A FLOATING PROSTHESIS FOR RADIAL-HEAD FRACTURES

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We report our experience over seven years with a floating radial-head prosthesis for acute fractures of the radial head and the complications which may result from such injury. The prosthesis has an integrated articulation which allows change of position during movement of the elbow.

We present the results in 12 patients with a minimum follow-up of two years. Five prostheses had been implanted shortly after injury with an average follow-up of 49 months and seven for the treatment of sequelae with an average follow-up of 43 months.

All prostheses have performed well with an improved functional score (modified from Broberg and Morrey 1986). We have not experienced any of the complications previously reported with silicone radial-head replacement. Our initial results suggest that the prosthesis may be suitable for the early or delayed treatment of Mason type-III fractures and more complex injuries involving the radial head.

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Fractures of the radial head usually result from a fall on the outstretched hand. They may be isolated or associated with more complex injuries such as fractures and dislocations around the elbow and rupture of the distal radioulnar joint. The Mason (1954) classification, as modified by Johnston (1962), is widely used. Type-I and undisplaced type-II fractures can be satisfactorily treated by conservative measures and displaced type-II fractures by a variety of techniques including wires (Odenheimer and Harvey 1979), compression screws (Shmueli and Herold 1981), AO small-fragment implants (Heim and Pfeiffer 1988) and Herbert screws (Bunker and Newman 1985).

Before the development of such techniques, early excision of the radial head was advocated for Mason type-II, type-III and type-IV fractures. Goldberg, Peylan and Yosipovitch (1986) and Coleman, Blair and Shurr (1987) claimed good results with early excision, while Radin and Riseborough's (1966) results were less conclusive. Broberg and Morrey (1986) concluded that initial retention of the radial head with delayed excision gave reasonable results. Mikic and Vukadinovic (1983), however, had poor overall results in 50% of their cases with complications such as valgus deformity, diminished elbow movement and distal radioulnar joint symptoms. These varying results have led to a search for a satisfactory prosthesis for a radial head which could not be preserved (Cherry 1953; Carr 1971; Swanson, Jaeger and La Rochelle 1981).

We present a retrospective review of our initial series of patients in whom a floating radial-head prosthesis had been inserted.

PATIENTS AND METHODS

Implant design. The implant (Figs 1 and 2) is in two parts, a radial head made of high-density polyethylene enclosed in cobalt chrome which articulates in a semiconstrained manner with the spherical end of a cemented, cobalt-chrome intramedullary stem (Tornier SA, Saint-Ismier, France). It was initially manufactured in titanium but cobalt chrome has been used since 1994 after reports of titanium wear in hip prostheses (Agins et al 1988). This change has been justified recently by Bischoff et al (1994) who noted lower wear rates with cobalt chrome.

The collared stem has a neck-shaft angle of 15°. The articulation created between the spherical end and the radial-head component allows free rotation and an arc of 35° of uniplanar movement in any direction. This gives excellent mobility while retaining full contact against the lateral humeral condyle and the ulnar notch.

There are two sizes of radial head with diameters of 19 mm and 22 mm and an identical height of 14 mm, and two sizes of radial stem, one with a diameter of 8 mm and a length of 60 mm and one with a diameter of 6.5 mm and a length of 55 mm. These components are interchangeable to allow different combinations of head and stem.

Acute injuries. From December 1988 to May 1995 we inserted the floating radial-head prosthesis into 18 elbows for acute, Mason type-III fractures of the radial head, either isolated or associated with other injuries. Of these we

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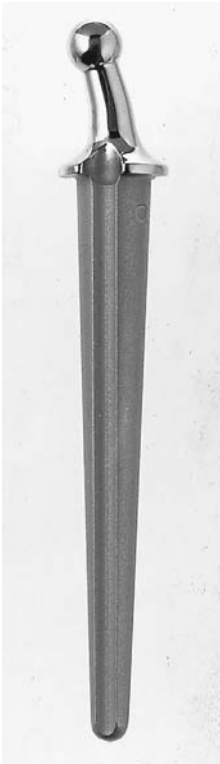

Fig. 1

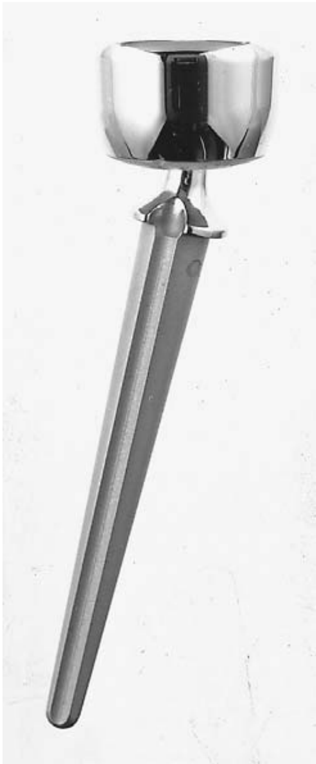

Fig. 2

Figure 1 – Collared intramedullary stem of prosthesis. Figure 2 – Radial-head component mounted on the stem.

report five cases with a mean follow-up of 49 months (24 to 65; Table I). There were two men and three women with a mean age of 43 years. All but one was treated within 48 hours of injury. In most there was symptomatic or clinical evidence of medial ligament injury (Fig. 3). The fifth patient was treated 17 days after excision of the radial head and the insertion of a Swanson prosthesis at another hospital. This was performed for instability and the presence of an untreated fracture of the coronoid. Repair of an ulnar fracture was performed simultaneously.

Delayed surgery. During the same period we inserted 20 floating-head prostheses for complications after radial-head excision. We report the first seven of these patients with a mean follow-up of 43 months (24 to 72; Table II). There were four men and three women with a mean age of 33 years. The time between the initial fracture and the insertion of the prosthesis was between two and 156 months. Many of these patients had had from one to four previous operations elsewhere; these included radial-head excision, the insertion of a Swanson prosthesis, temporary trans-articular pinning and a variety of procedures for associated fractures.

In these cases, the main reason for referral was post-traumatic elbow stiffness. The primary complaint in four patients was reduced flexion/extension and four had loss of pronation/supination. Elbow instability was a problem in two patients and three suffered severe pain. Two patients had distal radioulnar problems with proximal radial migration. The carrying angle was increased in a valgus direction in several cases but could not be accurately assessed in the stiff elbows. In two patients there was radiological evidence of degenerative changes in the elbow.

In both the acute and delayed groups, postoperative function was graded according to a modified Broberg and Morrey scoring system (Broberg and Morrey 1986; Table III). In the delayed group the preoperative rating and the

Table I. Details of five patients with acute fractures of the radial head

Case	Age (yr)	Sex	Side dominant (+/-)	Mason classification	Associated fractures	Operative treatment	Follow-up (mth)	Range of postop movements (°) extension flexion supination pronation	Broberg and Morrey score (1986)	Complications
1	40	M	L-	III	-	RHP*	57	0 140 85 90	Excellent	-
2	58	F	R+	III	-	RHP	50	0 140 80 90	Excellent	-
3	63	F	R+	III	-	RHP	49	-10 140 85 90	Good	-
4	25	F	R+	III	Coronoid	RHP Fixation of coronoid	24	-20 120 75 70	Good	-
5	31	M	R+	III	-	RHP	65	0 150 85 90	Good	-

* radial-head prosthesis

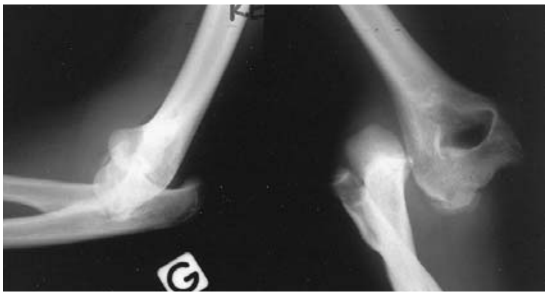

Fig. 3a

Fig. 3c

Fig. 3b

Radiograph showing fracture dislocation of the left elbow with a Mason type-III fracture of the radial head (a). The AP (b) and lateral (c) radiographs show the prosthesis in place.

pre- and postoperative range of movements were documented. Many of these patients also had soft-tissue release procedures to regain movement.

Operative technique. Under general or regional anaesthesia with tourniquet control and the patient supine, the radial head is exposed by a Kocher lateral or posterolateral approach. If present, the annular ligament is opened and the radial neck divided above the bicipital tuberosity. The forearm is pronated to protect the posterior interosseous branch of the radial nerve and to align the radial shift with the operative field. The intramedullary canal is prepared with small rasps and the size compared with trial stems. Separate radial-head templates are used to assess stability and avoid impingement against the humerus, allowing clearance of 1 mm.

The ulnar canal is plugged distally with bony fragments from the fractured radial head and a special rasp is used to ensure flush seating of the prosthetic collar against the radial shaft. Using a syringe, cement is inserted in a retrograde manner and the radial-shaft component is inserted with an impactor. The prosthetic neck is aligned with angulation similar to that of the normal anatomy; the collar rests on the resected radial surface. The radial-head templates are used again to confirm the most appropriate head prosthesis. If the large template extends well beyond the lateral epicondyle the smaller prosthesis is used.

The selected head component is placed on the spherical mounting. On reduction there may be a tendency to posterior subluxation when the elbow is near full extension, but this is usually corrected by the closure of the annular ligament or soft tissues and by the effect of normal muscle tone.

Postoperative care. Immediate mobilisation is encouraged with supervised physiotherapy. If there is marked medial instability or persistent posterior subluxation, we advise the use of a bivalved cast for six weeks. Non-steroidal anti-inflammatory drugs are prescribed and ice packs are used. For patients who have shown previous heterotopic ossification we sometimes advise a short course of postoperative radiotherapy.

RESULTS

Complications. In the delayed-surgery group there were two complications. One patient had a temporary palsy of the posterior interosseous nerve which fully recovered. The other, after a failed Swanson prosthesis, had the implant placed too high and it impinged against the condyle. Treatment by trimming the bone without revision of the implant produced good function. This complication alerted us to the importance of adequate resection of the radial neck.

Clinical results. In the acute-injury group all the patients had a good functional outcome as reflected by their Broberg and Morrey scores. The results were better in patients with isolated fractures than in those with more complex

Table II. Details of seven patients with delayed surgery for fractures of the radial head

Case	Age (yr)	Sex	Side dominant (+/-)	Initial injury/ previous surgery	Main presenting complaints	Range of preop movements (°) extension flexion supination pronation	Preoperative Broberg and Morrey score (1986)	Time between initial injury and radial head prosthesis (mth)	Operative treatment	Follow-up (mth)	Range of postop movements (°) extension flexion supination pronation	Postoperative Broberg and Morrey score (1986)	Complications
1	54	F	R+	Mason III	Stiffness	-80 0 20	Poor and pain	4 10	RHP*	72	-5 135 85 80	Good	-
2	38	M	R+	Mason III Monteggia fracture Essex-Lopresti lesion	Pain at distal radioulnar joint	0 140 5 60	Fair	8	RHP Soft-tissue release of distal radioulnar joint	58 125	-15 70 60	Good	-
3	21	F	R-	Mason III	Stiffness	-70 30 0 15	Poor	5	RHP Soft-tissue release	55	-55 50 10 140	Fair	-
4	18	M	R+	Mason III Olecranon fracture Fixation, radial-head excision, soft-tissue release	Stiffness	-80 15 60 40	Poor	10	RHP	30	-35 80 70 50	Fair	-
5	50	M	R+	Mason III Splintage, radial-head excision	Stiffness	-40 55 0 5	Poor	7	RHP Soft-tissue release	27	-15 125 45 90	Good	Temporary posterior interosseous nerve palsy
6	18	M	R+	Mason III Coronoid fracture Fixation, radial-head excision	Elbow instability	0 140 80 90	Poor	12	RHP	33	-5 140 85 90	Excellent	-
7	30	F	L+	Mason III Silastic prosthesis (fractured)	Pain and elbow instability Wrist pain	0 140 85 90	Fair	156	RHP	24	0 135 80 80	Good	Required chondroplasty

* radial-head prosthesis

Table III. Modified functional scoring system according to Broberg and Morrey (1986)

Grade	Pain	Strength (%)	Range of movements (°) flexion contracture flexion supination pronation	Stability
Excellent	-	Normal	Full	Normal
Good	Mild	80 to 100	<20 >90 >45 >50	Normal
Fair	Moderate	80	20 90 45 50	Normal or slight instability
Poor	Disabling	<80	>20 <90 <45 <50	Unstable

injuries.

In the delayed group the functional results were all improved compared with the preoperative levels. These patients pose a different problem from the acute group and are also at greater risk of postoperative complications. This is because of the variety of the problems, the delay before prosthetic replacement, the previous surgery and any established degenerative change.

The clinical improvement has been maintained in all cases; to date we have had no complications with the prosthesis such as fracture, loosening or breakage. Apart from the case already described we have seen no radiological signs of osteoporosis of the humeral condyle or of progressive joint-space narrowing. Finally, we have not experienced any of the biological complications that have been noted with silicone-rubber prostheses. There have been no clinical or radiological differences between the titanium and the newer cobalt-chrome implants.

DISCUSSION

The radiohumeral joint takes some 40% of the forces transmitted through the elbow especially in extension and pronation (Morrey 1991). The radial head resists valgus strain (Judet and Katti 1987) and while it is initially a secondary constraint to valgus forces, it is even more important if the medial collateral ligament is disrupted (Morrey 1991).

After excision of the radial head progressive valgus deformity with instability and proximal migration of the radius have been reported by several authors (McDougall and White 1957; Taylor and O'Connor 1964). Pain and degenerative changes at the wrist are associated with radial migration, but Morrey, Chao and Hui (1979) found that the degree of migration did not correspond to the symptoms or degenerative change.

To try to prevent these complications, especially after radial-head excision, several authors developed prosthetic radial heads using a variety of materials including acrylic (Cherry 1953), vitallium (Carr 1971) and silicone rubber (Swanson et al 1981). The silicone-rubber prosthesis did well in the originators' hands and moderately successful results were also reported by Mackay, Fitzgerald and Miller (1979). Mechanical failure, however, with fracture of the radial head itself or at the radial head/stem junction was reported by Mayhall, Tiley and Paluska (1981). Morrey, Askew and Chao (1981) and Carn et al (1986) showed that under stress loading the silicone-rubber prosthesis deformed. More disturbingly, there have been reports of pathological and biological problems including synovial and bony inflammation (Gordon and Bullough 1982), reactive synovitis (Worsing, Engber and Lange 1982) and inflammatory arthritis (Vanderwilde et al 1994).

We believe that the floating radial-head prosthesis overcomes many of these complications (Judet, Massin and Bayer 1994), and the seven years of our experience has shown it to be valuable for both acute injuries and delayed surgery.

The floating articulation and concave surface of the implant allow continual full contact to be maintained against the convex humeral condyle during flexion/extension and supination/pronation of the elbow. This movement has been viewed under image intensification and by dynamic radiography. We have seen no deformation and believe that the implant can withstand physiological loading across the radiohumeral joint. Neither have we seen radiological changes which might suggest cartilaginous erosion. The alloy composition of the implant has not provoked the biological problems attributed to silicone rubber implants.

Our indications for the immediate insertion of the implant are displaced Mason type-III fractures with ligamentous instability. This is particularly useful in the presence of associated destabilising fractures, such as those of the coronoid and it may also aid reconstruction of the articular surface when there are comminuted fractures of both the olecranon and the radial head. The prosthesis can restore radial length after metaphyseal fractures and acute distal radioulnar joint subluxations.

For fracture cases in which the radial head has been previously excised or has required excision for post-traumatic elbow stiffness, the implant has limited further valgus deformity and elbow instability and improved problems at the distal radioulnar joint. It has been used successfully to revise failed silicone rubber radial-head prostheses.

With our growing experience we now consider that the new prosthesis may be indicated in isolated Mason type-III radial-head fractures. We acknowledge that such fractures can be treated expectantly but their final outcome is sometimes poor with the late complications described above. We shall continue to review the longer-term outcome of this implant and compare its subsequent performance with conservative treatment.

Although none 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, benefits have been or will be received but are directed solely to a research fund, foundation, educational institution, or other non-profit institution with which one or more of the authors is associated.

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