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ORIGINAL PAPER

Pain and function in eight hundred and fifty nine patients comparing shoulder hemiprostheses, resurfacing prostheses, reversed total and conventional total prostheses

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Abstract
Purpose Functional results of reversed total prostheses (RTP) have—to a very limited degree—been compared with those of other shoulder prosthesis types. The aim of our study was to compare results of four different types of shoulder prostheses in terms of function, pain, and quality of life (QoL).
Methods Questionnaires were completed by 859 patients with shoulder prostheses registered in the Norwegian Arthroplasty Register. Patients with osteoarthritis (OA), rheumatoid arthritis (RA), or fracture sequela (FS) were included. Symptoms and function were assessed using the Oxford Shoulder Score (OSS, scale 0–48), and the EuroQoL-5D (EQ-5D) was used to assess QoL.
Results Best functional results were obtained using conventional total prostheses (TPs) and RTPs —mean OSS improvement 18 and 16 units, respectively, vs 11 with hemiprostheses (HPs). For patients with OA, TPs performed best; for those with RA and FS, RTPs performed best; and those with HPs had the worst results in all diagnostic groups. The greatest improvement in QoL was seen in patients with TPs and RTPs.
Conclusions Conventional TPs provide the best improvement in pain, function and QoL in OA patients; RTPs are superior in patients with RA and FS.

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Introduction

Only a few randomised controlled trials (RCTs) have been performed to study shoulder replacement surgery [1–5]. In a recent Cochrane review assessing surgery for shoulder osteoarthritis (OA), total shoulder prostheses (TPs) compared favourably with hemiprostheses (HP) with respect to shoulder function, but no difference in pain or quality of life QoL was found [6]. To our knowledge, no previous study comparing functional results for the four major shoulder prosthesis types has been published.

An increased rate of complications has been reported in relation to the reverse total prostheses (RTPs) [7], but clinical results have been promising [8]. Prosthesis survival is often used as a measure of success in arthroplasty surgery, being a tough and reliable outcome measure. Even so, it has been shown that although revision rates do not differ between treatment groups, there may be differences in the degree of pain experienced by the patients [9]. The Norwegian Arthroplasty Register (NAR) lacks information on functional results and pain, and to collect such information, patients with shoulder arthroplasties reported in the NAR were posted a questionnaire in 2010. The aim of the study was to evaluate and compare results of four major types of shoulder prosthesis in terms of function, pain and QoL.

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Materials and methods

A more detailed description of patients and methods can be found in our previous publication from the same survey [10].

Participants

In February 2010, questionnaires were posted to all patients aged 18 years or more with a shoulder arthroplasty reported to the NAR from 1994 to 2008 for any diagnosis except cancer (n=1,865). The inclusion process is shown in Fig. 1. Nonresponders were older (mean 70 vs 66 years), and there were more women nonresponders (79 % vs 72 %). The five year prosthesis survival rate was 89 % in nonresponders and 91 % in responders, p=0.31.

Data on patient demographics, diagnosis and type of prosthesis were obtained from the NAR (Fig. 1). More than one diagnosis may be registered in the NAR, but in this study, each patient was assigned one diagnosis according to a system in which FS ranked above RA and OA and RA ranked above OA. Sixty-four patients underwent at least one revision operation. Patients having undergone revision were analysed together with the other patients, but in addition, separate analyses were performed for these patients. Along with the questionnaire, a patient information letter and consent form was sent to and completed by all participants. The project was approved by the Regional Committee for Medical Research Ethics, Western Norway (date of issue: 07/01/2009; registration number: 246:09).

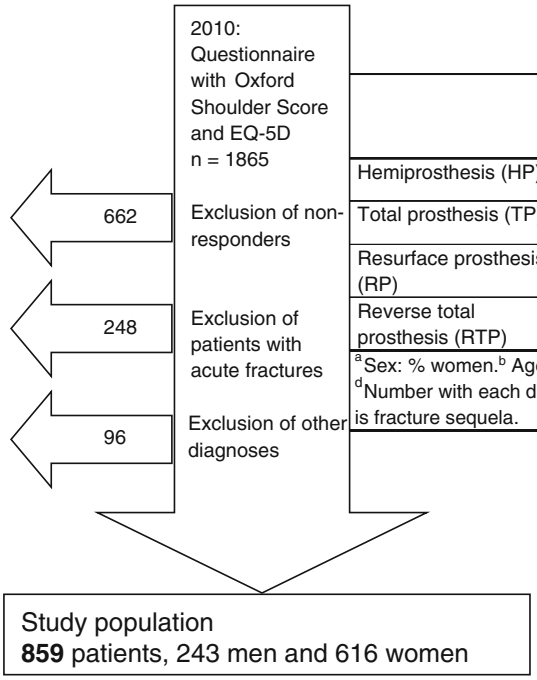
Implants

A complete list of all prosthesis brands used in the study is found in the annual report 2009 from the NAR http://nrlweb.ihelse.net/default.htm. Patients were divided into four groups according to prosthesis type: TP (Fig. 2a), HP (Fig. 2b), RTP (Fig. 2c) and resurfacing hemiprosthesis (RP, Fig. 2d). The use of these prosthesis types within each diagnostic group is shown in Fig. 1. No resurfacing total prostheses were reported to the register.

Outcome measures

The primary outcome measure was the Oxford Shoulder Score (OSS), which assesses patient-reported symptoms and function in relation to shoulder surgery [11]. The OSS consists of 12 items scored from 0 to 4, and in Table 1 mean results for each item are given. A total OSS ranging from 0 to 48 was calculated based on all 12 items. The patients completed one questionnaire concerning symptoms and function presurgery and another relating to the time of receiving the questionnaire. For the presurgery questionnaire, patients were specifically asked to address the time before the primary operation. Presurgery results were designated "preoperative" and results concerning the time of completing the questionnaire "present". In accordance with a previous publication, the minimal clinically important difference (MCID) for the OSS was set at 4.5 points (about 10 % of the range) [12].

A secondary outcome measure was the EuroQoL-5D (EQ-5D), which assesses QoL using a three-level system



	N	Sex[a]	Age[b]	Age at follow-up[b]	Follow-up time[c]	RA[d] n = 253	OA[d] n = 388	FS[d] n = 218
Hemiprosthesis (HP)	408	72	65 (12)	72 (11)	6.9 (3.8)	122	144	142
Total prosthesis (TP)	86	67	67 (10)	71 (10)	3.9 (3.3)	7	68	11
Resurface prosthesis (RP)	195	62	64 (12)	69 (12)	4.3 (2.8)	52	124	19
Reverse total prosthesis (RTP)	170	85	68 (11)	74 (10)	4.7 (8.8)	72	52	46

[a] Sex: % women. [b] Age: mean years, standard deviation (SD). [c] Time since primary operation: mean years, SD. [d] Number with each diagnosis within the prosthesis group. RA is rheumatoid arthritis, OA is osteoarthritis, FS is fracture sequela.

Fig. 1 Inclusion of patients and patient characteristics

Fig. 2 **a** Anatomical total prosthesis, **b** hemiprosthesis, **c** reverse total prosthesis, **d** resurfacing prosthesis

with the following five dimensions: mobility, self-care, usual activities, pain/discomfort, anxiety/depression [13]. The EQ-5D index score is calculated using population-based preference weights, and the score ranges from 0 to 1, where 1 represents perfect health and 0 is death. Negative values are allowed and represent a health status considered worse than death. Also included in the EQ-5D is a 20-cm vertical visual analogue scale (EQ-VAS) ranging from 0 to 100, where 0 is worst imaginable health state and 100 is best imaginable health state.

Statistics

Differences in mean change of EQ-5D between prosthesis groups were assessed using analysis of variance (ANOVA, Table 2). A multiple linear regression model with adjustment for diagnosis, age (≤60, 60–70, >70), sex and follow-up time was used to estimate differences in mean OSS change between groups (Table 3). In addition, separate analyses comparing the four prosthesis types within each diagnostic group (OA, RA, FS) were performed (results given in text only), as were separate analyses comparing results for patients never revised to those having undergone at least one revision, adjusting for age, sex, diagnosis, follow-up time and prosthesis type.

Due to a difference in mean follow-up time for prosthesis types (Fig. 1), analyses were adjusted for follow-up time. Furthermore, separate analyses were performed for a subgroup of patients operated upon between 2002 and 2008. The significance level was set at 5 %, and all p values were

Table 1 Mean end score and change for each of the 12 Oxford Shoulder Score (OSS) items in patients with four prosthesis types

OSS item [a]	Mean end score/change				*P* value[b]
	Hemiprosthesis	Total prosthesis	Resurfacing prosthesis	Reverse prosthesis	
Worst pain	2.7/1.1	2.1/1.9	2.7/1.3	2.3/1.6	<0.001/<0.001
Dressing	2.5/0.9	1.9/1.5	2.2/1.0	2.2/1.2	<0.001/<0.001
Car/public transport	2.1/0.6	1.7/0.9	1.8/0.6	2.0/0.8	0.003/0.01
Knife and fork	2.0/0.8	1.7/1.0	1.7/0.8	2.0/1.1	0.01/0.089
Shopping	2.3/0.5	1.8/1.0	2.0/0.7	2.3/0.8	0.001/0.01
Carry tray	2.6/0.8	2.0/1.4	2.2/0.9	2.6/1.1	<0.001/0.002
Brush hair	3.2/1.0	2.2/1.9	2.4/1.5	2.8/1.4	<0.001/<0.001
Usual pain	3.2/1.3	2.4/2.3	3.1/1.4	2.8/1.8	<0.001/<0.001
Hang clothes	3.3/0.9	2.5/1.9	2.6/1.3	2.8/1.5	<0.001/<0.001
Wash under arms	2.6/1.0	1.9/1.9	2.1/1.3	2.1/1.6	<0.001/<0.001
Pain influence on work	2.8/0.8	2.2/1.6	2.5/1.1	2.5/1.3	<0.001/<0.001
Pain at night	2.6/1.3	2.1/2.1	2.7/1.4	2.3/1.7	<0.001/<0.001

[a] The complete questions may be found at: http://www.orthopaedicscore.com/scorepages/oxford_shoulder_score.html

[b] Estimated using analysis of variance (ANOVA)

two-tailed. All analyses were performed using SPSS version 17.0 (SPSS Inc. Chicago, IL, USA).

Results

Pain and function according to prosthesis type

Patients with TPs had best mean end result for all 12 OSS items, followed by patients with RPs and RTPs. In the TP group, the greatest degree of improvement for all but one item was also seen (Table 1). Patients with RTPs had second-best results in terms of improvement for all but two items, whereas for all items, the worst end result and the smallest degree of improvement was seen in patients with HPs (Table 1). When considering total OSS, patients with TPs, RTPs and RPs reported best end results, as opposed to HP patients (35 vs 28 for TP vs HP, Table 2). The greatest improvement in OSS was seen in patients with TPs whose mean improvement was 18 units , 6.8 units more than the HP group ($p<0.001$, Table 3), the difference thus exceeding the MCID for OSS (4.5 units). Patients with RTPs

Table 2 Crude mean [standard deviation (SD)] preoperative and present Oxford Shoulder Score (OSS) and EuroQoL-5D (EQ-5D), and mean change in OSS and EQ-5D, according to prosthesis type

		Mean (SD) preoperative	Mean (SD) present	Mean (SD) change	*P* value[a]
OSS total	Hemiprosthesis (n=408)	17 (10)	28 (12)	11 (14)	
	Total prosthesis (n=86)	16 (8)	35 (13)	19 (14)	
	Resurfacing prosthesis (n=195)	18 (8)	32 (12)	14 (12)	
	Reverse total prosthesis (n=170)	15 (9)	32 (13)	17 (14)	
EQ-5D	Hemiprosthesis (n=408)	0.43 (0.26)	0.59 (0.24)	0.17 (0.32)	<0.001
	Total prosthesis (n=86)	0.37 (0.21)	0.73 (0.26)	0.36 (0.32)	
	Resurfacing prosthesis (n=195)	0.38 (0.19)	0.64 (0.26)	0.26 (0.29)	
	Reverse total prosthesis (n=170)	0.34 (0.20)	0.62 (0.24)	0.28 (0.29)	
EQ-5D VAS	Hemiprosthesis (n=408)	47 (25)	60 (26)	13 (31)	0.001
	Total prosthesis (n=86)	47 (22)	71 (24)	24 (33)	
	Resurfacing prosthesis (n=195)	46 (23)	67 (24)	22 (29)	
	Reverse total prosthesis (n=170)	43 (23)	66 (25)	24 (35)	

No statistic given for OSS because this is given in the adjusted analysis in Table 3

VAS visual analague scale

[a] Difference in improvement of EQ-5D and EQ-5D VAS, between the four prosthesis groups

Table 3 Difference in change from preoperative to present Oxford Shoulder Score (OSS) by diagnosis and prosthesis type, adjusted for sex, age and follow-up time

	Number[a]	Mean change[b]	Adjusted difference[c]	95 % confidence interval	*P* value[c]
Prosthesis type					
Hemiprosthesis	354	10.9	Ref		
Total prosthesis	78	17.8	6.8	(3.4 to 10.3)	<0.001
Resurfaced	177	12.8	1.9	(−0.7 to 4.5)	0.16
Reverse	153	16.2	5.2	(2.6 to 7.9)	<0.001
Diagnosis					
Fracture sequela	191	11.4	Ref		
Rheumatoid arthritis	235	16.0	4.7	(1.9 to 7.4)	0.001
Osteoarthritis	336	15.9	4.6	(2.0 to 7.1)	0.001
Sex					
Male	214	12.3	Ref		
Female	548	14.0	2.0	(−0.3 to 4.3)	0.08
Age in years					
<60	220	13.4	Ref		
60–70	250	14.5	0.8	(−1.8 to 3.4)	0.54
>70	292	12.7	−1.7	(−4.3 to 0.9)	0.21

[a]Number=762 because 97 patients had missing values for at least one of the included variables

[b]For diagnosis and prosthesis type, mean changes were adjusted for sex, age, and follow-up time while unadjusted mean change was given for sex and age groups

[c]Difference in change compared with reference group and corresponding *P* values calculated using linear regression analysis adjusting for variables in the table as well as for follow-up time

also had good results, with an OSS improvement of 5.2 units more than HP patients ($p<0.001$, Table 3). When comparing patients with and without revision, a mean OSS improvement of 7 units was found in revised patients compared with 14 in those never revised ($p<0.001$).

Patients with rheumatoid arthritis, osteoarthritis and fracture sequelae

In all three diagnostic groups, HPs performed worst. Apart from this, some differences were observed between groups.

Osteoarthritis OA patients with TPs reported remarkably good results, with a mean improvement in OSS of 20 units and an end result of 37 units, followed by patients with RTPs (mean improvement 17 units). A 13-unit change was seen for HPs and RPs ($p<0.001$ for TP vs HP and $p=0.07$ for RTP vs HP).

Rheumatoid arthritis In the RA group, the magnitude of improvement with TPs, RPs and RTPs was similar (mean OSS improvement 17 for TP and RTP, 16 for RP and 13 for HP). However, only RTPs were statistically significantly better than HPs ($p=0.032$), but the number of RA patients with TPs was low ($n=7$).

Fracture sequelae FS patients obtained best results with RTPs or RPs (mean OSS improvement 15 units), whereas a smaller improvement was obtained with TPs (10 units). HPs performed particularly badly, with a mean improvement in OSS of 7 units ($p=0.007$ and 0.07 for RTP and RP vs HP, respectively).

Quality of life

The best end results for QoL were reported by patients with TPs, and the mean improvement in EQ-5D was twice that seen in the HP group ($p<0.001$, Table 2). Furthermore, an improvement in EQ-5D VAS of 22–24 units was reported by patients with TPs, RTPs and RPs compared with 13 units for HPs ($p=0.001$, Table 2).

Patients operated upon 2002–2008

In patients operated upon between 2002 and 2008, similar results were found, but differences in OSS and EQ-5D between TPs and HPs were even more pronounced. For instance, the adjusted difference in OSS-change between TPs and HPs was 8.2 in patients operated upon from 2002 to 2008 compared with 6.8 for all patients.

Discussion

The main finding of our study was that patients provided with total prostheses, conventional or reverse, had superior results compared with hemiprostheses in terms of improved function, pain and QoL. Similar findings were reported in some previous articles comparing HP and TP [14–16], but results on RTP were not given in those studies.

Conventional and reverse total shoulder arthroplasty

In our study, the best end results as well as the greatest improvement in pain, function and QoL, were seen in OA

patients with TPs. This confirms the results of some previous studies [1, 2, 17]. We had no information on the state of the rotator cuff in our patients. Clinical experience would suggest that an RTP was more often used in patients with cuff tears. No RCTs have been performed comparing different prosthesis types in patients with RA [18]. Trail et al. found no difference in pain or function between RA patients with HPs or TPs [19], whereas Sperling et al., who reported no difference between TPs and HPs in RA patients with thin or torn rotator cuffs, found greater improvement with TPs than in HPs in patients with intact rotator cuffs [20]. Among RA patients in our study, RTPs were used much more frequently than TPs, and RTPs performed very well in this patient group. Good functional results and pain relief have previously been demonstrated for RTPs and in patients with RA [21–24], although no comparison of RTPs to HPs has previously been published. The frequent incidence of damaged rotator cuff in RA patients suggests the use of RTPs rather than TPs; randomised studies are needed to further investigate this.

In our study, RTPs were frequently used in patients with FS and performed better than both TPs and HPs. One reason for this might be that these patients often have damaged rotator cuffs and thus benefit from the design of the reverse implants, as was suggested in a previous publication [25].

Hemiprostheses and resurfacing hemiprostheses

Patients with HPs performed worst both for separate OSS items and total OSS, and the difference between HPs and TPs was clinically (greater MCID) and statistically significant. This is in agreement with findings of a previous study in which 46 % of patients with HPs vs 73 % of those with TPs reported themselves to be very satisfied [26]. The follow-up time was longer for patients with HPs, which might have influenced results adversely for the HP group. However, adjustment for follow-up time had little impact on findings; subanalyses assessing only patients operated upon after 2001 revealed the same or even more pronounced differences in OSS and EQ-5D between TPs and HPs. The results of HPs in patients with FS were so inferior that we believe no patients with FS should be treated using an HP if it can be avoided. The inferior results of HPs in general are in contrast to those of good implant survival of HPs shown in some previous studies [27, 28]. This indicates that prosthesis survival is not a sufficient measure of success for shoulder arthroplasty surgery. OSS end results were better for RPs than HPs, but no statistically significant difference in OSS improvement between RP and HP was found. However, with regards to QoL, results were better for RPs than for HPs both in terms of improvement and end results. Moreover, FS patients obtained best OSS results with RPs and RTPs.

Strengths and weaknesses

A weakness of this study is the responder rate of 65%. Reminders were sent to all nonresponders, but even so, we did not reach a higher response rate. Although nonresponders differed slightly in age and gender from responders, the five year implant survival rate was not significantly different between them. Even so, we cannot exclude the possibility of nonresponders being somewhat worse than responders. Another weakness is the retrospective collection of preoperative scores. However, we believe these scores may be trusted for several reasons. Firstly, with this large number of patients, it is reasonable to assume that patients will remember to a similar extent. Secondly, even if patients do exaggerate their preoperative complaints, the change in the score mirrors their perception of improvement due to the operation, which is really what counts. The length of follow-up might influence patients' recollection of the presurgery state, and thus a difference in follow-up time could influence results. For this reason, subanalyses were performed for patients treated between 2002 and 2008, with the finding of an even greater difference in results for TP vs HP. Finally, this was an observational study in which prosthesis type was not randomly allocated. Analyses were adjusted for all known possible confounders (such as age, gender, diagnosis and follow-up time), but even so, we may not rule out the possibility of unknown confounding factors influencing the results.

The most important strength of the study is its large population, allowing comparison of prosthesis types with adjustment for possible confounders, and with comparison within three diagnostic groups. We are not aware of any previous studies comparing the four major types of shoulder prostheses focusing on function, pain and QoL. In particular, functional results of RTPs have, to a very limited degree, been compared with those of other prosthesis types. Pfaler et al. included a similar study population, but only conventional HPs and TPs were compared [15]; our results are in accordance with their findings. Furthermore, as patients were identified using the NAR, patients populations operated upon at all types of hospitals and having a large spectrum of implants were contacted and included, resulting in good external validity. Although an RCT comparing the four prosthesis types in the major diagnostic groups would be desirable to confirm our results, such a study might be difficult to undertake because of the need for a large study population. We believe that the results obtained in

our study add new information regarding which prosthesis to select in given patient groups.

Conclusions

Best clinical results in terms of pain relief and improved function and QoL were obtained with TPs, and RTPs. TPs performed best in OA patients, whereas RTPs yielded good results in patients with RA and FS. HPs performed worst for all measured outcomes.

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

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