Cementless surface replacement arthroplasty of the shoulder

5- TO 10-YEAR RESULTS WITH THE COPELAND MARK-2 PROSTHESIS

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Cementless surface replacement arthroplasty of the shoulder is designed to replace the damaged joint surfaces and restore normal anatomy with minimal resection of bone. We have used the Copeland shoulder arthroplasty for 14 years. Between 1986 and 2000, 285 surface replacement arthroplasties were implanted in our unit. The prosthesis has evolved during this time, but the principle of minimal bone resection has remained the same. Between 1990 and 1994, 103 Mark-2 prostheses were inserted into 94 patients (9 bilateral). The operations were carried out for the treatment of osteoarthritis, rheumatoid arthritis, avascular necrosis, instability arthropathy, post-traumatic arthropathy and cuff arthropathy. The mean follow-up was for 6.8 years (5 to 10).

The best results were achieved in primary osteoarthritis, with Constant scores of 93.7% for total shoulder replacement and 73.5% for hemiarthroplasty. The poorest results were seen in patients with cuff arthropathy and post-traumatic arthropathy with adjusted Constant scores of 61.3% and 62.7%, respectively. Most patients (93.9%) considered their shoulder to be much better or better than before the operation. Of the 88 humeral implants available for radiological review, 61 (69.3%) showed no evidence of radiolucency, nor did 21 (35.6%) of the 59 glenoid prostheses. Three were definitely loose, and eight shoulders required revision (7.7%), two (1.9%) for primary loosening. The results of this series are comparable with those for stemmed prostheses with a similar follow-up and case mix. The cementless surface replacement arthroplasty diminishes the risk of complications involving the humeral shaft and periprosthetic fractures. Revision or arthrodesis can

be undertaken easily since the bone stock has been maintained with no loss of length.

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Early attempts at shoulder arthroplasty in Europe involved constrained prostheses in order to deal with the considerable loss of bone and soft tissues secondary to infection and tumour.¹ In the USA, Neer² developed a stemmed unconstrained humeral prosthesis specifically for the treatment of four-part fractures. His design was successful in providing a scaffold around which the proximal humerus could be rebuilt. Later this was used for arthritis and a glenoid component developed.³ Neither of these prostheses was specifically designed for use in arthritis of the shoulder. In the early 1980s came the idea of developing an arthroplasty using a surface replacement for use in the degenerative shoulder which was less worn.⁴⁻⁷ Neer² had shown that the prosthetic shoulder joint did not need to be mechanically constrained. This was certainly true in the presence of an intact rotator cuff and arguably so even if it was damaged. The design of Neer's stemmed humeral component was very similar to that widely used for hip replacement. However, it seemed unnecessary to use a stem if the tuberosities were intact.

Patients and Methods

Design concept. The intention was to mimic the normal anatomy as closely as possible, replacing the damaged surfaces of the joint with minimal interference. We used 20 cadaver shoulders and 20 dry bone specimens together with 200 radiographs of normal shoulders to assess the normal anatomical variation. These measurements were subsequently confirmed by Boileau and Walch,⁸ and three sizes of prosthesis were developed (Fig. 1).

All patients presenting for possible shoulder arthroplasty were considered for surface replacement. Only those with severe bone loss with no surface to replace or with acute fractures and nonunion of fractures were judged to require stemmed prostheses. Of the 320 primary shoulder arthroplasties, including acute fractures and nonunions, undertaken between 1986 and 2000, the Copeland surface replacement system was used in 285 (89%).

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Fig. 1

Photograph of the Copeland Mark-2 cementless surface replacement; humeral and glenoid components.

Fig. 2

Photograph of a cementless surface replacement arthroplasty on a dry bone model with minimal bone removal. The bone removed from the pilot hole is used for grafting defects in the head of humerus.

We have held to the principle that bone stock should be preserved whenever possible. The experience of replacement arthroplasty at both the hip and the knee indicates that, no matter how successful the prosthesis, a small number will fail and require revision. Loss of bone stock necessitates the use of larger prostheses and more cement, but if the uncemented surface replacement were to fail, only the amount of bone that lies immediately beneath the humeral cap would be lost. This is what is normally removed when inserting a standard stemmed humeral prosthesis (Fig. 2).

The use of cement in hip and knee replacement has been questioned and many cementless designs have been developed. Even with improved cementing techniques there will be considerable bone loss should infection or loosening occur. A simple grooved impact-fit taper peg was introduced for fixation.

Although most shoulder replacements are carried out in specialised centres, many are undertaken by surgeons who undertake only a few each year. Complicated instrumenta-

tion may not be available. We have therefore developed simple instruments to shape the joint surfaces and to guide positioning of the prosthesis.

There is little variation in the size of the glenoid and the head of the humerus, but anatomical version and inclination may vary greatly.⁸ An important geometrical variation is the posterior offset.^{9,10} The head of the humerus is not centred on the shaft, but offset posteriorly and medially by approximately 5 mm. If a stemmed prosthesis lies central in the shaft the head will not lie in an anatomical position unless it is specifically made for a left or right shoulder. More recent designs have allowed for this variation by modular design. If a surface replacement is used no instrumentation is required to calculate angles of version, inclination or offset. The offset is automatic and the varus angulation is determined from the original anatomical neck. Even in the presence of severe erosion of the head of the humerus, the anatomical neck can be visualised after removal of osteophytes and the drill guide jig for the head sited correctly.

Erosion caused by arthritis distorts the anatomy. It may be asymmetrical, anteriorly or posteriorly, and be more on the humeral or the glenoid side, but the net effect is to medialise the centre of rotation. This has a secondary effect of relative lengthening of both the rotator cuff and the deltoid. One of the aims of shoulder replacement is to restore the geometry by placing the centre of rotation more laterally. This may be an unrealistic goal since if the medial shift is gross and longstanding, relocation laterally will make the contracted soft tissues too tight. The surgical approach is usually anterior, dividing subscapularis. Even with lengthening of its tendon there may be difficulty in closure with the possibility of some internal rotation. This must be avoided and some external rotation allowed. If there is a fixed internal rotation deformity posterior translation will occur leading to posterior subluxation. A modular prosthesis may have many available sizes, but few are required. Different thicknesses of glenoid component are available if further lateralisation is deemed necessary, but these are also only needed rarely.

Evolution of the design. The first 19 implants (Mark I prosthesis) had a central pegged humeral component, which was secured initially with a screw from the lateral side of the proximal humerus, combined with a polyethylene glenoid element stabilised by a cementless finned peg.^{11,12}

It was soon seen that the screw was unnecessary. Some became loose and had to be removed. In vitro testing suggested that it did not contribute to fixation. In 1990 the Mark-2 prosthesis was introduced which added metal backing to the glenoid component and a fluted taper fit peg to both constituents. In the Mark-3 model hydroxyapatite coating was added and this has been in use since 1993. The results in this article pertain to the Mark-2 prosthesis only.

Patients. Between 1990 and 1994, we implanted 103 consecutive Copeland surface replacement cementless pros-

Fig. 3

Details of the stages of the surgical technique (see text).

theses into 94 patients (9 bilateral). The underlying aetiology was primary osteoarthritis in 41 shoulders, rheumatoid arthritis in 41, cuff tear arthropathy in eight, avascular necrosis in four, instability arthropathy in five, arthropathy secondary to septic arthritis in two, and other diagnoses in two. The indication for surgery was pain associated with limitation of function. Preoperative evaluation was undertaken using the Constant and Murley score.¹³ Early in the series this score was not in common use, but ranges of pain, activity and movement were noted and used in the statistical evaluation of the results.¹³ The outcome was recorded using the Constant score, the range of movement and a patient satisfaction score (Neer classification).¹⁴ Data were analysed using the chi-squared test and analysis of variance to compare preoperative and post-operative results within the different groups.

There were 73 women and 21 men with a mean age at

the time of surgery of 64.3 years (22 to 88). The women were slightly older than the men (66.4 v 57.8 years). Total shoulder replacement (TSR) was used in 68 shoulders and a hemiarthroplasty in 35.

Operative technique (Fig. 3). We used the standard deltopectoral approach before 1993 and the anterosuperior approach as described by Mackenzie¹⁵ after September 1993. The prosthesis is suitable for insertion by either route. The advantages of the anterosuperior approach are a smaller scar, a shorter postoperative recovery, easier access by the rotator interval to the glenoid, and to the posterior and superior rotator cuff for reconstruction. It also allows for excision arthroplasty of the acromioclavicular joint and acromioplasty if these are required.

If the rotator cuff is intact or repairable an anterior acromioplasty is undertaken with partial resection of the coracoacromial ligament. The coracoacromial arch is left

undisturbed if the rotator cuff is extensively torn. If pre-operative radiographs show degenerative changes of the acromioclavicular joint and symptoms suggest that this is a site of pain, an excision arthroplasty can be done at this stage and improves the exposure. The rotator interval is identified and incised longitudinally along the line of the long head of biceps to define the insertion of subscapularis which is then detached and the shoulder dislocated anteriorly. If the long head of biceps is intact it is displaced posteriorly over the humeral head. The anatomical neck of the humerus is defined and the neck-shaft angle identified. Removal of all osteophytes is essential to define the anatomical neck and the humeral shaper may then be applied to the centre of the head. As shown in Figure 3A the humeral drill guide is positioned over the head with its free edge parallel to the anatomical neck; it is then positioned in the centre of the head and parallel to the neck, thus adjusting automatically for retroversion and inclination. The degree of retroversion may vary between 5° and 55°. All morsellised bone generated by making the drill hole (Fig. 3B) is saved for later grafting. Further details of the operative technique have previously been described (Figs 3C and 3D).¹⁶ If a hemiarthroplasty only is to be done, the stability of the humeral component is tested and the range of movement confirmed.

The trial humeral cap is left in situ so that the prepared head is not damaged by subsequent retraction. An extensive capsulotomy must be made, sparing only the superior aspect and providing adequate exposure of the glenoid. The glenoid drill guide is inserted at the exact centre of the glenoid (Figs 3E and 3F). Asymmetrical erosion may have occurred and needs to be assessed. Reference to pre-operative imaging with an axillary view is helpful at this stage. The glenoid articular surface is prepared with the cutter placed in the pilot hole (Figs 3G and 3H). If there is severe erosion of the bone, graft may be added anteriorly or posteriorly, but this is rarely needed.

In primary and secondary osteoarthritis, as much of the sclerotic surface of the bone is retained as possible to provide a firm foundation for the prosthesis. Each component is impacted flush with the surface of the prepared bone, the joint is reduced and stability ensured. Since the centre of rotation may have been lateralised, an attempt is made to gain relative length in subscapularis either with a stepwise incision in the tendon or by medial transfer of its insertion to the free edge of the prosthesis. The rotator interval is closed. Any deficiency of the rotator cuff is repaired at this stage if possible.

Passive movement only is allowed for the first 48 hours and passive assisted movement for five days. Active movements begin at one week as determined by comfort and the sling may be discarded at three weeks.

Radiological assessment. Anteroposterior views in internal and external rotation, and axillary views (Fig. 4) were taken postoperatively, at three and six months, at one year, then annually and at the final review. This protocol was followed in 89% of patients. An assessment was made of lucent lines (Fig. 5) and their width in relation to time. Definite loosening was defined as a change in position of a component, and probable loosening when the position was unchanged, but progressive radiolucencies greater than 2 mm wide involved all or part of the component.

Results

All the operations were carried out by the same surgeon (SAC) and the independent assessment was by the other author (OL).

Six patients died, and for these the latest follow-up review was recorded. One patient died less than 24 months after shoulder replacement and was excluded. Four were lost to follow-up. The seven patients who were not able to attend were elderly and living at a great distance. They were assessed using a questionnaire based on a Constant

Fig. 4a

Fig. 4b

Anteroposterior (a) and axillary radiographs (b) of the Copeland cementless surface replacement hemiarthroplasty at ten years.

Fig. 5

Radiograph of a Copeland Mark-2 total shoulder arthroplasty at nine years showing a glenoid lucent line (non-progressive).

score equivalent.¹⁷ They also sent recent radiographs taken at a local hospital. Thus there were 98 shoulders available for review.

The mean follow-up was for 6.8 years (5 to 10). The preoperative average Constant scores were 1.8 of 15 points for pain, 4.0 of 20 points for daily activity, 8.2 of 40 for range of movement and 1.3 of 25 for strength. The total mean Constant score was 15.4 points or 24% after adjustments for age and gender. Table I shows the preoperative values with respect to the different aetiologies. The results after implantation of the Mark-1 prosthesis have been reported previously.¹²

Integrity of the rotator cuff. The rotator cuff was intact in 46 shoulders and in 18 it was thin and atrophic but in continuity. In 33 shoulders a full-thickness tear was found. In six the integrity of the cuff was not recorded. In 11 shoulders the rotator cuff was not repairable and in ten this was attempted but was incomplete. In 75 shoulders the rotator cuff was repaired and in seven repair was not recorded. The deltopectoral approach was used in 74 shoulders and the Mackenzie approach in 29.

Functional results. The results at follow-up are shown in Table II; they are related to diagnosis and include the basic information and the final Constant score. The best results were achieved in primary osteoarthritis with Constant scores of 93.7% for TSR and 73.5% for hemiarthroplasty. Early in the series TSR was almost invariably undertaken. Hemiarthroplasty was only carried out when a glenoid component could not be placed. The poorest results were encountered in patients with arthropathy of the cuff, instability arthropathy and other causes such as arthropathy secondary to septic arthritis, with adjusted Constant scores of 61.3%, 62.7% and 58.7%, respectively.

Active elevation improved by a mean of 69° to a mean of 133° for osteoarthritis and avascular necrosis, to a mean of 105° for rheumatoid arthritis, and for instability arthropathy and cuff arthropathy to a mean of 97° and 73°, respectively (Table II). Preoperative and postoperative differences were statistically significant for all disease groups ($p < 0.001$).

Patients' subjective assessment. Of those assessed, 68 patients (69.4%) considered that their shoulder was much better and 24 (24.5%) that it was better (93.9% much better or better). Six patients were disappointed and considered the shoulder to be unchanged by surgery, usually because of limited movement, but they were satisfied with the relief of pain (Table II).

Radiological results. Radiographs were available for 88 shoulders. In 61 (69.3%), no lucencies were seen around the humeral component. In 25 shoulders (28.4%), a lucent line less than 1 mm wide was seen and in two a progressive lucent line more than 2 mm wide was encountered.

Of the 59 glenoid implants available for radiological review, no lucencies were seen around the implant in 21 (35.6%). In 35 (59.3%) there was a partial lucent line less than 1 mm wide. In three shoulders (5.1%) we observed a progressive lucent line of more than 2 mm, with definite signs of loosening.

In five shoulders some degree of mild subsidence of the humeral prosthesis was found, with no effect on the outcome. The degree of subsidence was measured by the migration of the central peg of the humeral cap towards the lateral cortex. Subsidence of less than 2 mm was defined as mild; greater than 2 mm, but not as lateral as the lateral cortex, as moderate; and up to the lateral cortex of the proximal humerus and beyond as severe. In all the shoulders with mild subsidence, this was noticed early after surgery and the prosthesis settled in the new position with no progression.

There was no subluxation of the humeral head in 58 shoulders. There was mild superior subluxation in 15, moderate superior migration in seven and severe superior subluxation with obliteration of the acromiohumeral interval in eight. All of the last eight had massive tears of the rotator cuff and six underwent arthroplasty for cuff arthropathy as a 'limited goal' procedure. In six the cuff was not repairable, and in one the repair was incomplete.

Complications. One patient developed marked myositis ossificans with almost complete ankylosis. His presenting diagnosis was arthropathy following septic arthritis and he had undergone extensive previous surgery. One patient suffered a spontaneous pneumothorax, postoperatively. One shoulder was left with a hemiarthroplasty since the glenoid could not be exposed adequately; the original diagnosis was multiple epiphyseal dysplasia. During insertion of the glenoid component a minor part of the rim was fractured in six patients. This was noted at the time of operation, but was not associated with later loosening. Two superficial wound infections, treated by antibiotics, settled uneventfully.

Three patients required arthroscopy for unexplained

Table I. Preoperative details of the 94 patients (103 shoulders) who underwent cementless surface replacement arthroplasty

Diagnosis	Number of shoulders	Constant score values				Active flexion in degrees	Active abduction in degrees	External rotation in degrees	Internal rotation	Total points (Constant score)	Age-adjusted Constant score (%)
		Pain	Activity	Movement	Power						
Primary osteoarthritis	7	3.9	6.8	12.2	2.4	72	52	12	Buttock	25.3	40.0
Hemiarthroplasty TSR	34	2.1	5.2	9.6	3.1	62	49	13	Buttock	20	33.8
Rheumatoid arthritis									Buttock	11.8	19.6
Hemiarthroplasty TSR	14	1.6	4.4	5.8	0	50	35	5	Buttock*	6	9.0
	27	0	1	5	0	47	37	6	Buttock	12.5	18.8
Cuff arthroplasty									Buttock		
Hemiarthroplasty TSR	7	2.7	3	6	0.8	37	38	13			
Avascular necrosis	1								Buttock	9.25	11.0
Hemiarthroplasty	4	0	2.25	7	0	63	49	-3			
Instability arthroplasty									Thigh-buttock*	14	18.5
Hemiarthroplasty TSR	41	1	3	10	0	57	40	1			
Other									Thigh*	*	*
Hemiarthroplasty (1 for septic arthritis)	2	*	*	*	*	65	40	8			
TSR (1 for septic arthritis)											
Global average		1.8	4.0	8.2	1.3	56	33	8	Buttock	15.4	24.0

* Constant scores were available for only some of the patients; however, it was recorded in all these patients' notes that they were very painful and severely limited in function

Table II. Follow-up results for the 94 patients (98 shoulders)

Diagnosis	Number of shoulders	Constant score values				Active flexion in degrees	Active abduction in degrees	External rotation in degrees	Internal Rotation	Patient assessment				Total points (Constant score)	Age-adjusted Constant score (%)
		Pain	Activity	Movement	Power					Much better	Better	Same	Worse		
Primary osteoarthritis	5	13.7	15	25.3	3.7	130	90	47	L2	1	3	1	0	57.7	73.5
Hemiarthroplasty TSR	33	14.1	17.5	27.4	5.2	133	113	55	L2	27	3	3	0	64.2	93.7
Rheumatoid arthritis															
Hemiarthroplasty TSR	14	11.5	13.3	20.1	3.5	106	88	45	L4	12	2	0	0	48.4	72.1
	27	12	13.5	21.1	6	104	80	44	L4	17	9	1	0	52.7	71.8
Cuff arthroplasty	8	10.6	11.1	16.3	0.6	73	64	47	L4	5	3	0	0	38.6	61.3
Avascular necrosis	4	11.7	11	31.3	3.7	133	118	81	L1	3	1	0	0	57.7	74.0
Instability arthroplasty	3	14.3	12.7	17.3	1.3	97	87	43	L5	2	1	0	0	45.7	62.7
Other	4	9.7	8	18	7.3	115	110	45	L4	1	2	1	0	43	58.7
Global average		12.1	13.9	22.2	4.2	110	90	48	L4	68	24	6	0	52.4	75.2

Table III. Details of the eight patients who underwent revision surgery

Case	Age (yr)	Gender	Preoperative diagnosis	Operation	Time to revision (years)	Indication(s) for revision	Surgical procedure	Notes
1	68	F	Osteoarthritis	TSR	1.5	Glenoid component loosening after heavy fall from a bike	Removal of glenoid component. Revision to Copeland stemmed hemiarthroplasty	Humeral cap was not loose, but technically had to be revised to provide glenoid exposure
2	48	F	Avascular necrosis	Hemiarthroplasty	1.75	Acute trauma Subcapital fracture at the distal edge of prosthesis	Revision to Neer stemmed TSR	Very easy revision. Humeral cut was along the line of the fracture
3	72	F	Rheumatoid arthritis Massive cuff tear - limited goal procedure	TSR	2.75	Glenoid and humeral loosening	Removal of glenoid component. Revision to Neer stemmed hemiarthroplasty	Massive cuff tear - limited goal procedure
4	77	F	Osteoarthritis	TSR	4.0	Glenoid loosening	Removal of glenoid component. Revision to Neer stemmed hemiarthroplasty	Humeral cap was not loose, but technically had to be revised to provide glenoid exposure
5	72	F	Osteoarthritis	TSR	0.83	Malpositioning (excessive anteversion) of the glenoid component	Revision of glenoid component	Poor rotator cuff CSRA* used
6	69	F	Osteoarthritis	TSR	4.4	Dissociation of polyethylene from the metal back. No loosening of both components	Revision to Copeland stemmed TSR	Humeral cap was not loose, but technically had to be revised to provide glenoid exposure
7	46	M	Instability arthropathy Stabilisation operation for Bankart repair with staples	TSR	1.7	Severe instability	Shoulder arthrodesis	Bald head Non-repairable massive rotator-cuff tear
8	37	M	Instability arthropathy Missed posterior fracture-dislocation. Stabilisation operation with bone block	TSR	1 week	Infection	Shoulder arthrodesis	Poor quality rotator cuff Unstable shoulder

* cementless surface replacement arthroplasty

Table IV. Results of active movement (degrees) in our series compared with these using stemmed shoulder prosthesis

	Postoperative active elevation	Gain in active elevation	Postoperative external rotation	Gain in external rotation
Neer et al ¹⁴		+77		+51
Cofield ²⁷	141	+55	49	+35
Barrett et al ²⁴	117	+73		+33
Cofield and Daly ²⁸	154	+47	61	+49
Boileau and Walch ⁸	127	+48	41	+55
Torchia et al ²⁶	117	+40	48	+19
Gartsman et al ²⁹	129	+47	55	+39
Our series (average-all study group)	110	+54	54	+42
Our series (osteoarthritis)	133	+68	48	+40

pain. Two had a tear of the rotator cuff after a fall which required repair. One developed subacromial fibrosis with no loosening after being injured in a road-traffic accident.

Revision surgery. Two patients required arthrodesis after removal of the implant. Both underwent TSR for instability arthropathy with multiple previous operations. One developed deep infection and in the other stability could not be achieved (Table III). The prosthesis was revised in six patients (Table III). One had a fall sustaining a fracture of the head of the humerus at the margin of the humeral cap. The revision operation was easily achieved by removing the prosthesis with the bony fragments and inserting a standard stemmed prosthesis. In one patient, revision was required because of disassociation of the polyethylene from the metal-backed glenoid component. The latter was revised with revision of the humeral component in order to gain access to the glenoid. This complication has been obviated by a design change in the glenoid component. One patient required revision because of continuing pain. The version of the glenoid was altered which relieved her symptoms. One patient had loosening of the glenoid component after a fall. Arthroscopy was carried out and the glenoid component was noted to be loose; a revision procedure was undertaken using a stemmed humeral component. Two patients had primary loosening (1.9%). One involved both components and one the glenoid only. In four of six revision procedures, revision of the humeral cap was undertaken although it was not loose in order to gain access to the glenoid; all four were converted to stemmed prostheses.

Discussion

Cementless surface replacement arthroplasty of the shoulder differs in many aspects from a non-constrained stemmed shoulder prosthesis, but the results are similar to those published for the latter design including the new generation of modular prostheses (Table IV). In our series, 93.9% of the patients considered their shoulder to be much better or better after surgery. Because this is a different

design of prosthesis some of the complications differ from those of other models. Those which we have observed have been more easily dealt with due to the preservation of bone stock. Removal of the humeral surface component was easily and speedily effected since no cement or stem had to be exposed and removed. Removal of a cemented stemmed prosthesis is associated with loss of bone stock with a risk of perforation and fracture of the humeral shaft. Thus, in the patient who presented with a fractured anatomical neck, the line of bone resection was determined by the injury, and revision to a cemented stemmed prosthesis was easily accomplished. The patient with previous infection and the one with uncontrollable instability were also easily revised to an arthrodesis since bone stock had been preserved with no loss of length. Union of the arthrodesis was achieved rapidly. The incidence of periprosthetic fractures has been quoted as 3% and accounts for approximately 20% of all complications associated with total shoulder arthroplasty both during surgery and later.¹⁸⁻²³

At the time of operation no major complications were encountered; in particular there was no fracture or perforation of the shaft of the humerus since no preparation of it had been required. Stemmed prostheses create a stress riser effect at the tip of the stem in the midshaft of the humerus.^{19,20,22-24} The key to correct anatomical alignment of the humeral component is the identification of the anatomical neck. Previous reports of cemented prostheses have also noted a high incidence of lucency around the components. There is a similar incidence in this prosthesis (Marks 1 and 2). Since we started to use hydroxyapatite-coated implants (Mark 3), no lucent lines have been observed. The relevance of the radiolucent line is uncertain, but seems unrelated to the outcome. Further major surgery, either revision arthroplasty or arthrodesis, was required in eight patients (7.7%) which is comparable with the published results for stemmed prostheses with a similar period of follow-up.^{23,25,26}

During the period of the study the design of the prosthesis has evolved, but the basic concept of surface replacement with minimal removal of bone and cementless

fixation has remained. The indications and surgical technique have been refined. The results of hemiarthroplasty should not be compared with those of TSR. The indications are different. Early in the series a total replacement was attempted in all patients. The glenoid component was omitted only if it was thought that adequate fixation could not be achieved. Later in the study a hemiarthroplasty was chosen for preference. A glenoid component was added only if the rotator cuff was intact and the bony glenoid non-concentric.

This is a mid-term report with a maximum follow-up of ten years. The early results with the hydroxyapatite-coated prosthesis (Mark 3) are encouraging. We have demonstrated results at least equal to those of conventional stemmed prostheses, suggesting that the humeral component does not need a stem or cement for fixation. We believe that the only indications for the use of a stemmed prosthesis are in four-part fractures and in those patients with severe destruction of the humeral head such that no surface remains to be replaced.

One or more of the authors have received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article.

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