Ulnar Head Replacement

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ABSTRACT

Recent years have seen an increasing awareness of the anatomical and biomechanical significance of the distal radioulnar joint (DRUJ). With this has come a more critical approach to surgical management of DRUJ disorders and a realization that all forms of "excision arthroplasty" can only restore forearm rotation at the expense of forearm stability. This, in turn, has led to renewed interest in prosthetic replacement of the ulnar head, a procedure that had previously fallen into disrepute because of material failures with early implants, in particular, the Swanson silicone ulnar head replacement. In response to these early failures, a new prosthesis was developed in the early 1990s, using materials designed to withstand the loads across the DRUJ associated with normal functional use of the upper limb. Released onto the market in 1995 (Herbert ulnar head prosthesis), clinical experience during the last 10 years has shown that this prosthesis is able to restore forearm function after ulnar head excision and that the materials (ceramic head and noncemented titanium stem), even with normal use of the limb, are showing no signs of failure in the medium to long term. As experience with the use of an ulnar head prosthesis grows, so does its acceptance as a viable and attractive alternative to more traditional operations, such as the Darrach and Sauve-Kapandji procedures. This article discusses the current indications and contraindications for ulnar head replacement and details the surgical procedure, rehabilitation, and likely outcomes.

Keywords: distal radioulnar joint, DRUJ disorders, prosthetic replacement of head of ulna, ceramic, titanium

HISTORICAL PERSPECTIVE

Traditionally, painful arthritis at the distal radioulnar joint (DRUJ) has been treated by some form of excision arthroplasty (Darrach, Bowers, Watson, and Sauve-Kapandji). Although these procedures will normally relieve the arthritic pain, they all have an adverse effect on the biomechanics of the forearm, because rotation is achieved at the expense of an unstable pseudarthrosis, whereas the degree and the clinical effects of this instability are variable, depending on a number of factors such as surgical technique, patient expectations, demands, there is increasing evidence of the long-term disability that may result after such procedures.1-4

Once one accepts that the fact that an intact ulnar head is essential for normal function of the forearm and wrist, it becomes clear that surgical treatment of DRUJ arthritis should involve the use of some form of ulnar head replacement. To the best of our knowledge, the first person to recognize this was Dr Alfred Swanson,5 who modified his intramedullary stemmed silicone implant, previously used as an end-bearing cushion in amputation stumps, to act as an ulnar head replacement. In most of the cases reported by Dr Swanson, the implant was used for patients with rheumatoid arthritis (68/73), although it was also used in 4 cases of posttraumatic arthritis.

Recognizing the importance of the ulnar head and encouraged by the excellent clinical results reported by Dr Swanson, I (Herbert) decided, in 1981, to start using the Swanson silicone ulnar head implant when treating patients with symptomatic posttraumatic arthritis of the DRUJ; my results were published in 1992.6 Despite that most patients in this series were active young adults (mean age, 42.4 years) with posttraumatic arthritis of the DRUJ, the overall clinical results were most satisfactory and appeared to justify the use of an implant, even in this group of patients. However, medium-term radiological follow-up revealed serious problems with the implant design and material, similar
to those previously reported by McMurtry et al\textsuperscript{7} and Sagerman et al.\textsuperscript{8} As a result, I stopped using the Swanson implant and instead used a custom-made implant (isoelastic material; Synthes, Switzerland) on a case-to-case basis; however, this again proved unsuitable for long-term use. For these reasons, I decided to set about developing a more suitable ulnar head replacement, with assistance from the Department of Biomechanical Engineering, University of New South Wales.\textsuperscript{9}

By 1992, the design criteria had been agreed upon, and a commercial manufacturer (Martin Medizintechnik, Tuttingen, Germany) was approached for assistance with development of suitable prototypes for cadaver testing; the modular design of the prototype (interchangeable heads and stems in 3 different sizes) proved to be simple to insert, and it was agreed to go ahead with the manufacture of an implantable prosthesis.

To avoid the problems associated with the use of cement, particularly in small bones, we decided to use a noncemented stem made of porous coated titanium; titanium was chosen because of its known biocompatibility and a modulus of elasticity (100,000 N/mm\textsuperscript{2}) very similar to that of bone.\textsuperscript{10}

At the same time, we felt that the load between the prosthesis and the sigmoid fossa of the radius was such that a hemiarthroplasty would suffice, thus avoiding the problem of particulate wear associated with 2-part prostheses; ceramic (zirconium oxide) was chosen as the material most suitable for articulation with joint cartilage.\textsuperscript{10}

The Herbert ulnar head prosthesis (Martin Medizintechnik) first became available early in 1995, and the first 5 cases were carried out at that time, with most encouraging short-term results. A multicenter clinical trial was initiated later that year, and the prosthesis was released for general use in 1998. Since then, extensive experience has been gained worldwide, and long-term follow-up is showing excellent survival rates and clinical results.\textsuperscript{11–14}

In 1998, Avanta (San Diego, Calif) released a similar prosthesis in North America, although this was designed to be used with bone cement and has a metal head with holes for soft tissue attachment; to what extent these design differences affect the outcome is not yet clear, because, to date, little has been published in regard to clinical results.\textsuperscript{15} In the meanwhile, a number of other companies have also released similar ulnar head implants, but again, clinical data remain scarce.

Taking a different approach to the problem, Dr Luis Scheker has developed a multicomponent semiconstrained prosthesis, utilizing stainless steel radial and
ulnar components and a polyethylene articulating ball.\textsuperscript{16,17} I have no experience with the use of this prosthesis, but although I do not feel that there is any requirement for a semiconstrained prosthesis in most cases, I believe that this could prove valuable in those patients whose soft tissues are inadequate to provide sufficient stability for a single-component implant (see Indications and Contraindications).

In summary, the profusion of implants now available indicates a growing awareness of the need to maintain stability and normal forearm biomechanics after excision of the ulnar head.

\section*{INDICATIONS AND CONTRAINDICATIONS}

Before outlining the indications for the use of an ulnar head prosthesis, it is important to emphasize that no implant can ever function as well as the original; in other words, every possible effort should be made to preserve the ulnar head, and excision is justified only if the articular surfaces of the DRUJ have been irreversibly damaged.
there is any doubt about the condition of the joint surfaces, then these should be carefully inspected, either arthroscopically or at the time of surgery, assuming that a corrective osteotomy of radius and/or ulna is planned. If there is evidence of irreversible joint damage, then the ulnar head can always be replaced at the same time as the osteotomy. Indeed, ulnar head replacement is contraindicated in the case of severe joint damage.

Distal forearm fractures, malunion of the radius, in particular, are the most common cause of DRUJ problems. Radiographs often show what appears to be posttraumatic arthritis of the joint, but this appearance can be deceiving; once the deformity has been corrected and the joint fully reduced, a good range of forearm rotation may be expected, and only if this remains painful or restricted as a result of secondary arthritic changes should arthroplasty be considered. If

FIGURE 4. Ulnar head resection. A, Diagram showing various resection levels, depending which prosthesis is to be used. B, Resection guide in place, osteotomy being carried out at appropriate level. C, Ulnar head being dissected out from attached soft tissue.

of significant radial deformity, so that it is now becoming increasingly common for a corrective osteotomy to be carried out at the same time as the joint replacement.

Thus, the principle indication for use of an ulnar head replacement has been for posttraumatic osteoarthritis of the DRUJ, with or without deformity.

The second main indication has been as a revision procedure in patients with symptomatic instability after previous surgery, be this a Darrach, a hemiresection arthroplasty, or a Sauve-Kapandji. However, such surgery is often difficult, particularly in that rather common group of patients who have been unfortunate enough to undergo multiple procedures in an attempt to correct their instability. Fortunately, insertion of a prosthesis has proved to be an effective way of solving the problem; however, as might be expected, the results in this group tend to be less predictable than when the operation is carried out as a primary procedure.

For this reason, I now consider ulnar head replacement to be the procedure of choice for most patients with symptomatic arthritis of the DRUJ; excision arthroplasty should be reserved for patients with low functional demands in whom instability is unlikely to be a major problem.

Other indications for use of an ulnar head replacement have included acute trauma (eg, irreducible fracture dislocation) and bone tumour requiring excision of the distal ulna.
Ulnar head replacement is contraindicated whenever the bone stock is unsuitable or inadequate, for example, in the presence of severe osteoporosis or cystic bone disease, particularly when secondary to particulate synovitis. Similarly, and as already mentioned, it should not be carried out unless any preexisting deformity of the radius or ulna has been corrected.

Inadequate soft tissue for the flap repair may result in instability of the prosthesis; thus, ulnar head replacement may be contraindicated in patients with severe ligamentous laxity, scarring, or destructive rheumatoid arthritis. Ulnar head replacement should also be avoided in patients with persistent radioulnar instability associated with an Essex-Lopresti-type injury.

**TECHNIQUE: PRIMARY ULNAR HEAD REPLACEMENT**

**Preparation**
Radiograph templates, provided with the instruments, are used to plan the appropriate resection level and implant (Fig. 1). The patient is placed lying supine on the operating table, with the arm resting on a side table in full pronation. The operation is normally carried out in a bloodless field using a suitable tourniquet. An image intensifier is useful, to check both the resection level of the ulna and the positioning of the prosthesis.

**Approach**
A gently curved dorsal longitudinal skin incision, 5 to 8 cm in length, is centered over the DRUJ; the skin flaps are raised and dissected off the extensor retinaculum to expose the underlying fifth and sixth extensor compartments (Fig. 2). Great care is taken to identify and protect the dorsal sensory branches of the ulnar nerve throughout the procedure.

An ulnar-based capsuloretinacular flap, as previously described, is then marked out on the extensor retinaculum. The fifth extensor compartment is opened along the length of the incision, allowing the extensor digiti minimi tendon to be mobilized and retracted radially, thus exposing the underlying dorsal capsule of the DRUJ.
Exposure of the DRUJ
The capsuloretinacular flap is carefully raised using sharp dissection to free it proximally from the shaft of the ulna and distally from the dorsal surface of the triangular fibrocartilage complex (TFCC) (Fig. 3). The sixth extensor compartment is contained within the flap and should be kept intact (or repaired as necessary) to protect the extensor carpi ulnaris tendon. Once the flap has been raised, stay-sutures are placed at its apex, allowing it to be retracted, thus exposing the head of the ulna and the DRUJ.

Ulnar Head Resection
An elevator is used to provide good exposure of the ulnar head, at which time the state of the joint surfaces is carefully assessed, so that a final decision can be made as to the need to carry out a replacement (Fig. 4). Similarly, the adequacy of both the bone stock and the soft tissue flap are checked at this stage, before proceeding with resection of the ulnar head.

The resection guide is used to determine the correct level for the ulnar osteotomy: its hook is engaged over the distal end of the radius, and the appropriate resection level (determined preoperatively using the radiograph templates) is then marked on the neck of the ulna; an osteotomy, perpendicular to the long axis of the ulna, is then made using a small power saw.

The ulnar head is now grasped with the special bone holder provided and is removed by a combination of sharp and blunt dissection, taking care to preserve all of its surrounding “envelope” of soft tissues; by rotating the head back on itself (ie, distally), the underside of the TFCC is exposed, and this is carefully detached from its point of insertion on the head. Should there be a united fracture of the ulnar styloid process, then the loose bone fragment should be removed from the flap if there appears to be any risk of this causing persistent discomfort or becoming the focus for ectopic bone formation.

Reaming of Ulna
The ulnar shaft is lifted dorsally, using the special elevator/soft tissue protector; it is then reamed to the appropriate diameter, using first the broach, followed by

FIGURE 10. Closure. A, Definitive prosthesis in situ. B, Flap advanced over prosthesis prior to reattachment to sigmoid. C, Closure complete. D, Reduction and stability checked with image intensifier. Note that radiographic distortion is responsible for the fact that the stem of the prosthesis appears bent.
the hand reamers provided; the correct-sized reamer should fit snugly within the medullary canal (Fig. 5).

**Preparation of Sigmoid**
The sigmoid fossa is then examined and cleared of any loose osteophytes, debris, or scar tissue (Fig. 6).

If necessary (this is rare), it may be deepened using a small power burr, although care should be taken not to break into the medullary cavity of the radius. At this stage, 2 small holes may be drilled through the dorsal rim of the sigmoid, through which sutures are passed, to be used for later reattachment of the flap.

**Assessment of TFCC**
An important principle of this procedure is that there should be an intact TFCC, both to act as a cushion between the head of the prosthesis and the wrist joint and to provide stability to the ulnar side of the wrist after reattachment of the flap (Fig. 7). Thus, any tear or detachment of the TFCC should be carefully repaired, using fine nonabsorbable sutures; in the case where there is a major deficiency, or central tear of the TFCC, then a local flap of extensor retinaculum is used to repair the defect.

**Trial Reduction**
A trial prosthesis of appropriate size is then inserted, and the length is checked to ensure that the head is seated sufficiently proximal so as not to impinge on the TFCC in full pronation; if necessary, the trial prosthesis is removed, and a more proximal resection of the ulnar neck is carried out (Fig. 8). Similarly, should the resection level appear to be too proximal, then this may be corrected by reverting to the stem with a built-up collar.

The ulnar flap is then manually advanced over the prosthesis and held down onto the dorsal rim of the sigmoid to assess range of motion as well as stability of the prosthesis; any necessary adjustments can then be made (eg, change of head size, tightening or releasing the flap and/or adjacent soft tissues) to ensure a stable reduction with a full range of rotation.

An image intensifier should now be used to check for correct positioning of the prosthesis.

**FIGURE 11.** Revision prosthesis. A, Trial prosthesis used to check resection level; note the sutures in TFCC. B, Definitive prosthesis prior to flap closure. C, Closure completed. D, X-ray appearance, pre- and post-operative.
Definitive Prosthesis
The ulnar shaft is again elevated, and the appropriate size prosthesis is selected; the stem is implanted without cement, using the impactor to ensure that the collar sits snugly on the distal end of the ulna; undue force is not necessary, and if any difficulty is experienced, then further reaming is advised (Fig. 9).

The cone on the distal end of the stem should be clean and dry before the head is impacted to ensure a good interference fit between the 2 components. Before carrying out the final reduction, the sutures used to reattach the flap to the radius should have been passed through the predrilled holes on the dorsal rim of the sigmoid fossa.

Closure
The flap is then sutured to the dorsal rim of the TFCC before being advanced and reattached, under the appropriate degree of tension, to the radius (Fig. 10). The repair is completed by suturing the remainder of the flap back in place, with appropriate overlapping as required, to ensure a secure and stable repair.

Stability and range of motion are once again checked, as is the radiograph, and any necessary adjustments should be made before closure of the wound.

- REVISION TECHNIQUES
In the case of revision surgery, following one or more previous procedures, scar tissue often makes definition and raising of the flap difficult; experience with primary cases is recommended, before attempting a difficult revision procedure. However, the technique is otherwise similar to the above, with the following exceptions.

Resection and Preparation
The appropriate resection level of the ulna clearly depends on what procedure has been carried out previously; in the case of a previous Darrach or hemiresection arthroplasty, a decision needs to be made whether there remains sufficient ulnar length for a standard stem or whether a revision stem will be required (Fig. 11). In the latter case, the best way to determine the appropriate resection level is to lay a trial revision prosthesis in the correct position alongside the ulna once this has been exposed and mark off the resection level as indicated.

Attention must be paid to ensure that the sigmoid fossa has been adequately cleared of any scar tissue that may prevent a stable reduction, and reconstruction of the TFCC may require some inventiveness.

Previous Sauve-Kapandji Procedure
Where stump instability proves to be a chronic problem after a previous Sauve-Kapandji procedure, a decision should be made, according to preferences and previous experience, whether to resect the fusion mass and insert a standard prosthesis or whether to use the special spherical head prosthesis designed by Dr Diego Fernandez, which is designed to articulate within the previously fused ulnar head (Fig. 12).

- REHABILITATION
Provided that adequate stability has been achieved on the table, then active mobilization exercises are commenced as soon as the wound has healed. However, the soft tissue repair should normally be protected from
Ulnar Head Replacement

undue strain during the first 4 to 6 weeks by using removable support.

In the case where potential instability is likely to be a problem, then an above-elbow “gutter” splint may be used to prevent forearm rotation during the healing period. Conversely, where stiffness is likely to recur, then passive mobilization may be commenced within a few days of surgery.

In most cases, restoration of stability with relief of symptoms and restoration of function are to be expected within 6 to 12 weeks of surgery. Patients are normally allowed to resume full unprotected work and sport at this stage.

■ COMPLICATIONS

Most complications can be avoided by careful attention to preoperative selection and planning and by following the recommended surgical technique. However, particular attention to detail is required to avoid the following potential complications:

1. Recurrent instability—this is likely to be caused by one of the following:
   • incorrect selection (eg, severe rheumatoid, uncorrected radial deformity)
   • faulty surgical technique (eg, inadequate repair, incorrect head size)
   • inadequate postoperative immobilization

2. Ulnar impaction is rare and caused by faulty technique:
   • incorrect resection level (too distal)
   • incorrect prosthesis (too large)

3. Stem loosening and/or fracture is extremely rare and caused by faulty technique:
   • overreaming
   • undersized stem

4. Recurrent pain and loss of movement is rare, but the following causes have been identified:
   • ectopic calcification (cause uncertain)
   • sigmoid erosion (eg, overreaming, unrecognized subchondral defects)

■ RESULTS

The excellent early results of previous reports appear to be holding up over the medium to long term; the original study group still meets on a regular basis to share experiences and pool their results, and these are presently being prepared for publication. A significant number of patients now have a follow-up of more than 10 years, and, in all of these, the pain relief and improved function after surgery appear to be maintained.

Similarly, long-term radiological studies show that the prosthesis appears to be very well tolerated; although it is normal to see some early reactive bone remodeling, both at the sigmoid fossa and at the distal end of the ulna, this appears to be quite harmless, and the remodeling is nearly always complete within 12 to 18 months. Even after 10 years, there are still no obvious signs of wear, or of foreign-body reaction, although a few patients have developed what appears to be a degree of ectopic calcification in the TFCC and adjacent soft tissues, possibly related to the presence of a fragment of the ulnar styloid process.

More importantly, there have been no signs of late loosening of the prosthesis; indeed, it appears that full osteointegration of the stem is to be expected, which does raise some concern about the likely difficulties, should late revision be required for whatever reason. However, to date, the few revisions that have been required have all been early and the result of technical errors, so there is little reason to believe that this will prove to be a problem in the future.

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■ REFERENCES


