Prosthetic replacement of elbow for intercondylar fractures (recent or ununited) of humerus in the elderly

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Abstract Forty-one patients with an intercondylar fracture of the humerus (21 recent and 20 ununited) were treated by total elbow arthroplasty using Baksi's recent version of the sloppy hinge from January 2003 to April 2009. Twelve were AO classification type C2 and nine were type C3 recent closed fractures of seven days' mean duration according to Muller classification. Patient's mean age was 64 years. There were 20 nonunions (nine untreated nonunions of a mean of 11 months duration and 11 following failed internal fixation of a mean of 14 months duration); mean patient age was 58 years. The follow up period was 12–88 (mean 55.5) months. Mean arc of postoperative elbow flexion was 25–130° obtained in 39 (95.1%) patients. Mean arc of 65° pronation and 60° supination was obtained in 33(80.5%) patients. According to the Mayo elbow performance score, in the fresh-fracture group, excellent results were seen in 19 (90.5%), good in one (4.8%), and failure in one (4.8%), whereas in the nonunion group, excellent results were obtained in 17

(85%), good in two (10%), and failure in one (5%). Failure in the two patients was due to deep infection requiring prosthesis removal. Other complications were transient ulnar neurapraxia in three, disassembly of the prosthesis in one, patchy heterotopic ossification in two and localised radiolucency around the flanges of the humeral stem in one.

Introduction

The treatment of choice for most displaced intra-articular fractures of the humerus is open reduction and internal fixation [10, 11, 13]. In the elderly, this is particularly difficult because of marked osteoporosis and extensive comminution [10, 13, 27]. In elderly patients, the use of hip arthroplasty for femoral neck fracture is well accepted [6]. Similarly, elbow replacement is an excellent alternative to open reduction and internal fixation in selected cases of extensively comminuted fracture of the distal humerus in patients older than 65 years [5]. The higher complication rates and lower survivorship seen with total elbow arthroplasties compared with total knee and total hip arthroplasties were partly due to polyethylene wear of the articular surface or use on unconstrained resurfacing and nonlinked design of elbow prosthesis mainly for rheumatoid arthritis [8]. However prosthetic replacement of the elbow using a semiconstrained design, commonly Coonrad Morrey implants, in recent intercondylar fractures of the humerus among elderly patients older than 65 years in a small series has been reported [7, 9, 14–16, 18, 21, 24, 25] with satisfactory results.

In cases with established nonunion of the distal humerus (untreated or failed internal fixation), open reduction and internal fixation with autogenous bone grafting, contracture release and ulnar neurolysis remains an option [12]. Among

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Fig. 1 **a** Baksi's recent version of assembled sloppy hinge elbow prosthesis and **b** disassembled components. Its humeral hinge section (A) is shorter than the ulnar (B) and has a larger hole than the diameter of the smooth part of the main hinge screw (arrows) to allow 7–10° angular movement with side to side laxity. Two flanges are incorporated on each side of the shank of humeral prosthetic stem. **c** Flanges are seated in the longitudinal slots made on each side of lower cut end of the humerus in its coronal plane

the other treatment modalities, such as resection arthroplasty, arthrodesis, allograft reconstruction and total elbow arthroplasty (TEA), the latter is often preferred because it provides the best functional results with least morbidity [17, 23]. The success rate of TEA in the treatment of nonunion of the distal humerus is 86% [19]. Linked semiconstrained TEA as a salvage procedure can provide pain relief and restore motion and function in patients with distal humeral nonunion [4, 24]. Similarly, the results of TEA using the Baksi original sloppy hinge elbow were reported [2] in five cases of ununited intercondylar fractures and three with old open injuries with bone loss at the lower end of the humerus with encouraging results over a mean 9.6 years (2–13.5 years) follow-up period [2]. Here we report the results of the recent version of the Baksi sloppy hinge elbow in a series of intercondylar fractures (recent and ununited) of the humerus mainly in the elderly.

Materials and methods

Prosthesis

The original design of the Baksi sloppy hinge elbow based on an elbow simulator study [1] was redesigned [3] (Fig. 1) and has been in use since 2003 (Indian Registered design: 200755). This hinge design is simple, cost effective and made locally of stainless steel (SMO316LV). As with the original sloppy hinge design [2], the humeral hinge section is shorter than that of the ulnar and has a larger hole than the diameter of the smooth part of the main hinge screw to allow 7–10° angular movement with 7–10° side to side laxity but still limits axial rotation [2]. This is acceptable, as the elbow is a non-weight-bearing joint except during extension against gravity and weightlifting [2]. Moreover, because of the potential gap between the motion bearing surfaces, there is minimal articular contact during elbow motion and minimal metal dust liberation. The improved version (Fig. 1) differs from the previous design by its provision of two flanges each of 13-mm height, 10-mm breadth and 2.5-mm thickness incorporated on each side of the shank of the humeral stem in the coronal plane (Fig. 1), which is seated in the corresponding longitudinal slot cut on each side of the humeral shaft (Figs. 1c and 2c, d) extending from its transverse cut end to become single prosthesis bone assembly.

Fig. 2 **a, b** Anterior posterior (**a**) and lateral (**b**) radiograph of a 68-year-old woman with recent (3 days) AO classification type C3 intercondylar fracture of the right humerus. **c, d** Two years postoperative anteroposterior (**c**) and lateral (**d**) radiographs showing

prosthesis in situ. **e** Seventy-four months postoperative lateral radiograph showing radiolucency (*arrow*) at the lower end of the humerus around the flanges of the humeral prosthetic stem with a radiolucent line of 1 mm around the bone–cement interfaces

Further change was made by increasing the humeral stem length of two sizes (105 and 110 mm). Ulnar stem length remains 75 mm, as before. The grooves over the heads of the main linking and lock screws were made hexagonal. Stem surfaces were changed to polished surfaces for better cement contact. Different prosthesis sizes are used, as previously reported [2].

Patients

In the fresh-fracture group, according to Muller et al.'s AO classification [22], 12 were type C2 and nine were type C3 recent closed intercondylar fractures. Fracture duration was two to 13 (mean seven) days. Mechanism of injury was mostly from a minor fall. In the nonunion group, nine patients had neglected ununited intercondylar fracture. Fracture duration varied from seven months to two and half years (mean 11 months). Seven had unstable elbows. Eleven cases failed internal fixation with nonunion (Fig. 3a), which was recognised nine to 18 (mean 14) months after internal fixation. In this group, all patients has 40–75° flexion deformity with only 15–25° range of motions, whereas six had limited arc of supination and three pronation.

The ages of the patients with recent fractures varied from 56 to 78 (mean 64) years, whereas patients with nonunion varied from 55 to 70 (mean 58) years. There were 24 women and 17 men. Eighteen fractures were on the right and 23 on the left. Two patients were diabetic, and four

were hypertensive. Patients with nonunion (untreated or failed after internal fixation) were considered for total elbow replacement (Figs. 3b and 3c) because of poor bone quality and irreversible articular damage. Exclusion criteria were old open intercondylar fractures of over two years' duration, presence of any active infection around the elbow and age below 55 years or any patient having good quality of bone and anatomy of the fracture pattern suitable for internal fixation. All patients were operated upon by either by first or second author in association with the third author after providing informed consent.

Operation technique

The surgical technique described by Baksi [2] was principally followed but with addition of an insertion technique of the humeral stem flanges of the new version of the sloppy hinge (Fig. 1) into the shaft of the humerus (Fig. 1c) [3]. With the patient supine and under tourniquet control, a posteromedial incision was made over the elbow. Following subfascial dissection, the ulnar nerve was isolated and mobilised with flexor carpi ulnaris from the proximal ulna. Soft tissues around the medial epicondyle and the muscles from the fractured fragments of the anterior and posterior surfaces of the lower humerus were detached. The medial articular capsule was detached from the upper articular margin of the ulna. Further dissection was done laterally over the triceps posterior surface to reveal the lateral epicondyle and fractured lateral supracondylar ridge

while soft tissue around them were separated. The head of the radius was usually excised at the level of the annular ligament, as it serves no purpose after arthroplasty. The distal humerus was sectioned transversely just proximal to the olecranon fossa and upper limit of fracture. In patients in whom nonunion occurred after failure of internal fixation, the plate and screws used overlying the lateral and medial supracondylar ridge were removed, along with the screws, to facilitate transection of the lower humerus. Transverse screws used for fixation of fractured condyles were left undisturbed to facilitate isolation of lower humeral condyles en masse to remove them together, detaching the articular capsule from the upper end of the ulna.

A subarticular L-shaped cut was made over the upper end of the ulna to explore its medullary canal, preserving triceps insertion over the olecranon process and brachialis in front of the coronoid process. Reaming of the ulnar and humeral medullary canals was done with a harpoon-shaped reamer (Fig. 4) and rasp to provide snug fitting of the prosthetic stems. A longitudinal groove of 13 mm was cut on each side of the lower end of the humerus in its coronal plane, extending from its transverse cut end (Fig. 1c) for seating of the humeral stem flanges. Trial implants were used to finalise actual implant size. The ulnar stem was fixed in its medullary canal with bone cement. Cementing was done manually with the help of a cement pusher. The humeral stem was then snugly fitted within the medullary canal with the help of bone cement and its flanges seated in the corresponding longitudinal slots already created over the sides of the humerus.

Prosthesis assembly was done with the help of the main linking screw and secured firmly with the additional locking screw. Full range of elbow flexion and extension was tested. The wound was closed in layers, over a suction drain, around the prosthesis, and a well-padded compression bandage placed around the elbow was covered with a plaster cast in full extension.

Postoperative care

The suction drain was removed after 72 hours. The plaster cast was removed after the fifth day, and the elbow was placed in an adjustable turnbuckle splint in maximum flexion and extension, alternately, for four hours. Intermittent active and passive elbow movements were promoted out of the splint. After removal of the stitches, an elbow splint was used for one week, and if active elbow movements were free and painless, the splint was discarded. Weightlifting over two kilogrammes and physically strenuous work with the replaced elbow were banned permanently.

Mean hospital stay was eight (range seven to ten) days. All patients were evaluated at four weeks, then at two, four, eight, 12 and 24 months and periodically thereafter. However, if any patient complained of pain and increased local temperature

around the elbow and limited postoperative elbow motion, he or she was instructed to see us at our follow-up clinic without delay. At each visit, we recorded elbow and forearm range of motion, elbow stability, presence of any local pain, ability to carry out routine daily activities, overall subjective assessment of the outcome and radiographic study of replaced elbow.

Results

Twenty-one fresh and 20 intercondylar fracture nonunions of the distal humerus were treated using the recent version of the Baksi sloppy hinge prosthetic replacement from January 2003 to April 2009. Follow-up varied from 12 to 88 (mean 55.5) months. All patients had postoperative fixed flexion deformity of 10–30°, with terminal flexion up to 120–140°. Mean arc of elbow motion was 25–130°, with motion varying from 90° to 110°. Mean postoperative supination arc was 60° and mean pronation 65°, apart from six patients with nonunion whose preoperative limited forearm motion remained unaltered after total elbow replacement (TER), which may be due to preoperative contracture of the interosseous membrane. Mayo elbow performance score (MEPS) [20] was used for functional evaluation of the replaced elbow (Table 1). According to MEPS [20] an excellent result scored between 90 and 100, good between 75 and 89, fair between 60 and 74 and poor <60 points. Using this score, overall results in the fresh-fracture group were excellent in 19 (90.5 %), good in one (4.8%) and failure in one (4.8%) due to late deep infection. In the nonunion group, results were excellent in 17 (85%), good in two (10%) and failure in one (5%) due to deep infection. In the fresh-fracture group, one patient had terminal restriction of elbow motion with an arc of 105° and showed good results. In the nonunion group, two patients had painless restriction of motion and limitation of elbow function due to heterotopic ossification but with good results.

Complications

Overall, 11 complications were recorded in 41 patients after TER. Superficial wound infection occurred in two patients and resolved with dressings and antibiotics. Three patients with in the nonunion group with ulnar neurapraxia recovered spontaneously. One patient in the fresh-fracture group showed evidence of delayed deep infection at 14 months postoperatively. One patient with fracture nonunion following primary internal fixation developed deep infection five months after TER. In both the cases, after failure of wound debridement and antibiotic treatment, the prosthesis was removed. On prosthesis removal, the elbow was immobilized at 110° flexion in a plaster cast for six weeks to promote more fibrosis. Subsequently, with

Fig. 3 **a** Anteroposterior radiograph of a 58-year-old man showing nonunion of intercondylar fracture of the right humerus 14 months after failure of internal fixation. **b, c** Sixty months postoperative anteroposterior (**b**) and lateral (**c**) radiograph showing prosthesis in situ without evidence of erosion or radiolucent line around the prosthetic stems

physiotherapy, satisfactory functional outcome with relatively stable 15–130° motion was recovered. Prosthetic component disassembly due to breakage of the main linking screw at the level of the lock-screw hole occurred in one patient during the 18 months follow-up as a result of habitually carrying five to six kilogrammes load for several hours a day, against our advice. This was the first time we have experienced this problem. However, revision with new linking and locking screws was possible, with recovery of 10–130° elbow motion. Patchy heterotopic ossification was noted in two patients in the nonunion group posterior to the

prosthetic hinge during several months to years in the post-operative period. This might have contributed to their 10–30° fixed-flexion deformity, though they recovered arc motions of 80–90° with good results. Localised radiolucency around the humeral-stem flanges (Fig. 2e) was observed in one patient, with no clinical evidence of loosening at 74 months follow-up.

Discussion

A comparative study of open reduction and internal fixation with primary TER in the treatment of intra-articular fractures of the distal humerus in women older than 65 years showed that TER provided comparable [18] to better results [7]. One study [24] comparing the results of TER in recent fractures and nonunion of one year duration showed inferior results in nonunion. However, no statistically significant differences in functional outcome were found in the two groups. In contrast, our series showed no significant difference between excellent and good results and functional outcome of TER in fresh fractures and nonunion of 11 months' mean duration. In our series, 39 patients (95.1%) achieved satisfactory functional outcome and two (4.8%) failed due to deep wound infection. Encouraging results associated with the recent version of the Baksi sloppy hinge prosthesis can be explained by its inherent properties: varus–valgus stability is provided by the in-built 7–10° side to side laxity at the hinge section, for which any strain occurring at the hinge section is dissipated

Fig. 4 Harpoon-shaped reamers for reaming the ulnar medullary canal

Table 1 Mayo elbow performance score [19]

Function (points)	No. of elbows	
	Fresh fracture (<i>n</i> =21)	Ununited fracture (<i>n</i> =20)
Pain (max 45)		
None (45)	20	19
Mild (30)	0	0
Moderate (15)	1	1
Severe (0)		0
Mean	43.57	43.5
Range of motion (max 20)		
Arc >100° (20)	20	17
Arc 50–100° (15)	1	2
Arc <50° (5)	0	1
Mean	19.76	18.75
Stability (max 10)		
Stable (10)	20	19
Moderately unstable (5)	1	1
Grossly unstable (0 point)	0	0
Mean	9.76	9.75
Function (max 25)		
Able to comb hair (5)	20	18
Able to feed oneself (5)	20	18
Able to perform personal hygiene tasks (5)	19	17
Able to put on shirt (5)	20	18
Able to put on shoes (5)	19	17
Mean	23.33	22
Mean total (max 100)	96.42	94

primarily to the surrounding soft tissues, and less strain occurs at the bone–cement prosthesis interfaces [1]. Axial stability is provided by the main linking and locking screw fixation of the hinge components. Rotational stability is provided by the snugly fitting triangular-shaped shank of the humeral stem, along with its flanges impacted into the longitudinal slot on each side of the humeral cut end. This minimises stress at the humeral bone–cement prosthesis interfaces. The anteroposterior stability is provided by the broadened humeral stem shank, which distributes the cyclical compression and distraction forces during flexion and extension over the larger bony areas of the lower end of the humerus, where the flanges of the humeral prosthetic stem are seated. As a result of these larger areas, stress per unit area is greatly reduced. Absorption of such stresses by the flanges is evidenced by the development of a localised radiolucent area around the flanges (Fig. 2e) in one of our patients. Furthermore, 10–30° fixed flexion deformity in a majority of patients with 90–110° arc of flexion counteracts stress during terminal extension [2], thereby increasing prosthesis longevity.

In the cases of intercondylar fractures, even after excision of humeral condyles, this design allows secure

fixation by impaction of triangular-shaped humeral stem into the medullary canal of the humerus fixed with bone cement, along with snugly fitting flanges into the longitudinal slot over each side of the humeral cut end, thereby functioning as a single assembly and helping overcome the wind-shield-wiper effect of the humeral stem. Thus, this prosthesis needs only humeral diaphysis to obtain secure fixation in the absence of humeral condyles. Condylar reconstruction is not mandatory [26]; hence, the linked semiconstrained prosthesis must have a stem for stable anchorage in the humeral shaft.

In developing countries, such fractures may present late, making open reduction and internal fixation difficult and impractical. TER using our prosthesis is economical and affordable, as the prosthesis costs approximately US \$150. This is in comparison with Morrey's prosthesis, which costs about US \$1,800. In the series of patients reported here, in both the fresh-fracture and nonunion groups, failure was due to either late infection or flare-up of dormant infection from previous internal fixation. However, in cases with nonunion following failure of internal fixation, implants were removed in one stage, and if no infecting organisms were found, prosthetic replacement was contemplated two

weeks later. Moreover, in the event of prosthesis failure and removal, relatively stable elbow function was obtained due to fibrosis connecting the adjacent bone ends and reorientation of muscle balance [2]. Similar functional stability was observed in two patients in this series in whom the prosthesis needed to be removed. Thus, the results of TER in our series were quite satisfactory among elderly patients having low functional demand in day to day activities. This recent design may be used even in relatively younger individuals, particularly in patients with nonunion of intercondylar fracture the humerus.

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