

Osteoarthritis and Cartilage



Anatomical total shoulder arthroplasty used for glenohumeral osteoarthritis has higher survival rates than hemiarthroplasty: a Nordic registry-based study

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SUMMARY

Objective: To report the 10-year survival rates of different shoulder arthroplasty types used for glenohumeral osteoarthritis.

Design: Data from 2004 to 2013 was prospectively collected by the national shoulder arthroplasty registers in Denmark, Norway and Sweden and merged into a harmonized dataset under the umbrella of the Nordic Arthroplasty Register Association. The common dataset included data that all three registers could deliver and where consensus regarding definitions could be made. Revision was defined as removal or exchange of any component or the addition of a glenoid component.

Results: The cumulative survival rates at 10 years after resurfacing hemiarthroplasty (RHA) ($n = 1,923$), stemmed hemiarthroplasty (SHA) ($n = 1,587$) and anatomical total shoulder arthroplasty (TSA) ($n = 2,340$) were 0.85, 0.93 and 0.96 respectively ($P < 0.001$, Log rank test). RHA (HR: 2.5; CI 1.9–3.4, $P < 0.001$) and SHA (HR: 1.4; CI 1.0–2.0, $P < 0.04$) had an increased risk of revision compared to TSA. Gender, age and period of surgery were included in the Cox regression model. For patients below 55 years, the 10-year cumulative survival rates were 0.75 (RHA, $n = 354$), 0.81 (SHA, $n = 146$), and 0.87 (TSA, $n = 201$).

Conclusions: Anatomical TSA had the highest implant-survival rate. Young patients had, independently of the arthroplasty type, lower implant-survival rates. The treatment of young patients with end-stage osteoarthritis remains a challenge.

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Introduction

Previous literature has shown that anatomical total shoulder arthroplasty (TSA) is an effective treatment of end-stage

glenohumeral osteoarthritis with pain-relief and significant improvement in shoulder function^{1–4}. It is recommended by the American Academy of Orthopedic Surgeons in patients with an intact rotator cuff function⁵. Nevertheless, concerns have been raised about the arthroplasty longevity and especially glenoid loosening⁶. Furthermore, bone loss after glenoid loosening is associated with a technically demanding revision procedure with varying and, in many cases, disappointing outcomes^{7–11}.

Especially in the young patient with long life-time expectancy other arthroplasty types such as resurfacing hemiarthroplasty (RHA) has been used in order to avoid replacement of the glenoid. Theoretically, revision to a TSA is facilitated by the bone preserving

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Table 1
The hierarchy of diagnoses and the indication for revision

Diagnoses	Indications for revision
1. Acute Fracture	1. Infection
2. Fracture Sequelae	2. Periprosthetic fracture
3. Inflammatory arthritis	3. Luxation and instability
4. Rotator Cuff Arthropathy	4. Loosening of any component
5. Osteoarthritis	5. Rotator cuff problem
6. Others	6. Others

design^{12,13}, and some surgeons may see the RHA as the first in a series of arthroplasties. RHA is, however, associated with a high risk of revision mainly because of glenoid wear¹⁴ and previous literature has, despite the bone preserving design, reported disappointing outcomes of the revision procedure^{15,16}.

Thus, revision arthroplasty is a complex and demanding procedure that is inconvenient for the patient and a considerable economic burden for healthcare providers. Information about implant survival and risk factors for revision is sparse. The number of arthroplasties in single- and multi center studies or even national registry studies may not have sufficient numbers to report survival rates, especially not for a specific arthroplasty type or age category.

The aim of this study was to report the risk of revision after different shoulder arthroplasty types used for glenohumeral osteoarthritis using data from the combined Nordic Arthroplasty Register Association.

Method

Study settings

Data came from the Nordic Arthroplasty Register Association, which is the collaboration between the national shoulder arthroplasty registers in Denmark, Finland, Norway and Sweden. The

registers in Denmark, Norway and Sweden have collected data on shoulder arthroplasty surgery since 2004, 1994 and 1999 respectively. The Finnish register has collected data on shoulder arthroplasty surgery since 1980, but was unable to deliver data for the present study because of incomplete format.

All hospitals and private clinics performing shoulder arthroplasty surgery reported patient-related data (gender, age and diagnosis) and operative data (date, arthroplasty type and brand) at the time of surgery, both for primary and revision arthroplasties. The Norwegian¹⁷ and Danish¹⁸ registers have documented completeness of 90% whereas the completeness in the Swedish¹⁹ register is approximately 80%. Data from the national registers were harmonized and merged into a common dataset in 2014. The dataset only includes variables that all registries could deliver and where consensus regarding definitions and classification systems could be made²⁰.

Study population

The dataset contains records of 19,857 primary shoulder arthroplasties in 18,709 patients reported between January 2004 and December 2013. The time of surgery was divided into three categories: 2004–2007, 2008–2010, and 2011–2013. The indication for surgery was based on a hierarchy, Table 1. Thus, in cases where osteoarthritis was reported together with fracture, inflammatory arthritis or rotator cuff arthropathy, osteoarthritis was not regarded as the principal indication for arthroplasty. In the present study we reviewed all patients with osteoarthritis who underwent a stemmed hemiarthroplasty (SHA), a RHA or a stemmed anatomical TSA. Patients who underwent a stemless, metaphyseal fixed implant, arthroplasty with ($n = 210$) or without a glenoid component ($n = 165$) were not included in the present study because of limited number of arthroplasties. Patients who underwent a reverse shoulder arthroplasty ($n = 593$) were not included because of uncertainties regarding the rotator cuff status. The

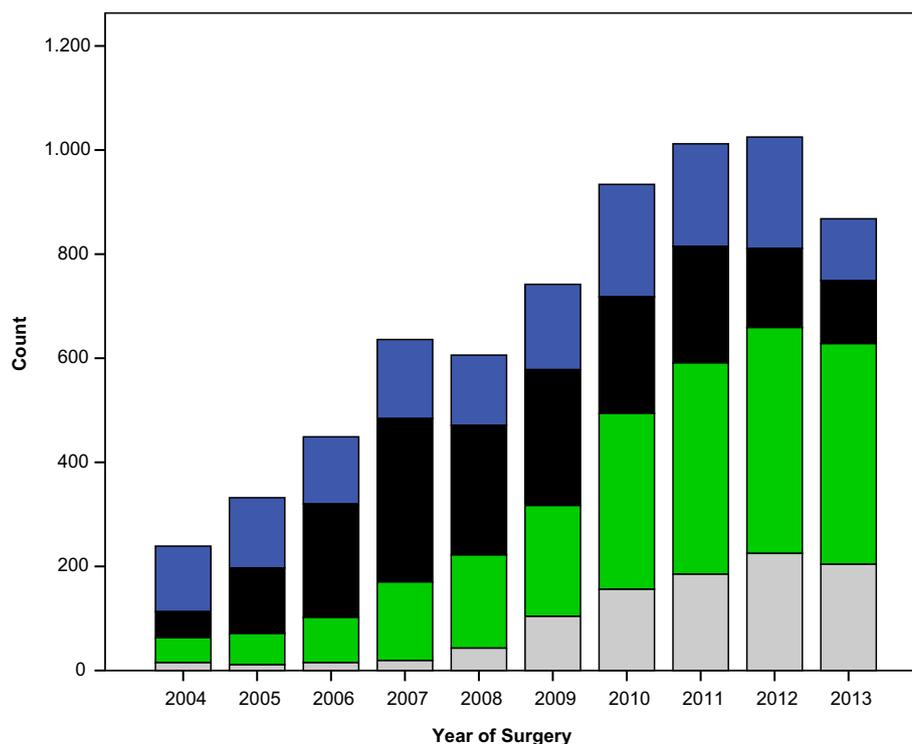


Fig. 1. The number of RHA (Black), SHA (blue), TSA (green), and others including reverse shoulder arthroplasty and stemless, metaphyseal fixed implant, arthroplasties (grey).

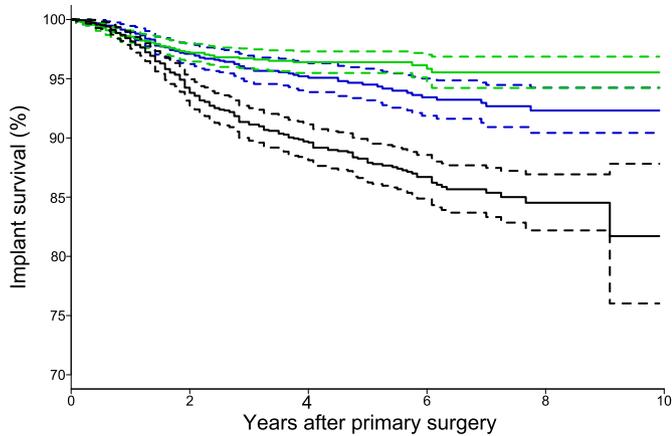


Fig. 2. The unadjusted cumulative survival rate of RHA (black), SHA (blue), and TSA (green), $P < 0.001$.

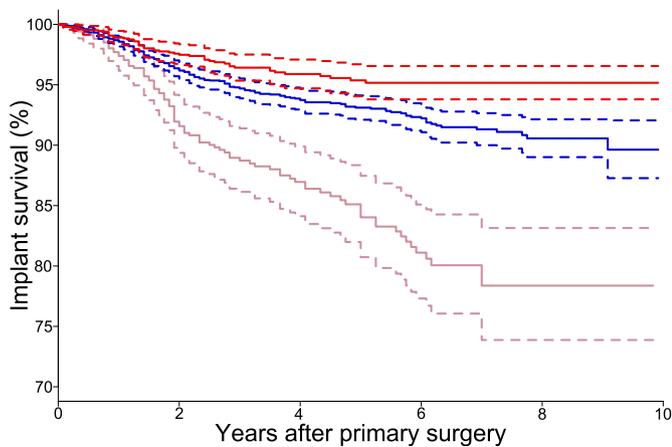


Fig. 3. The unadjusted cumulative survival rate of age categories: >75 years (red), 55–75 years (blue) and <55 years (pink), $P < 0.001$.

patients were divided into three age categories based on the age at the time of the primary arthroplasty: Under the age of 55 years, between 55 and 75 years, and older than 75 years.

Study outcome

We used revision for any reason as the primary outcome. A revision was defined as removal or exchange of any component or the addition of a glenoid component. In the Nordic countries, all patients can be identified by a unique civil registration number given at birth. The civil registration number was used to accurately link a revision to the primary procedure and to track patients who died or emigrated. For patients who emigrated or died the date of emigration or death were regarded as the end of follow-up. For those who were revised before emigration or death the revision was recorded as usual and included in the survival analyses. The indication for revision was based on a hierarchy in cases where more than one indication was reported, so that only one indication for revision was analyzed, [Table I](#).

Statistical analysis

Descriptive statistics were used to report demographic data, follow-up time, time to revision, and reasons for revision. The Kaplan–Meier method was used to illustrate the unadjusted

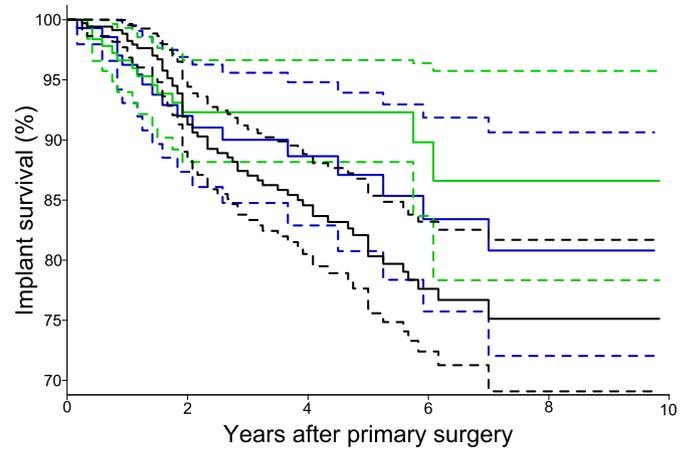


Fig. 4. The unadjusted cumulative survival rate of RHA (black), SHA (blue) and TSA (green) in patients younger than 55 years, $P = 0.005$.

10-year survival rates and the Log rank test was used for comparison. The Cox regression model was used to calculate hazard ratios (HR) with 95% confidence interval (95% CI). Age (continuous variable), gender, and period of surgery (2004–2007, 2008–2010 and 2011–2013) were included in the model when we compared arthroplasty types. Log–log plots and Schoenfeld residuals were used to check that the proportional hazards assumption was fulfilled. Patients with bilateral shoulder arthroplasty procedures were included in the survival analysis as if they were independent. The level of statistical significance was set at $P < 0.05$ and all p-tests were two-tailed. The analyses were performed using SPSS version 21.0 (IBM Corp., Armonk, New York) and [Figs. 2–4](#) were made using R Version 3.4.1 (The R Foundation, Vienna, Austria).

Results

Study population

We included 1,923 resurfacing hemiarthroplasties, 1,587 stemmed hemiarthroplasties and 2,340 total shoulder arthroplasties, [Table II](#). The incidence of shoulder arthroplasty in general and TSA in particular has increased during the study period, [Fig. 1](#). The mean observed follow-up time was 4.3 years (SD 2.4) for RHA, 4.3 years (SD 2.7) for SHA, and 3.1 years (SD 2.3) for TSA.

Arthroplasty survival rates

The cumulative implant-survival rates at 10 years after RHA, SHA and TSA were 0.85, 0.93 and 0.96 respectively, [Fig. 2](#). RHA (HR: 2.5; CI 1.9–3.4, $P < 0.001$) and SHA (HR: 1.4; CI 1.0–2.0, $P < 0.04$) had a higher hazard of revision compared to TSA. The mean time to revision for RHA, SHA and TSA was 2.4 years (SD 1.9), 2.5 years (SD 1.7), and 1.4 years (SD 1.3). The most common indications for revision of RHA and SHA were rotator cuff problem and other indications. These include: glenoid wear, malposition of the components and pain with no other reason reported. There were few revisions of TSA, and only 12 out of 2,340 arthroplasties were revised because of glenoid loosening (0.5%). For all arthroplasty types less than 1% percent were revised because of infection, [Table III](#).

There were few total shoulder arthroplasties in the beginning of the study period, and the indication for this arthroplasty type may have been rather selective in the first years. However, in the Cox regression model we included period of surgery and found no

Table II
Demographic data. SHA, RHA and anatomical TSA with number (N) and proportion (%) of primary arthroplasties

	RHA		SHA		TSA	
	N	%	N	%	N	%
Gender						
Male	875	45.5	651	41.0	997	41.8
Female	1048	54.5	936	59.0	1363	58.2
Age category						
<55 years	354	18.4	146	9.2	201	8.6
55–75 years	1175	61.0	914	57.6	1575	67.3
>75 years	564	20.4	526	33.1	564	24.1
Time of Surgery						
2004–2007	699	36.4	542	34.2	346	14.8
2008–2010	728	37.9	514	32.4	730	31.2
2011–2013	492	25.6	530	33.4	1264	54.0

Table III
Reasons for revision and revision arthroplasty type after SHA, RHA and anatomical TSA with number (N) and proportion (%) of primary arthroplasties. “Others” include glenoid wear, malpositioning of the arthroplasty and pain with no other reasons reported

	RHA		SHA		TSA	
	N	%	N	%	N	%
Reasons for revision						
Infection	8	0.4	8	0.5	15	0.6
Periprosthetic fracture	3	0.2	1	0.1	1	0.0
Luxation and instability	6	0.3	9	0.6	10	0.4
Loosening of any component	2	0.6	3	0.2	12	0.5
Rotator cuff problem	35	1.8	15	0.9	4	0.2
Others	118	6.1	27	1.7	12	0.5
Missing	29	1.0	15	0.9	12	0.5
Total revision	202	10.5	78	4.9	66	2.8
Revision arthroplasty type						
Anatomical shoulder arthroplasty	119	58.9	35	44.9	29	43.9
Reverse shoulder arthroplasty	61	30.2	36	46.2	20	30.3
Missing information or others	22	10.9	7	9.0	17	25.8
Including spacer						

significant difference for 2004–2007 (HR: 1.28; CI 0.93–1.76, $P = 0.13$) and 2008–2010 (HR: 1.19; CI 0.85–1.66, $P = 0.31$) with 2011–2013 as the reference.

Age as a risk factor for revision

The three categories of age had different proportions of arthroplasty types, Table IV. The cumulative implant-survival rates at 10 years for patients younger than 55 years was 0.75, 0.89 for patients between 55 and 75 and 0.95 for patients older than 75 years, Fig. 3. For the patients who were younger than 55 years, the 10-year cumulative implant-survival rates of RHA, SHA and TSA were 0.75, 0.81 and 0.87 respectively, Fig. 4.

Discussion

Our results, with a high 10-year cumulative survival rate and few cases of glenoid loosening, support the use of anatomical TSA when shoulder arthroplasty surgery is chosen for end-stage osteoarthritis. The young patients had, independently of the arthroplasty type, low implant-survival rates.

Arthroplasty types

Hemiarthroplasty in general and RHA in particular, were frequent in the beginning of the study period. The reason for using

Table IV
Number and percentage of arthroplasty types within the 3 age categories

<55 years	701
Resurfacing hemiarthroplasty	354 (50.5%)
Stemmed hemiarthroplasty	146 (20.8%)
Total shoulder arthroplasty	201 (28.7%)
55–75 years	3662
Resurfacing hemiarthroplasty	1173 (32.0%)
Stemmed hemiarthroplasty	914 (25.0%)
Total shoulder arthroplasty	1575 (43.0%)
>75 years	1483
Resurfacing hemiarthroplasty	393 (26.5%)
Stemmed hemiarthroplasty	526 (35.5%)
Total shoulder arthroplasty	564 (38.0%)

hemiarthroplasty is not registered, but surgeons may have avoided replacement of the glenoid because of technical demands of the primary procedure as well as suspected difficulties with revision of cases with glenoid loosening. Furthermore, knowledge about the outcome of TSA compared with hemiarthroplasty was sparse in the beginning of the study period, and the surgeons may have regarded the outcome of SHA, RHA and TSA as equal. New knowledge about the benefits and harms of shoulder arthroplasty may explain the increased number and proportion of TSA in the more recent years.

Information about shoulder arthroplasty survival rates comes from either national or regional shoulder arthroplasty registries, large institutional registries or from multicenter studies. The New Zealand Joint Registry reported the revision rate of 1,596 total shoulder arthroplasties of which 96% were used for osteoarthritis²¹. There were 1,065 cemented and 531 uncemented glenoid components. The 5-year cumulative survival rates were approximately 0.98 and 0.92 and the 10-year cumulative survival rates 0.95 and 0.92 respectively. Glenoid loosening was reported as the indication for revision in eight (0.8%) arthroplasties with cemented glenoid components and in three (0.6%) arthroplasties with un-cemented glenoid components.

The Kaiser Permanente Shoulder Arthroplasty registry²² reported the indications for revision of 5,291 patients with elective surgery including 3,790 patients with osteoarthritis. There were 130 resurfacing hemiarthroplasties, 818 stemmed hemiarthroplasties and 2,836 total shoulder arthroplasties. There were no separate results for patients with osteoarthritis, but for patients with elective surgery, glenoid component failure after TSA was rare (0.7%). Glenoid wear was the most common indication for revision after RHA (7.3%) and SHA (3.2%).

A multicenter study, involving 609 anatomical total shoulder arthroplasties used between 1991 and 1998 for osteoarthritis, reported a 10-year cumulative survival rate of approximately 0.70. The reason for these disappointing results was, however, regarded to be related to a use of metal-backed glenoid components²³. An unacceptable survival rate of un-cemented metal-backed glenoid components was later confirmed²⁴.

A large institutional register study reported the results of 1,640 anatomical total shoulder arthroplasties used for osteoarthritis between 1976 and 2008. 212 (8.2%) arthroplasties were revised with a 10-year cumulative survival rate of 0.90²⁵. The same center used the same population to report the survival rates of various glenoid designs. They found that the all-polyethylene glenoid components had a low risk of revision compared with that of metal-backed components. Thus, the 10-year cumulative survival rates of 497 anatomical total shoulder arthroplasties with an all-polyethylene glenoid component was 0.94²⁶.

The complication rates and indication for revision after TSA reported in smaller observational and randomized clinical trials have been summarized in a review. Bohsali and colleagues reviewed the literature published between 2006 and 2015. They

included 33 studies and found 345 complications in 3,360 total shoulder arthroplasties (10.3%) of which 130 (3.9%) were glenoid loosening⁶.

There is no information about the design of the glenoid component design in the Nordic Arthroplasty Register Association dataset. Thus, we were unable to further analyze the reason for the low risk of revision after anatomical TSA in general, and of loosening of the glenoid component in particular. Still, the survival rate and risk of glenoid loosening in the present series is comparable to those reported by other shoulder arthroplasty registries and in series using an all-poly glenoid design^{21,24,26}.

Rotator cuff problem was reported as the most frequent reason for revision after TSA by the New Zealand Joint Registry (1.1%)²¹ and the Kaiser Permanente Registry (0.7%)²⁷. This is in contrast to the present study where only 0.2% total shoulder arthroplasties were revised because of rotator cuff problem. The reason for this is speculative, but it may be related to the way data are collected and analyzed. In both the New Zealand Joint registry and in the Kaiser Permanente Registry more than one reason for revision can be reported whereas the NARA dataset only allows one reason for revision. Thus, in cases where rotator cuff problem was reported together with periprosthetic fracture, luxation/instability, or loosening, then rotator cuff problem was not regarded as the principal reason for revision.

Information about survival rates of hemiarthroplasty is sparse. A large institutional register study reported 26 revisions (7.5%) in 348 hemiarthroplasties used for osteoarthritis with a 10-year cumulative survival rate of 90.3%²⁸. The Danish Shoulder Arthroplasty Registry reported 63 (7.5%) revisions in 837 resurfacing hemiarthroplasties with a 5 year cumulative revision rate of 12.1%¹⁴.

It is important to bear in mind that the factors leading to the decision to revise are not fully understood and low revision rates do not necessarily reflect satisfactory clinical outcomes. Some failures are never revised because of comorbidity or technical difficulties and some revisions lead to good functional outcome and cannot be considered as persisting failures. Thus, the comparison of arthroplasty types in the present study should be interpreted with caution. The revision procedure of a TSA may be more challenging than the hemiarthroplasty in general and the RHA in particular, thus introducing a bias by a different threshold to revise the failed arthroplasty. This could indicate an underestimation of the real number of failures of the anatomical TSA compared with that of hemiarthroplasty.

Age as a risk factor for revision

The clinical and the patient-reported outcome of shoulder arthroplasty in young patients are less favorable than the outcome in older patients disregard the arthroplasty type^{14,21,29,30}. The reason for this is uncertain, but may be related to higher functional demands or higher expectations of the treatment³¹. It can also be hypothesized that primary osteoarthritis in young patients is rare, and previous trauma, recurrent instability or other pathologies may be the main cause for glenohumeral osteoarthritis. If the cause is not adequately addressed at the time of the shoulder arthroplasty procedure these patients may have an increased risk of poor functional outcome and a higher risk of revision.

Previous observational studies of young patients are often small series with less than 100 cases of total shoulder arthroplasties^{32–36}, stemmed hemiarthroplasties³⁰ or resurfacing hemiarthroplasties^{13,37,38}. These numbers of cases may be sufficient to report a pain score, range of motion, functional outcome score, patient-reported outcome or the ability to return to previous occupation or sport activities, but they may not be sufficient to report on the implant survival rates.

A large institutional study³⁹ included 5,494 patients of which 2,509 were diagnosed with osteoarthritis. 92 were under the age of 50, 728 were between 50 and 65 years and 1,689 were older than 65 years. There was no separate reporting of survival rates for patients with osteoarthritis, but in a Cox regression model, which included indication and arthroplasty type, patients between 50 and 65 years and patients older than 65 years had a decreased risk of revision compared to patients younger than 50 years of 35% and 55% respectively.

Similar findings were reported by the Kaiser Permanente Shoulder Arthroplasty registry²². 504 patients under the age of 59 of which 408 were diagnosed with osteoarthritis were included. After adjusting for arthroplasty type and diagnosis, the risk of revision for younger patients was 2.1 compared with older patients. For younger patients the risk of revision after RHA and SHA were 5.8 and 2.2 respectively compared with TSA. Cumulative implant survival rates were not reported.

To our knowledge, there are no studies, with a large consecutive number of cases, comparing the cumulative survival rate of different shoulder arthroplasty types used for young patients with osteoarthritis. The survival rate of 0.75 after RHA in young patients found in this study is, in our opinion, worrying. Theoretically, RHA has a bone preserving design that facilitates revision to any other arthroplasty type in case of failure. However, a recent publication on revision arthroplasty after failed RHA in patients less than 55 years reported inadequate patient-reported outcomes and high risk for a new revision¹⁵. Thus, accepting lower survival rates of hemiarthroplasty in younger patients with a presumed good result after later revision to total arthroplasty seems not justified.

With a 10-year survival rate of 0.87 found in this study, anatomical TSA had a better survival than hemiarthroplasty for younger patients, but lower than anatomical TSA among older patients. Thus, there is still a need for studies comparing shoulder arthroplasty, joint preserving surgery and non-operative treatment in order to improve treatment strategy for end-stage osteoarthritis in the young patients⁴⁰.

Methodological considerations

The inclusion of bilateral procedures in the survival analyses violates the assumption of independency, but this is probably of little practical relevance⁴¹. When arthroplasty survival rates are reported, patients are censored and no longer at risk of revision when they die or immigrate. This violates the assumption of competing risk. The Cox regression model is, however, recommended to report HR after arthroplasty surgery⁴². Even so, these statistical limitations are worth considering when the results are being interpreted.

The study has the limitations known to observational studies in general and registry studies in particular including bias by indication. The decision to use a specific implant type might be based on baseline factors that are not collected by the registries. These include: Co-morbidity; functional demands; glenoid wear; rotator cuff status; and if the bone stock of the glenoid is considered too poor for a glenoid implant. Another limitation related to register studies is that incorrect reporting may diminish the accuracy and reliability of the registry data. In this perspective, the results should be interpreted with caution.

The strength of the study is the unique collaboration between 3 national shoulder arthroplasty registers established with the purpose of identifying arthroplasty types and brands with unacceptable revision rates. Furthermore, because of the high number of patients, the study has a unique opportunity to report precise survival rates of different arthroplasty types with separate analyses of patients who are younger than 55 years.

Conclusion

We found the highest implant-survival rate for anatomical TSA. This supports the use of TSA when shoulder arthroplasty surgery is chosen for end-stage osteoarthritis. The younger patients, independently of the arthroplasty type, had a low implant-survival rate. The results may have been influenced by differences in baseline characteristics. Readers should keep that in mind when the results are interpreted.

Author contribution

JVR, BS and SLJ conceived the study idea and developed it in collaboration with the other co-authors. All Authors contributed to the design of the study. JVR, BS and RH collected the data and JVR carried out the analysis. All authors participated in the discussion and interpretation of the results. JVR organized the writing and wrote the first draft. All authors revised the manuscript for intellectual content and approved the final version before submission. JVR (jevera01@heh.regionh.dk) take responsibility for the integrity of the data and the accuracy of the data analysis.

Conflict of interest

No conflict of interest.

Role of the funding source

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Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.joca.2018.02.896>.

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