Mid-term results of Copeland shoulder cementless surface replacement arthroplasty from an independent centre

Nicholas Hwang, Chetan S Modi, Stephen J Drew & Stephen M Turner

Warwick Orthopaedics, Shoulder and Elbow Unit, University Hospitals Coventry and Warwickshire NHS Trust, Coventry, UK

ABSTRACT

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Conflicts of Interest

None declared

Correspondence

Nicholas Hwang, Warwick Orthopaedics, Shoulder and Elbow Unit, University Hospitals Coventry and Warwickshire NHS Trust, Clifford Bridge Road, Coventry CV2 2DX, UK.

Tel.: +44 (0)24 7696 4000.

E-mail: nick.hwang.8@gmail.com

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Background The present study reports our experience of Copeland shoulder cementless surface replacement arthroplasty (CSRA) and whether glenoid microfracture influences the progression of glenoid erosion.

Methods One-hundred-and-twelve CSRAs were performed in 101 patients between 2002 and 2007. Eighty-three patients were alive at the median follow-up time of 72 months (range 9 to 121 months; interquartile range 46 to 93 months). Assessment included an Oxford shoulder score (OSS), patient satisfaction score and plain radiographs.

Results The mean (range) OSS was 27 (7 to 48) and 64 of 73 (87.7%) patients were 'very satisfied' or 'satisfied' with their shoulder. Twenty-three (20.5%) shoulders had over 2 mm of glenoid erosion. Microfracture was performed in 43 of 112 shoulders (38.4%) and did not influence the progression of glenoid erosion. Further surgery was performed in 27 (24.1%) shoulders, including 15 revisions, eight arthrolyses and four subacromial decompressions. Revision to total shoulder arthroplasty was performed in 14:10 for glenoid erosion; one each for loosening, periprosthetic fracture, deep infection, and chronic pain. One was revised to reverse arthroplasty for chronic pain.

Conclusions CSRA performed in an independent centre reproduces the functional outcomes reported by the designer. Glenoid erosion, however, was a common occurrence and the main cause of revision – microfracture did not influence its progression.

INTRODUCTION

The technical goals of shoulder arthroplasty are to reproduce the patient's normal anatomy and restore the centre of rotation of the joint to optimize rotator cuff function where appropriate. Humeral cementless surface replacement arthroplasty (CSRA) is able to achieve this and also has the advantages over conventional stemmed humeral implants of preserving bone stock to facilitate future revision and reducing the risk of periprosthetic fractures by avoiding stress risers in the humeral shaft, especially in patients with an ipsilateral elbow replacement [1–4]. The Copeland shoulder CSRA was designed at the Reading Shoulder Unit with the Mark I (3 M, Rotherham, UK) originally being implanted in 1986, consisting of a central pegged humeral component secured with a screw from the lateral side of the proximal humerus. The Mark II (Zimmer, Swindon, UK) was introduced in 1990, with a fluted taper fit peg and the screw was removed because it was considered unnecessary. The latest Mark III version (Biomet Merck, Swindon, UK) was introduced in 1993 and included hydroxyapatite coating for improved bone implant fixation [1].

Studies published over the last decade from the designer's institution have reported excellent functional outcomes, prosthesis survival and equivalent results compared to conventional stemmed implants for osteoarthritis, rheumatoid arthritis, cuff tear arthropathy, osteonecrosis, and post-traumatic arthritis [1,5–7]. Although limited in numbers and

follow-up, studies from independent centres have demonstrated that the functional results appear to be reproducible [8–11]. However, higher rates of glenoid erosion than those seen in the designer's institution have been reported [9–11]. Although this has not resulted in revision surgery in all cases, it remains a cause for concern regarding the possible increase in requirement for revision surgery in the future with longer follow-up and the available glenoid bone stock for these procedures.

The present study reports our experience with the Mark III Copeland shoulder CSRA used as a hemiarthroplasty (HA) and determines whether glenoid microfracture affects the progression of glenoid erosion at mid-term follow-up.

MATERIALS AND METHODS

All consecutive patients treated with the Mark III Copeland shoulder CSRA as a HA between 2002 and 2007 were included in the present study (Table 1). In total, 112 implants were inserted into 101 patients, of whom 11 patients underwent staged bilateral procedures. The median age at the time of surgery was 75 years [range 41 years to 89 years; interquartile range (IQR) 63 years to 80 years] and the cohort consisted of 75 females and 26 males. The majority of cases were performed for primary osteoarthritis (OA) (86%). Other indications for CSRA included rheumatoid arthritis (RA) ($n=8$), chronic

Table 1 Patient demographics and characteristics.

Diagnosis	Number of cases	Median age (years) (interquartile range)	Male	Female	Right	Left
Primary osteoarthritis	96	75 (65 to 81)	23	73	54	42
Rheumatoid arthritis	8	54 (46 to 66)	2	6	4	4
Avascular necrosis	3	38 (37 and 70)	2	1	1	2
Chronic dislocation	4	70 (45 to 85)	2	2	2	2
Rotator cuff arthropathy	1	79	1	0	0	1

dislocation ($n = 4$), avascular necrosis (AVN) ($n = 3$) and rotator cuff arthropathy (RCA) in one case.

Data concerning patient demographics, operative details, surgical outcomes and additional procedures were extracted from a prospectively maintained electronic medical notes system. Postoperative functional outcomes were measured using the Oxford Shoulder Score (OSS) [12] and were collected through postal questionnaires. This is a 12-item patient-reported outcome score specifically designed and validated to assess the outcomes of shoulder surgery and ranges from 0 points to 48 points, where 48 is the best score. In addition, patients were surveyed on their overall satisfaction (yes or no) following their surgery. Research and ethics approval was obtained through the institution's review committee.

All procedures were carried out or supervised by one of the two senior authors (SMT and SJD). The McKenzie approach was used in 16 cases (14%), whereas a deltopectoral approach was adopted in the majority of procedures. A humeral head resurfacing HA was performed in all cases and the insertion of the humeral component followed the surgical technique described previously by Copeland et al. [1]. The standard size humeral head was inserted in the majority of cases ($n = 85$), whereas 15 patients had large and 10 patients had small-sized humeral components implanted. Data on the humeral head size were not available for two patients. At the time of primary operation, microfracture drilling of the glenoid was performed in cases where there was an intact rotator cuff and nonconcentric wear of the glenoid. No glenoid components were implanted at the time of the primary procedure. Postoperatively, all patients underwent a standardized graduated physiotherapy regime of passive movements in the first two days followed by passive-assisted movements until day five. Full active movement began at one week.

Patients were followed-up until 1 August 2012. The duration of follow-up was calculated from the date of their index procedure to the date of death or last known follow-up on medical records. Patients were reviewed at six weeks, six months and annual intervals thereafter following surgery. Anteroposterior and axillary radiographs were obtained on each visit and serial films were reviewed for prosthetic complications.

Descriptive statistics were used to summarize the data. Median and ranges are reported for nonparametric

characteristics, whereas numbers and percentages are presented for categorical attributes. Survival curves were calculated using the Kaplan–Meier method for two terminal events, including glenoid erosion and revision. Univariate (log rank) and multivariate (Cox proportional hazard model) analyses were employed to investigate the influence of glenoid drilling on the progression of glenoid erosion. A probability of a type-1 error was set at 0.05.

RESULTS

At a median follow-up of 72 months (range 9 to 121 months; IQR 46 to 91 months), there were 83 patients alive for analysis. Eighteen patients died at a median 42 months (IQR 32 to 55 months) after surgery and there were no deaths directly attributed to surgery.

Functional outcomes

Questionnaires were sent to all patients and the response rate was 88% (73 out of 83 patients alive). The mean OSS score was 27 (7 to 48) at a median of 72 months (IQR 46 to 93 months) after the index procedure. Sixty-four of 73 patients (87.7%) also reported being 'very satisfied' or 'satisfied' with their shoulder.

Complications

The complications are summarized in Table 2. Revision to a total shoulder replacement (TSR) was required for deep infection in one case, loosening in one shoulder and in one patient with non-union after sustaining a periprosthetic fracture. Progression of glenoid erosion accounted for the most frequent complication (21%) and developed at a median of 18 months (IQR 11 months to 34 months) after primary surgery. Thirteen patients were managed conservatively, whereas five patients were revised to a TSR. Another five cases were managed by resurfacing the glenoid with the Copeland CSRA polyethylene-lined glenoid peg. Among those with nonconcentric posterior erosion who had their glenoid drilled at the time of the primary procedure ($n = 43$), Kaplan–Meier estimation with progressive glenoid erosion as the primary outcome showed survival rates of 90% (SE 0.05), 80% (SE 0.06) and 67% (SE 0.09) at one year, three years and five years, respectively.

Table 2 Summary of complications and subsequent surgical management following Copeland shoulder resurfacing arthroplasty.

Complications	Number of cases (%)	Outcome (number of cases)
Adhesion/stiffness	12 (11%)	Arthrolysis (8), Decompression (2), MUA (2)
Deep infection	1 (0.9%)	At 46 months, revision to TSR
Loosening	3 (3%)	Average 49 months (35 to 62) Revision to TSR (1)
Cuff tear	5 (4%)	Decompression (2)
Periprosthetic fracture	3 (3%)	Conservative treatment (2), TSR revision for non-union (1)
Glenoid erosion	23 (21%)	Conservative (13), Revision (10)
Chronic pain and stiffness	2 (2%)	Revision to TSR (2)

MUA, manipulation under anesthesia; TSR, total shoulder replacement.

Fig. 1 The occurrence of glenoid erosion following Copeland shoulder resurfacing arthroplasty according to glenoid drilling.

This compared to 97% (SE 0.02) at one year, and 92% (SE 0.04) at three years and 79% (SE 0.06) at five years among patients with concentric glenoids who did not have their glenoid drilled ($n=67$). Data on the glenoid were not available for two patients and were excluded from analysis. Although the rate of progressive glenoid erosion appeared to be less in patients without glenoid drilling, there was no significant difference between the two groups (Fig. 1) (log rank: $p=0.12$). There continued to be no effect on the risk of progressive glenoid erosion in patients with nonconcentric posterior erosion that had glenoid drilling, even after adjustments for humeral head component size, OSS, sex and age (hazards ratio = 2.1; 95% confidence interval = 0.79 to 5.7; Cox hazard ratio $p=0.14$).

Patient and implant survival

The overall revision rate in our series was 13%. The survival of the primary prosthesis was 99% at one year and this declined to 88% and 82% at three years and five years, respectively

Fig. 2 Comparison between patient and implant survival.

(Fig. 2). This compared to a patient survival of 100% at one year, 93% at three years and 84% at five years.

DISCUSSION

In the present study, sixty-four of 73 (87.7%) patients reported that they were 'very satisfied' or 'satisfied' following Copeland shoulder CSRA, although their mean OSS of 27 (range 7 to 48) was below the suggested threshold of 33 for an acceptable symptom state [13]. The survival of the prosthesis was 99% at one year and declined to 88% at three years and 82% at five years. A comparison between the present study and the literature from both the designer's institution and independent centres is presented in Table 3. The OSS has only been used in more recent studies [10–12], with older studies using the Constant score (CS) [14]. Levy et al. reported that 92 of 98 (93.9%) patients were either 'much better' or 'better' after surgery with a mean age-adjusted CS of 93.7% after TSR and 73.5% after HA for OA and 74.0% after HA for AVN [1].

Table 3 Comparing results of Copeland cementless surface replacement arthroplasty.

Study (DI/IC)	Size	Pathology	Implant type	Glenoid procedure (n)	Follow-up (mean)	OSS	Reoperation, n (%) [*]	Revision, n (%)
Levy and Copeland, [1] (DI)	103 (68 TSR; 35 HA)	OA, RA, RCA, AVN, IA, post-infection	Mark 2 and 3	Glenoid component (68)	81.6	NR	14 (13.6)	8 (7.8)
Levy et al. [5] (DI)	75 (42 TSR; 33 HA)	RA	Mark 2 and 3	Glenoid component (42)	78.0	NR	3 (4.0)	3 (4.0)
Levy and Copeland [6] (DI)	79 (42 TSR; 37 HA)	OA	Mark 2 and 3	Glenoid component (42)	91.2 TSR 52.8 Hemi	NR	6 (7.6)	4 (5.1)
Mullett et al. [7] (DI)	29 (7 TSR; 22 HA)	OA, RA, RCA, AVN (>80 years)	Mark 3	Glenoid component (7), MF (22)	53.6	NR	1 (3.4)	1 (3.4)
Thomas et al. [8] (IC)	56 HA	OA, RA, RCA, PT	Mark 3	NPP	34.2	NR	5 (8.9)	1 (1.8)
Rumian et al. [9] (IC)	53 HA	RA	Mark 3	NR	62.5	NR	5 (9.4)	0 (0)
Al-Hadithy et al. [10] (IC)	53 HA	OA	Mark 3	NR	50.4	Pre 22 (9 to 31) Post 42 (18 to 48)	3 (5.7)	1 (1.9)
Alizadehkhayat et al. [11] (IC)	102 HA	OA, RA, RCA, AVN	Mark 3	NPP	48.0	28 ($\pm$ 16.3)	14 (13.7)	13 (12.7) 8 further planned
Present study (IC)	112 HA	OA, RA, AVN, RCA, IA	Mark 3	MF (43)	72.0	27 (7 to 48)	27 (24.1)	15 (13.4)

DI, designer's institution; IC, independent centre; OSS, Oxford shoulder score; OA, osteoarthritis; RA, rheumatoid arthritis; RCA, rotator cuff arthropathy; AVN, avascular necrosis; IA, instability arthropathy; NR, not reported; TSR, total shoulder replacement; HA, hemiarthroplasty; MF, microfracture; NPP, no procedure performed; PT, post-traumatic.

^{*}Includes revision surgery.

The age-adjusted CSs were lower for RA (71.8% TSR; 72.1% HA), RCA (61.3%), instability arthropathy (62.7%) and post-septic arthropathy (58.7%). In a cohort of patients specifically with RA, Levy et al. also reported high satisfaction (72/75 either 'much better' or 'better') and age-adjusted CS (76.0 ± 13.4% TSR; 71.0 ± 19.8% HA) [5]. The best outcomes, however, were in patients with OA by Levy et al. (89.9% 'much better' or 'better'; age-adjusted CS 94% TSR, 91% HA) [6]. Independent centres have attempted to reproduce these results. Thomas et al. reported improvement in the CS from a mean 16.4 points preoperatively to 50.4 points postoperatively, although in a small cohort of 56 patients with a variety of pathologies and a mean follow-up of only 34.2 months (age-adjusted CS not reported) [8]. Rumian et al. [9] reported similar results to Levy et al. [5] in a cohort of RA patients [42/46 (91.3%) 'much better' or 'better'; CS 46.3 ± 15.5 points]. More recently, Al-Hadithy, et al. [10] reported similar satisfaction compared to Levy et al. [6] for OA patients exclusively treated with the Mark III prosthesis [46/50 (92%) 'much better' or 'better'], although the age-adjusted CS were comparatively lower (mean 75.1%; range 36 to 87). Alizadehkhayat et al. reported a similar OSS (mean 28 ± 16.3) and satisfaction rate (85% very satisfied/somewhat satisfied) to our series with similar patient numbers and follow-up, although they had almost equal proportions of patients with OA [48/102 (47.1%)] and RA [41/102 (40.2%)], which is unique to their series [11]. They also highlighted that the better results were in patients with OA and AVN, with poorer outcomes in RA and RCA, in keeping with the findings of Levy et al. [1].

Although the functional outcomes were satisfactory for most patients in our series, a significant proportion had complications, many of which resulted in further surgical procedures and revision surgery (Table 2). Twenty-seven (24.1%) shoulders underwent further surgery, of which 15 (13.4%) included revision. Other procedures included arthrolysis in eight shoulders and subacromial decompression in four. Furthermore, 23 (20.5%) shoulders had radiological evidence of glenoid erosion of over 2 mm that accounted for 10 of 15 revisions. Glenoid microfracture was performed in 43 of 112 shoulders with nonconcentric posterior erosion and was not found to significantly influence the progression of glenoid erosion after correcting for age, sex, humeral head size and OSS. Estimation of overstuffing related to oversizing was difficult to measure as a result of preoperative X-rays being unavailable to measure offset. Only 15 shoulders had a large size humeral CSRA, of which five were revised as a result of glenoid erosion. The comparative reoperation and revision rates from other series are presented in Table 3. Levy et al. [1,5,6] reported three cases of loosening of the Mark II humeral component but no cases since the introduction of the hydroxyapatite-coated Mark III prosthesis. Most revisions in their series were related to problems with the glenoid CSRA component. They did not report glenoid erosion as a problem seen in their cohort of patients. Thomas et al., however, reported three cases of loosening of the Mark III prosthesis with revision performed in one shoulder at the time of the study [8].

Glenoid erosion greater than 2 mm was seen in seven of 46 (15.2%) rheumatoid shoulders in the study by Rumian et al., although none have so far required revision of the components [9]. Al-Hadithy et al. also reported mild erosion in eight of 50 (16%) and moderate erosion in six of 50 (12%) shoulders, none of which required revision surgery [10]. They did, however, identify that all five humeral prostheses that were oversized with an increased offset resulted in moderate glenoid erosion. One revision was performed for a periprosthetic fracture. Alizadehkhayat et al. reported a much higher revision rate of 13 (12.7%), with the commonest mode being rotator cuff failure and eight being revised to a reverse arthroplasty [11]. Severe glenoid erosion was noted in one shoulder that resulted in inability to implant a glenoid component. Revision surgery is still planned for eight shoulders.

The present study contains limitations in its methodology, including the use of the OSS to measure the functional outcome without preoperative scores for comparison. It is also difficult to compare with other studies because different outcome measures have been reported. This methodology did, however, enable us to follow-up this population 5 years to 9 years after primary surgery by postal questionnaire with a high response rate of 88% and we also had annual radiographs available until the last follow-up date.

Overall, our series demonstrates that acceptable outcomes can be obtained for most patients after the Mark III Copeland shoulder CSRA, although there may be a considerable risk of progressive glenoid erosion. Although this has not always translated to a definite need for revision surgery within the present study and the current literature at the level of follow-up currently available, it may lead to an exponential requirement for future revision surgery as demonstrated in the study by Alizadehkhayat et al. [11]. A further eight shoulders are still awaiting revision, which would increase their revision rate to 21%. Another consideration is that the revision procedures may be more complex as a result of the amount of glenoid bone loss, although this problem was not encountered within the present series.

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