A REVIEW OF THE LIVERPOOL ELBOW PROSTHESIS
FROM 1974 TO 1982

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Eighty elbows in 65 patients with an average age of 57 years have had two-part non-constrained Liverpool elbow arthroplasties performed since 1974. Fifty-five had rheumatoid arthritis, eight osteoarthritis or ankylosis secondary to injury, one osteochondritis dissecans and one pyknodysostosis. The average pre-operative range of movement was 42° to 112° with 47° of pronation and 42° of supination. There was significant gain in the arc of movements at follow-up: 32° in the extension–flexion range (average range 32° to 134° of flexion) and 42° in forearm rotation (average pronation 69° and supination 62°). Before operation severe pain was the predominating symptom in 43 elbows (53.8%) but after replacement there was only moderate pain in five elbows (6.2%). The results were excellent in 42 (52.5%), good in 15 (18.7%), fair in 9 (11.3%) and unsatisfactory or poor in 14 (17.5%). Eight elbows required revision of the arthroplasty: three were post-traumatic, disorganised or osteoarthritic joints, three rheumatoid and both elbows in the patient with pyknodysostosis. Loosening of the prosthesis (particularly the humeral component) was the common factor necessitating revision. Of six rheumatoid elbows needing removal of the implant, four had deep infection, one had a dislodged humeral component as a result of injury and in one a divided olecranon had developed non-union.

Rheumatoid elbows benefited more than post-traumatic arthritic elbows from the operation. Though the overall complication rate was 57.5% (most of them occurring during the early years of the study), only 17.5% of the complications were long-term and adversely affected the final outcome. An average follow-up of three and a half years confirmed the ability of the prosthesis to provide a pain-free mobile, stable and durable joint.

The success of total hip replacement (Charnley 1961) stimulated research into prosthetic replacement of other joints. Whereas any ball-and-socket arrangement will give more or less satisfactory results in the hip, the same is not true for other joints.

The elbow forms part of a mechanical complex the purpose of which is to place the hand in the position and orientation required for use and to provide power to support the hand. Both the elbow and the shoulder are very versatile and to a certain extent each can compensate for deficiencies in the other. However, severe pain in either joint may markedly inhibit the use of the other and of the hand. Consequently, a very painful elbow can be a severe disability, while in the absence of pain, restriction of movement in the joint is a lesser disability. However, complete fusion of the elbow, particularly both elbows, makes it very difficult for the patient to carry out toilet and feeding activities.

The elbow is commonly involved in rheumatoid arthritis and similar arthropathies. It is also quite frequently involved with osteoarthritis secondary either to osteochondritis dissecans or to fractures.

The elbow is subjected to considerable force in many directions, dependent on the particular activity at that time. An important example of this occurs when lifting an object with the elbow flexed at 90° and the arm abducted; an extreme torsional force is then exerted. This force has to be absorbed by an elbow prosthesis. In addition, in rheumatoid patients using crutches, the elbow frequently functions as a weight-bearing joint.

The first attempts to devise an elbow arthroplasty employed fully constrained hinges with stems on both components similar to those which were in use for the knee at that time (Dee 1972). The results of this kind of arthroplasty were not very encouraging (Weiss 1970; Souter 1973a, b; Gschwend 1975; Nederpert 1975). The most frequent complication was loosening of one or both stems at the bone–cement interface and the incidence of this complication appears to increase directly with the length of follow-up.

Souter (1973b) reported that 17 out of 25 hinged elbow prostheses were loose from 14 to 40 months after operation. Clearly this kind of fixation and this kind of device were not satisfactory. As a result of these findings an attempt was made to design a non-constrained
replacement for the humero-ulnar articulation, one which did not depend on stems for fixation. This has been previously reported (Cavendish and Elloy 1976, 1977). This design was introduced into clinical practice in February 1974.

The Liverpool prosthesis (Figs 1 to 3) is a close approximation to a physiological elbow joint. The axis of rotation is located as near as possible to the natural axis and an attempt is made during insertion to reproduce the carrying angle. In addition, as a safety measure, the prosthesis is designed so that accidental loads result in dislocation rather than loosening. The fixation of the prosthesis has been laboratory tested and the forces required to loosen the humeral component greatly exceed those to which the elbow is likely to be subjected; in fact, in the specimen tested, fracture of the humerus occurred first.

Wear testing has not been carried out specifically in the elbow although the materials in use have been tested in relation to other joints. Since the majority of movements of the elbow occur while the joint is not loaded it seems likely that wear will not exceed that found in the hip or knee and should, therefore, be acceptable.

MATERIAL AND METHODS

The Liverpool elbow arthroplasty has been performed at our hospital since February 1974. Eighty elbows (35 right, 15 left and 15 bilateral) in 65 patients were available for review. There were 36 women and 29 men with an average age at operation of 57 years (range 24 to 83 years). Five patients had secondary osteoarthritis resulting from injury and three had post-traumatic bony ankylosis; one patient had osteochondritis dissecans and one pyknodysostosis; the remaining patients had seropositive rheumatoid arthritis, three of them with diabetes. Patients with rheumatoid arthritis generally had severe disease, as evidenced by the fact that 31 of the 55 patients had had arthroplasty of three or more other joints. Sixteen elbows had had previous operations such as synovectomy, radial head excision or operative treatment of fractures. With most patients, the history of trouble with the elbow was a long one ranging from 1 to 33 years (average 13 years). Twenty-three patients had been on steroids for more than five years before operation.

The average operating time for implantation of the Liverpool prosthesis was 40 minutes (range 30 to 60 minutes). All operations were performed in a room with a conventional Charnley–Howorth enclosure and a tourniquet was always used. The follow-up ranged from one to eight years with a mean of three and a half years. Classification of pain. Pain was classified into four grades (Table I) and the patients were assessed both before and after operation.

Table I. Grading of pain

<table>
<thead>
<tr>
<th>Grades</th>
<th>Description</th>
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<tr>
<td>1</td>
<td>Normal</td>
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<tr>
<td>2</td>
<td>Slight pain, not interfering with sleep or activity</td>
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<tr>
<td>3</td>
<td>Moderate pain, limiting use of the elbow, but not interfering with sleep</td>
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<tr>
<td>4</td>
<td>Severe, with night pain, preventing most activities</td>
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Assessment. The results were rated objectively by evaluation of the elbow (Dee 1972) and subjectively by the patients’ opinions of the results. The subjective assessment correlated well with the clinical assessment. Excellent results were those with more than 90° of flexion and more than 60° of pronation and of supination. The elbows were stable and painless and the patients were enthusiastic.

Good results had the same criteria but had required secondary procedures such as manipulation of the elbow under anaesthesia, open arthrolysis to release adhesions, or ulnar nerve exploration or transposition. Secondary surgical interventions were required to deal with the complications resulting from dividing the olecranon process, an approach used only in the early years of the study. The patients in this category were satisfied.

Fair results were those with 50° to 90° of flexion in a useful arc, and between 40° and 60° of rotation. There was discomfort in the elbow, but this did not prevent the patient carrying out the activities of daily living. The patients were non-committal. Poor results were those with less than 50° arc of flexion in the functional range, less than 40° of rotation, persistent loss of function due to pain or instability, and any infection or loosening requiring removal of the prosthesis or revision. These patients were disappointed.

The results were rated in 42, good in 15, fair in 9 and poor in 14. The cause of failure in the 14 poor results was loosening in eight, deep infection in four, traumatic dislodgement eight years after an operation with an excellent result in one, and non-union of the divided olecranon with loosening of the ulnar component in the other. The last six elbows in which removal of the implant was required were all in patients with rheumatoid arthritis.

The eight elbows with loosening all underwent revision. These eight comprised three of the 69 elbows replaced for rheumatoid arthritis, three of the eight operated on for post-traumatic arthritis and both elbows in the patient with pyknodysostosis who had previously had a pseudarthrosis of both elbows. Of the five elbows subjected to revision of both components, one was rheumatoid, two pyknodysostotic and two were post-traumatic. Of the three where the humeral component only was revised two were rheumatoid and one post-traumatic.

Of the eight elbows with post-traumatic arthritis only one was rated excellent; two were good, two fair and three poor. One had been treated by excision of the lower end of the humerus for post-traumatic bony ankylosis, and a special custom-made stemmed prosthesis was inserted. This was rated fair; the patient had painful locking of the prosthesis at the extreme of flexion and initially had to unlock it by hand to extend the elbow, but subsequently this improved. Two elbows with poor results had sustained side-snap injuries, rated as Groups 3 and 4 on Shorbe’s (1941) scale, with considerable soft-tissue injuries and joint deformity. One of these had had bony ankylosis of the elbow at 90°, and within a year required revision of both components because of loosening. No specific reason for loosening was evident in the third poor elbow.

All the eight revisions were done using larger prosthetic components except one in which a stemmed prosthesis was used. The time from the initial surgical procedure to revision ranged from nine months to eight years with an average of 39 months. Five of the revisions had satisfactory restoration of painless elbow movement one to three and a half years after operation (average one and a half years). Three had approximately 60° of movement with discomfort but could use the elbow freely. One had painful loosening of the prosthesis and underwent a further revision.

Four patients with deep sepsis of the elbow had been on steroids for more than five years because of rheumatoid disease; all belonged to the early years of the study and were operated upon through a trans-olecranon approach (Figs 4 to 7). The diagnosis of sepsis was made between 4 and 24 months postoperatively. Two late infections

RESULTS

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occurred one year after a period of satisfactory function. All these septic cases were subjected to excision of the olecranon bursa and removal of the wire or screw (used for olecranon fixation) in an unsuccessful attempt to salvage the prosthesis. They eventually required removal of the prosthesis to control the infection. No prosthesis has been reimplanted after an infection. The patients whose prostheses had been removed were left with more than 90° of painless movement in a useful arc but with obvious instability. No elbow has shown evidence of recurrence of infection at one to six years (average 46 months) after removal.

**Movement.** Maintenance of movement is the advantage of arthroplasty over arthrodesis. Good improvement was noted in the range of movement (Table II). Fifty-seven elbows had more than 90° of flexion and more than 60° of rotation postoperatively. These included three of the eight elbows with post-traumatic arthritis. This improvement is significant when we note that only 26 elbows, all rheumatoid, were so rated pre-operatively. Elbows with a poor range of movement before operation usually did not achieve more than 90° of flexion and more than 60° of rotation postoperatively: 23 elbows fell into this category. None of the elbows in the series exhibited less than 50° of flexion and less than 40° arc of rotation.

Table II. Average limits of movements (degrees)

<table>
<thead>
<tr>
<th></th>
<th>Maximal extension</th>
<th>Maximal flexion</th>
<th>Flexion-extension range</th>
<th>Pronation</th>
<th>Supination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-operative</td>
<td>42</td>
<td>112</td>
<td>70</td>
<td>47</td>
<td>42</td>
</tr>
<tr>
<td>Postoperative</td>
<td>32</td>
<td>134</td>
<td>102</td>
<td>69</td>
<td>62</td>
</tr>
<tr>
<td>Gain in movement</td>
<td>10</td>
<td>22</td>
<td>32</td>
<td>22</td>
<td>20</td>
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</table>

Complications

There were 46 complications, an overall complication rate of 57.5%. Thirty-two were short-term complications which did not adversely affect the functional outcome; only 10 required reoperation and five needed manipulation under anaesthesia.

Reoperation was carried out for removal of the olecranon screw (4), reattachment of the olecranon (2), ulnar nerve entrapment which required exploration and anterior transposition (2), arthrolysis for adhesions (1), and removal of part of the radial head (1). Of the five elbows requiring manipulation under anaesthesia, three were for immediate postoperative dislocation and two for stiffness. The other 17 complications were ulnar nerve neuropathy, resolving within 6 to 10 months (4), soreness over the olecranon process due to ulceration and delayed wound healing (3), subluxation on extension (3), recurrent subluxation (1), locking of the prosthesis at the extreme range of flexion (1), tourniquet palsy (1), unexplained brachial plexus palsy (1), collateral instability (2) and periarticular ossification (1). No elbow was found to have significant weakness of the triceps mechanism.

Fourteen major complications requiring revision or removal of the implant have already been mentioned.

**Pain** was the main indication for operation in most patients. Complete relief of pain was obtained in 81% of elbows (Table III). Fifteen elbows operated on early in the series through the trans-olecranon approach had varying amounts of pain after operation. All except one were eventually found to have mechanical or infective loosening of the prosthesis and required revision or removal of the prosthesis. As is shown in Table III, five elbows were found to be moderately painful; one had no evidence of prosthetic failure, and no explanation of the pain was found on exploration. The three elbows with no pain before operation were those with post-traumatic bony ankylosis. There was no significant difference in pain relief after the operation between the other post-traumatic elbows and those with rheumatoid arthritis.

**Stability.** In contrast to hinged elbows with inherent stability, non-constrained prostheses depend on collateral structures for stability. Six elbows in the current series were found to have collateral laxity pre-operatively with associated muscle wasting; four did well after operation. Two elbows exhibited collateral laxity but the patients were quite satisfied despite the instability.

### DISCUSSION

The selection of patients and of elbows best suited for total arthroplasty must be done very carefully, remembering the place of conservative surgery; for example, synovectomy with or without excision of the radial head gives satisfaction to 70% of patients for as long as five years after operation (Marmor 1972; Taylor, Mukerjea and Rana 1976; Inglis and Pellicci 1980).

As a result of failures, a great deal has been learned about the stresses to which elbow implants are subjected; the designs have correspondingly improved. The current prosthesis was designed to overcome the high incidence of loosening (Dee 1972; Dobyns et al. 1976; Ewald et al. 1980), and the poor salvage potential of the conventional constrained or semi-constrained prostheses. For the soft tissues to exert a maximal protective influence after
elbow arthroplasty, the prosthesis must be inserted with minimal soft-tissue distortion, to allow tensioning of the collateral structures (Elloy, Wright and Cavendish 1976). Thus, the success of the arthroplasty depends not only on the design of the joint but equally on the expertise with which the joint is aligned and implanted; unless the prosthesis is correctly inserted, the results will, at best, be sub-optimal, and at worst a failure. Improved instrumentation (Fig. 3) has contributed to improvement in accuracy of insertion.

Fig. 8
Fig. 9
Fig. 10
Fig. 11
A patient later in the series. Figures 8 and 9—Pre-operative radiographs of the left elbow with rheumatoid changes. Figures 10 and 11—Post-operative radiographs two years after replacement with the Liverpool elbow, via the standard approach through the triceps tendon. The elbow is comfortable and functional.

The prosthesis (Fig. 1) and the operative technique have been described previously (Cavendish and Elloy 1976, 1977). In the early cases this prosthesis was used in a wide variety of elbows, some of which were unsuitable because of excessive bone loss. The stemmed modification (Fig. 2) would be used in these today, thus eliminating some of the failures. In addition, the trans-olecranon approach (Figs 6 and 7) has been abandoned in favour of the standard approach through the triceps tendon (Figs 10 and 11). If these early cases are eliminated, the success rate is much improved.

The operation is fairly quick and simple in suitable cases, particularly in rheumatoid elbows (Figs 4 and 8) and success rates approaching those in hip replacement are anticipated. This has become a routine procedure in our unit, and in recent years the results have been encouragingly predictable and reproducible because of the simplicity of the design and the technique of implantation.

Should the operation fail due to infection, salvage is a simple procedure involving removal of the components and conversion to a pseudarthrosis; this will give good movement and pain relief, but poor stability. Other failures can be revised using a larger prosthesis or one modified to incorporate an intramedullary stem.

Local postoperative complications do not appear to be excessively common in selected patients operated upon through the standard trans-triceps posterior approach. The lack of intrinsic stability, characteristic of an unconstrained prosthesis, can allow dislocations to occur but this was the case in only three elbows in the early postoperative period in the entire series, which is significantly less than in other series (Ewald et al. 1980). Loosening was more common in post-traumatic elbows, a finding experienced by others (Morrey et al. 1981). Even considering the unfavourable nature of some of the cases, the results in this series compare favourably with those previously published (Morrey et al. 1981), and are superior to those of constrained hinges (Dee 1972).

The very good results which are generally observed in the period immediately after total arthroplasty are regrettably no guarantee of permanent success in the long term, since even if a prosthesis is firmly fixed in place for a short or long period after implantation, various factors can eventually lead to loosening at a later date. Two elbows which appeared excellent up to one year were found to be rated poor when reviewed between one and two years after operation. The lack of any long-term series with a sufficient number of patients does not enable any firm conclusions to be drawn regarding the limitations of elbow replacement. However, the current series is a step in that direction. Whether the risk of mechanical loosening of the humeral component increases with pre-existing fixed flexion deformity remains to be determined.

The results of the present series indicate that 71% of unselected severely damaged elbows can be reconstructed with this prosthesis with resulting stability, and mobility of about 90° at the elbow and about 60° of rotation. After elbow replacement some patients have returned to fairly strenuous activity (one is a miner) without any trouble. For most patients, such an elbow becomes a “forgotten joint”.

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REFERENCES


