THE DEVELOPMENT OF AN UNCONSTRAINED ELBOW ARTHROPLASTY

A CLINICAL REVIEW

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This paper describes the development, operative technique and results of an unconstrained total elbow arthroplasty. Forty-seven elbow replacements were carried out in 44 patients between 1974 and 1982. There was a high rate of loosening in the early condylar replacements. The results in patients with post-traumatic arthritis were poor. The later design employs an ulnar stem, with a humeral stem if the distal humeral bone stock is poor. When used in carefully selected patients with rheumatoid arthritis, pain is reduced significantly, stability and movement are preserved and function is improved.

In rheumatoid arthritis involvement of the elbow is relatively common, but symptoms can usually be controlled by conservative measures or by such surgical procedures as excision of the head of the radius and synovectomy. However, there is a limit to what can be expected of synovectomy (Souter 1973), and it is not advised when joint movement is severely restricted or with advanced bone erosion and incongruity of the humero-ulnar joint (Copeland and Taylor 1979). In such patients, arthrodesis is difficult to achieve and is in any case contra-indicated when there is multiple joint involvement. Excisional arthroplasty also gives unsatisfactory results (Souter 1973). Total replacement of the elbow is therefore indicated in a small number of patients with uncontrolled pain from advanced rheumatoid arthritis. It has also been employed in the treatment of patients severely disabled by post-traumatic osteoarthritis. Because of dissatisfaction with the early constrained hinge arthroplasties, attention has more recently been focused on semi-constrained and unconstrained prostheses (Coonrad 1979). This paper describes the development, the operative technique and the clinical results of an unconstrained total elbow replacement in use at Northwick Park Hospital between 1974 and 1982.

DEVELOPMENT

In 1973 when work on the project began, attention was focused on the concept of hemiarthroplasty in order to minimise bone resection and because of the relative success at that time of the MacIntosh hemiarthroplasty of the knee (Lowe, Kates and Kay 1972).

Fig. 1

Radiograph of the original condylar implant.

A detailed examination of 50 cadaveric elbow joints was carried out and this showed a wide variation in the diameters of the medial, central and lateral parts of the trochlea. Nevertheless, a single-component condylar implant was constructed in titanium and inserted into the olecranon with bone cement, the radial head being excised (Fig. 1). There were three sizes of implant, and two types—a left and a right. This prosthesis was used in two patients but failure occurred at a relatively early stage in both. However, revision was not difficult because a minimal amount of bone had been resected. In

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Fig. 2

The humeral and ulnar condylar implants; the ulnar implant is on the left.

Fig. 3

The stemmed humeral and ulnar implants.

rheumatoid arthritis, the distal end of the humerus is nearly always destroyed and there is a need for a two-component prosthesis in the majority of cases. A new prosthesis to match the ulnar component was therefore developed; this humeral component was made of high-density polyethylene and was cemented over the shaped lower end of the humerus. With such a two-component prosthesis, the anatomical complexity of the humero-ulnar articulation could be disregarded and the design was simplified to two geometrically matched components in one size only, to fit both elbows (Fig. 2).

The initial results were encouraging but, at a relatively early stage, a high incidence of loosening occurred. To obtain more secure fixation, stems were therefore added to both components (Fig. 3). The present policy is to use an ulnar component with a stem routinely, and a humeral stem if the distal humeral bone stock is poor. The humeral stemmed component is also used for revision operations.

MATERIALS AND METHOD

Between 1974 and 1982, 47 elbow prostheses were inserted in 44 patients at Northwick Park Hospital. For the purpose of this review, 36 patients have been examined clinically and radiographically. One patient had died in the early postoperative period; the remaining seven were assessed from the follow-up notes and the radiographs, which were adequate for this purpose. All the operations had been carried out by one surgeon (LWL). There were 16 men and 28 women with an average age of 52 years (range 19 to 75 years). There were 29 patients with seropositive and six with seronegative rheumatoid arthritis. Two patients had juvenile chronic arthritis and seven had post-traumatic osteoarthritis. The mean follow-up was three years (range 1 to 9 years). Twenty patients had had previous operations: synovectomy (1), synovectomy with radial head excision (11), open reduction and internal fixation after a fracture (5), or ulnar nerve neurolysis (3). Most of the patients with rheumatoid arthritis had widespread disease and other joints were involved in the same limb: the shoulder (7), the wrist (9), the hand (13) or all three (18).

Table I. Pain assessment

Grade 1: No pain
Grade 2: Occasional ache
Grade 3: Moderate pain
Grade 4: Severe pain
Grade 5: Permanent severe pain

Pain before and after operation was assessed on a five-point scale (Table I) and the overall result was graded satisfactory or unsatisfactory on the clinical criteria used by Porter, Richardson and Vainio (1974) and given in Table II.

Operative technique. With the patient lying supine, the arm is exsanguinated by elevation, a high tourniquet is applied and the arm placed across the chest. A long straight posterior incision is made and extended well

Table II. The criteria for grading clinical results

Satisfactory:	Patient pleased
	Good pain relief
	No symptomatic instability
	Range of movement preserved within limits defined below
Unsatisfactory:	Patient dissatisfied or uncertain
	Pain worse, unchanged, or only slightly improved
	Unstable joint
	Significant loss of movement

A loss of up to 25° of flexion or 20° of extension is accepted provided the total loss does not exceed 35°.

distal to the olecranon process. The triceps is exposed and incised as an inverted V. The arms of the V are extended down into the upper forearm posteriorly, making sure that sufficient fascia is left on the olecranon for repair. Both medially and laterally subperiosteal dissection of the distal humerus is performed, carrying the ulnar nerve, which must be identified and protected, forward on the medial side. When it is under tension or when its bed is severely damaged or scarred, it may be necessary to transpose the nerve. It is mobilised *en bloc* with surrounding soft tissue in order to preserve the blood supply. This approach exposes the elbow joint including both epicondyles. The elbow is dislocated and an excellent view is now obtained of both the humerus and the ulna. At this stage, the head of the radius, if present, is excised.

For a condylar replacement, the humeral surface is now shaped to fit the prosthesis. For a stemmed prosthesis, the middle of the humeral articular surface is removed and the intramedullary cavity of the humerus is found and reamed. The channel is enlarged medially and laterally with a small rasp. At this stage care must be taken not to fracture the medial or lateral humeral condyle. If the stemmed humeral component is too large for the medullary cavity it can be trimmed to size although this is rarely necessary. The stemmed ulnar component is introduced by excising a block of bone to the size of the prosthesis and then reaming down the ulnar shaft using a high-speed burr and again a small reamer. The tip of the olecranon has to be excised when the stemmed prosthesis is inserted. Both components are now cemented in place using low-viscosity cement and a pressurising syringe.

When closing the wound, care is taken to equalise the tension of the soft-tissue repair both medially and laterally so that a stable reduction is achieved. A Redivac drain is inserted and a plaster cylinder applied with the elbow in 90° of flexion. The Redivac drain is removed at 48 hours and the plaster and sutures are removed at two weeks. Gentle exercises are started but a triangular sling is worn for a further four weeks. Physiotherapy is not given routinely.

RESULTS

Post-traumatic osteoarthritis

The results of the seven patients with post-traumatic osteoarthritis were poor and these were analysed as a

Table III. Results in seven patients with post-traumatic osteoarthritis

1	Clinically satisfactory
1	Prosthesis removed for infection
1	Prosthesis removed for recurrent dislocation
1	Revised for loosening, but still unsatisfactory
3	Unsatisfactory because unstable

One patient had a condylar prosthesis; the remaining six had stemmed prostheses

separate group in Table III. In the one case that was clinically satisfactory at review, radiographs showed marked evidence of loosening. It was concluded, therefore, that this prosthesis was unsuccessful in this group of patients and should not be used.

Rheumatoid arthritis

The analysis which follows is confined to patients with rheumatoid arthritis and juvenile chronic arthritis. There were 39 elbows in 36 patients. Three prostheses had been removed and these are analysed separately. Revision surgery was required in 14 elbows and the results after revision have been included in the assessment at the time of review.

Fig. 4

Pain grading before and after operation.

Pain. Pain scores before and after operation are shown in Figure 4. There was a significant reduction in pain ($\chi^2 = 54.5$; $df = 4$; $P < 0.001$). The postoperative pain score was worse in only one patient.

Range of movement (Fig. 5). There was a reduction in the mean fixed flexion deformity, but this improvement just

Fig. 5

Average range of flexion before and after operation.

Fig. 6

Average range of pronation and supination before and after operation.

failed to reach statistical significance ($P=0.07$). In contrast there was an increase in the postoperative range of flexion which was significant ($P<0.01$). There was a significant improvement ($P<0.05$) in the ability to supinate the forearm. However, the range of pronation which was frequently satisfactory before operation, was not significantly increased (Fig. 6).

Functional assessment. Improvement in function is one of the main aims of the operation but this has been difficult to assess because, in rheumatoid patients, several joints are involved in the same limb. A gross assessment of upper limb function is shown in Table IV.

Table IV. Assessment of function in 36 elbows

Function	Before operation	After operation
Able to get hand to mouth	26	32
Able to get hand to hair	12	27
Able to attend to personal toilet	15	32

Radiological assessment. Five elbows showed evidence of radiological loosening, namely a radiolucent line of 2 mm or more in width at the cement-bone junction, or bone erosion. The radiographic appearances, however, were often at variance with the clinical results. In one patient the tip of the ulnar prosthetic stem had perforated the ulnar shaft at the time of operation but the clinical result was good.

Complications and re-operation. One patient died in the early postoperative period from a myocardial infarction. *Excision arthroplasty.* The prosthesis was removed in three patients, either for infection after revision for recurrent dislocation, or for further loosening after revision; all these patients originally had condylar prostheses which were revised to stemmed prostheses. However, as only a relatively small amount of bone had been resected, the resulting fibrous ankylosis was reasonably stable.

Infection. Deep infection necessitated removal of the prosthesis in one patient; two patients had chronic low-grade infections which were controlled by long-term antibiotics.

Peripheral nerve lesions. Three patients developed ulnar nerve lesions after operation: two recovered completely but one had a complete irrecoverable lesion. One patient had a complete lesion of the radial nerve after recurrent dislocation; this did not recover after removal of the prosthesis.

Instability. In eight patients the arthroplasty was unstable. This ranged from a feeling of instability on use to recurrent episodes of dislocation, which occurred in four patients. The symptoms were severe enough to necessitate removal of the prosthesis in one case.

Fractures. There were two cases of humeral fracture resulting from falls, one in a patient with a condylar prosthesis and one in a patient with a stemmed prosthesis.

Fig. 7

The overall results of the condylar prostheses.

Fig. 8

The results of the stemmed prostheses inserted as a primary procedure.

Fig. 9

The results of the stemmed prostheses inserted as a revision procedure for failed condylar prostheses.

Union around the stemmed humeral prosthesis proceeded uneventfully but there was malunion of the distal humerus around the condylar prosthesis with loosening of the humeral component.

Overall assessment. Since the development of the prosthesis has passed through two main phases (the early condylar replacements and the later stemmed version), the overall results of each type are presented separately. *Condylar prosthesis.* The fate of the 23 condylar prostheses is shown in Figure 7. Twelve elbows required revision because of loosening. There were a further three patients with unsatisfactory results, all because of loosening.

Stemmed prosthesis. There were 28 stemmed prostheses inserted. This figure includes 16 that were initially inserted (Fig. 8) plus 12 inserted on revision after the failure of condylar prostheses (Fig. 9). Twenty-two elbows remain satisfactory at review.

DISCUSSION

Large forces are transmitted across the elbow joint. As well as flexion and extension, there are changes in the carrying angle with movement and torsional stresses due to forearm rotation (Inglis and Pellicci 1980). The abducted upper arm also increases the torsional load of the forearm on the elbow and under certain loading conditions the resulting forces may reach three times body weight (Walker 1977). These facts can explain the high incidence of loosening in constrained hinged elbow arthroplasties (Souter 1973; Inglis and Pellicci 1980). The elbow implant developed at Northwick Park Hospital began with unconstrained condylar, ulnar and humeral implants, but early loosening occurred, particularly of the ulnar component. A stemmed component was then used for the ulna with a condylar implant for the humerus, if there was adequate bone stock; if not, a stemmed humeral component was used.

In rheumatoid arthritis, the prosthesis of this latter design is capable of increasing elbow movement significantly and provides very satisfactory relief of pain. In addition, overall upper limb function is improved. However, the follow-up of these prostheses is as yet short and we can make no comment on the long-term results or possible prosthetic loosening. On the basis of our

results, it would appear that there is no place at the present time for prosthetic replacement in osteoarthritic elbows and this experience is similar to that of other series (Inglis and Pellicci 1980; Morrey *et al.* 1981).

Instability can be a problem when replacing a destroyed unstable joint with an unconstrained prosthesis. Our prosthesis allows for an element of rotational subluxation but self-centring follows which enhances the stability. However, instability was a symptom in eight patients and excision arthroplasty was necessary in one patient for recurrent dislocation.

There was a high revision rate (36%) in this series, an experience similar to that described in other recent reports. Morrey *et al.* (1981) from the Mayo Clinic, reported a 24% revision rate and a 55% complication rate. Similarly, Inglis and Pellicci (1980) quote a 22% reoperation and a 53% complication rate. As with other joints, the major complications, such as infection and ulnar nerve damage, are more prevalent after revision.

In early rheumatoid arthritis, synovectomy of the elbow combined with excision of the radial head can give excellent results. However, in advanced disease, joint replacement with an unconstrained prosthesis can provide significant relief of pain with preservation of stability, movement and improvement in function.

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