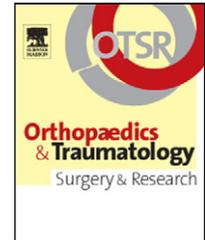




Available online at  
**SciVerse ScienceDirect**  
www.sciencedirect.com

Elsevier Masson France  
**EM|consulte**  
www.em-consulte.com/en



ORIGINAL ARTICLE

# Shoulder hemiarthroplasty: Outcomes and long-term survival analysis according to etiology

F. Gadea<sup>a,\*</sup>, G. Alami<sup>b</sup>, G. Pape<sup>c</sup>, P. Boileau<sup>d</sup>, L. Favard<sup>a</sup>

<sup>a</sup> Department of Orthopaedics and Trauma surgery 1, Trousseau Hospital, Tours François-Rabelais University, 37044 Tours cedex 9, France

<sup>b</sup> Department of Orthopaedics surgery, Saint-Jérôme Hospital, Saint-Jérôme, Quebec J7Z 5T3, Canada

<sup>c</sup> Department of Orthopaedic Surgery, Division of Upper Limb Surgery, University of Heidelberg, Schlierbacher Landstrasse 200A, 69118 Heidelberg, Germany

<sup>d</sup> Department of Orthopaedics surgery and Sports Trauma, hôpital de l'Archet, Nice-Sophia-Antipolis University, 151, route de St-Antoine-de-Ginestière, 06202 Nice, France

Accepted: 19 March 2012

## KEYWORDS

Arthroplasty;  
Shoulder;  
Long-term effects;  
Survival rate;  
Outcome measures

## Summary

**Background:** The indications for hemiarthroplasty in glenohumeral joint diseases remain controversial and depend mainly on the original underlying diagnosis. Our objective was to investigate the influence of the primitive aetiology on long-term prosthesis survival and on the Constant-Murley score.

**Materials and methods:** We studied 272 shoulders with the following diagnoses: fracture sequelae ( $n=73$ ), primary osteoarthritis ( $n=67$ ), cuff tear arthropathy ( $n=43$ ), avascular necrosis ( $n=40$ ), rheumatoid arthritis ( $n=31$ ), and other ( $n=18$ ). Of the 272 shoulders, 139 were evaluated after at least 8 years (mean follow-up, 134 months). In all, 30 prostheses required removal. Functional status was evaluated using the Constant-Murley score and survival rate using the Kaplan-Meier method with prosthesis removal or conversion to total arthroplasty as the endpoint.

**Results:** Ten-year prosthesis survival was 88.13% overall, 100% in the rheumatoid arthritis group, 94.9% in the avascular necrosis group, 94.2% in the primary osteoarthritis group, 81.5% in the cuff tear arthropathy group, and 76.8% in the fracture sequelae ( $P=0.05$ ). The mean Constant-Murley score after 8 years or more was 70.1 in avascular necrosis, 60.7 in primary osteoarthritis, 57.7 in fracture sequelae, 55.3 in rheumatoid arthritis, and 46.2 in cuff tear arthropathy ( $P=0.0006$ ). The complication rate with the initial population as the denominator was 24.7% in fracture sequelae, 18.6% in cuff tear arthropathy, 15% in avascular necrosis, 8.9% in primary osteoarthritis, and 3.2% in rheumatoid arthritis.

\* Corresponding author. Tel.: +33 6 23 24 13 62.  
E-mail address: [gadea.f@gmail.com](mailto:gadea.f@gmail.com) (F. Gadea).

**Conclusions:** The best indication for shoulder hemiarthroplasty is avascular necrosis and the worst indications are cuff tear and post-traumatic fracture sequelae. Rheumatoid arthritis and primary glenohumeral osteoarthritis are good indications in patients younger than 50 years of age.

**Level of evidence:** Level IV, retrospective study.

© 2012 Elsevier Masson SAS. All rights reserved.

## Introduction

The first case-series of shoulder hemiarthroplasty was reported by Neer in 1970 [1]. The patients had four-part proximal humeral fractures, and the outcomes were good. Since then, hemiarthroplasty has been used in many other shoulder diseases including osteoarthritis (OA) [2], avascular necrosis (AVN) [3] rheumatoid arthritis (RA) [4], cuff-tear arthropathy (CTA) [5] and fracture sequelae (Seq) [6]. Improvements in function, motion range, and pain were often substantial in AVN, variable in OA and RA, and disappointing in CTA and Seq. In CTA, the reverse prosthesis developed by Grammont et al. [7] seems more effective [8]. Thus, shoulder hemiarthroplasty is widely accepted [9–11] for patients with an intact rotator cuff and little or no glenoid wear, two conditions met in AVN. However, in young patients with glenoid wear, there is no consensus about the optimal type of arthroplasty [10]. Hemiarthroplasty can result in glenoid erosion, which is the main cause of clinical deterioration and short- and medium-term revisions [12–14]. Total shoulder arthroplasty carries a risk of glenoid component loosening, which becomes increasingly common over time and correlates with increased pain and diminished function [15–18]. In addition, bone stock alterations are common after total shoulder arthroplasty and complicate revision surgery. Consequently, selection of the best type of prosthesis, and more specifically the decision to perform hemiarthroplasty, should be based on factors that influence prosthesis survival and functional outcomes.

Here, our objectives were to evaluate prosthesis survival, complications, and the Constant-Murley score [19] in patients evaluated at least 8 years after shoulder hemiarthroplasty; and to determine whether the results were influenced by the aetiology of the shoulder disorder. Our hypothesis was that the aetiology would substantially affect prosthesis survival and functional outcomes.

## Material and methods

We conducted a retrospective multicentre European study of all primary shoulder hemiarthroplasties (Aequalis® Tornier Inc., Edina MN, USA) performed before 31st December 2000. The patients were evaluated in 2009 to establish outcomes after at least 8 years. All indications for shoulder hemiarthroplasty were included except tumours and recent fractures. We identified 272 consecutive shoulder hemiarthroplasty procedures performed between May 1988 and December 2000.

The 272 procedures were done in 261 patients (11 patients had bilateral surgery), 180 women and 81 men (M/F ratio, 1/2.22), with a mean age at surgery of 59 years

(range, 16–82). The dominant side was affected in 57% of cases. Two-thirds of patients were retired or had no paid occupation. The underlying diagnoses were Seq in 73 cases, primary OA in 67, CTA in 43, AVN in 40 (including four with radiation-induced necrosis), RA in 31, instability in 10, and miscellaneous disorders in eight.

At follow-up, 54 patients with 59 hemiarthroplasties had died with the prosthesis in place and 46 patients with 47 hemiarthroplasties had been lost to follow-up without any record of hemiarthroplasty complications. Among the 161 remaining patients, with 166 hemiarthroplasties, 30 required prosthesis removal (including 3 after at least 8 years) and 12 experienced complications that did not require prosthesis removal. Thus, 134 patients who still had 139 prostheses were re-evaluated after at least 8 years; mean follow-up was 11.2 years (range, 8–16.6 years). Mean age at re-evaluation was 69.8 years (range, 30–94 years). Table 1 reports the distribution across underlying aetiologies.

The instability and miscellaneous diagnoses groups were too small for a meaningful statistical analysis. Despite a long-standing consensus that hemiarthroplasty is not appropriate in CTA [20], several surgeons were reluctant to switch to reverse arthroplasty and continued to perform hemiarthroplasty in this indication.

At baseline, the non-weighted and weighted Constant-Murley scores [19] were 26.5% and 34.4%, respectively. Active forward elevation was 78.4° and active external rotation with the elbow at the side was 10.6°. At follow-up, the Constant-Murley score was determined and active motion ranges in forward elevation and external rotation with the elbow at the side were measured. Poor outcomes were defined as any of the following: non-weighted Constant-Murley score less than 30, weighted Constant-Murley score less than 50%, Constant-Murley pain item subscore less than 10, or active forward elevation less than 90° with active external rotation elbow at the side less than 10°.

Prosthesis survival curves were established using the Kaplan-Meier method [21] with computation of the 95% confidence intervals (95% CIs). The endpoint was prosthesis removal defined as changing the humeral stem, converting to total arthroplasty, or performing arthrodesis. Patients who died with their prosthesis in place were censored.

Each aetiological group was studied separately. Preoperative and postoperative data were compared using the Wilcoxon test for paired data. The Constant-Murley scores at last follow-up at least 8 years after hemiarthroplasty were compared across aetiological groups using the Mann-Whitney U test and the Kruskal-Wallis test for unpaired data. Values of *P* smaller than 0.05 were considered significant. Statistical analyses were done using Statview software (Abacus Concepts Inc. Berkeley, CA, USA).

**Table 1** Distribution of the hemiarthroplasties according to aetiologies.

Aetiology	Initial population	Follow-up after $\geq 8$ years	No follow-up			Mean age <sup>a</sup> (years)	Mean follow-up (months)
			Died	Lost to follow-up	Removal (< 8 years)		
Seq	73	34	13	14	12	59	140.5
OA	67	42	9	13	3	66	123.5
CTA	43	18	15	3	7	70	141.9
AVN	40	20	3	14	3	46	141.9
RA	31	14	14	3	0	41	144.5
Instability	10	5	4	0	1	65	128.7
Miscellaneous	8	6	1	0	1	59	115.5
Total	272	139	59	47	27	59 (16–82) <sup>b</sup>	134.4 (96–199) <sup>b</sup>

CTA: cuff tear arthropathy; OA: glenohumeral osteoarthritis; RA: rheumatoid arthritis; AVN: avascular necrosis; Seq: fracture sequelae.

<sup>a</sup> Age at surgery.

<sup>b</sup> Range in parentheses.

## Results

Over the entire follow-up period, 42 complications were recorded. The two main complications were pain from glenoid erosion (17 cases, all of which required prosthesis removal) and stiffness (eight cases, of which five required prosthesis removal). The other complications required prosthesis removal in eight cases. Table 2 reports the complications and cases of prosthesis removal by underlying aetiology. Symptomatic glenoid erosion was an early complication that usually occurred within the first 3 years; however, four cases occurred after at least 8.5 years, with the underlying aetiologies being Seq in two cases, CTA in one case, and AVN in one case. In the patient with AVN, anterior wear developed gradually after a subscapularis tear was diagnosed within the first postoperative year. Complication rates were 24.7% in the Seq group, 18.6% in the CTA group, 15% in the AVN group, 8.9% in the primary OA group, and 3.2% in the RA group.

Re-evaluation of the 139 shoulders with the prosthesis in place after at least 8 years showed significant improvements in the Constant-Murley score and in each of its components (Table 3). The greatest gain occurred in the primary OA group, with a 33-point increase. Mean Constant-Murley scores at last follow-up after at least 8 years differed significantly across aetiological groups ( $P=0.0006$ ): 70.1 (40–89) in AVN, 60.7 (9–93) in primary OA, 57.7 (28–84) in Seq, 55.3 (36–87) in RA, and 46.2 (24–77) in CTA. The Constant-Murley score in the AVN group was significantly higher than in the Seq group ( $P=0.0145$ ), RA group ( $P=0.0022$ ), and CTA group ( $P<0.0001$ ) and non-significantly higher than in the primary OA group ( $P=0.082$ ). In the AVN group, the range-of-motion component of the Constant-Murley score was significantly better than in all other aetiological groups (PFA,  $P=0.0065$ ; RA,  $P=0.003$ ; CTA,  $P=0.0004$ ; and primary OA,  $P=0.0124$ ). The RA group had the best pain score (although the difference with the other groups was not statistically significant) and the lowest range-of-motion score.

Table 4 reports the poor outcomes by aetiological group. Constant-Murley score values less than 30 occurred in 17% of CTA shoulders and 12% of Seq shoulders. Pain scores less than 10 were seen in 39% of CTA shoulders and 19% of primary OA shoulders. Limited mobility (forward elevation less than 90° and external rotation elbow at the side less than 10°) was noted in 29% of RA shoulders, 23% of Seq shoulders, and 22% of CTA shoulders (NS). The aetiological group with the lowest rate of poor outcomes was AVN (NS).

The prosthesis was removed in 30 cases. Overall prosthesis survival was 92.1% after 5 years and 88.13% after 10 years. Prosthesis survival was 100% in the RA group, 94.9% in the primary OA group, 94.2% in the AVN group, 81.5% in the CTA group, and 76.8% in the Seq group. Table 5 reports survival rates across aetiological groups after 5 and 10 years and Fig. 1 the Kaplan-Meier survival curves, which indicated significant differences ( $P=0.05$ ). The instability group and the group of miscellaneous aetiologies were not taken into account in the survival curve analysis. As no events occurred in the RA group, this aetiology is not indicated on the curve. Survival rates remained stable after the fifth year in the primary OA and AVN groups but continued to decline significantly in the Seq and CTA groups.

## Discussion

The indications for shoulder hemiarthroplasty in patients with glenohumeral joint disorders remain controversial. Total arthroplasty carries a risk of glenoid component loosening in the long term, whereas hemiarthroplasty can result in glenoid erosion. In the literature, the best balance between these two risks is unclear but seems to depend on both the underlying aetiology and patient-related factors. Our study establishes that the aetiology exerts a major influence on the survival of shoulder hemiarthroplasty and that a high prosthesis survival rate fails to correlate consistently with good functional outcomes.

Our study has a number of limitations. The long inclusion period over more than a decade explains the large

**Table 2** Distribution of complications according to aetiologies (number of complications/number of prostheses removed).

	Seq (73) <sup>a</sup>	OA (67) <sup>a</sup>	CTA (43) <sup>a</sup>	AVN (40) <sup>a</sup>	RA (31) <sup>a</sup>	Instability (10) <sup>a</sup>	Miscellaneous (8) <sup>a</sup>	Total (272) <sup>a</sup>
Glenoid erosion	7/7	3/3	4/4	3/3				17/17
Stiffness	1/1	2/0	2/2		1/0	1/1	1/1	8/5
Rotator cuff tear	2/2			1/0			1/0	4/2
Infection	2/2			1/1				3/3
Humeral fracture	3/0							3/0
Anterior instability	1/1		1/1					2/2
Stem loosening	1/0		1/0					2/0
Tuberosity	1/1							1/1
Posterior instability		1/0						1/0
Hematoma				1/0				1/0
Total complication/removal	18/14	6/3	8/7	6/4	1/0	1/1	2/1	42/30

CTA: cuff tear arthropathy; OA: glenohumeral osteoarthritis; RA: rheumatoid arthritis; AVN: avascular necrosis; Seq: fracture sequelae.

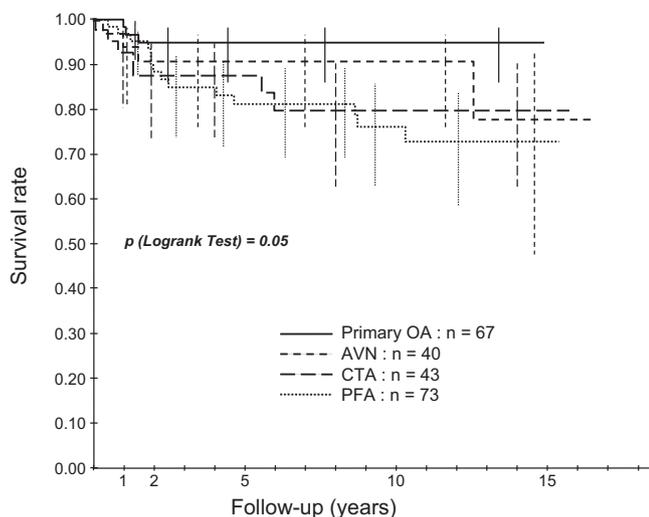
<sup>a</sup> Number of prostheses in the initial population.

**Table 3** Mean Constant-Murley scores in the population re-evaluated after at least 8 years, across aetiologies.

	Pain		ADL		Range of motion		Strength		Constant score	
	Preoperatively	Last follow-up	Preoperatively	Last follow-up	Preoperatively	Last follow-up	Preoperatively	Last follow-up	Preoperatively	Last follow-up
AVN (20) <sup>a</sup>	3.8	12.2	7.5	16.2	17.6	32.4	3.3	9.3	32.2	70.1
P	0.0001		0.0001		0.0003		0.002		0.0001	
OA (42) <sup>a</sup>	3.3	11.4	6.4	15.1	13	26.5	4.3	7.7	27	60.7
P	<0.0001		<0.0001		<0.0001		0.0004		<0.0001	
Seq (34) <sup>a</sup>	4.7	11.2	6	14.6	13.6	24.8	5	7.1	29.3	57.7
P	<0.0001		<0.0001		<0.0001		0.0117		<0.0001	
RA (14) <sup>a</sup>	5.1	12.4	7.4	13.7	12.3	22	1.9	7.1	26.2	55.3
P	0.001		0.001		0.001		0.005		0.001	
CTA (18) <sup>a</sup>	4.3	10.2	6	11	13.9	22.3	2.6	2.7	26.8	46.2
P	0.0006		0.0034		0.0031		0.234		0.0006	

CTA: cuff tear arthropathy; OA: glenohumeral osteoarthritis; RA: rheumatoid arthritis; AVN: avascular necrosis; Seq: fracture sequelae.

<sup>a</sup> Number of prostheses in the population re-evaluated after at least 8 years.



**Figure 1** Prosthesis survival across diagnostic groups (Kaplan-Meier method; asymmetric 95% confidence interval according to Rothman).

OA: glenohumeral osteoarthritis; AVN: avascular necrosis; CTA: cuff tear arthropathy; PFA: post-fracture arthropathy.

number of patients who died or were lost to follow-up. The choice between total arthroplasty and hemiarthroplasty was at the discretion of each surgeon, and the criteria may have varied across centres. The large number of centres and outcome assessors raises concerns about the reproducibility of the clinical evaluation. The number of patients was small in some of the aetiological groups. Finally, we did not consider the radiographic data, particularly glenoid cavity morphology at baseline.

Prosthesis survival after shoulder hemiarthroplasty is important to consider and is even crucial for patients younger than 50 years of age. In a study of patients younger than 50 years with a mean follow-up of 16.2 years, total arthroplasty was superior over hemiarthroplasty, with 10-year survival rates of 97% and 84%, respectively [22]. However, the underlying aetiologies were not clearly differentiated in this study.

Few studies compared long-term outcomes after total arthroplasty and hemiarthroplasty in AVN, and most of them included trauma-related necrosis, which raises specific issues [23,24]. After a mean follow-up of 8.9 years, functional outcomes were similar with the two procedures, although survival was better with total arthroplasty [23]. A study with a shorter follow-up of 4.8 years found no clinical differences between the two procedures but showed a 22% complication rate after total arthroplasty compared to only 8% after hemiarthroplasty [24]. The 94% survival rate after 10 years in our study is among the best reported to date and is consistent with the 95% survival rate after 15 years reported in an earlier study [3]. These good results after hemiarthroplasty are all the more relevant that the patients were young (46 years in our re-evaluated patients with AVN, Table 1). When used after radiation-induced necrosis, hemiarthroplasty has produced disappointing outcomes [25], which were not clearly replicated in our four patients, although 1 of these patients developed an infection requiring prosthesis removal within the first year. Our data confirm

that AVN is a reliable indication for hemiarthroplasty that is associated with excellent tolerance by the glenoid in the long term, regardless of the cause of the necrosis.

Two prospective randomised studies have been performed in primary OA. In one of these studies, total arthroplasty produced better outcomes for pain, mobility, and revision rates [26]. The other, in contrast, showed no significant difference, although a trend in favour of total arthroplasty was noted [27]. Follow-up was brief in both studies, 36 months [26] and 24 months [27], respectively, and the results cannot be extrapolated to the long term. Prosthesis survival after hemiarthroplasty was 86% in a study of 51 cases with a follow-up of 11.3 years [28] and 72% in a study of 20 cases with a follow-up of 7 years [29]. Our survival rate of 94.2% after 10 years is among the best reported to date. In all three cases of prosthesis removal, the procedure was required within the first 18 months, because of pain due to glenoid erosion. In another study, mean time to revision was 1.5 years and the main reason for prosthesis removal was pain due to glenoid erosion [14]. Early occurrence of pain may be due to wear of the posterior glenoid cavity [30,31]. A correlation has been reported between joint space narrowing and functional outcomes [13] but there is no consensus about the source of pain in patients with glenoid cartilage erosion. Nevertheless, our study shows that hemiarthroplasty is a reasonable treatment option in primary OA. Although total arthroplasty may be more effective in relieving residual pain, hemiarthroplasty does not carry the risk of glenoid component loosening with bone stock alteration that occurs 10 to 15 years after total arthroplasty in young patients.

A study in RA indicated that long-term pain relief was better after total arthroplasty than after hemiarthroplasty, except in patients who had rotator cuff lesions [4]. Prosthesis survival was better after total arthroplasty, with a 5.6% revision rate for glenoid component failure, compared to 7.4% for pain due to glenoid erosion after hemiarthroplasty. In contrast, the survival curve was stable after hemiarthroplasty starting at the 5th year but continued to decrease after total arthroplasty, so that the two curves intersected eventually (after 15–20 years). In another study of RA patients, glenoid component loosening with upwards migration of the humeral implant due to rotator cuff tears occurred in 42% of cases [16]. A study with a follow-up of at least 15 years showed that glenoid component loosening developed in 87% of cases and rotator cuff tears in 100% of cases [32]. In our study, the 10-year prosthesis survival rate in the RA group was 100%. An earlier study in 303 cases with a mean follow-up of 12.1 years found a 10-year survival rate of 89%; the prosthesis was removed in 10 cases, the reason being pain from glenoid wear in eight cases, in the absence of specific predictive factors [4]. Our case-series is too small to challenge the results of this large earlier study [4]. The mean age of our re-evaluated patients (40.5 years in our re-evaluated patients with RA, Table 1) was younger, and we believe the good prosthesis survival rate supports the use of hemiarthroplasty in this young population. The functional outcomes in our series were only fair overall, most notably regarding range of motion, although the results on pain were satisfactory. The earlier study [4] established the pain-relieving effect of hemiarthroplasty in RA [4]. This favourable effect on pain, the young age of the patients, the

**Table 4** Distribution of poor results at re-evaluation after at least 8 years, according to aetiology.

	AVN (20) <sup>a</sup>	OA (42) <sup>a</sup>	Seq (34) <sup>a</sup>	RA (14) <sup>a</sup>	CTA (18) <sup>a</sup>
Constant < 30 (%)	0	3 (7)	6 (12)	0	3 (17)
Weighted Constant < 50 (%)	1 (5)	5 (12)	8 (15)	1 (7)	4 (22)
Pain < 10 (%)	3 (15)	8 (19)	7 (13)	0	7 (39)
AFE < 90° + AER < 10° (%)	0	5 (12)	12 (23)	4 (29)	4 (22)

CTA: cuff tear arthropathy; GHOA: glenohumeral osteoarthritis; RA: rheumatoid arthritis; AVN: avascular necrosis; Seq: fracture sequelae; AFE: active forward elevation; AER: active external rotation.

<sup>a</sup> Number of prostheses in the population re-evaluated after at least 8 years, used as the denominator for the percentages given in parentheses.

**Table 5** 5-year and 10-year prosthesis survival rates according to diagnoses.

Diagnosis	Initial population	5 years		10 years	
		Remaining shoulders	Survival rate	Remaining shoulders	Survival rate
RA	31	16	1	11	1
OA	67	46	0.949	19	0.949
AVN	40	25	0.942	15	0.942
CTA	43	25	0.885	14	0.815
Seq	73	43	0.816	25	0.768

CTA: cuff tear arthropathy; OA: glenohumeral osteoarthritis; RA: rheumatoid arthritis; AVN: avascular necrosis; Seq: fracture sequelae.

risk of glenoid component loosening in the long term, and the good prosthesis survival rate support hemiarthroplasty rather than total arthroplasty in patients with RA aged less than 50 years, despite the limited effect on range of motion.

In CTA, total arthroplasty carries a risk of glenoid component loosening [33], and hemiarthroplasty produces disappointing results with loss of motion and upwards humeral head migration that erodes the acromial vault [34]. In our study, this group had the worst functional outcomes and a low prosthesis survival rate. There is now a consensus that reverse arthroplasty is indicated in CTA, except in very young patients, and produces far better functional outcomes than does hemiarthroplasty [35].

In the Seq group, outcomes after hemiarthroplasty were not as good as those reported after first-line hemiarthroplasty for fracture treatment [36]. The prosthesis survival rate of 76.8% in this aetiological group was the lowest recorded in our study. Thus, hemiarthroplasty does not seem reliable in patients with Seq. The low survival rate was due in large part to revisions because of glenoid erosion, suggesting a far greater degree of cartilage damage than estimated on the radiographs. The analysis of poor outcomes in this group (26%) and, above all, the high rate of prosthesis removal show that Seq is a poor indication for hemiarthroplasty. At least in elderly patients, when the need for replacement surgery has been established, total arthroplasty seems preferable.

In conclusion, AVN is undoubtedly the best indication for hemiarthroplasty. Primary OA and RA in patients younger than 50 years of age are also good indications, given the high rate of long-term glenoid component loosening after total arthroplasty, particularly when the rotator cuff is torn (which is common in RA and affects a substantial number of patients with primary OA). In contrast, hemiarthroplasty

should be viewed with circumspection in patients with CTA or Seq, as the results are disappointing. The best option is no doubt reverse total arthroplasty in CTA and either total or reverse total arthroplasty in Seq depending on the nature of the lesions.

## Disclosure of interest

Luc Favard receives royalties from Tornier Inc.

Pascal Boileau receives royalties from Tornier Inc.

## References

- [1] Neer CS. Displaced proximal humeral fractures. Treatment of three-part and four-part displacement. *J Bone Joint Surg Am* 1970;52:1090–103.
- [2] Wirth MA, Tapscott RS, Southworth C, Rockwood CA. Treatment of glenohumeral arthritis with a hemiarthroplasty: a minimum five-year follow-up outcome study. *J Bone Joint Surg Am* 2006;88:964–73.
- [3] Smith RG, Sperling JW, Cofield RH, Hattrup SJ, Schleck CD. Shoulder hemiarthroplasty for steroid-associated osteonecrosis. *J Shoulder Elbow Surg* 2008;17:685–8.
- [4] Sperling JW, Cofield RH, Schleck CD, Harmsen WS. Total shoulder arthroplasty versus hemiarthroplasty for rheumatoid arthritis of the shoulder: results of 303 consecutive cases. *J Shoulder Elbow Surg* 2007;16:683–90.
- [5] Williams G, Rockwood C. Hemiarthroplasty in rotator cuff-deficient shoulders. *J Shoulder Elbow Surg* 1996;5:362–7.
- [6] Pape G, Zeifang F, Bruckner T, Raiss P, Rickert M, Loew M. Humeral surface replacement for the sequelae of fractures of the proximal humerus. *J Bone Joint Surg Br* 2010;92:1403–9.
- [7] Grammont P, Trouilloud P, Laffay JP. Étude et réalisation d'une nouvelle prothèse d'épaule. *Rhumatologie* 1987;39:17–22.

- [8] Sirveaux F, Favard L, Oudet D, Huquet D, Walch G, Molé D. Grammont inverted total shoulder arthroplasty in the treatment of glenohumeral osteoarthritis with massive rupture of the cuff. Results of a multicentre study of 80 shoulders. *J Bone Joint Surg Br* 2004;86:388–95.
- [9] Walch G, Boileau P, Noël E. Shoulder arthroplasty: evolving techniques and indications. *Joint Bone Spine* 2010;77:501–5.
- [10] Boileau P, Sinnerton RJ, Chuinard C, Walch G. Arthroplasty of the shoulder. *J Bone Joint Surg Br* 2006;88:562–75.
- [11] Boyd AD, Thomas WH, Scott RD, Sledge CB, Thornhill TS. Total shoulder arthroplasty versus hemiarthroplasty. Indications for glenoid resurfacing. *J Arthroplasty* 1990;5:329–36.
- [12] Sandow M, Gartsman G, Kirkley S. Total or hemiarthroplasty for OA shoulder: meta-analysis of trials. *J Bone Joint Surg Br* 2002;84(Suppl. 3):256.
- [13] Parsons IM, Millett PJ, Warner JJ. Glenoid wear after shoulder hemiarthroplasty: quantitative radiographic analysis. *Clin Orthop Relat Res* 2004;421:120–5.
- [14] Haines JF, Trail IA, Nuttall D, Birch A, Barrow A. The results of arthroplasty in osteoarthritis of the shoulder. *J Bone Joint Surg Br* 2006;88:496–501.
- [15] Bryant D, Litchfield R, Sandow M, Gartsman G, Guyatt G, Kirkley A. A comparison of pain, strength, range of motion, and functional outcomes after hemiarthroplasty and total shoulder arthroplasty in patients with osteoarthritis of the shoulder. A systematic review and meta-analysis. *J Bone Joint Surg Am* 2005;87:1947–56.
- [16] Sjøbjerg JO, Frich LH, Johannsen HV, Sneppen O. Late results of total shoulder replacement in patients with rheumatoid arthritis. *Clin Orthop Relat Res* 1999;366:39–45.
- [17] Brenner BC, Ferlic DC, Clayton ML, Dennis DA. Survivorship of unconstrained total shoulder arthroplasty. *J Bone Joint Surg Am* 1989;71:1289–96.
- [18] Torchia ME, Cofield RH, Settergren CR. Total shoulder arthroplasty with the Neer prosthesis: long-term results. *J Shoulder Elbow Surg* 1997;6:495–505.
- [19] Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res* 1987;214:160–4.
- [20] Field LD, Dines DM, Zabinski SJ, Warren RF. Hemiarthroplasty of the shoulder for rotator cuff arthropathy. *J Shoulder Elbow Surg* 1997;6:18–23.
- [21] Rothman KJ. Estimation of confidence limits for the cumulative probability of survival in life table analysis. *J Chronic Dis* 1978;31:557–60.
- [22] Sperling J, Cofield R, Rowland C. Neer hemiarthroplasty and Neer total shoulder arthroplasty in patients fifty years old or less. Long-term results. *J Bone Joint Surg Am* 1998;80:464–73.
- [23] Hattrup SJ, Cofield RH. Osteonecrosis of the humeral head: results of replacement. *J Shoulder Elbow Surg* 2000;9:177–82.
- [24] Feeley BT, Fealy S, Dines DM, Warren RF, Craig EV. Hemiarthroplasty and total shoulder arthroplasty for avascular necrosis of the humeral head. *J Shoulder Elbow Surg* 2008;17:689–94.
- [25] Mansat P, Huser L, Mansat M, Bellumore Y, Rongières M, Bonnevalle P. Shoulder arthroplasty for atraumatic avascular necrosis of the humeral head: nineteen shoulders followed up for a mean of seven years. *J Shoulder Elbow Surg* 2005;14:114–20.
- [26] Gartsman GM, Roddey TS, Hammerman SM. Shoulder arthroplasty with or without resurfacing of the glenoid in patients who have osteoarthritis. *J Bone Joint Surg Am* 2000;82:26–34.
- [27] Lo IK, Litchfield RB, Griffin S, Faber K, Patterson SD, Kirkley A. Quality-of-life outcome following hemiarthroplasty or total shoulder arthroplasty in patients with osteoarthritis. A prospective, randomized trial. *J Bone Joint Surg Am* 2005;87:2178–85.
- [28] Rispoli DM, Sperling JW, Athwal GS, Schleck CD, Cofield RH. Humeral head replacement for the treatment of osteoarthritis. *J Bone Joint Surg Am* 2006;88:2637–44.
- [29] Bartelt R, Sperling JW, Schleck CD, Cofield RH. Shoulder arthroplasty in patients aged fifty-five years or younger with osteoarthritis. *J Shoulder Elbow Surg* 2011;20:123–30.
- [30] Edwards TB, Kadakia NR, Boulahia A, Kempf JF, Boileau P, Némoz C. A comparison of hemiarthroplasty and total shoulder arthroplasty in the treatment of primary glenohumeral osteoarthritis: results of a multicenter study. *J Shoulder Elbow Surg* 2003;12:207–13.
- [31] Levine WN, Djurasovic M, Glasson JM, Pollock RG, Flatow EL, Bigliani LU. Hemiarthroplasty for glenohumeral osteoarthritis: results correlated to degree of glenoid wear. *J Shoulder Elbow Surg* 1997;6:449–54.
- [32] Betts HM, Abu-Rajab R, Nunn T, Brooksbank AJ. Total shoulder replacement in rheumatoid disease: a 16- to 23-year follow-up. *J Bone Joint Surg Br* 2009;91:1197–200.
- [33] Franklin JL, Barrett WP, Jackins SE, Matsen FA. Glenoid loosening in total shoulder arthroplasty. Association with rotator cuff deficiency. *J Arthroplasty* 1988;3:39–46.
- [34] Sanchez-Sotelo J, Cofield RH, Rowland CM. Shoulder hemiarthroplasty for glenohumeral arthritis associated with severe rotator cuff deficiency. *J Bone Joint Surg Am* 2001;83:1814–22.
- [35] Favard L, Oudet D, Hugué TD, Sirveaux F, Mole D. Résultats des prothèses anatomiques et prothèses inversées dans l'omarthrose excentrée. In: Boileau P, Walch G, editors. *Cahiers d'enseignement de la SOFCOT: prothèses d'épaule. État actuel*; 2008. p. 311–6.
- [36] Norris TR, Green A, McGuigan FX. Late prosthetic shoulder arthroplasty for displaced proximal humerus fractures. *J Shoulder Elbow Surg* 1995;4:271–80.