Sphere total knee systems that were incorrectly registered as other types, mainly CS/UCOR. In this report, all GMK Sphere knee systems are counted as medial pivot, regardless of the type chosen locally at data entry.

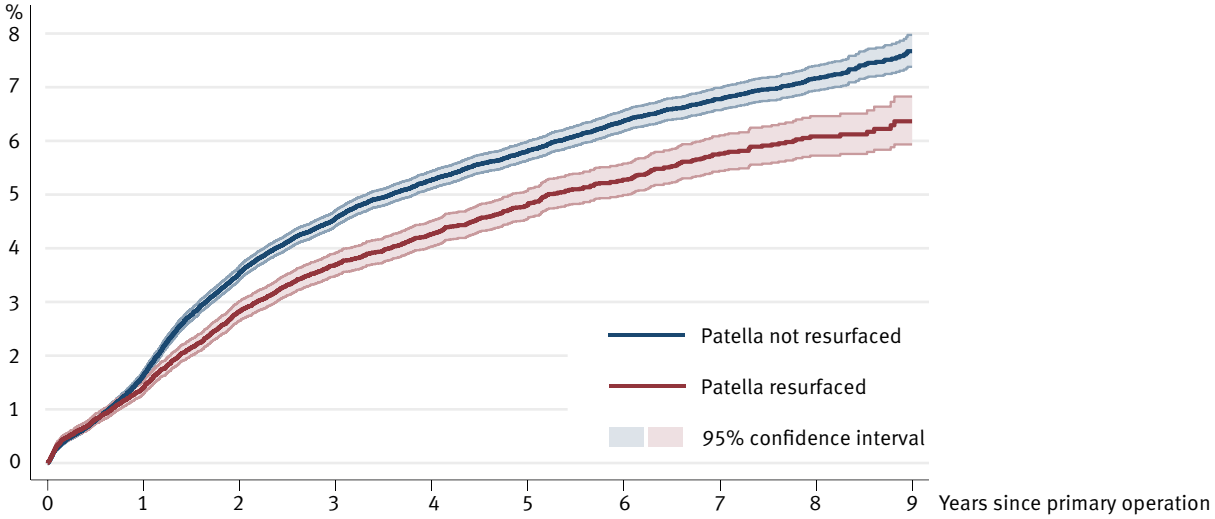
Both perspectives show that only infections were revised relatively early (median 5.8 months after index surgery) and most other reasons for revising a TKA were conducted relatively late (after one year), reflecting the usual pattern in patients with unsatisfactory results after TKA: "wait and see". After an average of nine months, stiff knees were revised, while on average all the other reasons for early revisions took place more than one year after TKA **(Figure 4.4a).** This pattern drives the revision rates upwards with ongoing time, in what might resemble logistic growth curves (slow increase followed by steeper growth and then a flattening out effect). Patella problems contributed to the revision rates observed in this fashion, causing a disproportionate number of revisions between one and three years after implantation with the median 14.6 months after primary TKA **(Figure 4.4e).**

Comparing the different knee systems, CS/UCOR and PCR knees showed advantages compared to medial pivot, PS systems and those classified as other, being visible after one year and becoming significant at five years after primary TKA **(Figure 4.4d).** The reason is unclear and could be partly explained by selection bias. At least in the German-speaking part of Switzerland, less constrained knees were implanted routinely, and medial pivot and PS were selected in more advanced arthritis with bone loss and/or partial ligament instability, e.g. in valgus arthritis knees. This effect is well known in Australia, the so-called "CR continent", where PS knees have a higher revision rate due to a case selection, as mentioned above.

Figure 4.4e

Estimated failure rates of primary total knee arthroplasty: status of patella after primary operation

All diagnoses



	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
Patella resurfaced	**1.4** (1.3-1.5)	**2.8** (2.7-3.0)	**3.7** (3.5-3.9)	**4.3** (4.0-4.5)	**4.8** (4.5-5.1)	**5.3** (5.0-5.6)	**5.8** (5.4-6.1)	**6.4** (5.9-6.8)
Patella not resurfaced	**1.6** (1.6-1.7)	**3.5** (3.4-3.7)	**4.6** (4.4-4.7)	**5.3** (5.1-5.4)	**5.8** (5.6-6.0)	**6.4** (6.2-6.6)	**6.8** (6.6-7.0)	**7.7** (7.4-8.0)

4.5 Results of implants in total knee arthroplasty

Table 4.5a shows Switzerland's most commonly used TKA systems, with 68,862 (75%) TKAs from 2016 until 2021. The 21,031 implants (25%) in this period belonged to the less common systems used. Only 533 implant combinations (0.6%) could not be classified.

Long-term evaluation since 2012 is depicted in **Table 4.5b**. Primary TKA subsystems were analysed in bigger numbers (such as CR or PS) and differed considerably if compared to the revision rates of the whole group in some cases.

The numbers in the third column, cas concentration score (CSS), indicate the share of the main user hospital services. A low percentage means that the implant was used in many different services making the revision rates more independent from a single hospital or surgeon. A share of 50% and more suggests a concentration of the implant to a few users with the increasing risk of a local bias influencing outcome. Different implant combinations performed quite differently in the short and medium terms **(Table 4.5b).** Higher confidence intervals reflect higher variability due to small numbers.

One system had an acceptable revision rate at one year, but then the rate steadily increased from one

Table 4.5a

Top 75% of primary total knee arthroplasty systems

All diagnoses, all component fixations 2016–2021.

	2016	2017	2018	2019	2020	2021	2016–2021
Attune CR-FB	599	729	675	674	841	1244	4,762
Attune CR-RP	1,308	1,238	1,039	1,168	1,334	1,396	7,483
Attune PS-FB	587	526	567	544	462	498	3,184
Attune PS-RP	661	774	976	835	743	728	4,717
Balansys CR	159	171	236	294	355	517	1,732
Balansys PS	344	449	547	663	599	622	3,224
Balansys RP	739	728	573	522	445	316	3,323
Balansys UC	642	514	362	358	387	434	2,697
First/First REV	383	273	276	304	191	113	1,540
GMK sphere	1,125	1,363	1,720	2,007	2,069	2,445	10729
Innex RP	535	462	319	221	167	121	1,825
Journey II	396	469	397	371	263	178	2,074
LCS complete cemented/hybrid	551	551	604	676	670	503	3,555
Persona CR-MC	71	379	504	695	969	1237	3,855
Persona CR-UC	951	924	1034	1099	1161	1092	6,261
Persona PS/CPS	670	747	779	700	599	919	4,414
Sigma CR-FB	455	380	386	326	288	182	2,017
Triathlon PS	121	113	154	182	349	551	1,470
Other systems	4,145	3,500	3,311	3,35	3,324	3,216	21,031
Total	**14,442**	**14,290**	**14,459**	**15,174**	**15,216**	**16,312**	**89,893**

*Constrained/hinged systems were included if used for cases of primary OA including OA after meniscectomy

for the Table below:

* Case concentration score.
Share of implants accounted for by main user hospital service.
A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Younger mean age signifies that the case mix is less "usual" and potentially biased towards higher revision risk

Table 4.5b

Long term evaluation: Failure rates of primary total knee arthroplasty systems (all diagnoses, all component fixations)

Time since operation, 2012–2021. Please note that if reported systems involves multiple sub-variants, it is possible that the long-term performance of these sub-variants may be significantly different from their combined performance.

Knee system	Total number	CCS*	Mean age**	1 year (95% CI)	3 years (95% CI)	5 years (95% CI)	7 years (95% CI)	9 years (95% CI)
Advance	1,844	20	68	**2.2** (1.6-3.0)	**5.3** (4.3-6.5)	**6.5** (5.3-7.8)	**7.5** (6.2-9.1)	**7.5** (6.2-9.1)
Attune CR-FB	5,321	18	69	**1.2** (1.0-1.6)	**3.9** (3.3-4.6)	**5.1** (4.4-6.0)	**6.8** (5.4-8.5)	
Attune CR-RP	9,338	12	69	**2.0** (1.7-2.3)	**5.5** (5.0-6.0)	**6.7** (6.1-7.3)	**7.4** (6.7-8.2)	
Attune PS-FB	4,139	17	70	**1.6** (1.2-2.0)	**4.1** (3.5-4.9)	**5.3** (4.6-6.3)	**7.0** (5.9-8.5)	
Attune PS-RP	5,324	16	70	**1.7** (1.4-2.1)	**4.7** (4.1-5.4)	**6.6** (5.7-7.5)	**8.8** (7.1-10.8)	
Balansys CR	2,196	16	70	**0.7** (0.4-1.2)	**2.0** (1.4-2.9)	**3.2** (2.3-4.4)	**3.8** (2.8-5.3)	**3.8** (2.8-5.3)
Balansys PS	4,080	53	69	**1.2** (0.9-1.7)	**3.2** (2.6-3.9)	**4.5** (3.8-5.4)	**5.6** (4.6-6.8)	**5.6** (4.6-6.8)
Balansys RP	6,060	14	70	**1.3** (1.0-1.6)	**4.0** (3.6-4.6)	**5.4** (4.8-6.0)	**6.5** (5.8-7.3)	**7.6** (6.6-8.7)
Balansys UC	4,296	24	70	**1.0** (0.8-1.4)	**4.0** (3.4-4.7)	**5.1** (4.4-5.9)	**6.6** (5.7-7.7)	**6.8** (5.8-7.9)
E.Motion	1,991	63	70	**2.0** (1.4-2.7)	**4.5** (3.6-5.6)	**5.7** (4.7-7.0)	**7.3** (6.0-8.9)	**7.3** (6.0-8.9)
First/First REV	2,526	40	70	**1.7** (1.3-2.3)	**5.3** (4.5-6.3)	**6.3** (5.4-7.5)	**8.0** (6.7-9.5)	**8.2** (6.9-9.7)
GMK primary CR/UC-RP	2,503	19	69	**1.6** (1.2-2.2)	**4.1** (3.4-5.0)	**5.0** (4.2-6.0)	**6.0** (5.0-7.1)	**6.4** (5.4-7.6)
GMK primary PS	1,959	25	70	**1.1** (0.8-1.7)	**3.6** (2.8-4.5)	**5.0** (4.0-6.1)	**6.1** (5.0-7.5)	**7.0** (5.6-8.6)
GMK sphere	12,203	13	69	**1.8** (1.5-2.0)	**4.6** (4.2-5.1)	**6.1** (5.6-6.8)	**6.8** (6.1-7.6)	**6.8** (6.1-7.6)
ITotal	1,425	22	68	**0.4** (0.2-0.9)	**2.7** (1.9-3.9)	**3.5** (2.5-5.0)	**4.7** (3.0-7.3)	**4.7** (3.0-7.3)
Innex FB	1,710	42	71	**1.4** (1.0-2.1)	**4.5** (3.6-5.7)	**5.4** (4.3-6.6)	**6.3** (5.2-7.7)	**8.0** (6.4-10.1)
Innex RP	4,675	17	69	**1.7** (1.4-2.1)	**4.4** (3.8-5.0)	**5.4** (4.8-6.2)	**6.2** (5.5-7.0)	**7.2** (6.3-8.3)
Journey II	2,366	30	67	**3.2** (2.6-4.1)	**8.0** (6.9-9.3)	**10.3** (9.0-11.9)	**13.0** (10.7-15.8)	
LCS complete cemented/hybrid	6,588	23	70	**1.5** (1.2-1.8)	**4.7** (4.1-5.2)	**5.8** (5.2-6.5)	**6.5** (5.9-7.3)	**7.2** (6.4-8.1)
LCS complete cementless	2,782	26	69	**1.9** (1.5-2.5)	**5.4** (4.6-6.3)	**6.1** (5.2-7.1)	**6.4** (5.5-7.5)	**6.4** (5.5-7.5)
Legion	1,449	23	67	**2.1** (1.5-3.1)	**6.8** (5.4-8.4)	**9.0** (7.4-11.1)	**10.7** (8.7-13.2)	
NK flex	1,838	41	70	**1.2** (0.8-1.8)	**4.0** (3.1-5.0)	**5.0** (4.1-6.1)	**6.0** (4.9-7.3)	**6.8** (5.4-8.6)
Nexgen CR/LPS-Flex	2,014	13	70	**1.5** (1.0-2.1)	**3.4** (2.7-4.4)	**4.4** (3.6-5.5)	**4.8** (3.9-5.9)	**6.3** (5.0-8.0)
Origin	1,018	19	69	**1.7** (1.0-3.0)	**4.8** (3.2-7.1)			
Persona CR-MC	3,855	10	69	**1.1** (0.8-1.6)	**2.9** (2.3-3.7)	**3.0** (2.3-3.9)		
Persona CR-UC	7,389	39	70	**1.0** (0.8-1.2)	**2.8** (2.4-3.2)	**3.7** (3.2-4.3)	**4.2** (3.5-4.9)	
Persona PS/CPS	5,624	12	70	**1.6** (1.3-2.0)	**3.8** (3.3-4.4)	**5.2** (4.5-6.0)	**6.3** (5.4-7.4)	
RT-plus	962	12	77	**2.3** (1.5-3.5)	**4.4** (3.1-6.1)	**4.8** (3.5-6.6)	**5.3** (3.8-7.5)	**5.3** (3.8-7.5)
Sigma CR-FB	4,518	29	70	**0.8** (0.6-1.1)	**2.3** (1.9-2.8)	**3.1** (2.6-3.7)	**3.6** (3.0-4.2)	**4.1** (3.3-5.0)
Sigma CR-RP	2,213	40	68	**2.4** (1.9-3.2)	**5.6** (4.7-6.7)	**6.6** (5.6-7.9)	**7.0** (5.9-8.3)	**8.1** (6.6-9.9)
Sigma PS-FB	1,246	56	72	**0.9** (0.5-1.6)	**3.0** (2.2-4.3)	**3.8** (2.7-5.1)	**4.2** (3.1-5.7)	**5.0** (3.6-6.8)
Sigma PS-RP	1,643	11	70	**1.5** (1.0-2.2)	**3.7** (2.8-4.7)	**4.4** (3.5-5.5)	**5.0** (4.0-6.3)	**5.8** (4.5-7.6)
TC-plus primary FB	2,398	29	69	**1.4** (1.0-2.0)	**3.6** (2.9-4.5)	**4.5** (3.7-5.6)	**5.3** (4.3-6.5)	**5.8** (4.6-7.3)
TC-plus primary RP	1,766	31	70	**1.4** (0.9-2.0)	**3.9** (3.0-5.0)	**5.5** (4.4-6.9)	**7.2** (5.8-8.9)	**8.1** (6.3-10.4)
Triathlon CR	1,495	46	68	**2.6** (1.9-3.5)	**6.3** (5.1-7.8)	**7.7** (6.3-9.4)	**9.3** (7.6-11.4)	**10.9** (8.2-14.4)
Triathlon PS	1,840	23	69	**2.4** (1.7-3.2)	**5.9** (4.6-7.5)	**6.9** (5.4-8.8)	**7.8** (6.1-10.0)	**7.8** (6.1-10.0)
Vanguard CR	1,111	26	67	**1.5** (0.9-2.4)	**4.1** (3.0-5.5)	**5.3** (4.0-7.0)	**6.9** (5.3-9.1)	**7.7** (5.8-10.2)
Vanguard PS	1,073	57	68	**1.8** (1.2-2.9)	**4.9** (3.8-6.5)	**6.9** (5.4-8.8)	**8.1** (6.4-10.3)	**9.0** (7.0-11.6)
Other systems	6,210		70	**1.8** (1.5-2.2)	**4.9** (4.3-5.5)	**6.5** (5.8-7.3)	**7.7** (6.8-8.6)	**9.5** (8.1-11.1)
CH average for group				**1.6** (1.5-1.6)	**4.3** (4.2-4.4)	**5.5** (5.4-5.7)	**6.4** (6.3-6.6)	**7.3** (7.0-7.5)

and a half years after index surgery up to 9 years einding up with an elevated revisiosn rate. **(Figure 4.5a).**

Another showed an increased revision rate from the beginning and remained higher than average implants up to 9 years after primary TKA. This one was identified as an outlier. **(Figure 4.5b).** In contrast, two older TKA systems performed significantly better than the Swiss average **(Figure 4.6c).** This does not speak automatically for a better performance as older systems were often used in older patients being more reluctant to revision surgery

Figure 4.5a

Implant combinations with elevated long-term revision rates (all TKA)

An elevated revision rate was defined as a deviation of at least 50% above the group average at any time between year 5 and year 9 (and lower bounds of the 95% confidence interval exceeding the upper bound of the group average; and at least 50 cases at risk at 5 years). The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).

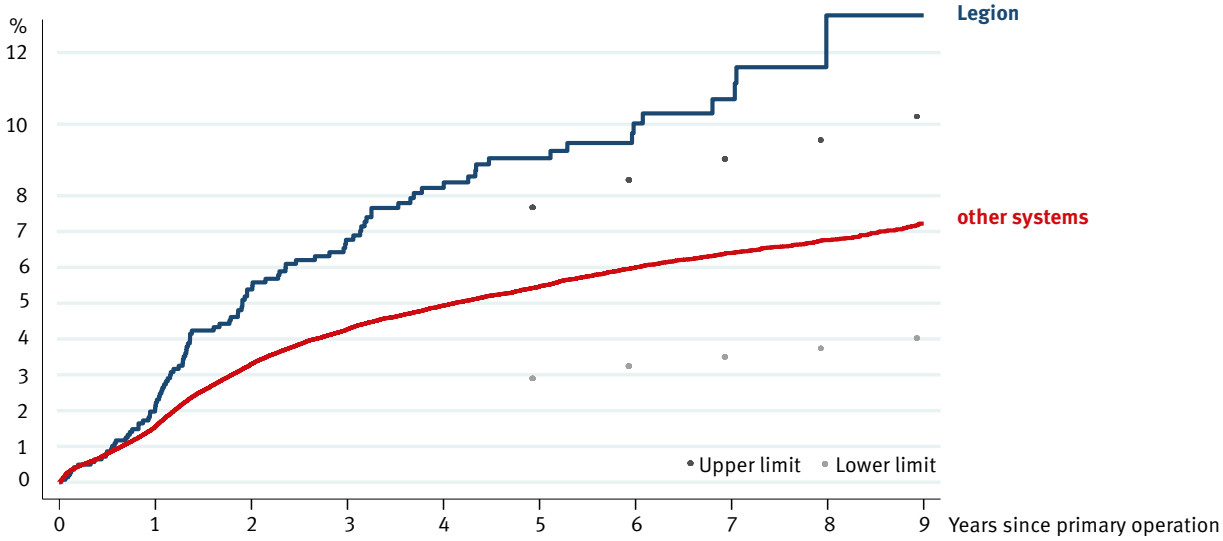
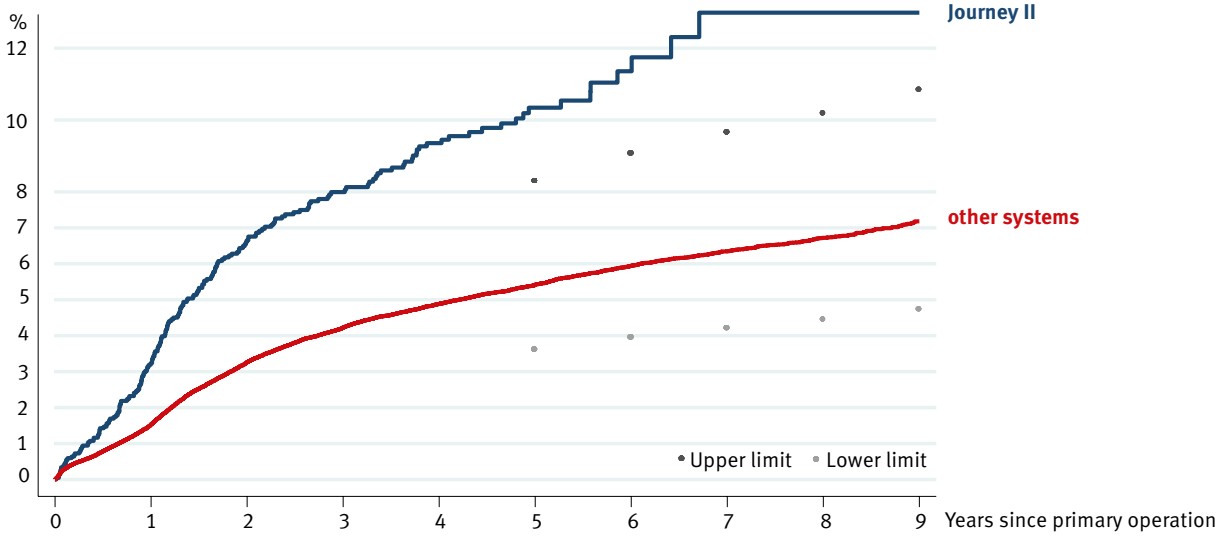


Figure 4.5b

Implant combinations with long-term evaluation outlier status (all TKA)

Outlier status was defined as a revision rate of twice the group average at any time between year 5 and year 9 (and lower bounds of the 95% confidence interval exceeding the upper bound of the group average; and at least 50 cases at risk at 5 years). The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).

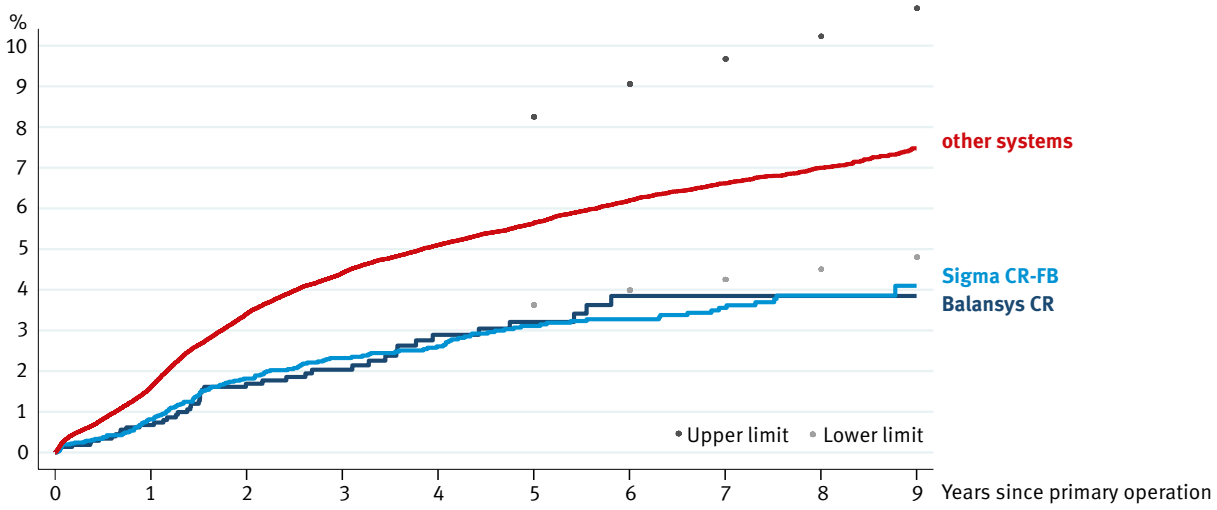


than younger and more active patients. All remaining systems with an average revision risk are shown in groups of up to six in **Figures 4.5d.** The two-year revision rate of the implants is shown in **Figure 5.5e,** reflecting the implants performed between January 1, 2016, and December 31, 2019, with a completed two-year follow-up by December 31, 2021. Of the 51 implant combinations used (the rest summarised under "other systems"), two systems must be considered as potential outliers as the revision rate doubled the average of all implants, but the lower confidence interval still lies in these borders. As usual, the potential outlier systems will result in outlier reports investigating the reasons for the observed deviations from the national average.

Figure 4.5c

Implant combinations with below-average long-term revision rates (all TKA)

Below-average was defined as a 9-year revision rate of up to 66% of the group average (and upper bounds of the 95% confidence interval staying below the lower bound of the group average; and at least 25 cases at risk at 9 years). The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).

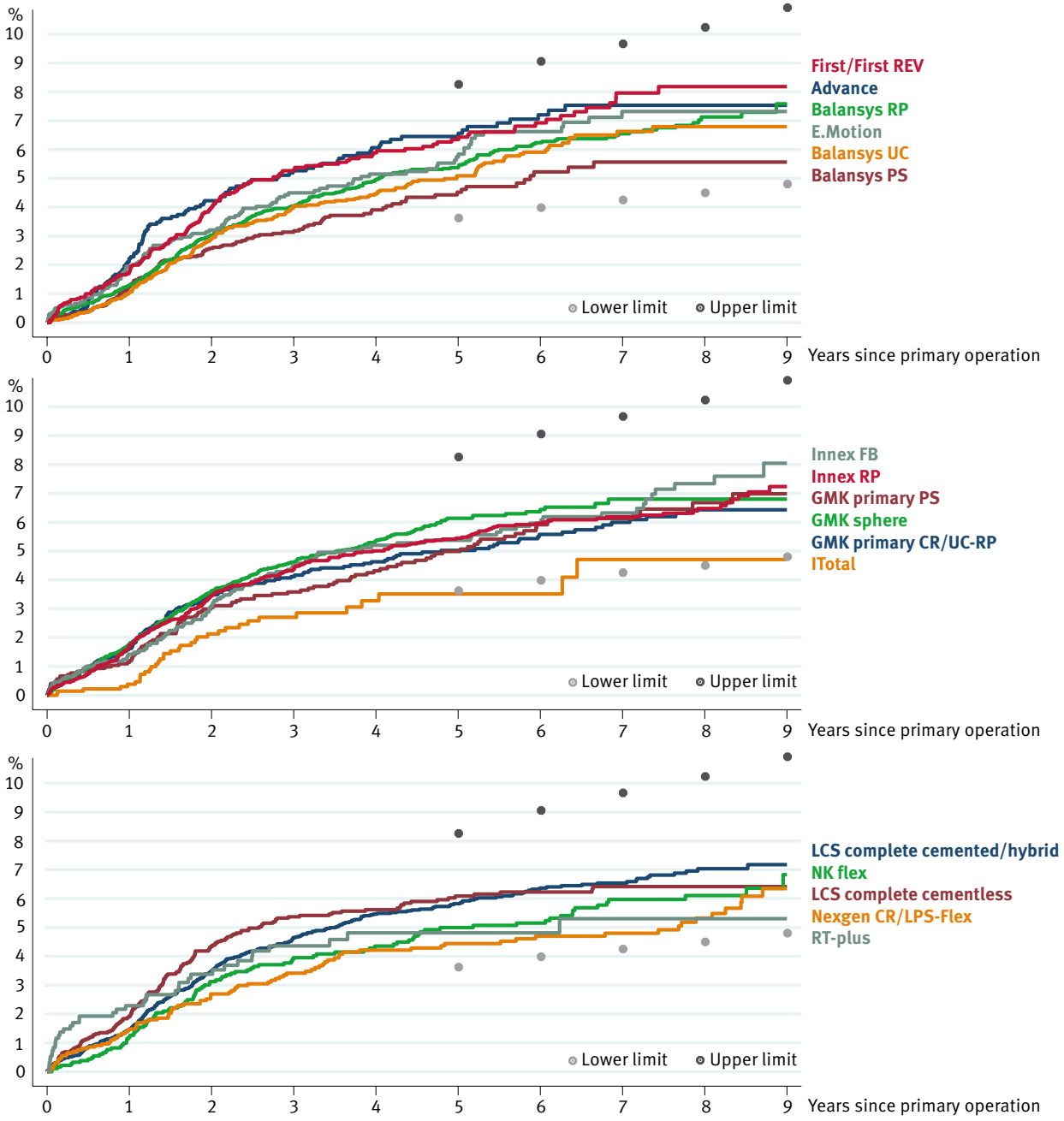


Figures 4.5d (Part 1)

All remaining implant combinations with average revision risks / sorted by volume (all TKA)

Also showing upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively). Only showing combinations with at least 100 cases still at risk at 5 years follow-up.

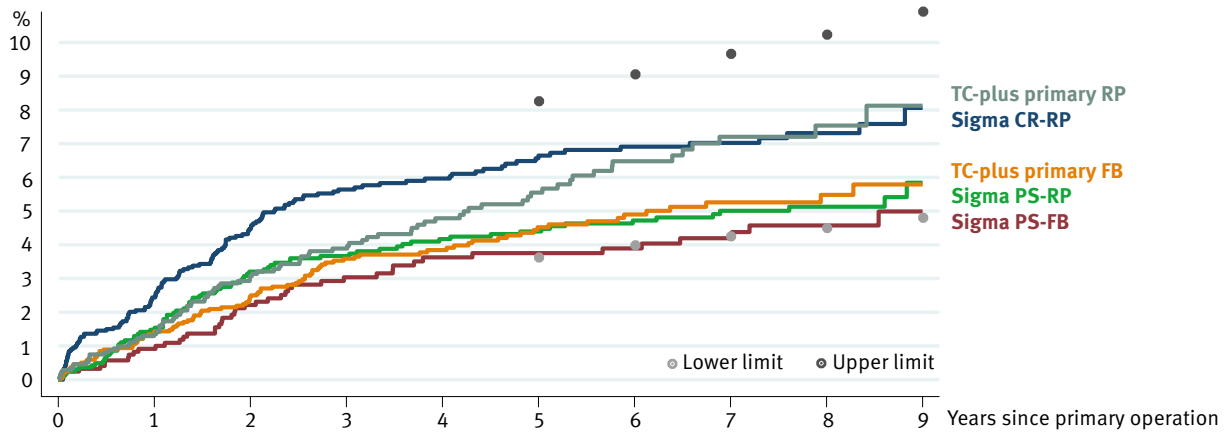
The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).

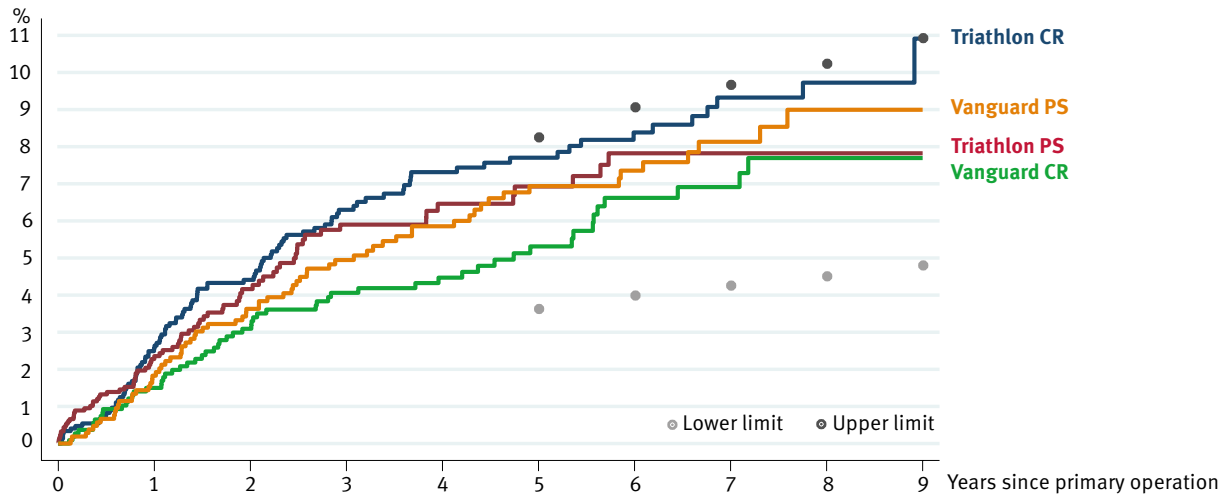


Figures 4.5d (Part 2)

All remaining implant combinations with average revision risks / sorted by volume (all TKA)

Also showing upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively). Only showing combinations with at least 100 cases still at risk at 5 years follow-up.
The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).





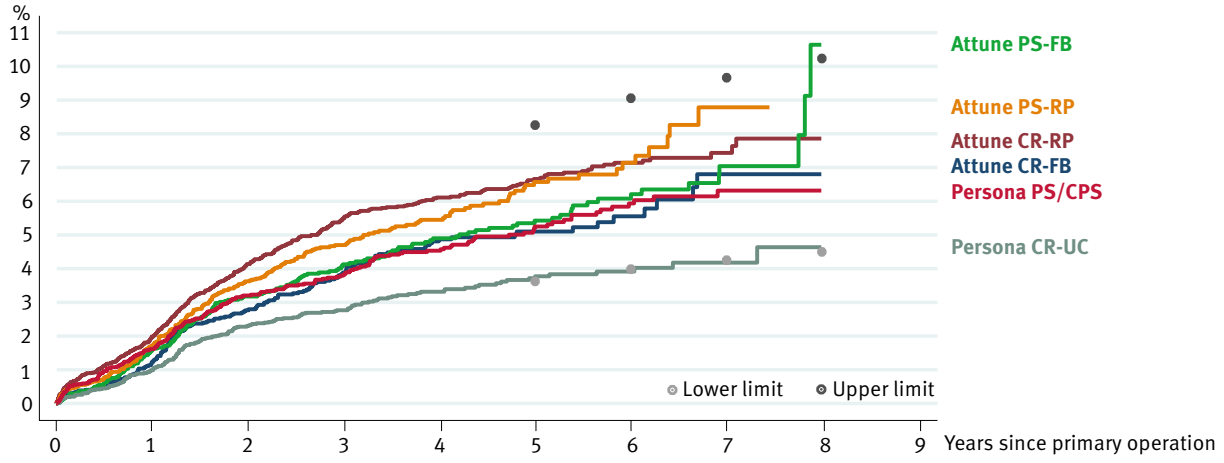


Figure 4.5e (Part 1)

2-year evaluation: Revision rates of primary total knee arthroplasty systems within 24 months

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

Knee system	CCS*	Mean age	at risk N**	Revised N	Revised % ***(95% CI)
3D	49	68	128	4	3.1 (1.2-8.2)
Advance	41	68	696	39	5.7 (4.2-7.7)
Anatomic	50	70	234	4	1.8 (0.7-4.6)
Attune CR-FB	23	69	2677	72	2.8 (2.2-3.5)
Attune CR-RP	9	69	4753	197	4.2 (3.7-4.9)
Attune PS-FB	20	70	2224	63	2.9 (2.3-3.7)
Attune PS-RP	15	70	3246	118	3.7 (3.1-4.4)
Balansys CR	21	70	860	10	1.2 (0.6-2.2)
Balansys PS	51	69	2003	59	3.0 (2.3-3.8)
Balansys RP	16	70	2562	85	3.4 (2.7-4.2)
Balansys UC	25	70	1876	54	2.9 (2.3-3.8)
E.Motion	63	70	870	27	3.2 (2.2-4.6)
First/First REV	40	70	1236	70	5.8 (4.6-7.3)
GMK hinge	25	75	132	5	3.9 (1.6-9.0)
GMK primary CR/UC-RP	31	69	774	31	4.0 (2.9-5.7)
GMK primary PS	22	71	673	20	3.1 (2.0-4.7)
GMK sphere	15	69	6215	230	3.8 (3.3-4.3)
Gemini SL	88	67	134	3	2.3 (0.7-6.8)
HLS kneetec	55	70	181	5	2.8 (1.2-6.7)
ITotal	23	68	747	17	2.3 (1.4-3.7)
Innex FB	73	71	491	18	3.7 (2.4-5.8)
Innex RP	32	69	1537	51	3.4 (2.6-4.4)
Journey II	28	67	1633	115	7.1 (6.0-8.5)
LCS compl. cem./hybrid	28	70	2382	76	3.3 (2.6-4.1)
LCS compl. cementl.	30	68	1091	54	5.0 (3.9-6.5)
Legion	35	67	649	35	5.5 (4.0-7.6)
MBT revision	22	74	63	1	1.6 (0.2-10.7)
NK flex	45	70	402	17	4.3 (2.7-6.8)
Nexgen CR/LPS-Flex	22	69	501	17	3.5 (2.2-5.5)
Nexgen LCCK	21	71	200	5	2.6 (1.1-6.1)
Nexgen RHK	18	78	126	2	1.6 (0.4-6.2)
Origin	14	69	248	15	6.1 (3.7-9.9)
Persona CR	34	69	83	2	2.5 (0.6-9.7)
Persona CR-MC	13	69	1649	37	2.3 (1.7-3.1)
Persona CR-UC	40	69	4009	75	1.9 (1.5-2.4)
Persona PS/CPS	12	70	2896	93	3.3 (2.7-4.0)
Physica KR/PS	55	69	166	14	8.7 (5.3-14.3)

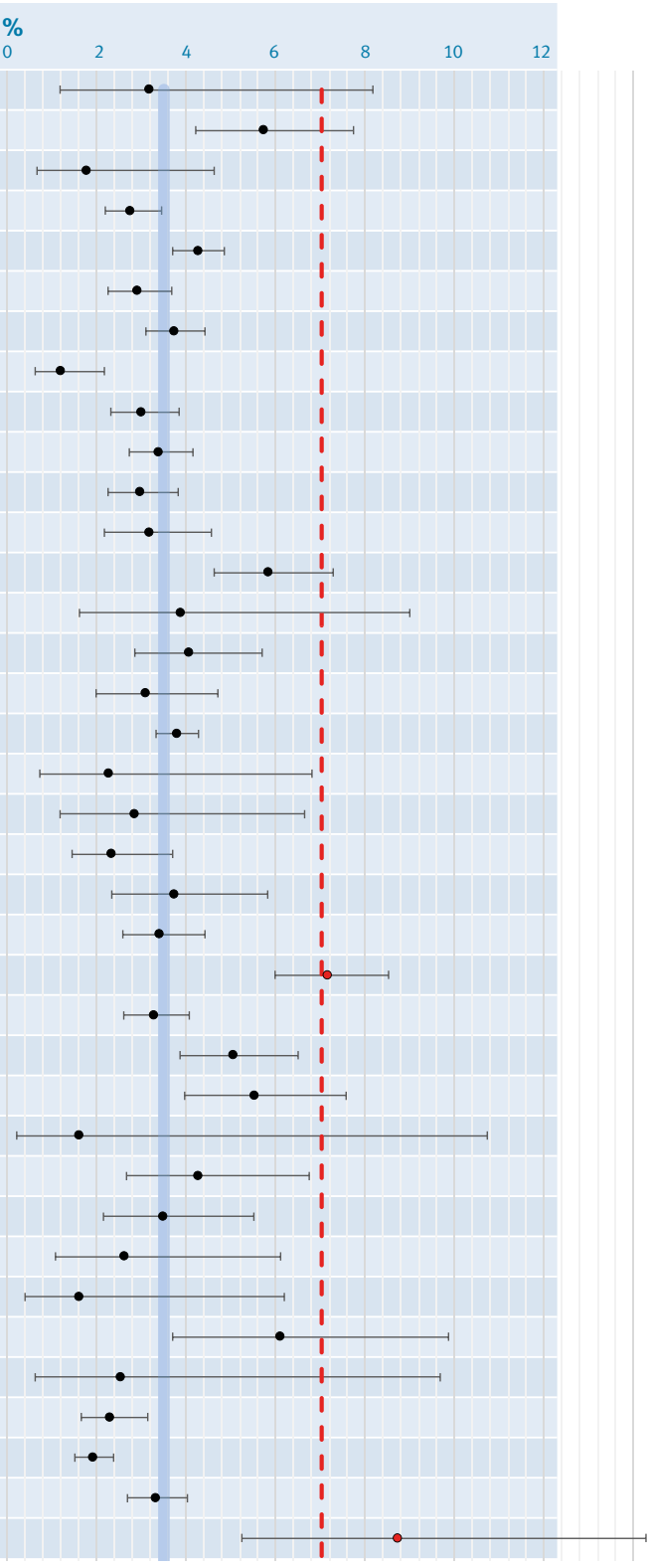
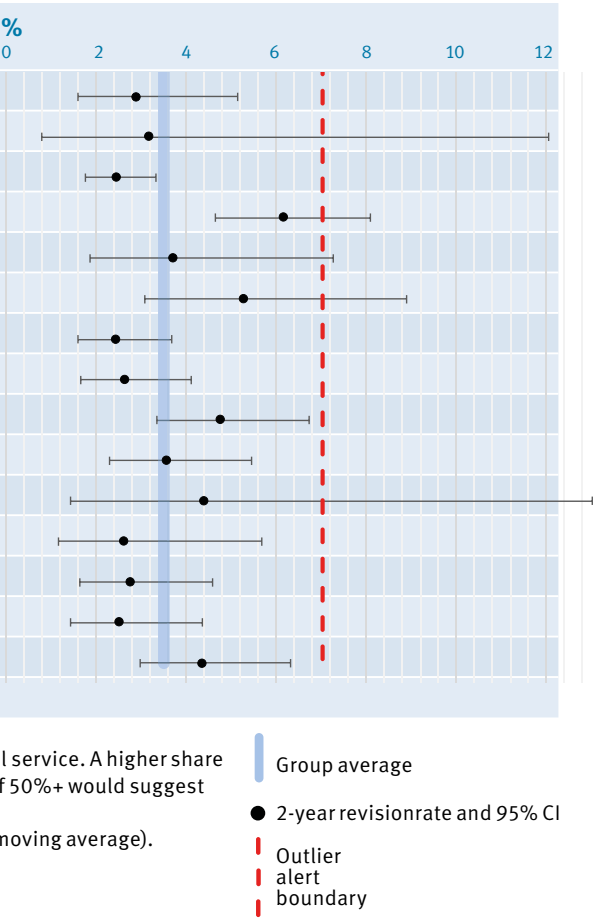


Figure 4.5e (Part 2)

2-year evaluation: Revision rates of primary total knee arthroplasty systems within 24 months

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

Knee system	CCS*	Mean age	at risk N**	Revised N	Revised %***(95% CI)
RT-plus	13	77	389	11	2.9 (1.6-5.1)
Score	61	69	66	2	3.2 (0.8-12.1)
Sigma CR-FB	31	70	1547	37	2.4 (1.8-3.3)
Sigma CR-RP	61	68	778	47	6.1 (4.7-8.1)
Sigma PS-FB	59	72	226	8	3.7 (1.9-7.3)
Sigma PS-RP	26	72	253	13	5.3 (3.1-8.9)
TC-plus primary FB	35	70	919	22	2.4 (1.6-3.7)
TC-plus primary RP	26	70	698	18	2.6 (1.7-4.1)
Triathlon CR	58	68	651	30	4.8 (3.3-6.7)
Triathlon PS	24	69	570	20	3.6 (2.3-5.5)
U2	88	70	74	3	4.4 (1.4-13.0)
Unity	40	67	234	6	2.6 (1.2-5.7)
Vanguard CR	40	67	517	14	2.7 (1.6-4.6)
Vanguard PS	68	68	487	12	2.5 (1.4-4.4)
Other systems		71	610	26	4.3 (3.0-6.3)
CH average for group					3.5 (3.4-3.7)



* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

*** Rates adjusted for effects of mortality and emigration.

Important information on the use of the implant performance tables below

- Estimated revision rate exceeds the alert boundary, but we do not identify this implant combination as an outlier because the 95% confidence interval overlaps the confidence zone of the reference group.
- Identified as potential outliers. Please note the statistical confidence intervals. The outlier status comes with varying degrees of statistical probability. We consider the potential outlier status „highly likely“ when both the estimated revision rate and the complete confidence interval exceed the outlier alert boundary.

Please be aware that relatively rare implant combinations are frequently used in only a small number or indeed only in one hospital in Switzerland. Observed revision rates may be determined by local factors and performance may differ significantly between locations. Manufacturers of detected outlier implants and the hospitals where they were used (and revisions occurred) have been informed by SIRIS.

Partial knee arthroplasty

Ten Years of Swiss Hip and Knee Registry

4.6 Primary partial knee arthroplasty

Since recording commenced in 2012, 25,207 primary partial knee arthroplasties (PKA) were registered **(Table 4.1a),** of which 17,134 PKAs were implanted within the period since 2016. Since 2015, documentation has included recording the morbidity state (ASA classification) and the body mass index (BMI). To overcome the problem of overaged (antiquated) data, analyses were carried out within a four-year moving window, including the last four years with a completed two-year follow-up. This report analysed implantations carried out between January 1, 2016, and December 31, 2019, with a completed two-year follow-up before December 31, 2021. However, for Kaplan-Meier survival estimates and the calculation of cumulative revision rates, the entire period from 2012 onwards was used to extend the follow-up period to its maximum.

Between 2016 and 2021, implantation of 17,134 PKAs was performed, accounting for 15.8% of all knee arthroplasties in this period **(Table 4.2a and 4.6a).** This proportion remained constant over the past five years and is the highest in the international community, although in almost all western countries, including Australia, the rate of partial knees has significantly increased, closing the gap with Switzerland. In part, this effect is internationally connected to increased technical support during surgery by PSI or robotics, whereas the high rate of PKA in Switzerland seems to be rooted in local surgical tradition. The mean age at surgery was 64.5 years **(Table 4.6a)** from 2016 to 2021; 48.4% of patients were women. Only 9.5% of the osteoarthritis cases were classified as secondary, with osteonecrosis at 5.0% being the most prominent, followed by ligament lesions with 1.9% as the predominant underlying causes. 2.1% of partial knee replacements were performed on patients younger than 45 and 14.7% on patients 45–54 years old. 15.8% of partial knee replacements were performed on elderly patients of 75–84 years old. 2.1% of the patients were older than 85. Overall, partial knee arthroplasties were more frequently implanted in younger patients (peak in the age group 55–64 years), whereas the peak for total knee arthroplasty was in the age group 65–74 years **(Table and Figure 4.1a).** The mean BMI was 28.4 kg/m2 in the partial knee replacement group. BMI was not recorded in 15% of the cases. The ASA classification for the vast majority (82.7%) of patients was 1 or 2. The morbidity state was not recorded in 6% of cases **(Table 4.6a).** Hospitals with more than 100 interventions per year performed only 25.4% of

Table 4.6a

Primary partial knee arthroplasty: Baseline patient characteristics by year

		2016	2017	2018	2019	2020	2021	2016–2021
N		**2,458**	**2,616**	**2,704**	**3,045**	**3,145**	**3,166**	**17,134**
Diagnosis [%]	Primary OA*	91.5	90.5	91.2	90.5	91.0	88.8	90.5
	Secondary OA	8.5	9.5	8.8	9.5	9.0	11.2	9.5
	Inflammatory origin	0.0	0.2	0.1	0.1	0.2	0.3	0.2
	Fracture	0.7	1.0	0.9	0.6	0.8	0.7	0.8
	Lesion of ligament	1.4	1.8	1.6	2.1	2.1	2.3	1.9
	Infection	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Osteonecrosis	5.0	4.6	5.0	5.4	4.5	5.6	5.0
	Other**	1.5	2.1	1.4	1.6	1.7	2.3	1.8
Women [%]		49.1	50.6	47.9	48.7	47.8	46.8	48.4
Mean age (SD)	All	64.3 (10.0)	64.2 (10.2)	64.8 (10.4)	64.7 (10.3)	64.6 (10.2)	64.5 (10.0)	64.5 (10.2)
	Women	64.0 (10.3)	63.9 (10.6)	64.8 (10.8)	64.6 (10.8)	64.2 (11.0)	64.3 (10.1)	64.3 (10.6)
	Men	64.6 (9.7)	64.5 (9.7)	64.8 (9.9)	64.8 (9.9)	65.0 (9.5)	64.7 (10.0)	64.8 (9.8)
Age group [%]	<45	1.9	2.3	2.2	2.1	2.2	1.9	2.1
	45–54	15.2	15.9	14.1	14.5	14.3	14.5	14.7
	55–64	34.7	34.4	32.7	34.1	34.1	34.6	34.1
	65–74	30.8	30.5	32.2	30.6	31.1	31.8	31.2
	75–84	15.4	15.1	16.4	16.4	16.1	15.2	15.8
	85+	2.0	1.8	2.5	2.4	2.2	2.0	2.1
N unknown BMI (%)		558 (23)	474 (18)	448 (17)	441 (14)	345 (11)	290 (9)	2,556 (15)
N known BMI		1,900	2,142	2,256	2,604	2,800	2,876	14,578
Mean BMI (SD)		28.4 (4.7)	28.4 (4.7)	28.4 (5.4)	28.5 (5.5)	28.5 (4.9)	28.4 (5.4)	28.4 (5.1)
BMI [%]	<18.5	0.4	0.4	0.4	0.5	0.5	0.3	0.4
	18.5–24.9	25.1	23.5	24.0	24.9	24.7	25.6	24.7
	25–29.9	42.7	42.9	43.7	41.7	40.9	40.0	41.8
	30–34.9	23.0	25.1	24.5	23.0	24.8	24.0	24.1
	35–39.9	7.0	6.2	5.8	8.1	7.4	8.0	7.2
	40+	1.8	2.1	1.6	1.8	1.8	2.0	1.8
N unknown ASA (%)		253 (10)	202 (8)	175 (6)	163 (5)	153 (5)	56 (2)	1,002 (6)
N known ASA		2,205	2,414	2,529	2,882	2,992	3,110	16,132
Morbidity	ASA 1	20.0	17.8	17.1	16.8	14.6	14.8	16.6
state [%]	ASA 2	64.9	65.7	66.0	65.2	68.4	65.9	66.1
	ASA 3	14.9	16.1	16.7	17.8	16.7	19.1	17.0
	ASA 4/5	0.1	0.3	0.2	0.2	0.2	0.3	0.2

* As of SIRIS version 2021, and pending further review, this category includes the newly introduced category „secondary arthritis after meniscus surgery". This category accounts for more than 6% of current entries, but shows large variability between hospitals.

** A small number of newly added cases with „secondary OA caused by patellar instability" were added to this category.

the partial knee replacements **(Table 4.6b).** A total of 62% of the patients had not had any form of knee surgery before their partial knee replacement; 21.3% had previously undergone arthroscopy of the knee; 23.6% had had a meniscectomy; 1.8% had had previous ACL reconstruction; 1.5% had undergone an osteotomy close to the knee at the tibia or the femur **(Table 4.6c).**

Medial uni-compartmental replacement was performed in 83.7% of cases, lateral in 6.0% and patellofemoral replacement in 6.4%. In 0.9%, "other" was selected, meaning mainly combinations of PKA. In 3.0%, the type was incorrectly classified as a TKA (mentioned as "other, type unknown"), but the implant data identified them as PKA **(Table 4.6c).**

Table 4.6b

Baseline patient characteristics of primary partial knee arthroplasty by hospital service volume

Calculations of hospital service volume based on primary knee surgeries in each included year (2016-2021).

Hospital service volume		<100	100–199	200–299	300+
N (2016–2021)		**2,815**	**4,219**	**3,650**	**6,450**
Women [%]		49.3	46.3	47.3	50.0
Mean age (SD)	All	64.4 (10.3)	64.1 (10.0)	64.4 (10.1)	65.0 (10.3)
	Women	64.2 (11.0)	63.8 (10.4)	63.8 (10.3)	65.0 (10.7)
	Men	64.6 (9.6)	64.4 (9.6)	64.9 (9.9)	65.0 (9.8)
Age group [%]	<45	2.2	2.0	2.3	2.0
	45–54	15.5	15.0	14.4	14.3
	55–64	34.0	36.3	34.2	32.7
	65–74	30.3	29.7	32.9	31.5
	75–84	15.4	15.1	14.1	17.3
	85+	2.6	1.8	2.1	2.2
Diagnosis [%]	Primary OA	92.1	91.7	88.8	90.1
	Secondary OA	7.9	8.3	11.2	9.9
N unknown BMI (%)		532 (19)	743 (18)	334 (9)	951 (15)
N known BMI		2,283	3,476	3,316	5,499
Mean BMI (SD)		28.7 (4.8)	28.8 (4.9)	28.4 (4.9)	28.1 (4.7)
BMI [%]	<18.5	0.4	0.4	0.3	0.5
	18.5–24.9	23.0	22.7	24.4	26.8
	25–29.9	42.6	40.6	42.4	42.0
	30–34.9	24.3	25.9	24.1	22.8
	35–39.9	7.8	8.3	6.9	6.3
	40+	2.1	2.1	1.9	1.5
N unknown ASA (%)		146 (5)	256 (6)	365 (10)	235 (4)
N known ASA		2,669	3,963	3,285	6,215
ASA state [%]	ASA 1	16.5	19.0	15.1	16.0
	ASA 2	68.4	65.7	65.6	65.6
	ASA 3	14.8	15.2	18.9	18.2
	ASA 4/5	0.2	0.2	0.4	0.2

* Note that service volume is defined as the sum of primary procedures per year

Under surgical technique, conventional was selected in 72.4% of cases. Minimally invasive was selected in 19.2%, but the latter is now seen as a form of conventional technique and is no longer featured on the new 2021 version of the SIRIS forms. It must be stated that any PKA is minimally invasive when considering the surgical approach, which is smaller than for TKA. Patient-specific instrumentation (PSI) was used in 5.4% and computer navigation in 2.1%. 2.6% were classified as other, with most of those cases being assisted by robots **(Table 4.6c).** Robotic assistance is now a new response category on the 2021 forms and was registered in 128 PKAs in 2021 (0.7%); conventional computer navigation was used only in nine cases (0.1%) in the same year. In summary, technical support in PKA was still rare

Table 4.6c

Primary partial knee arthroplasty: Surgery characteristics

All diagnoses, all component fixations

2016–2021	N	%
Previous surgery		
None	10,630	62.0
Knee arthroscopy	3,646	21.3
Meniscectomy	4,047	23.6
ACL reconstruction	311	1.8
Osteotomy tibia close to knee	236	1.4
Osteosynthesis tibia close to knee	74	0.4
Surgery for patella stabilization	179	1.0
Synovectomy	85	0.5
Osteotomy femur close to knee	23	0.1
Osteosynthesis femur close to knee	28	0.2
Surgery for treating infection	7	0.0
Surgery for tumor	6	0.0
Other	401	2.3
Intervention		
Unicompartment medial	14,341	83.7
Unicompartment lateral	1,023	6.0
Femoropatellar	1,095	6.4
Other (including combinations)	158	0.9
Other (type unknown)*	517	3.0
Technology		
Conventional	12,401	72.4
Computer assisted	357	2.1
Patient specific instrumentation	917	5.4
Minimally invasive	3,285	19.2
Computer navigation (v2021)	9	0.1
Robotic-assisted (v2021)	128	0.7
Other	439	2.6

* In those cases TKA categories were chosen on the data entry form but partial knee systems registered. We consider implant registration more reliable than form entry and therefore recognise them as partial knee procedures

in Switzerland even though robotics was introduced in 2018 **(Figure 4.7_J).** The share was also far less than in TKA (see Chapter 4.2).

Over the past six years, the use of cementless devices was 13.9%, but this rate has seen some variation over time, more recently a slight decline from a previous peak in 2018. The share of cementless implants was 11.8% in 2021. Hybrid fixation was used only in 1.7% of the cases. The vast majority (84.0%) of partial knee replacements performed between 2015 and 2020 were fully cemented.

Figure 4.6a

Primary partial knee arthroplasty: Component fixation

Percentage per year, all diagnoses

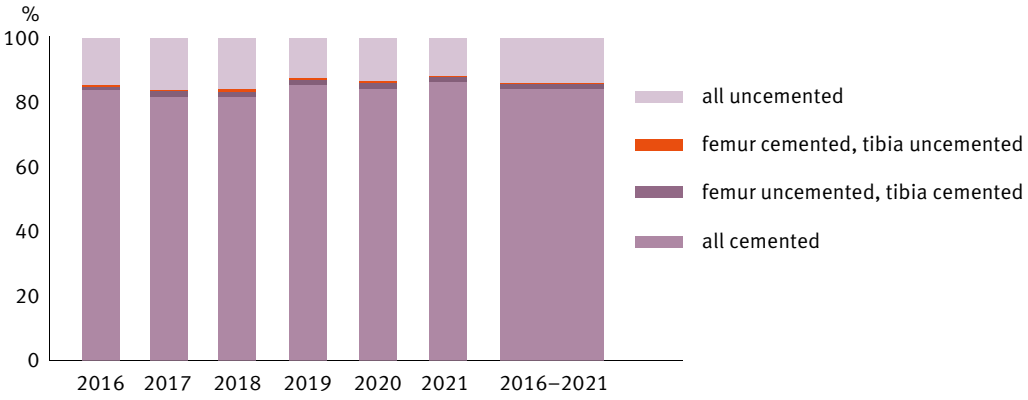


Table 4.6d

Primary partial knee arthroplasty: Component fixation

Percentage per year, all diagnoses.

Year	2016	2017	2018	2019	2020	2021	2016–2021
N	**2,303**	**2,441**	**2,527**	**2,884**	**2,920**	**2,964**	**16,039**
All uncemented	14.7	16.0	15.9	12.4	13.4	11.8	13.9
Reverse hybrid*	0.5	0.3	0.8	0.6	0.5	0.2	0.5
Hybrid**	1.0	1.9	1.8	1.6	1.9	1.8	1.7
All cemented	83.8	81.7	81.6	85.4	84.2	86.2	84.0

* femur cemented, tibia uncemented
** femur uncemented, tibia cemented

4.7 First revision of a primary partial knee arthroplasty

First revisions of PKA or TKA cover all revisions linked to primary implantations registered in SIRIS and that occur for the first time. Re-revisions were therefore not included here but are integrated into Chapter 4.3. Overall, the share of linked revisions was 48.6%, steadily increasing with time and reaching 62.5% in 2021, including linked revisions of total and partial knee arthroplasties **(Figure 4.1_A).**

We distinguish between early revisions within the first two years after implantation and revisions in the longer term, currently up to 9 years after implantation. Kaplan-Meier (KM) survival estimations and cumulative revision rates were calculated for long-term outcomes. For benchmarking, the two-year revision rate of an implant, hospital, or surgeon was calculated for primary PKA for the treatment of primary osteoarthritis (OA), including additionally all cases after meniscus surgery.

Table 4.7a

First revision of primary partial knee arthroplasty within 24 months overall and according to baseline characteristics

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021). All diagnoses, all component fixations.

			Revised		95% CI	
		N at risk[1]	N	%[2]	lower	upper
Overall		10,823	532	5.0	4.6	5.4
Gender	Women	4,736	236	5.1	4.5	5.7
	Men	5,005	223	4.5	4.0	5.2
Age group	<55	1,514	106	7.1	5.9	8.6
	55–64	3,355	180	5.5	4.7	6.3
	65–74	3,084	122	4.0	3.4	4.8
	75–84	1,577	46	3.0	2.2	3.9
	85+	210	5	2.4	1.0	5.7

[1] Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).
[2] Rates adjusted for effects of mortality and emigration.

Table 4.7b

Reason for early first revision of primary partial knee arthroplasty

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021). Early first revisions are those occurring within 2 years of the primary arthroplasty.
Multiple responses possible (percentages do not sum to 100). All diagnoses, all component fixations.

	N	%
Loosening tibia	155	29.1
Pain*	87	16.4
Progression of unicomp. OA	73	13.7
Loosening femur	52	9.8
Patella problems	41	7.7
Femorotibial instability	38	7.1
Infection	38	7.1
Component malposition tibia	29	5.5
Periprosthetic fracture tibia	29	5.5
Component malposition femur	20	3.8
Wear of inlay	14	2.6
Joint stiffness/arthrofibrosis	12	2.3
Patellar instability	6	1.1
Sizing femoral component	5	0.9
Loosening patella	4	0.8
Periprosthetic fracture femur	4	0.8
Sizing tibial component	4	0.8
Periprosthetic fracture patella	2	0.4
Other	72	13.5
Total	**685**	

*Pain was frequently reported alongside other reasons. The proportion of „isolated pain“ was7.3%.

The analysis of first revisions was performed for TKA based on revisions involving any exchange of prosthetic components after primary PKA.

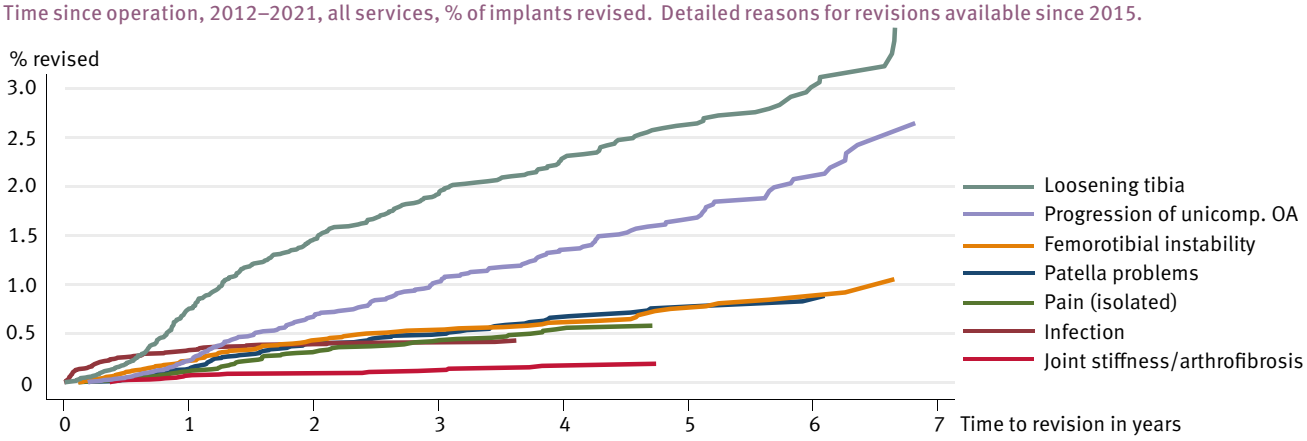
Of the 25,207 documented partial knee arthroplasties (PKA) implanted since 2012, 10,823 were at risk as they fell within the four-year moving average time window for primary surgery between January 1, 2016, to December 31, 2019, and had at least two years of follow-up by December 31, 2021. Of the implants at risk, 532 knees were revised, accounting for a two-year revision rate of 5.0% (CI 95% 4.6–5.4%). Younger patients were much more at risk (e.g. 7.1% in the age group under 55 years) than older patients (e.g. 3.0% in the age group 75–84 years) **(Table 4.7a).** Compared to the 2021 report, the revision rate of PKA has also increased. The reason for this is likely the improved linkage rate, leading to the detection of formerly unrecognised revisions.

Cumulative revision risks of the different systems are depicted in a Kaplan-Meier estimation in **Figures 4.7a and 4.7b.** The most frequent reason for early revision was loosening of the tibia (29.1% = 155 cases), followed by pain in 16.4%, progression of osteoarthritis in 13.7%, loosening of the femur in 9.8%, as well as infection in 7.1% **(Table 4.7b).** Like in TKA, surgical technical problems such as instability, malpositioning and sizing were responsible for most early revisions in partial knee arthroplasty. 13.5% of the revision reasons were classified as "other".

Figure 4.7a

Cumulative incidence rates for different revision diagnosis of partial knee arthroplasty

Time since operation, 2012–2021, all services, % of implants revised. Detailed reasons for revisions available since 2015.



67.1% of the failed PKAs were converted to total knee arthroplasty **(Table 4.7d).** This share is far more than the reported 40.8% published in the 2021 SIRIS report. The reason is that many locally entered "complete revisions" were re-coded as conversion to TKA. The polyethylene was exchanged in 16.2% of PKA revisions, followed by tibial revision in 5.8%. All the other revision types were rare; only 2.3% were named "other" **(Table 4.7d).** Pain was often named in combination with other reasons as a typical symptom for revision after PKA (16.4%). In only 7.3% of cases, pain was the single reason for revision, which still was higher than in TKA (3.2%). Conversions dominate the types of revisions by a clear margin **(Figure 4.7c)**, except for the first six months after primary operations. Conversions, PE replacements and all other revisions account for a similar share of revisions in the first six months. By the end of the first year, however, conversions were the dominant form of revision, affecting nearly 2% of all primary partial knees. Femoropatellar partial arthroplasties (PFJ) had a significantly higher revision risk than either medial or lateral arthroplasties **(Figure 4.7d).** Cemented PKA implants were revised less often than cementless implants during the first nine years after surgery, which was statistically significant, most clearly early after surgery. This effect can be expected as cementless implants must

Figure 4.7b

Time interval between primary partial knee arthroplasty and first revision by reason

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021).
Early first revisions are those occurring within 2 years of the primary arthroplasty.

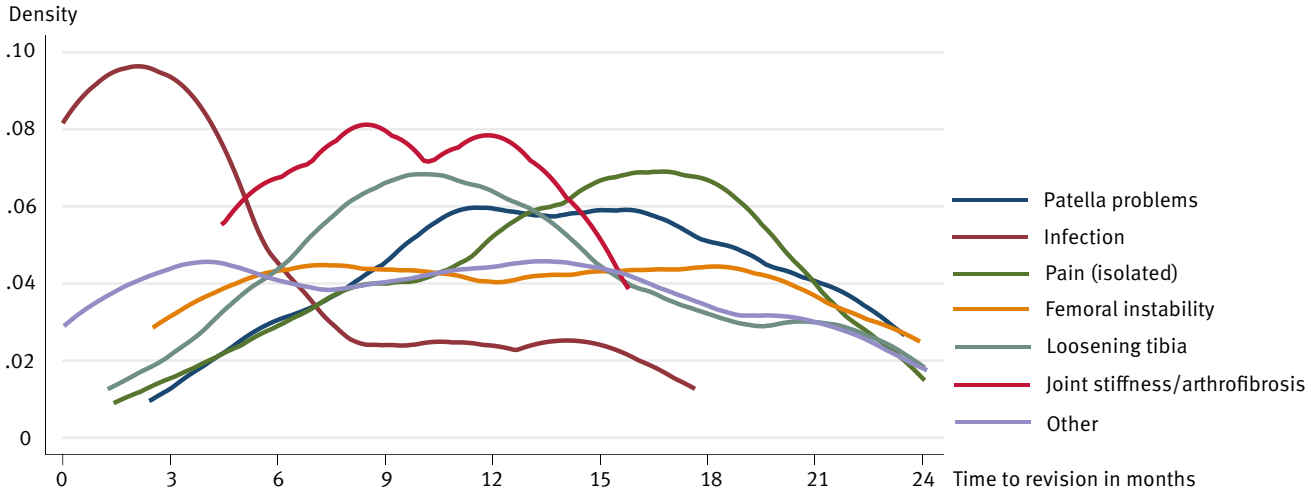


Table 4.7c

Median time interval between primary partial knee arthroplasty and early first revision (in months) according to reason

all diagnoses

	N	Median	IQR 25%	IQR 75%
Patella problems	41	14.3	9.9	18.9
Infection	38	2.9	0.7	7.6
Pain (isolated)	39	15.1	10.2	18.8
Femoral instability	38	13.4	6.9	18.7
Loosening tibia	155	11.6	8.1	16.0
Joint stiffness/arthrofibrosis	12	10.1	5.5	12.1
Other	270	11.3	4.7	16.4

osteointegrate, which might be critical in some cases. After the initial disadvantage had been established, the failure curve of the uncemented implants remained largely parallel to that of the cemented implants **(Figure 4.7e).** The gap closed from the seventh year after surgery; the difference was no longer significant from eight years after index surgery onwards.

PSI and conventional computer navigation seemed to perform similarly to conventional techniques **(Figures 4.7f and g).** In the beginning, computer navigated PKA seemed to be revised less until some revisions five years after surgery closed the gap with the conventional technique **(Figure 4.7g).** Numbers for these techniques were small, which explains the broad and increasing confidence interval over time.

Table 4.7d

Type of early first revision of primary partial knee arthroplasty

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021).
Early first revisions are those occurring within 2 years of the primary arthroplasty. All diagnoses, all component fixations

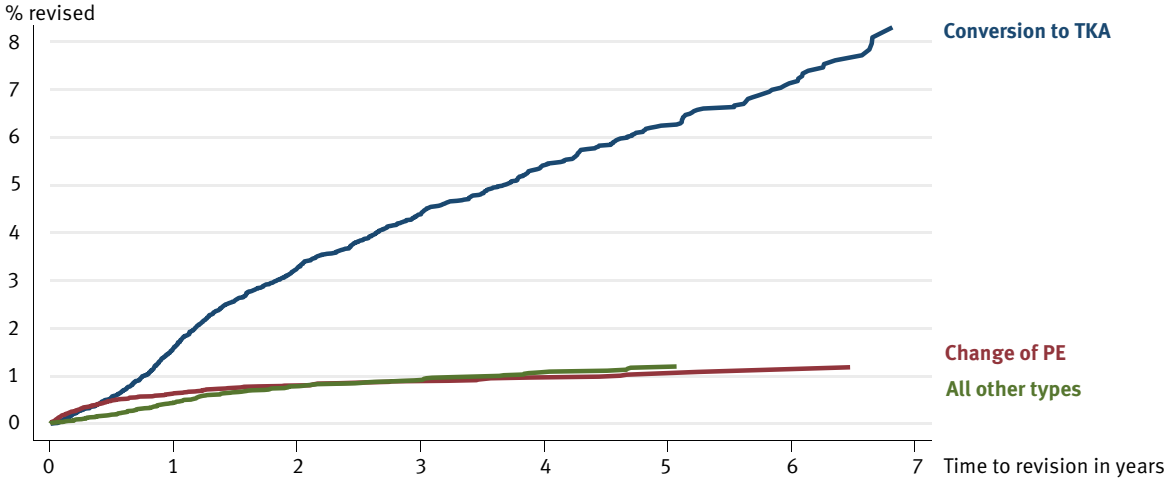
	N	%
Conversion from unicomp. to total prosthesis*	357	67.1
Exchange of PE	86	16.2
Tibial revision	31	5.8
Subsequent patella prosthesis	10	1.9
Complete revision*	10	1.9
Femoral revision	10	1.9
Patella revision	4	0.8
Component removal with spacer implantation	3	0.6
Reimplantation of prosthesis	2	0.4
Subsequent partial prosthesis, second compartment	6	1.1
Subsequent patella prosthesis with exchange of PE	1	0.2
Other	12	2.3
Total	**532**	

* A large share of conversions is entered locally as „complete revisions". Such responses have been recoded as conversions if TKA components were registered or if a TKA was indicated on the revision proforma.

Figure 4.7c

Cumulative incidence rates for different types of revisions of partial knee arthroplasty

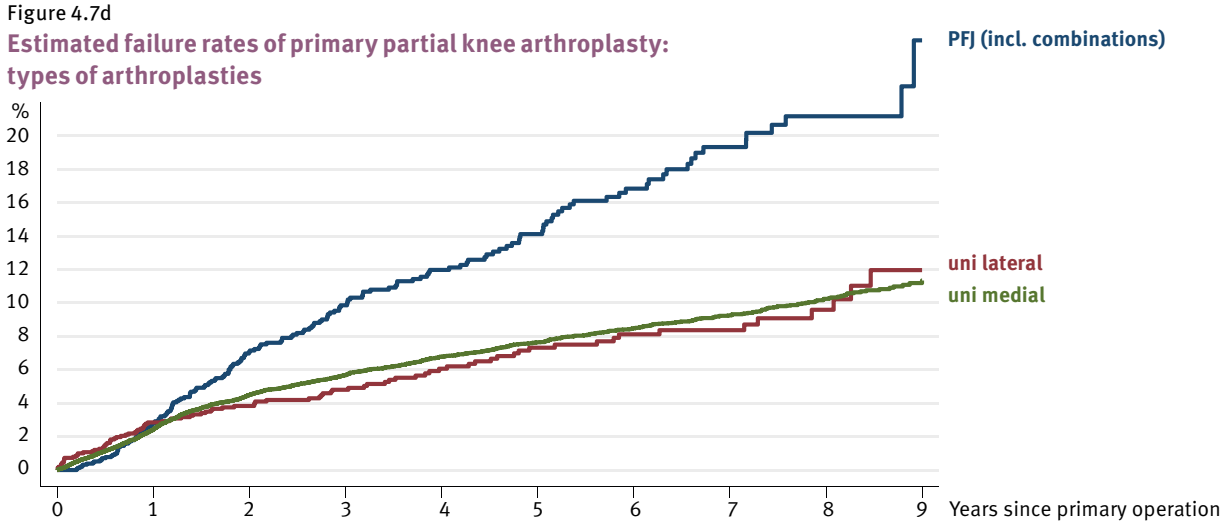
Time since operation, 2012–2021, all services, % of implants revised. Detailed reasons for revisions available since 2015.



Cumulative incidence for PKA revision shows what proportion of implants was subjected to at least one revision for a particular underlying cause (e.g. revision due to loosening of a component). In this type of graph, a line starts when the first relevant revision in the SIRIS dataset is recorded and ends with the last revision registered **(Figure 4.7a and 4.7b).** The timing of the revisions shares similarities with TKA revisions. Infections were revised relatively early (first year with a peak at three months), while all other revision causes were mostly associated with revisions from 9 months after surgery onwards

Figure 4.7d

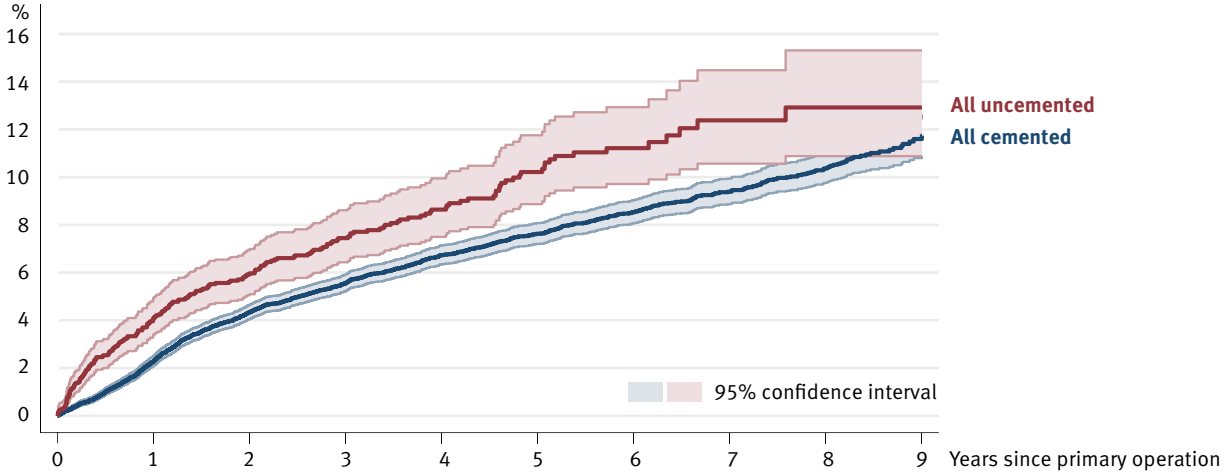
Estimated failure rates of primary partial knee arthroplasty: types of arthroplasties



	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
uni medial	**2.4** (2.2-2.7)	**4.5** (4.2-4.8)	**5.7** (5.3-6.0)	**6.8** (6.4-7.2)	**7.6** (7.2-8.1)	**8.5** (8.0-9.0)	**9.2** (8.7-9.8)	**11.3** (10.5-12.2)
uni lateral	**2.8** (2.1-3.9)	**3.8** (2.9-5.0)	**4.8** (3.8-6.1)	**6.1** (4.8-7.6)	**7.3** (5.9-9.1)	**8.1** (6.5-10.1)	**8.4** (6.7-10.4)	**12.0** (8.9-16.0)
PFJ (incl. combinations)	**2.8** (2.0-3.7)	**7.1** (5.8-8.6)	**9.9** (8.3-11.7)	**12.0** (10.2-14.0)	**14.1** (12.1-16.5)	**16.8** (14.4-19.6)	**19.3** (16.5-22.6)	**25.7** (19.4-33.6)

Figure 4.7e

Estimated failure rates of primary partial knee arthroplasty for main types of component fixation

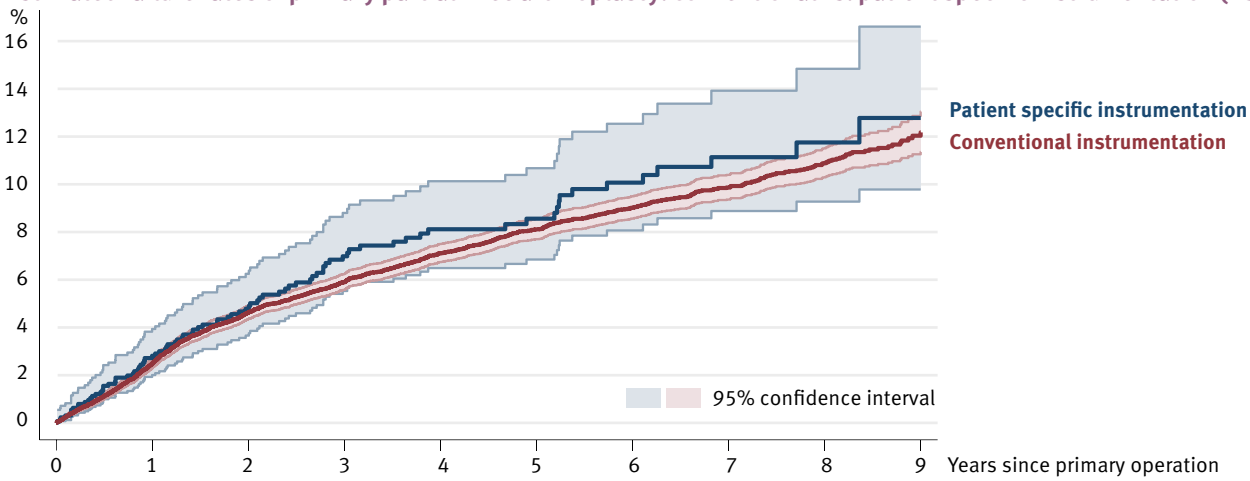


	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
All cemented	**2.3** (2.1-2.5)	**4.3** (4.1-4.6)	**5.6** (5.2-5.9)	**6.7** (6.3-7.1)	**7.6** (7.2-8.1)	**8.5** (8.1-9.0)	**9.4** (8.9-9.9)	**11.7** (10.9-12.6)
All uncemented	**4.1** (3.4-4.9)	**6.0** (5.1-7.0)	**7.4** (6.4-8.6)	**8.6** (7.5-9.9)	**10.2** (8.9-11.8)	**11.2** (9.7-12.9)	**12.4** (10.6-14.5)	**12.9** (10.9-15.3)

(Figure 4.7b). Loosening of the tibial component started early after index surgery and peaked shortly after one year and the maximum at 17 months after surgery after primary PKA **(Figure 4.7b).** However, the cumulative incidence chart clearly shows that after the two years of early revisions, loosening of the tibia and progression of OA drove the long-term revision rates up **(Figure 4.7a).**

Figure 4.7f

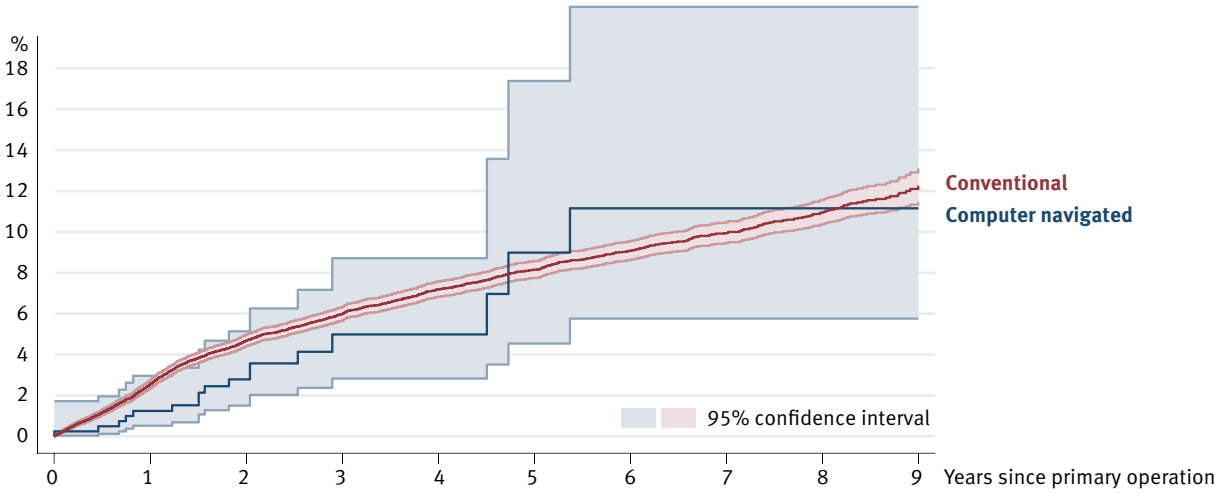
Estimated failure rates of primary partial knee arthroplasty: conventional vs. patient specific instrumentation (PSI)



	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
Conventional	**2.5** (2.3-2.7)	**4.6** (4.4-4.9)	**5.9** (5.6-**6.2**)	**7.1** (6.7-7.5)	**8.1** (7.7-8.5)	**9.0** (8.6-9.5)	**9.9** (9.4-10.4)	**12.2** (11.4-13.0)
PSI	**2.8** (2.0-3.9)	**4.8** (3.7-6.2)	**7.0** (5.5-8.8)	**8.1** (6.5-10.1)	**8.6** (6.8-10.7)	**10.1** (8.1-12.5)	**11.1** (8.9-13.9)	**12.8** (9.8-16.6)

Figure 4.7g

Estimated failure rates of primary partial knee arthroplasty: conventional vs. computer navigated



	1 year	2 years	3 years	4 years	5 years	6 years	7 years	9 years
Conventional	**2.5** (2.3-2.7)	**4.7** (4.4-5.0)	**6.0** (5.7-6.3)	**7.2** (6.8-7.6)	**8.1** (7.7-8.6)	**9.1** (8.6-9.5)	**9.9** (9.4-10.5)	**12.2** (11.4-13.1)
Computer navigated	**1.2** (0.5-3.0)	**2.8** (1.5-5.1)	**5.0** (2.8-8.7)	**5.0** (2.8-8.7)	**9.0** (4.5-17.4)	**11.2** (5.8-21.0)	**11.2** (5.8-21.0)	

4.8 Results of implants in partial knee arthroplasty

Table 4.8a shows the top 10 PKA systems used in Switzerland, accounting for 94% of all PKAs, or 14,909 cases since 2016. Other systems were only used in 1,007 cases between 2016 and 2021; 104 implants (0.6%) could not be classified.

Long-term revision rates are found in **Table 4.8b,** again with the share of implants for hospital services (case concentration score CCS) in the third column. For instance, Allegretto has been performed in only one hospital service since 2012. **Figure 4.8a** demonstrates a PKA system with an elevated revision rate starting right after surgery and staying above the average until nine years af-

Table 4.8a
Top 10 (94%) of primary partial knee arthroplasty systems (all diagnoses, all component fixations) 2016-2021

Knee system	2016	2017	2018	2019	2020	2021	2016–2021
Allegretto	104	93	89	101	67	84	538
Balansys uni system	284	304	280	354	298	349	1,869
GMK uni	124	184	196	222	204	156	1,086
Journey uni	113	127	90	89	88	75	582
Oxford cemented/hybrid	490	472	350	308	271	249	2,140
Oxford cementless	322	353	362	316	353	316	2,022
Persona partial knee	0	90	346	417	409	437	1,699
Physica ZUK	294	219	199	251	330	334	1,627
Restoris MCK	0	0	35	128	110	112	385
Sigma partial knee	413	424	416	496	602	610	2,961
Other systems	137	158	141	168	174	229	1,007
Total	**2,808**	**2,977**	**2,999**	**3,441**	**3,563**	**3,613**	**19,401**

Table 4.8b

Long term evaluation: Failure rates of primary partial knee arthroplasty systems (all diagnoses, all component fixations)

Time since operation, 2012–2021. Please note that if reported systems involves multiple sub-variants, it is possible that the long-term performance of these sub-variants may be significantly different from their combined performance.

Knee system	Total number	CCS*	Mean age**	1 year (95% CI)	3 years (95% CI)	5 years (95% CI)	7 years (95% CI)	9 years (95% CI)
Allegretto	985	100	70	**0.4** (0.2-1.2)	**1.4** (0.8-2.4)	**3.1** (2.0-4.6)	**4.3** (2.9-6.4)	**4.7** (3.2-7.0)
Balansys uni system	2,964	51	65	**2.2** (1.7-2.8)	**4.7** (4.0-5.6)	**6.1** (5.2-7.2)	**7.2** (6.1-8.5)	**10.2** (8.2-12.8)
GMK uni	1,480	20	66	**3.1** (2.3-4.2)	**7.6** (6.2-9.3)	**9.5** (7.9-11.5)	**11.0** (9.0-13.4)	**14.5** (11.1-19.0)
Journey uni	976	11	64	**3.6** (2.6-5.0)	**9.3** (7.6-11.5)	**16.6** (14.0-19.6)	**19.1** (16.2-22.5)	**25.1** (18.0-34.3)
Oxford cemented/hybrid	3,896	22	65	**2.6** (2.1-3.1)	**5.4** (4.7-6.2)	**7.4** (6.6-8.4)	**9.4** (8.4-10.6)	**11.9** (10.4-13.7)
Oxford cementless	2,358	12	64	**4.1** (3.3-5.0)	**6.8** (5.7-7.9)	**8.8** (7.5-10.3)	**10.3** (8.4-12.5)	**10.3** (8.4-12.5)
Persona partial knee	1,699	16	65	**2.1** (1.4-2.9)	**5.0** (3.8-6.5)			
Physica ZUK	3,149	17	65	**1.7** (1.3-2.3)	**5.3** (4.5-6.2)	**6.8** (5.9-7.9)	**8.7** (7.6-10.0)	**10.0** (8.5-11.7)
Sigma partial knee	4,235	15	65	**2.4** (1.9-2.9)	**5.6** (4.8-6.4)	**7.3** (6.4-8.3)	**8.1** (7.0-9.3)	**9.6** (8.1-11.4)
Other systems	1,701		64	**2.9** (2.1-3.9)	**7.5** (6.1-9.2)	**10.2** (8.4-12.4)	**13.8** (11.2-17.0)	**15.5** (12.2-19.7)
CH average for group				**2.5** (2.3-2.7)	**5.7** (5.4-6.0)	**7.8** (7.4-8.2)	**9.4** (8.9-9.9)	**11.5** (10.7-12.3)

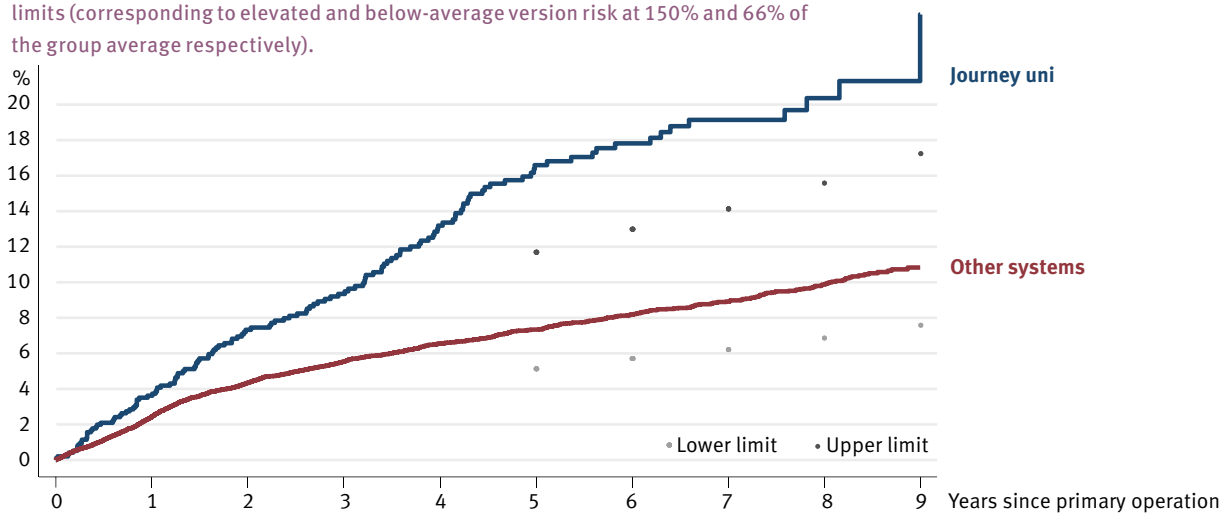
* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Younger mean age signifies that the case mix is less "usual" and potentially biased towards higher revision risk

Figure 4.8a

Implant combinations with long-term evaluation outlier status (all PKA)

Outlier status was defined as a revision rate of twice the group average at any time between year 5 and year 9 (and lower bounds of the 95% confidence interval exceeding the upper bound of the group average; and at least 50 cases at risk at 5 years). The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).



ter PKA. On the other hand, the already mentioned Allegretto performed significantly better than the PKA average between 2012 and 2021 **(Figure 4.8b).** All remaining systems for which the long-term evaluation has been performed are shown in in **Figure 4.8c.** Please note that this Kaplan-Meier graph also shows the relevant boundaries for elevated or better-than-average performance.

Figure 4.8d shows the two-year revision rate of PKA in the moving four-year window from January 1, 2016, to December 31, 2019, with a completed two-year follow-up before December 31, 2021. All the top 10 PKA systems used performed within the borders, not exceeding twice the average revision rate of all implants. The differences between the systems used were, however, considerable. Interest-

Figure 4.8b

Implant combinations with below-average long-term revision rates (PKA)

Below-average was defined as a 9-year revision rate of up to 66% of the group average (and upper bounds of the 95% confidence interval staying below the lower bound of the group average; and at least 25 cases at risk at 9 years). The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).

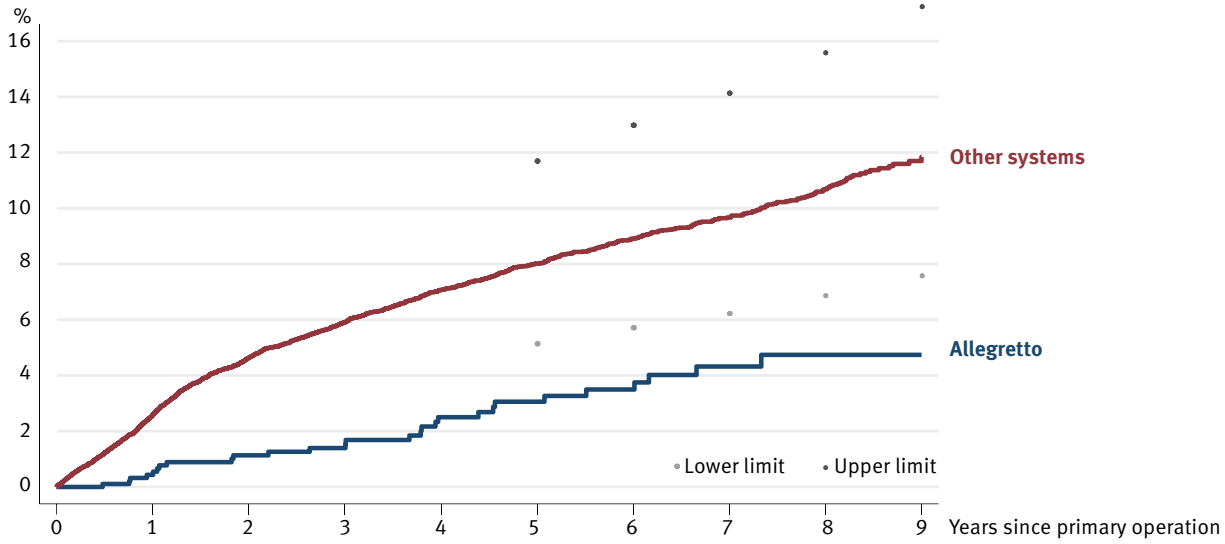


Figure4.8c

All remaining implant combinations with average revision risks

Also showing upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively). Only showing combinations with at least 100 cases still at risk at 5 years follow-up. The dots indicate upper and lower limits (corresponding to elevated and below-average version risk at 150% and 66% of the group average respectively).

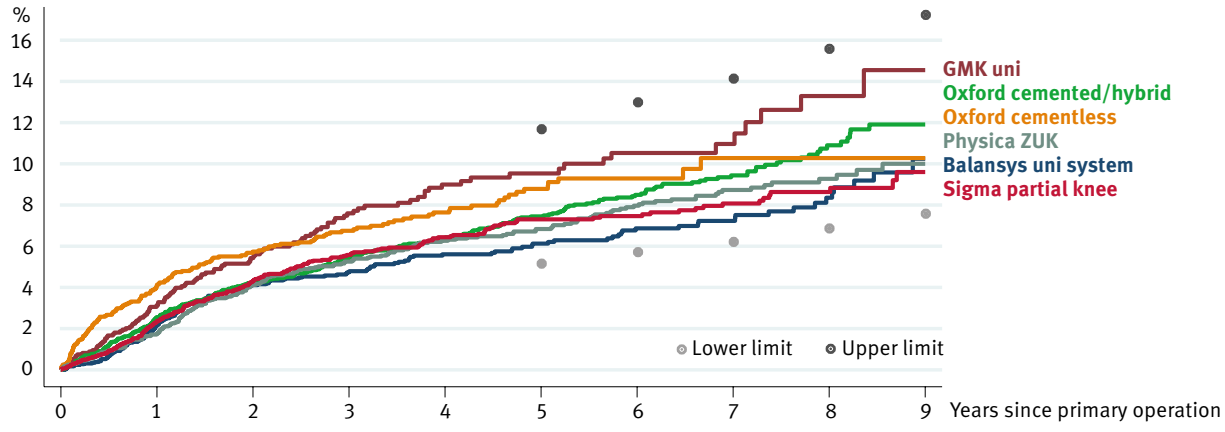
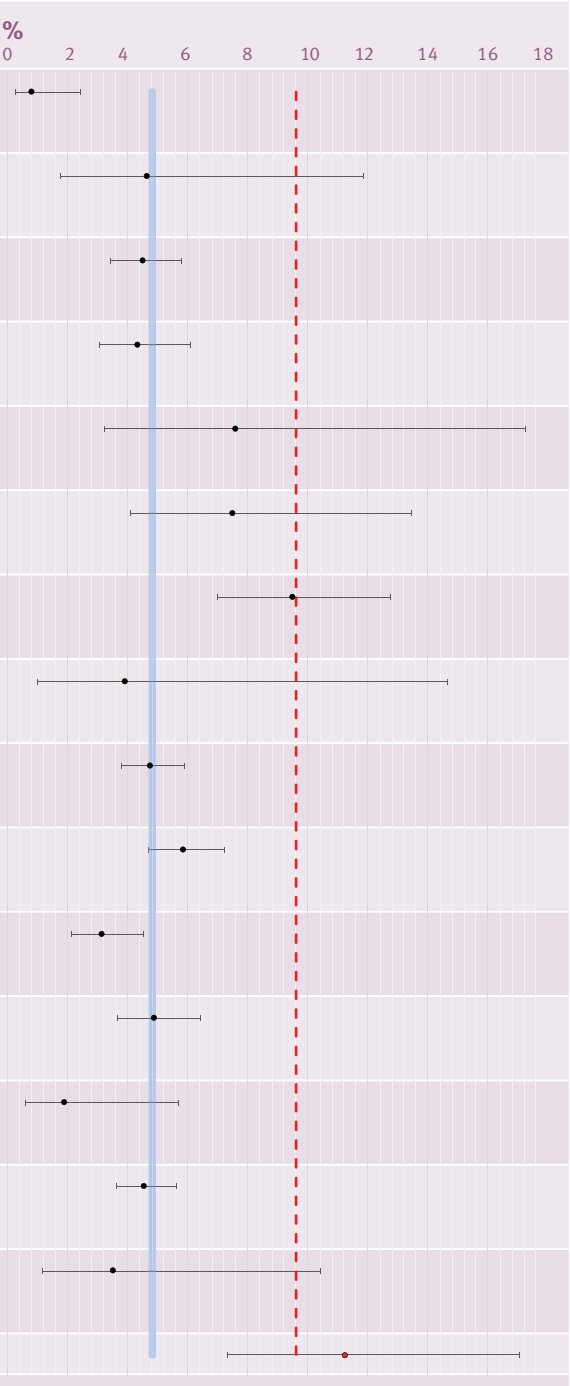


Figure 4.8d

2-year evaluation: Revision rates of primary partial knee arthroplasty systems within 24 months

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

Knee system	CCS*	Mean age	at risk N**	Revised N	Revised %***(95% CI)
Allegretto	100	71	387	3	0.8 (0.3-2.4)
Alpina	44	65	87	4	4.6 (1.8-11.9)
Balansys uni system	53	65	1,222	54	4.5 (3.4-5.8)
GMK uni	22	66	726	31	4.3 (3.1-6.1)
IBalance uni	36	61	69	5	7.6 (3.2-17.2)
IUni	20	61	135	10	7.5 (4.1-13.4)
Journey uni	11	63	419	39	9.5 (7.0-12.7)
Moto	75	69	52	2	3.9 (1.0-14.7)
Oxford cemented/hybrid	23	65	1,620	76	4.7 (3.8-5.9)
Oxford cementless	12	64	1,353	78	5.8 (4.7-7.2)
Persona partial knee	12	65	853	26	3.1 (2.1-4.5)
Physica ZUK	18	65	963	46	4.9 (3.7-6.4)
Restoris MCK	51	65	163	3	1.9 (0.6-5.7)
Sigma partial knee	14	65	1,749	77	4.5 (3.6-5.6)
Triathlon PKR	52	63	87	3	3.5 (1.1-10.4)
Other systems		62	174	19	11.2 (7.3-17.1)
CH average for group					4.8 (4.4-5.2)



* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

*** Rates adjusted for effects of mortality and emigration.

Group average

2-year revisionrate and 95% CI

Outlier alert boundary

ingly, "other systems" reached the classification potential outlier (confidence interval still inside the borders) irrespective of the PKA type implanted.

For the first time, patella-femoral partial knee arthroplasties (PFJ) were analysed separately, as the numbers were now sufficient to be analysed **(Table 4.8c).** Five systems used represented 95% of all PFJs or 1,118 implantations from 2016 to 2021. 57 PFJs were classified as "other", and 60 could not be classified at all (4.9%). **Table 4.8d** compares the most often used system to the others summarised in a second group. The different systems had two-year revision rates in the boundaries of the average of all PFJs used in Switzerland **(Figure 4.8e).**

Table 4.8c

Top 5 (95%) of primary patellofemoral joint systems (all diagnoses, all component fixations) 2016-2021

Knee system	2016	2017	2018	2019	2020	2021	2016–2021
Gender PFJ	69	72	101	102	159	107	610
Hemicap PF classic/wave (PFJ)	20	24	26	23	30	39	162
IBalance PFJ	28	38	29	17	24	17	153
Journey PFJ	19	17	20	18	20	18	112
Restoris MCK PFJ	0	0	4	24	25	28	81
Other systems	20	16	2	0	6	13	57
Total	**156**	**167**	**182**	**184**	**264**	**222**	**1,175**

Table 4.8d

Long term evaluation: Failure rates of primary patellofemoral joint systems (all diagnoses, all component fixations)

Time since operation, 2012–2021. Please note that if reported systems involves multiple sub-variants, it is possible that the long-term performance of these sub-variants may be significantly different from their combined performance.

Knee system	Total number	CCS*	Mean age**	1 year (95% CI)	3 years (95% CI)	5 years (95% CI)	7 years (95% CI)	9 years (95% CI)
Gender PFJ	761	10	58	**2.5** (1.5-3.9)	**8.4** (6.3-11.2)	**11.8** (9.1-15.3)	**16.8** (12.6-22.2)	
Other systems	849		57	**3.0** (2.0-4.5)	**11.0** (8.9-13.7)	**16.1** (13.2-19.6)	**19.7** (16.2-23.8)	**27.0** (19.7-36.4)
CH average for group				**2.7** (2.0-3.7)	**9.8** (8.2-11.7)	**14.2** (12.1-16.7)	**18.3** (15.6-21.4)	**24.5** (18.4-32.0)

* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

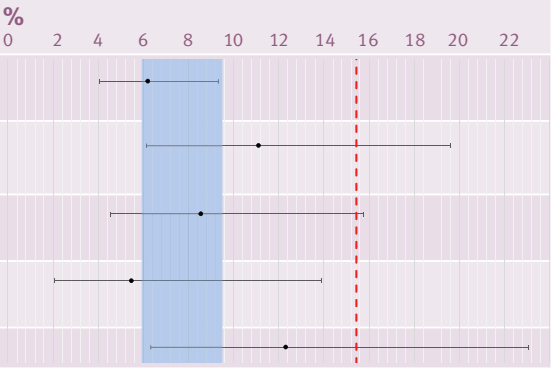
** Younger mean age signifies that the case mix is less "usual" and potentially biased towards higher revision risk

Figure 4.8e

2-year evaluation: Revision rates of primary patellofemoral joint systems within 24 months

4-year moving average covering implants between 01.01.2016 and 31.12.2019, with two years follow-up (31.12.2021)

Knee system	CCS*	Mean age	at risk N**	Revised N	Revised %***(95% CI)
Gender PFJ	10	58	344	21	6.2 (4.1-9.3)
Hemicap PF classic/wave (PFJ)	13	54	93	10	11.1 (6.1-19.6)
IBalance PFJ	20	57	112	9	8.5 (4.5-15.7)
Journey PFJ	20	55	74	4	5.5 (2.1-13.9)
Other systems		59	66	8	12.3 (6.3-23.1)
CH average for group					7.7 (5.9-10.0)



* Case concentration score. Share of implants accounted for by main user hospital service. A higher share signifies an increased likelihood of biased figures due to local effects. A share of 50%+ would suggest that reported results are likely determined by one hospital service.

** Number of patients with at least two years follow-up (i.e. primary prosthesis in moving average).

*** Rates adjusted for effects of mortality and emigration.

Group average

2-year revisionrate and 95% CI

Outlier alert boundary

Important information on the use of the implant performance tables below

- Estimated revision rate exceeds the alert boundary, but we do not identify this implant combination as an outlier because the 95% confidence interval overlaps the confidence zone of the reference group.
- Identified as potential outliers. Please note the statistical confidence intervals. The outlier status comes with varying degrees of statistical probability. We consider the potential outlier status „highly likely“ when both the estimated revision rate and the complete confidence interval exceed the outlier alert boundary.

Please be aware that relatively rare implant combinations are frequently used in only a small number or indeed only in one hospital in Switzerland. Observed revision rates may be determined by local factors and performance may differ significantly between locations. Manufacturers of detected outlier implants and the hospitals where they were used (and revisions occurred) have been informed by SIRIS.

SIRIS outlier watch list – hip implants

Implant or implant combination	Detected as outlier in report	Risk-adjusted hazard ratios for 2-year revision risk						Summary
		for age and sex			for age, sex, BMI, ASA and Charnley Class (from 2015, if available)			
		HR	lb95%	ub95%	HR	lb95%	ub95%	
Uncemented stem/cup combinations (primary osteoarthritis)								
Alloclassic + Fitmore	**2022**	1.49	1.02	2.17	1.26	0.60	2.64	It is very unlikely that this combination represents an actual outlier combination. The potential outlier detection is based on an unusual number of revisions detected after 2017 against a falling number of primary uses. In fact, few uses were registered in 2021 (down from 100+ per year before 2016). It was mainly in use in one hospital and therefore there is a high likelihood of a local effect in 2017. Performance before the 2017 peak in revisions was unremarkable. Recommended course of action: investigate reasons for revisions of implants used in 2017 and observe further performance locally.
AMIStem + Mpact	2019							Not anymore identified as a potential outlier. The outlier status in 2019 was caused by early implants. Performance since 2017 has been average or better.
(AMIStem + Versafitcup DM)	2020	2.14	1.02	4.51	2.30	1.03	5.15	Due to the reclassification of implants in 2022, we narrowed down the stem in this combination to the Amistem-H proximal coating variant. This particular combination was mainly used in one hospital and only between 2016 and 2020. A small absolute number of revisions was recorded against a moderate number of primary procedures, but the deviation from an average 2-year-revision rate is still very marked, albeit with very limited statistical precision. It is also noteworthy that the stem and the cup observed individually are performing adequately at two years.
	2021	2.00	0.95	4.21	2.18	0.98	4.88	
Amistem-H prox coating + Versafitcup DM	**2022**	3.11	1.29	7.49	3.17	1.31	7.62	
Corail + Delta motion	2019							Not anymore identified as a potential outlier. The outlier status in 2019 was caused by early implants. Performance since 2017 has been average or better.
Exception + Exceed	2020	1.53	0.69	3.40	1.30	0.33	5.22	Not anymore identified as a potential outlier because of lack of statistical certainty. We already noted in past reports that it was unlikely that this combination represented a genuine outlier because current use is limited to one hospital where the performance is statistically inconclusive due to small numbers.
	2021	1.59	0.76	3.33	1.48	0.48	4.61	
GTS + Exceed	2019							Not anymore identified as a potential outlier. This combination is not in active use anymore.
GTS + G7 bi-spherical	2019							GTS + G7 bi-spherical is very likely a problematic stem-cup combination. It was practically in use in one hospital and there were no further uses recorded in 2021. It is noteworthy that both stem and cup observed individually have been performing poorly.
	2020	5.27	3.22	8.62	3.39	1.52	7.57	
	2021	5.15	3.24	8.19	3.84	1.92	7.71	
	2022	5.15	3.28	8.09	3.96	2.06	7.63	
(Harmony + Gyracup)	2020	3.97	1.98	7.94	3.55	1.76	7.13	Due to the reclassification of implants this combination is now correctly identified as Harmony + Symbol DMHA/DS. evolution (Gyracup being an alternative brand name not actually used in Switzerland). It was in use in only one hospital and active use ceased in 2019 after an unusual number of revisions.
Harmony + Symbol DMHA/DS evolution	**2022**	3.67	1.83	7.35	3.20	1.60	6.42	
Polarstem + EP-fit	2020	1.93	1.30	2.86	2.52	1.42	4.45	POLARSTEM and EP-FIT is a potential outlier combination, as its risk adjusted hazard ratio just exceeds the relevant threshold of two. In 2021 it was in active use in two hospitals and it is noteworthy that an unusual number of infections was recorded as reasons for revisions. Without those infections, the combination's performance would have been average. Recommended course of action: investigate reasons for revisions and observe further performance.
	2021	1.89	1.30	2.74	2.31	1.39	3.84	
	2022	1.92	1.36	2.71	2.14	1.38	3.33	
SPS evolution + April ceramic	2020	2.22	1.72	2.88	3.67	2.47	5.47	SPS Evolution + APRIL Ceramic is probably a problematic outlier combination considering the overall performance over several years of both the combination and the separate components in more than one hospital. It is noteworthy that the risk-adjusted hazard ratio clearly exceeds the critical value of two including its confidence interval. Recommended course of action: investigate causes of revisions where those are higher than average and observe future performance.
	2021	2.33	1.84	2.96	3.50	2.42	5.06	
	2022	2.50	2.01	3.11	3.50	2.51	4.88	

Implant or implant combination	Detected as outlier in report	Risk-adjusted hazard ratios for 2-year revision risk						Summary
		for age and sex			for age, sex, BMI, ASA and Charnley Class (from 2015, if available)			
		HR	lb95%	ub95%	HR	lb95%	ub95%	
SPS HA + April ceramic	2021	2.61	1.44	4.73	2.85	1.18	6.87	SPS HA + April ceramic appears to be following the same pattern as the other SPS/April ceramic combinations, although only actively used in significant numbers in two hospitals and only rarely between 2017 and 2019. Active use practically stopped in 2021 with only 2 registered uses.
	2022	2.61	1.44	4.72	2.84	1.18	6.85	
SPS modular + April ceramic	2019							Not identified anymore as an outlier combination. The last registered use was in 2018.
	2020	2.95	1.94	4.49	1.61	0.23	11.50	
	2021	2.90	1.91	4.41	1.59	0.22	11.32	
Stelia-stem + Ana.nova hybrid	2019							Not identified anymore as an outlier combination. The last registered use was in 2019. It is still listed in the annual report with an unremarkable revision rate. This is due to the fact that years with particularly poor performance have been replaced with years with better performance in the evaluation period.
	2020	2.65	1.71	4.12	2.30	1.26	4.22	
	2021	2.60	1.68	4.04	2.20	1.20	4.01	
Twinsys + Selexys PC	2020	1.96	0.98	3.93	4.93	1.58	15.34	Not identified anymore as an outlier combination. The last use was registered in 2019.
Hybrid fixation stem/cup combinations (primary osteoarthritis)								
CCA + RM Pressfit vitamys	2020	1.83	0.75	4.45	1.91	0.60	6.07	**Not anymore identified as a potential outlier because of lack of statistical certainty.**
	2021	2.05	0.91	4.63	1.86	0.59	5.91	
PF + Fitmore	2020	0.84	0.27	2.61	1.04	0.14	7.45	PF Stems + Fitmore Cups was not actually an outlier combination. The potential outlier status (sitting exactly on the alert level boundary in the Annual Report 2020) was an artefact of only 3 revisions against a very small volume of operations in the reporting timeframe. The stem-cup combination is also not actively used anymore.
Twinsys cemented + RM pressfit	2019							Not anymore identified as a potential outlier. It remains in active use and recent performance has been average.
Weber + Alloclassic	2019							Not anymore identified as a potential outlier. Active use ended in 2020.
	2020	2.91	1.20	7.05	3.48	1.10	11.02	
Uncemented stem/cup combinations (fractures)								
CLS Spotorno + Allofit	**2022**	2.18	1.20	3.95	3.48	0.94	4.81	This combination is in active use in only a few hospitals. Most revisions are registered by its main user, which leads to the conclusion that the outlier status is a result of a local effect. Recommended course of action: investigate reasons for revisions and observe further performance locally. It is noteworthy that it is the performance of the stem that appears to be determining the outlier status whilst the cup's performance is unremarkable.
Fitmore + Allofit	**2022**	1.37	0.77	2.43	1.87	0.88	3.98	It is unlikely that this combination represents a genuine outlier. Its performance is unremarkable in the main using hospital, as has been recent performance in general. The outlier status has been caused by poor performance among several small volume users between 2016 and 2019.

SIRIS outlier watch list – knee systems

Implant or implant combination	Detected as outlier in report	Risk-adjusted hazard ratios for 2-year revision risk						Summary
		for age and sex			for age, sex, BMI, ASA and Charnley Class (from 2015, if available)			
		HR	lb95%	ub95%	HR	lb95%	ub95%	
Total knee systems								
E.motion PS	2019							Not anymore identified as a potential outlier. The outlier status in 2019 was caused by early implants. Performance has been improving over time. As of AR2022 we only report the combined knee system E.Motion.
Journey II	2019							It is likely that Journey II represents a problematic system in the sense that it consistently registers above average revision rates. The longer-term performance beyond the report's primary focus of 2-year revision rates would indicate that the system in its current use has problems, at least in some hospitals. The reported hazard ratios (after controls) suggest that the revision risk is indeed doubled compared to all other systems, but it could still be lower or even higher. The revision burden appears to deviate markedly from the group average at about one year after implantation and patella problems/revisions are relatively more common in Journey II than in other systems. The system is used in several hospitals, but about 40% of implants were used in one hospital alone. Recommended course of action: investigate reasons for revisions locally and observe future performance. The 2-year revision rate is actually falling and as of 2022 it is only slightly above the outlier boundary.
	2020	2.17	1.81	2.61	2.10	1.69	2.61	
	2021	2.06	1.74	2.46	2.00	1.63	2.45	
	2022	1.93	1.64	2.29	1.81	1.48	2.20	
Physica KR	2019							As of 2022, we combined Physica PS and KR into one system in our reporting.
	2020	3.97	2.13	7.38	3.20	1.20	8.54	
	2021	3.80	2.04	7.07	3.06	1.14	8.17	
Physica PS	2019							As of 2022, we combined Physica PS and KR into one system in our reporting.
	2020	3.32	1.96	5.61	3.06	1.73	5.41	
	2021	3.11	1.84	5.25	2.91	1.65	5.51	
Physica KR/PS	**2022**	3.25	2.17	4.85	2.83	1.73	4.63	It is likely that Physica KR/PS represents a problematic knee system at least in the hospital where the majority of implants have been used. The probability of a local hospital effect must be rated as rather high given the evidence. Active use ended in 2019.
Partial knee system								
Journey Uni	2020	1.82	1.38	2.39	1.56	0.96	2.53	It is likely that JOURNEY UNI represented a problematic knee system at least between 2015 and 2019, but there are signs of improvement in 2020 and 2021. While the statistical precision within the report's main timeframe of interest (2-year revision rate) is relatively low, and the system actually fell below the outlier boundary in 2022, the development of the revision risk beyond two years follow-up strongly suggests an unusual pattern. The system was identified as an outlier in the first round of long-term-evaluation (from 5 years) in 2022. It should also be noted that the better position in 2022 is mainly due to the inclusion of poorly performing "other systems" in the evaluation and thus a right-shift of the outlier boundary. Recommended course of action: investigate reasons for revisions and observe future performance.
	2021	1.81	1.39	2.35	1.68	1.10	2.58	
	2022	1.61	1.25	2.08	1.51	1.02	2.23	

List of manufacturers and distributors

List of companies with implants registered in the SIRIS registry
2021

Company	Headquarters Switzerland	Corporate domicile
Amplitude Switzerland	Genf	France
Argomedical AG	Cham	Switzerland
Arthrex Swiss AG	Belp	Germany
Arthrosurface	-	USA
ATF	-	France
B. Braun Medical AG	Sempach	Germany
CeramTec	-	Germany
Conformis	-	Germany
Corin GSA GmbH	Solothurn	United Kingdom
Dedienne Santé	-	France
DePuy Synthes Johnson&Johnson	Zuchwil/Zug	USA
Exactech International Operation AG	-	USA
Heraeus Medical Schweiz AG	Zürich	Germany
Implantcast Suisse SA	Basel	Germany
Lima Switzerland	Rotkreuz	Italy
Link Implants AG	Bern	Germany
Mathys (Schweiz) GmbH, enovis	Bettlach	Switzerland
Medacta International SA	Frauenfeld	Switzerland
OHST Medizintechnik AG	-	Germany
Permedica ORTHOPAEDICS (I)	Scairolo di Collina d'Oro	Italy
Peter Brehm GmbH (Schweiz)	Dietikon	Germany
PLUSOrtho Prothetik GmbH	Oftringen	Switzerland
Smith&Nephew Orthopaedics AG	Baar	United Kingdom
Stemcup Medical Products AG	Zürich	Switzerland
Stryker Osteonics SA	Biberist	USA
Swiss Synergy AG	Baar	Switzerland
Symbios Orthopédie SA	Yverdon-les-Bains	Switzerland
United Orthopedic Corporation Suisse SA	Yverdon-les-Bains	Switzerland
Zimmer Biomet	Winterthur	USA

Definitions

Acetabular component The part of a hip prosthesis that is implanted into the acetabulum – the socket part of a ball and socket joint.

Arthrodesis A procedure in which a natural joint is fused together.

Arthrofibrosis Rigidity of the joint as a consequence of connective tissue adhesion.

Arthrotomy The opening of a joint during surgery.

Articulation The two surfaces that move together (articulate) in a total joint replacement.

ASA score The scoring system of the American Society of Anaesthesiologists (ASA) for grading the overall physical condition of the patient, as follows: I: fit and healthy; II: mild disease, not incapacitating; III: incapacitating systemic disease; IV: life-threatening disease.

Benchmark Comparing the performances at a specific hospital to the mean performances of hospitals throughout Switzerland.

Bilateral Replacing the same joint on both sides of the body (typically both hips or knees) by means of a prosthesis (here meaning the replacement on both sides in one session).

Body Mass Index. . Is obtained by dividing body weight in kilograms by height in meters squared. Interpretation: ‹18.5: underweight; 18.5–24.9: normal weight; 25–29.9: overweight; 30–34.9: obese class I; 35–39.9: obese class II; ›40: obese class III.

Case mix Term used to describe variation in the population, relating to factors such as diagnosis, patient age, gender and health condition.

Cement Material (polymethyl methacrylate) used to fix joint replacements to bone.

Charnley score Clinical classification system – A: one joint affected; B1: both joints affected; B2: contralateral joint with a prosthesis; C: several joints affected or a chronic disease that affects quality of life.

Competing risks survival analysis Method to calculate survival taking into account various outcomes, in this case revision and death.

Cumulative incidence Overall incidences over a specific period of an event (such as the revision of a prosthesis or death of a patient).

Cumulative revision percentage Overall revision percentage over a specific period.

Femoral component Part of a hip or knee prosthesis that is implanted into the femur (thigh bone) of the patient.

Girdlestone Hip revision procedure in which the hip joint or hip prosthesis is removed and no new prosthesis is implanted (usually because of a bacterial infection).

Hybrid fixation Fixation of a prosthesis in which one of the two parts of a prosthesis is cemented and the other one uncemented.

Head component Part of a hip prosthesis that is implanted on top of the femoral component of a hip prosthesis and moves inside the acetabular component of the hip joint.

Hospital service volumes In the tables depicting the total number arthroplasty procedures per year. Four categories of hospital service volume were used (‹100, 100–199, 200–299, 300+ procedures per year). The calculation of the annual volume was performed separately for hip and knee surgeries, using the average of all (primary and revision) procedures recorded in each hospital service in 2013–2021.

Acetabular inlay (insert) Intermediate component (inner layer), made usually of polyethylene (but also other materials), which is placed in the acetabular component.

Kaplan-Meier survival analysis Method to calculate survival, in which only one end point is possible, in this case revision.

Kernel density plot A variation of a histogram that uses kernel smoothing to plot values. The underlying kernel is usually Gaussian distribution. One advantage of density plots over histograms is that they are not stepped depending of the number of bins used (histogram bars), but are always smooth lines. The second advantage is that several lines can be plotted over each other and still be visible, which could be difficult with more than two overlaying histograms.

Knee inlay (insert) Intermediate component of the knee prosthesis. It is made of polyethylene and placed between the femoral and tibial components.

Lateral collateral ligament Lateral (outer) knee ligament.

Malalignment Malpositioning of prosthetic components significantly deviating from physiological norms.

Meniscectomy Meniscus removal.

Metallosis Deposition of metal debris in soft tissues of the body, usually around the prosthesis.

Osteoarthritis Disease of the joint in which the cartilage is damaged/destroyed, and the underlying bone altered

Osteochondral bone defect Defect of the joint surface in which both cartilage and the underlying bone are affected

Osteonecrosis Cellular death of bone tissue.

Osteosynthesis Securing broken bone parts together with plates, pins and/or screws.

Osteotomy Cut of the bone with a saw or chisel in order to correct its position, to shorten or lengthen it.

Patellar component Part of a knee prosthesis that is implanted on the inner side of the knee cap.

Patellofemoral prosthesis Two-piece knee prosthesis that provides a prosthetic (knee) articulation surface between the patella and trochlea (furrow) of the thigh bone (femur).

Primary prosthesis The first time replacement of the original joint with a prosthesis .

PROMs Patient Reported Outcome Measures.

Resurfacing hip arthroplasty Hip prosthesis in which the cup (acetabulum) is replaced and a metal cap is implanted on top of the femoral head.

Reverse hybrid fixation hip prosthesis Fixation of a hip or knee prosthesis in which one component is cemented and the other uncemented.

Revision A revision procedure is a secondary surgical procedure of a patient's hip or knee joint whereby the complete primary implant or parts thereof are replaced by new components.

Reoperation All secondary procedures, where no components of the primary implantation are removed.

Revision burden The ratio of revision procedures to all primary and arthroplasty procedures.

Sarcopenia The degenerative loss of skeletal muscle mass and strength associated with aging.

Synovectomy Removal of inflamed mucosa in a joint.

Tibial component Part of a knee prosthesis that is inserted in the tibia (shin bone) of a patient.

Total joint arthroplasty Arthroplasty in which the entire joint of a patient is replaced.

Unicompartimental knee arthroplasty Replacement of half the knee (either inner or outer side) by a prosthesis.

Abbreviations

ASA	American Society of Anaesthesiologists
AVN	Avascular Necrosis
BMI	Body Mass Index
CI	Confidence Interval
CRF	Case Report Form
HA	Hemiarthroplasty of the hip
HR	Hazard ratio
IQR	Interquartile range
KLM	Kaplan Meier estimate
lb/ub	Lower, upper bound (of a convidential ratio)
MCL	Medical Collateral (Inner Knee) Ligament
OA	Osteoarthritis
PROMs	Patient Reported Outcome Measures
SD	Standard Deviation
SHR	Subhazard ratio
Sig	Significance
THA	Total Hip Arthroplasty
TKA	Total Knee Arthroplasty
UKA	Unicompartmental Knee Arthroplasty

Participating hospitals (153)

	Group	Clinic
AG		Kantonsspital Aarau
AG		Kantonsspital Baden
AG		Spital Muri
AG		Spital Zofingen
AG	Asana Gruppe	Spital Leuggern
AG	Asana Gruppe	Spital Menziken
AG	Gesundheitszentrum Fricktal	Spital Rheinfelden
AG	Hirslanden Gruppe	Klinik Aarau
AG	Swiss Medical Network	Privatklinik Villa im Park
AI		Kantonales Spital und Pflegezentrum Appenzell
AR		Berit Klinik AG
AR	Hirslanden Gruppe	Klinik Am Rosenberg AG
AR	Spitalverbund Appenzell (AR)	Spital Herisau
AR	Spitalverbund Appenzell (AR)	Spital Heiden
BE		Klinik Hohmad
BE		Spitalzentrum Biel
BE	Hirslanden Gruppe	Klinik Beau-Site
BE	Hirslanden Gruppe	Klinik Linde AG
BE	Hirslanden Gruppe	Salem-Spital
BE	Hirslanden Gruppe	Klinik Permanence
BE	Swiss Medical Network	Hôpital du Jura bernois, Saint-Imier
BE	Swiss Medical Network	Hôpital de Moutier SA
BE	Insel Gruppe	Spital Aarberg
BE	Insel Gruppe	Inselspital, Unispital Bern
BE	Insel Gruppe	Spital Münsingen
BE	Insel Gruppe	Spital Riggisberg
BE	Insel Gruppe	Spital Tiefenau
BE	Lindenhofgruppe	Lindenhofspital
BE	Lindenhofgruppe	Sonnenhofspital
BE	Spital Emmental	Standort Burgdorf
BE	Spital Emmental	Standort Langnau
BE	Spitäler fmi	Spital Frutigen
BE	Spitäler fmi	Spital Interlaken
BE	Spital Region Oberaargau SRO	Spital Langenthal
BE	Spital STS	Spital Thun
BE	Spital STS	Spital Zweisimmen
BE	Swiss Medical Network	Privatklinik Siloah
BS		Merian Iselin Klinik für Orthopädie und Chirurgie
BS	Universitätsspital Basel	Standort Betesda
BS	Universitätsspital Basel	Standort Uni-Spital
BL		Praxisklinik Rennbahn
BL	Hirslanden Gruppe	Klinik Birshof
BL	Kantonsspital Baselland	Liestal
BL	Kantonsspital Baselland	Bruderholz
FL		Liechtensteinisches Landesspital
FR	Hôpital fribourgeois HFR	HFR Hôpital cantonal
FR	Hôpital fribourgeois HFR	HFR Riaz
FR	Hôpital fribourgeois HFR	HFR Tafers
FR	Swiss Medical Network	Clinique Générale Ste-Anne
GE		Clinique Vert Pré
GE		Hôpital de La Tour
GE		Hôpitaux universitaires de Genève HUG
GE	Hirslanden Gruppe	Clinique La Colline SA
GE	Hirslanden Gruppe	Clinique des Grangettes SA
GE	Swiss Medical Network	Clinique Générale-Beaulieu
GL		Kantonsspital Glarus
GR		Flury Stiftung Spital Schiers
GR		Gesundheitszentrum Unterengadin
GR		Kantonsspital Graubünden
GR		Regionalspital Surselva AG
GR		Spital Davos
GR		Spital Oberengadin
GR		Spital Thusis
GR	Klinik Gut	Standort Fläsch
GR	Klinik Gut	Standort St. Moritz
JU	Hôpital du Jura	Site de Delémont
LU	Hirslanden Gruppe	Klinik St. Anna AG
LU	Hirslanden Gruppe	St. Anna in Meggen
LU	Luzerner Kantonsspital LUKS	Luzern
LU	Luzerner Kantonsspital LUKS	Sursee
LU	Luzerner Kantonsspital LUKS	Wolhusen
NE	Réseau hospitalier neuchâtelois	La Chaux-de-Fonds
NE	Réseau hospitalier neuchâtelois	Pourtalès
NE	Swiss Medical Network	Clinique Montbrillant
NE	Swiss Medical Network	Hôpital de la Providence
NW		Spital Nidwalden AG
OW		Kantonsspital Obwalden

	Group	Clinic
SG		Spital Linth
SG	Hirslanden Gruppe	Klinik Stephanshorn AG
SG	Spitalregion Fürstenland Toggenburg	Spital Wattwil
SG	Spitalregion Fürstenland Toggenburg	Spital Wil
SG	Spitalregion Rheintal Werdenberg Sarganserland	Spital Altstätten
SG	Spitalregion Rheintal Werdenberg Sarganserland	Spital Grabs
SG	Spitalregion Rheintal Werdenberg Sarganserland	Spital Walenstadt
SG	Kantonsspital St. Gallen	Kantonsspital St. Gallen
SG	Kantonsspital St. Gallen	Spital Flawil
SG	Kantonsspital St. Gallen	Spital Rorschach
SG	Swiss Medical Network	Rosenklinik
SH	Spitäler Schaffhausen	Kantonsspital Schaffhausen
SH	Swiss Medical Network	Privatklinik Belair
SO	Solothurner Spitäler AG	Bürgerspital Solothurn
SO	Solothurner Spitäler AG	Kantonsspital Olten
SO	Solothurner Spitäler AG	Spital Dornach
SO	Swiss Medical Network	Privatklinik Obach AG
SZ		Spital Lachen
SZ		Spital Schwyz
SZ	AMEOS	Spital Einsiedeln
TG		Klinik Seeschau
TG	Spital Thurgau AG	Kantonsspital Frauenfeld
TG	Spital Thurgau AG	Kantonsspital Münsterlingen
TI		Clinica Luganese Moncucco
TI		Clinica Santa Chiara
TI	Ente Ospedaliero Cantonale	Ospedale Regionale di Bellinzona e Valli
TI	Ente Ospedaliero Cantonale	Ospedale Regionale di Locarno - La Carità
TI	Ente Ospedaliero Cantonale	Ospedale Regionale di Lugano-Civico
TI	Ente Ospedaliero Cantonale	Ospedale Regionale di Lugano - Italiano
TI	Ente Ospedaliero Cantonale	Ospedale Regionale di Mendrisio
TI	Swiss Medical Network	Clinica Ars Medica
UR		Kantonsspital Uri
VD		CHUV Centre hospitalier universitaire vaudois
VD		Clinique de la Source
VD		Clinique La Prairie
VD	Clinique CIC Suisse SA	Clinique CIC Montreux
VD	Ensemble Hospitalier de la Côte EHC	Hôpital de Morges
VD	Etablissements Hospitaliers du Nord Vaudois eHnv	Hôpital de Saint-Loup
VD	Etablissements Hospitaliers du Nord Vaudois eHnv	Hôpital Yverdon-les-Bains
VD	Groupement Hospitalier de l'Ouest Lémanique (GHOL)	Hôpital de Nyon
VD	Hirslanden Gruppe	Clinique Bois-Cerf
VD	Hôpital intercantonal de la Broye HIB	Payerne
VD	Hôpital Riviera-Chablais HRC	Centre hospitalier de Rennaz
VD	Pôle Santé du Pays-d'Enhaut	Hôpital du Pays-d'Enhaut
VD	Réseau Santé Balcon du Jura RSBJ	Site des Rosiers
VD	Swiss Medical Network	Clinique de Genolier
VD	Swiss Medical Network	Clinique de Montchoisi
VS	Clinique CIC Valais	Clinique CIC Saxon
VS	Hôpital du Valais - Spital Wallis	Standort Brig
VS	Hôpital du Valais - Spital Wallis	Standort Visp
VS	Hôpital du Valais - Spital Wallis	Site Sion
VS	Hôpital du Valais - Spital Wallis	Site Martigny
VS	Swiss Medical Network	Clinique de Valère
ZG		Zuger Kantonsspital
ZG	Hirslanden Gruppe	AndreasKlinik Cham Zug
ZH		Kantonsspital Winterthur
ZH	Swiss Medical Network	Klinik Pyramide am See
ZH		Schulthess Klinik
ZH		Spital Affoltern
ZH		Spital Bülach
ZH		Spital Limmattal
ZH		Spital Männedorf
ZH		Spital Uster
ZH		Spital Zollikerberg
ZH		Universitätsspital Zürich
ZH		Universitätsklinik Balgrist
ZH	Adus-Medica AG	Adus Klinik
ZH	GZO	Spital Wetzikon
ZH	Hirslanden Gruppe	Klinik Hirslanden
ZH	Hirslanden Gruppe	Klinik Im Park
ZH	See-Spital	Standort Horgen
ZH	See-Spital	Standort Kilchberg
ZH	Stadtspital Zürich	Stadtspital Zürich Triemli
ZH	Stadtspital Zürich	Stadtspital Zürich Waid
ZH	Swiss Medical Network	Privatklinik Bethanien
ZH	Swiss Medical Network	Privatklinik Lindberg

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Ten Years of Swiss Hip and Knee Registry