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REVIEW ARTICLE

Arthroplasty options in femoral-neck fracture: answers from the national registries

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Abstract
Purpose Femoral-neck fracture in the elderly population is a problem that demands the attention of the orthopaedic community as life expectancy continues to increase. There are several different treatment options in use, and this variety in and of itself indicates the absence of an ideal single treatment option. Recent debate has focussed on the probable superiority of total hip arthroplasty (THA) over hemiarthroplasty for femoral-neck fracture. Clinical trials and systematic reviews of such trials have not provided a convincing answer to this question.
Methods We analysed data from national registries evaluating prosthetic replacements for femoral-neck fracture in the elderly. We compared revision and reoperation rates of hemiarthroplasty and THA, analysed the prognostic variables that influenced implant survival and the major causes of failure.
Results Data from the Australian and Italian registries indicate that THA has an increased revision rate compared with bipolar hemiarthroplasty in femoral-neck fracture in the elderly. The registries identify that age over 75 years and the use of the anterior surgical approach are associated with better survivorship in patients who have a hemiarthroplasty. Cemented fixation of the femoral stem in hemiarthroplasty and THA is supported by registry data. Acetabular erosion accounted for a very low percentage of hemiarthroplasty revisions and reoperations.
Conclusion Our review of data from national registries supports the continued use of bipolar hemiarthroplasty in femoral-neck fracture in the elderly and identifies age, method of fixation and surgical approach as important prognostic variables in determining implant survival.

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Introduction

The increasing proportion of the elderly demographic, coupled with increasing life expectancy, translates into an expected global rise in the incidence of osteoporotic hip fractures [1]. Hip fractures in the elderly are associated with considerable morbidity, mortality, loss of function and independence among the survivors [1, 2]. Thus, prevention and appropriate treatment of these fractures demand attention. An international survey by Bhandari et al. estimated that treatment for femoral-neck fractures (FNF) favours internal fixation in patients under 60 years of age and arthroplasty in patients over 80 years of age [3]. The 60- to 80-year age group constitute a gray zone, where factors such as physiological age, bone quality, functional demand and medical comorbidities need to be considered when deciding upon appropriate management. Arthroplasty options for FNF include hemiarthroplasty, which can be nonmodular (such as the Austin–Moore or Thompson), or modular with unipolar or bipolar components; and total hip arthroplasty (THA). The ideal arthroplasty option would be one that is least invasive, has a short operating time, allows safe and immediate postoperative mobilisation and has low postoperative morbidity, reoperation and mortality rates.

Comparative clinical trials [4–12] and systematic reviews of such trials [13, 14] have been done to address this issue. High-quality randomised controlled trials and systematic reviews or meta-analyses of such studies are considered to have the highest ability to establish causality with respect to outcome and are therefore considered foremost amongst the levels of evidence. However, these do not include data from a very large database—the national registries.

The approach of registries with respect to data collection and analyses is different from that of a clinical trial. The main intent of the registry is not to establish causality but to correlate between various factors and outcomes. Such correlations provide surgeons the necessary feedback to choose the right treatment option for their patients. Results of randomised trials, usually conducted at large hospitals, may differ from those obtained in community practice. National registries, on the other hand, include population-level data from a large number of patients and implants, from surgeons with all levels of experience and with practically no exclusions. Hence, data may be considered more representative of community practice. The national registries are also uniquely positioned to avoid publication bias and conflicts of interest. The growing number of national registries is an indication of their value and popularity among orthopaedic surgeons.

We therefore analysed data from national joint registries to investigate whether data from these large databases could add to the existing knowledge on arthroplasty options for FNF. Our objectives were to: (1) compare survival rates of prostheses used in FNF; (2) identify prognostic factors for failure of prostheses used in FNF; (3) identify the important modes of failure of these prostheses.

Materials and methods

We searched for data on THA and hemiarthroplasty performed for FNF from the annual reports of national joint- and hip-fracture registries. We reviewed data available in Australian, Swedish, Canadian, Danish, New Zealand, Norwegian, Italian (Emilia-Romagna), Romanian, Scottish, Slovakian and UK national registries. We used the key words “hip fracture” and “joint replacement registries” to identify any articles in PubMed that reported data from the national registries. The Australian Orthopaedic Association National Joint Replacement Registry [15] had data on THA as well hemiarthroplasty in FNF. Swedish National Hip Arthroplasty Register [16] had data on hemiarthroplasty but lacked detailed information on THA in FNF. The National joint Registry of England and Wales provided data on THA but not on hemiarthroplasty in FNF [17]. In the hip-fracture registry of the UK, results of hemiarthroplasty and THA were compiled together and separate data for the two options could not be found [18]. The recent annual reports of the Canadian, Danish, New Zealand, Italian, Norwegian, Romanian, Scottish and Slovakian national joint registries revealed no detailed information on THA or hemiarthroplasty for FNF. Additionally, we requested registries, through emails, for unpublished data pertaining to our question. The Australian and Italian registries kindly provided additional unpublished information, which we included in our analysis [19, 20]. We compared revision rates of hemiarthroplasty and THA performed for FNF. We also identified and studied the influence of prognostic variables on implant survival from the national joint replacement registries. These consisted of: (1) age; (2) gender; (3) type of fixation; 4) surgical approach. We finally analysed the major causes of failure of prostheses used in FNF.

Revision rates were estimated using the Kaplan–Meier survival analysis method [15–17]. Cumulative percent revision (CPR) along with 95% confidence intervals (CI) was provided in the Australian and the England and Wales registries [15, 17]. This term refers to the complement (in probability) of the Kaplan–Meier survivorship function at a certain time ×100. CPR CIs are unadjusted point-wise estimates. Hazard ratios (HR), calculated using multivariate Cox proportional hazards model in Australia [15] and using multivariate linear and Cox regression in England and Wales [17], were used to evaluate the relative risks related to each risk factor with adjustment for the other factors. P values <0.05 were considered significant. HRs were used to compare prostheses survival in the Australian and the England and Wales registries; when unavailable, we used the CI of CPR for comparison. Age- and gender-adjusted relative risk (RR) for revision, computed using Cox multivariate analysis, was made available by the Italian registry [20]. In the Swedish registry, patients who underwent hip-fracture-related hemiarthroplasty were analysed with regard to risk factors for reoperation by logistic regression analysis for gender and Cox regression analysis for the other risk factors [16]. RR and 95% CI were provided, and the RR was considered statistically significant if the 95% CI was outside 1.

Results

The Australian registry, which has complete coverage of all hospitals in the country performing joint replacement, contained data on 19,792 unipolar monoblock hemiarthroplasties, of which 97.4% were done for FNF; 12,753 unipolar modular hemiarthroplasty procedures, of which 92.7 % were done for FNF; 9,811 bipolar hemiarthroplasties, of which 89.2% were done for FNF; and 6,208 THA procedures for FNF [15]. CPRs up to nine years were available for unipolar monoblock hemiarthroplasty, bipolar hemiarthroplasty and THA in FNF and up to seven years for unipolar modular hemiarthroplasty [15]. The England and Wales registry, which had a compliance rate of 114.4% for reporting in 2009–2010, provided data on 1,301 THA procedures for FNF, and three year revision rates were available [17]. Swedish registry with a coverage of 97.4% for THA and 96.1% for hemiarthroplasty had data on 20,828 hemiarthroplasty procedures performed between 2005 and 2009, and five year revision rates were made available [16]. The Italian registry, with a 97% capture rate, had accumulated data regarding 4,871 THA and 21,026 hemiarthroplasty procedures (of which 20,492 were bipolar arthroplasty), with a cumulative follow-up of nine years [20].

In Australia, THA done for FNF had a higher revision rate than bipolar hemireplacement arthroplasty (Fig. 1) [15, 19]. The nine year CPR of THA was 8% as against 4.3% for bipolar and 7.7% for unipolar monoblock hemiarthroplasty. The seven year CPR of unipolar modular hemiarthroplasty was 6.9%. After adjustment for age and gender, the failure rate of bipolar hemiarthroplasty was significantly lower than for THA in the first three months (HR=0.75, p=0.035) [19]. Beyond three months, the RR was 0.89 in favour of bipolar, but the difference was not statistically significant. Analysed with regard to age, the overall RR of failure of bipolar compared with THA was significantly lower in patients over 75 years of age (HR = 0.63 in the 75- to 84-year age group and 0.55 in the over 85 age group) and lower (HR=0.89, p=0.399) but not statistically significant in those under 75 years [19]. In comparison with THA, unipolar modular hemiarthroplasty had a lower revision rate in the first three months (HR=0.70, p=0.005) and a higher revision rate beyond two years (HR=1.97, p= 0.001) [19]. Between three months and two years, the difference in revision rates was not statistically significant [19]. Unipolar monoblock had a higher revision rate than THA beyond three months (HR=1.97, p=0.001). In the first three months, the difference was insignificant [19]. In Italy, bipolar arthroplasty had a significantly lower cumulative risk of revision at nine years (RR 0.77, p<0.02) than did THA [20]. In Sweden, hemiarthroplasties performed between 2005 and 2009 had a reoperation rate of 3.6% and a revision rate of 2.9% [16]. In England and Wales, the three year revision rate for THA performed for FNF was 2% (95% CI 1.4–2.8%) (Table 1) [17].

With regard to risk factors for implant failure in FNF, age was considered in the Swedish, Italian and Australian registries (Table 2). [15, 16] In Australia, the risk of revision decreased with increasing age, and this was observed with all three types of hemiarthroplasty prostheses [15]. Age was not found to be significantly associated with THA revision rates [19]. In Italy, the revision rate of both hemiarthroplasty and THA decreased with increasing age [20]. In Sweden, the five year survival of hemiarthroplasty was 91.9% for patients under 75 years of age compared with 96.4% for those over 85 years [16].

Gender was found to influence reoperation rates after hemiarthroplasty in Sweden [16]. Men had a higher risk of reoperation, with an RR of 1.44 (95% CI: 1.39–1.50) after adjustment for age, approach and type of implant. They had significantly increased risk of periprosthetic fracture, with an RR of 2.44 (CI: 1.68–3.55) [16]. In Australia, only revision rates (and not reoperation rates) were available, and this was not significantly different between men and women for unipolar monoblock [15], unipolar modular [15], bipolar stems [15] and THA [19]. In Italy, the

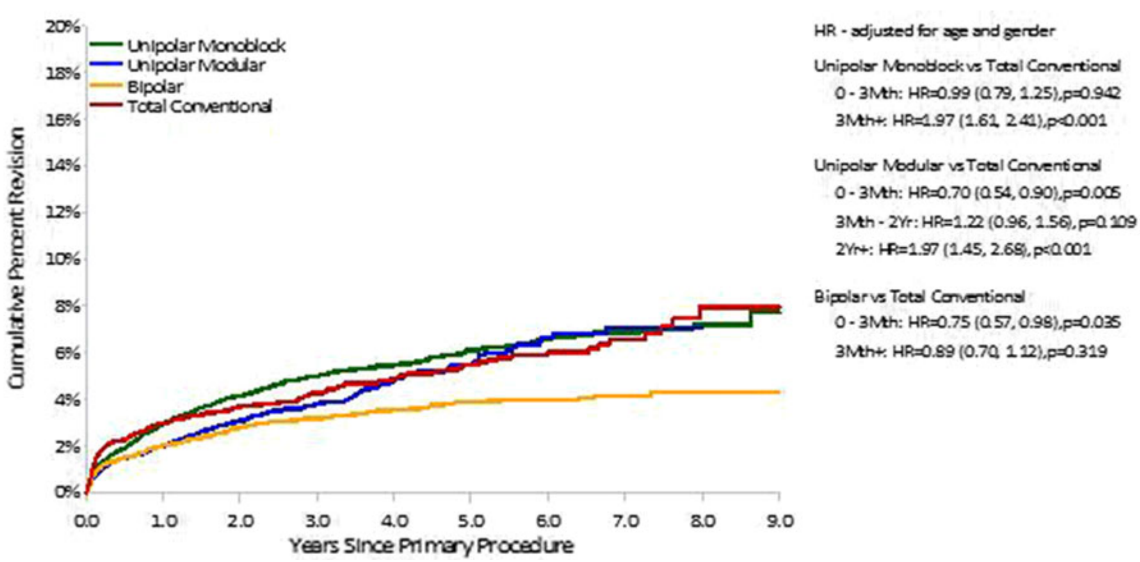

Fig. 1 Survivorship of prostheses used in femoral-neck fracture in Australia (kindly provided by Australian Orthopaedic Association National Joint Replacement Registry)

Table 1 Cumulative percent revision rates (with confidence intervals in parentheses) of prostheses used in femoral-neck fracture

Registry		1 year	3 years	5 years	7 years	9 years
Australia	Unipolar monoblock	2.9 (2.7–3.2)	5 (4.6–5.4)	6.1 (5.6–6.6)	6.9 (6.2–7.5)	7.7 (6.5–9.1)
	Unipolar modular	2 (1.8–2.3)	3.8 (3.4–4.3)	5.5 (4.8–6.3)	7.1 (6–8.4)	
	Bipolar	2 (1.7–2.4)	3.2 (2.8–3.6)	3.9 (3.4–4.4)	4.2 (3.6–4.8)	4.3 (3.7–5.0)
	THA	3 (2.5–3.4)	4.3 (3.7–4.9)	5.4 (4.7–6.3)	6.6 (5.6–7.7)	8 (6.4–9.9)
Italy	Hemiarthroplasty	2	2	3	3	3
	THA	3	4	6	6	7
England and Wales	THA		2			
Sweden	Hemiarthroplasty (all types)	2.9% revision rate over 5 year period				

cumulative survival at nine years for THA in men was 91% compared with 94% in women, whereas it was 97% for hemiarthroplasty in both sexes [20].

In Sweden, the method of fixation was found to have a significant correlation to reoperation rates. Hemiarthroplasty with cementless stems had an RR twice that of cemented stems [16]. This difference persisted even when only the newer cementless stems (excluding the Austin–Moore prosthesis) were considered. The modern cementless stems had 3.8 times increased risk of periprosthetic fracture compared with cemented stems. In Australia, unipolar monoblock stems during the first 1.5 years, unipolar modular stems up of five years and bipolar stems during the first three months had a higher risk of revision when used without cement [15]. Cemented THA had the lower revision rate than hybrid THA, which in turn had a lower revision rate that cementless THA [19]. The adjusted RR of cementless THA failure compared with cemented THA was particularly high in the first month (HR 7.29, $p<0.001$) [19]. In England and Wales, the revision rate with a cementless THA for FNF was 2.9 (95% CI 1–8.1) times higher and with the hybrid THA 2.1 (95% CI 1–7.6) times higher compared with a cemented THA [17]. The 30-day mortality rate was not significantly different between the three types (Table 3) [17]. In Italy, cemented THA and hybrid THA with cemented stems had the lowest nine year revision rates (3.5%), whereas hybrid THA with cementless stems had the highest revision risk (9.8%). Cemented and cementless hemiarthroplasty had similar nine year revision rates in Italy (1.7% and 1.5%, respectively) [20].

The Australian and Swedish registries vary in their comparison of unipolar and bipolar hemiarthroplasty. In Australia, unipolar modular and bipolar procedures had overlapping 95% CPR CI up to three years. However, at five years and seven years, bipolar had lower CPR (Table 1) [15]. In Sweden, bipolar hemiarthroplasty has shown a higher reoperation rate than unipolar hemiarthroplasty at five years, with RR of 1.4 (95% CI 1.1–1.8) [16]. This has been attributed to a higher rate of dislocation-related reoperations with the bipolar method. Comparison was not feasible in the Italian registry due to the small number of unipolar arthroplasty procedures.

The anterior approach for hemiarthroplasty is associated with a lower risk of reoperation secondary to dislocation (RR 0.6, 95% CI 0.5–0.8) in the Swedish registry [16]. However, the five year implant survival was not affected by surgical approach. Secondary hemiarthroplasty following failure of internal fixation has a higher risk of reoperation in Sweden (RR 2.1, 95% CI 1.7–2.7) [16].

In Sweden, dislocation was the leading cause of reoperation after hemiarthroplasty (46.4%), followed by infection and periprosthetic fracture [16]. In Australia,

Table 2 Influence of age on failure of hemiarthroplasty prostheses used in femoral-neck fracture

Registry	Prosthesis	Outcome measure	Age		
			<75 years	75–84 years	>85 years
Australia	Unipolar monoblock	7-year CPR (CI)	17.4 (14.6–20.6)	7.1 (6.3–8)	3.4 (2.9–4)
	Unipolar modular	7-year CPR (CI)	13.4 (10.7–16.7)	5.5 (4.4–6.9)	
	Bipolar	7 Yr CPR (CI)	6.0 (4.8–7.5)	3.5 (2.9–4.3)	2.9 (2.2–3.8)
Sweden	Hemiarthroplasty (all types)	5-year CPR (CI)	8.1 (5.5–10.7)	4.9 (4–5.8)	3.6 (2.6–4.6)
Italy	THA	9-year CPR (CI)	7.9 (6.4–9.5)	4.5 (3.0–6.0)	
	Hemiarthroplasty (all types)	9-year CPR (CI)	8.1 (4.9–6.5)	3.5 (2.5–3.0)	1.3 (0.9–1.7)

CPR cumulative percent revision, *CI* confidence interval

Table 3 Influence of fixation type on failure of prostheses used in femoral-neck fracture

Registry	Prosthesis	Follow-up period	Hazard ratio
Australia	Unipolar monoblock (cementless vs cemented)	0–3 month	1.94 (p <0.001)
		3 month–9 month	4.49 (p <0.001)
		9 month–1.5 years	2.62 (p <0.001)
		1.5- 8 years	0.94 (p = 0.684)
	Unipolar modular (cementless vs cemented)	6 years	1.52 (p <0.001)
	Bipolar (cementless vs cemented)	0–3 month	2.08 (p <0.001)
		3 month–7 years	1.04 (0.69–1.57), (p =0.840)
	THA (cementless vs cemented)	0–1 month	7.29 (p<0.001)
		1 month–8 years	2.04 (p=0.004)
	THA (hybrid vs cemented)	8 years	2.31 (p<0.001)
	THA (cementless vs hybrid)	0–1 month	3.16 (p<0.001)
		1 month–8 years	0.88 (p=0.431)
England and Wales	THA (cementless vs cemented)	3 years	2.9
	THA (cementless vs hybrid)	3 years	2.1

loosening or lysis accounted for the majority (50.6%) of revisions on monoblock stems, whereas aseptic loosening, fracture, infection and dislocation were important causes of revision in modular stems [15]. Only 5.1% of revisions in Australia and 4.7% in Sweden were attributed to acetabular erosion (Table 4) [15, 16]. In Italy, acetabular erosion was responsible for revision of 0.3% (62/20,126) of hemiarthroplasty procedures. The leading cause of THA revision in Australia and Italy was dislocation (37.2% and 33.5%, respectively) [19, 20].

Discussion

The increasing popularity of prosthetic replacement over internal fixation in displaced FNF in the elderly has made it necessary to search for the ideal arthroplasty option. Studies comparing hemiarthroplasty and THA have generally fallen short on numbers and have had short follow-up periods and therefore have not been able to determine which arthroplasty type gives a superior outcome. The largest published randomised trial on this topic, by van den Bekerom et al. [4], found no difference in revision rates at five years and noted lower blood loss and operating times in favour of hemiarthroplasty. However, the primary outcome measure in their study was the Harris Hip Score, and the sample size was calculated to detect a significant difference in this measure, not revision rates.

Systematic reviews are a valuable source of evidence when individual studies are unable to provide a conclusion. Systematic reviews have been done by Parker et al. [13] and Hopley et al. [14]. Parker et al. systematically reviewed randomised and quasirandomised studies and found a statistically higher “major” reoperation rate (RR 2.22,

Table 4 Causes of failure of hemiarthroplasty prostheses used in femoral-neck fracture

Registry	Australian			Swedish		Italian	
Prosthesis	Unipolar monoblock	Unipolar modular	Bipolar	Hemiarthroplasty (all types)		Hemiarthroplasty (all types)	
Cause of failure	% of revisions	% of revisions	% of revisions	% of reoperations	% of primary hemiarthroplasty	% of revisions	% of primary hemiarthroplasty
Loosening/ lysis	50.6	18.4	23.5	1.7	0.03	16.67	0.28
Fracture	17.3	17.3	22.1	15.6	0.6	5.3	0.09
Dislocation	10.4	18.7	17.4	46.1	1.6	42.7	0.7
Infection	9.3	18.4	18.8	29	1.0	7.62	0.13
Pain	6.9	14.6	8.7				
Chondrolysis/ erosion	3	9.5	4.7	4.7	0.2	17.5	0.3

95% CI 1.09–4.51) and a lower "minor" reoperation rate (RR 0.50, 95% CI 0.26–0.95) for hemiarthroplasty [13]. They noted that the higher major reoperation rate in the hemiarthroplasty group was mainly due to a higher complication rate in those with cementless hemiarthroplasty. Hopley et al. included retrospective comparative cohorts in addition to randomised and quasirandomised studies [14]. Their study revealed a significantly lower reoperation rate with THA compared with hemiarthroplasty, with a risk difference of 4.4% in favour of THA [14]. However, they cautioned that the advantage of THA with regard to reoperation rates mitigated in studies that had enrolled only oriented and ambulatory patients, used only cemented hemiarthroplasty stems and respected the intention to treat principle [14].

Systematic reviews, however, do not include data from national registries, which have earned their place and respect in the orthopaedic community and have stood the test of time. The wealth of information that these registries provides can be better appreciated if we note that the largest systematic review on this subject, by Hopley et al., consisted of data pertaining to 1,669 patients from seven randomised or quasirandomised studies and seven retrospective cohort studies, of which only two studies had a follow-up more than two years [14]. The systematic review by Parker et al. consisted of seven randomised or quasirandomised studies comparing hemiarthroplasty and THA for FNF, and pooled data from 734 participants were analysed [13]. In comparison, the Swedish, Italian, English and Australian registries together contained data 83,309 hemiarthroplasty procedures and 12,380 THA procedures for FNF. The longer follow-up periods available in the registries add to their value. A summary of the information available through clinical trials and national registries is presented in Table 5.

The Australian and Italian registries reveal a lower revision rate for bipolar arthroplasty than for THA at a follow-up of nine years [15, 19, 20]. In Australia, the difference was not significant in patients under 75 years but was significantly lower in those over 75 years [19]. Considering the low functional demand and the morbidity of revision surgery in patients over 75 years of age, these results favour the use of bipolar hemiarthroplasty in this age group. The unipolar modular design showed a lower revision rate than for THA only up to three months; after two years, there was a higher revision rate [19].

Data from the registries identify key prognostic variables that influence the survival of implants used in FNF. The use of cemented over cementless hemiarthroplasty is supported by data from both the Australian and Swedish registries [15, 16], whereas use of cemented over THA cementless stems is supported by data from the Australian and the England and Wales registry [15, 17]. This complements the advantage of better function and lower pain scores in those with cemented stems, which is noted in the systematic review by Parker et al. [13]. In addition, those authors noted the lack of influence of cementing on mortality rates. The Italian registry showed no significant difference in survival between cemented and cementless fixation for hemiarthroplasty or THA [20]. Age less than 75 years has been identified as a poor prognostic indicator for hemiarthroplasty survival in Australia, Sweden and Italy [15, 16, 20]. The Swedish registry noted a lower incidence of dislocations when the anterior approach is used for hemiarthroplasty [16]. This accords with findings of a meta-analysis that sought to answer this question [21].

The reasons for failure of monoblock and modular (unipolar and bipolar) stems were different, with aseptic loosening accounting for the majority of monoblock stem revisions in Australia [15]. It is also noteworthy that

Table 5 Comparison of information available from clinical trials and national registries

Parameter	Information from clinical trials or systematic reviews of such trials	Information from national registries
Reoperation/ revision rates	Lower reoperation rate with THA than with hemiarthroplasty, but difference mitigated in trials restricted to oriented and ambulatory patients, cemented hemiarthroplasty and intention to treat principle [13] Lower major reoperation rate with THA, mainly due to inclusion of uncemented hemiarthroplasty [12]	Lower revision rate with bipolar than with THA (Australian and Italian registries)
Method of fixation	Better function and lower reoperation rate with cemented hemiarthroplasty	Lower revision and reoperation rates with cemented hemiarthroplasty (Australian, England and Wales, and Swedish registries)
Surgical approach	Lower dislocation rate with anterior approach	Lower dislocation rate with anterior approach (Swedish registry)
Unipolar vs bipolar	No significant difference	Conflict between Australian and Swedish registries
Age		Revision rates lower with increasing age (Australian, Italian and Swedish registries)

acetabular erosion is a rare cause of hemiarthroplasty revision in Australia, Italy and Sweden [15, 16, 20]. Femoral side failure was recorded as the major cause of hemiarthroplasty revision in all registries. Thus, using THR to prevent acetabular erosion is not supported by registry data. However, a longer follow-up may change this recommendation.

Registries, despite having a very large database, have a number of limitations. Firstly, data from all registries is not directly accessible, and few registries contain data on FNF. Secondly, data collection quality is not uniform and complete across registries. The England and Wales registry, for example, noted they were likely to underestimate the revision rate by 15%. Thirdly, registry data often lack information on patient-related data apart from chronological age and gender (e.g., body weight, prefracture cognitive and physical status, comorbidities), surgical experience and surgical technique. Physiological age, which is generally used to decide the treatment option in FNF, cannot be gauged from registries. They also do not take into account possible differences in patient selection for different surgical procedures in these regions. These factors may entail confounding and contribute to bias. This also limits the generalisation of results to surgeons practising in a different environment. Fourthly, registry data do not assess clinical outcomes, such as patient satisfaction, quality of life and radiographic outcomes, and they are confined to evaluation of revision and reoperation rates. Fifthly, registry data provides feedback to surgeons and has an impact on indications, procedures and implant selection. This unknowingly creates a positive bias in terms of general use. Finally, revision rates obtained from Kaplan–Meier analysis in this elderly age group with FNF tend to be overestimated due to death being a competing risk to revision.

In summary, registries offer interesting and clinically relevant information with regard to arthroplasty options for FNF. The Australian and Italian registries have shown a better intermediate-term survival for bipolar arthroplasty compared with THA. Acetabular erosion is only a rare cause of hemiarthroplasty failure and, by itself, does not justify the use of THA. Support for prosthesis component cementing in FNF is uniform across registries and prosthesis types.

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Conflict of interest The authors declare that they have no conflict of interest.

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