Arthroplasty of the Wrist:  
Part II Distal Radio-Ulnar Joint

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The management of arthritis at the distal radio-ulnar joint, whether as a result of an inflammatory condition, degenerative change or trauma, has presented problems for clinicians for many years. Indeed its management still remains both controversial and, at times, difficult. Different options range from osteotomy or arthrodesis, specifically the Sauvé-Kapandji procedure, through to excision, either partial or total. Certainly complete excision or Darrach’s procedure has been used successfully for many years in the elderly and patients with inflammatory arthritis. Undoubtedly, however, problems can ensue, particularly instability of the distal ulnar stump, a problem seen especially in younger more active individuals. It is for this reason that ulnar head replacement has been developed to restore length and stability, whilst allowing pain-free pronosupination and a better grip.

Surgical Anatomy

As stated previously the distal radio-ulnar joint has been described as the ‘forgotten joint’ at the wrist. Not only can it develop its own inherent problems but it can also suffer as a result of injuries to the radio-carpal joint, as well as its treatment. It is for this reason that surgeons treating problems of the distal radio-ulnar joint should also have an appreciation of the anatomy of the whole wrist.

On the ulnar side, however, there are a number of important soft tissue structures that can be damaged as a result of either trauma or surgery. Cutaneous branches of the ulnar nerve often cross the incision sites and can, if transected, lead to the development of neuromata with prolonged localised discomfort. The surgeon should also be aware that these branches can cross obliquely from volar to dorsal, thus crossing the usual longitudinal incision. Secondly, the extensor tendons, extensor digiti minimi (EDM) and extensor carpi ulnaris (ECU) pass longitudinally over the dorsum of the distal radio-ulnar joint. As a consequence, capsular incisions lie either in the base of their sheaths or between to prevent damage to these tendons and also allow repair. The flexor carpi ulnaris (FCU) and volar capsule can be reflected anteriorly. Directly related to this, distally lies the triangular fibrocartilage complex (TFCC) which links the distal radio-ulnar and the radio-carpal joints. Of particular importance are the volar and dorsal radio-ulnar ligaments, which confer stability on the DRLU. Effectively, these should be preserved or at least repaired to prevent subsequent instability. Ideally, any implant should lie just under the TFCC, allowing the latter to function normally as an extension of the radio-carpal joint. Removal of the ulnar head including the ulnar styloid obviously destabilises the TFCC. However, if the capsular attachments remain, they should allow the TFCC and ligaments to heal in an anatomical position, thus conferring stability on the replacement. If the TFCC is worn or damaged, most surgeons recommend direct repair at the time of surgery.

Finally, some consideration should be given to the bony configuration of the sigmoid notch. Once osteophytes have been removed, the sigmoid notch will be found to be virtually flat although, to a degree, convex. Previous research has shown significant disparity between the radii of curvature of the ulnar head and sigmoid notch, the latter being the larger. This incongruity allows a head to be both easily contained and facilitate rotation and translation. Any ulnar head replacement should ideally be the same size as the head removed and, as a consequence, allow the same movements to occur. At the same time the head should not be too large to make repair of the capsule and ligament difficult.

Biomechanics and Implant Design

The distal radio-ulnar joint (DRLU) has not been the subject of such intense investigation as the radio-carpal joint and as a consequence less is known of the biomechanics. From anatomical studies, however, we do know that there is significant disparity between the radius of curvature of the sigmoid notch and ulnar head, resulting in marked incongruity. This allows the head not only to rotate but also translate during pronation and supination and as a consequence confers a considerable degree
of ‘forgiveness’, i.e. the joint can accommodate significant deformity yet still function. This is particularly well seen after distal radial fracture. The major concern for the surgeon, therefore, is not to place too large an ulnar head component in the joint but, as far as possible, mirror the existing ulnar head. In the anterior/posterior plane, the sigmoid notch can be either vertical or sloped in an oblique fashion, the latter towards or away from the radio-carpal articular surface. Generally, this has little effect on an arthroplasty, although it is important that any ulnar head is placed at the correct level, as any disparity in an oblique sigmoid notch could lead to load concentration and localised wear. Ishii et al using pressure-sensitive measuring devices confirmed that, with the forearm in neutral, only 12.5% of the sigmoid notch was in contact with the ulnar head, whilst in pronation the contact pressure was distributed dorsally and, in supination, on the palmar aspect of the sigmoid notch.

With regard to the relationship between the shaft of the ulnar and the ulnar head, work using CT scans quantified the geometry of the distal ulnar and found no correlation between the diameter of the ulnar head and the intramedullary ulnar canal, indicating that monoblock components may not be the most anatomical replacements and that a modular system may be better in recreating the normal anatomy, specifically the eccentric offset of the head.

Stability of the distal radio-ulnar joint is conferred on the palmar aspect by the osteo-cartilaginous lip of the sigmoid notch as well as the dorsal and volar radio-ulnar ligaments. Research has indicated that the dorsal ligament tightens during pronation and the palmar ligament during supination. They also noted that the ulnar ligament during supination.

Researchers have indicated that the dorsal ligament tightens during pronation and the palmar ligament during supination. With regard to the interosseous membrane, whilst this undoubtedly confers stability in the longitudinal plane, it only has a secondary role in the antero-posterior plane.

Otherwise, some work is now available on the effect of the presence or absence of an ulnar head replacement on the stability of the DRUJ. Sauerbier et al from the Mayo Clinic identified considerable forearm instability after a direct resection arthroplasty, much of which was restored after the introduction of an ulnar head prosthesis. This was further improved by directly suturing the triangular fibro-cartilage complex (TFCC) to the prosthesis. Masaoka et al compared two ulnar head replacements, again in cadaveric specimens. They examined for diastasis but also palmar subluxation, with the forearm in various positions. They concluded that, despite some reduction in movement, both prostheses restored near normal biomechanics when compared to resection alone.

Finally Gordon et al undertook further research, this time an in vitro study using a joint simulator and an electro-magnetic tracking device at the distal radio-ulnar joint. They compared the kinematics of a normal forearm with that after the insertion of a partial or total ulnar head replacement and also after complete ulnar head excision. They found that complete excision produced radio-ulnar instability in the form of radio-ulnar convergence and increased antero-posterior translation. There were, however, no differences between the kinematics of the normal joint and those having had a replacement.

### Results

Of the newer anatomical designs, the only implant with any published or albeit brief clinical evaluation is that developed by Herbert. Initially, in 2000, Van Schoonhoven et al reported the results in twenty-three patients with painful instability following partial or total resection of the ulnar head that had had this implant inserted combined with a soft tissue repair. After a mean follow up of twenty-seven months all but one patient had marked symptomatic improvement including improved stability. In addition, pain diminished and grip strength improved from 42% of the contralateral side pre-operatively up to 68% post-operatively. Range of movement also improved from a prono-supination range of 118° pre-operatively to 158° post-operatively, many of these improvements being statistically significant. Radiological assessment showed appropriate congruity in all cases, with some signs of remodelling of the sigmoid fossa around the ceramic head. All the patients showed one to two millimetres of bone resorption beneath the collar although this was not progressive. A later follow-up by the same authors reported no long-term deterioration. They concluded that arthroplasty of the distal radial ulna joint is a reliable and reproducible procedure.

In 2006 Fernandez et al from Switzerland also reported the use of the modular non-cemented Herbert ulnar head prosthesis, consisting of a spherical cobalt-chrome head and a porous coated titanium stem, to salvage failed Sauvé-Kapandji procedures. At a mean follow-up of 2.6 years, pain had improved in all patients, as had grip strength. Range of motion had improved in 7 out of the 10 patients in the series. Indeed 9 had returned to their previous occupation. At follow-up radiologically the implant was found to be stable, with no evidence of radio-ulnar convergence. It should be noted that, in this series, the Sauvé-Kapandji fusion was left in situ and the prosthesis subsequently...
articated with the under surface of the fusion mass. As a result of this, 2 patients experienced fractures of the radio-ulnar fusion mass and a further developed a painful periprosthetic calcification.

At Wrightington Hospital, the Herbert ulnar head prosthesis had been used for a number of years to treat conditions affecting the distal radial ulna joint. The most recent evaluation of 78 implants with a range of follow-up has revealed active pronation of, on average, 80º and 53º of supination. Grip strength was 67% of the average, 80º and 53º of supination. The implant appears again to have been used in a salvage situation only, in that 14 patients had undergone an average of 2 or more previous procedures. In 8 cases the implant was used to treat symptomatic instability and, in the other 12, primary osteoarthritis. Post-operatively 80% of patients were satisfied with the procedure and 100% felt there had been some improvement. Eighty per cent reported no pain, 15% mild pain and one continuing pain. There was no significant change in motion of the wrist and forearm; with, on average, 138º of pronosupination. Grip strength, however, did improve by 7% as compared with the contralateral limb. There were two early complications: an undisplaced ulna shaft fracture, which occurred during the insertion of a press fit prosthesis and, secondly, a sensory cutaneous nerve dysesthesis. There were four chronic complications: 1 neuroma requiring excision, 1 revision which involved a further soft tissue stabilisation and 2 revision prostheses related to loosening at 7 and 14 months post-operatively. Mild collar resorption was noted in 8 cases without progression. Overall the authors felt that their early results were encouraging.

An update on this was presented by Cooney and Berger at the American Hand Society meeting in September 2005. In this study, they reported the results of 28 consecutive ulnar head arthroplasties performed in 26 patients. In this group, the average age was 51 years, with a follow-up of 30 months. At review 80% of patients were satisfied with their procedure and 100% felt that there had been some improvement. With regard to pain 80% were pain-free, there was mild pain in 15% and unimproved pain in one patient. Pronation averaged 75º and supination 70º. Grip strength improved 10% as compared with the contralateral limb. Of the prostheses, 18 were press-fit and 10 cemented. Again, the authors concluded that endoprosthetic arthroplasty is an effective means of providing pain relief, stability and improvement in strength for patients with either chronic instability or arthritis of the distal radio-ulnar joint. They also stressed the importance of soft tissue repair or reconstruction as part of this procedure. Finally, they also recommended that the ulnar stem be secured by bone cement in patients with a previous fusion of the wrist.

Latterly, Kakar et al from the Mayo Clinic reported a retrospective review of 47 patients who had undergone this joint replacement. Generally, there was a decrease in pain and improvement in function. With regard to movement, however, there was no significant improvement and a Kaplan-Meier analysis demonstrated 83% survival at 6 years. A total of 14 patients (30%) required additional procedures. These included soft tissue surgery to stabilise the flexor carpi ulnaris, screw removal and capsule reconstruction.

In 2008, Laurentin-Pérez et al from Louisville in the USA reported their results of the Scheker distal radio-ulnar joint prosthesis. This design is a semi-constrained ball and socket joint composed of a radial and ulnar component. Both components are uncemented and linked by an ultra high molecular weight polyethylene ball. This allows rotation and migration. The study reported the outcome in 31 patients with a mean follow-up of 5.9 years. Pronation and supination had improved, with significant diminution in pain. There was also an improvement in grip strength. They did not report any incidence of radiological loosening.
Conclusion

With regard to distal radio-ulnar joint replacement, again this began a number of years ago with the Swanson silastic replacement. Plainly, for the reasons expressed previously, this was not successful in the long term. More recently, specifically over the last 4 to 5 years, we have gained increasing experience with the Herbert ulna head replacement. Initially this was used purely in 'salvage' cases, effectively, in younger patients who, for one reason or another, had a Darrach’s procedure which had resulted in instability of the distal ulna, the latter resulting in a significant functional deficit. In this particularly difficult group of patients, we have to say that the prosthesis has worked extremely well. With regard to the design itself, whilst we are sure that various further modifications will be made, at present the design does seem reasonably optimal, insomuch that the current range of head and stem sizes does seem to fit well at the intended sites. In addition, the surgical technique is straightforward and complications, at least in the early phase, seem to be limited and manageable.

With increasing follow-up, however, we are noting firstly some erosion of the sigmoid notch, particularly when ceramic heads are used and, secondly, some stress shielding around the ulna, particularly under the neck of the prosthesis. Whether either of these becomes significant clinically is unknown and will only become clear with long-term follow-up. Certainly at this time we recommend the use of this implant in the salvage situation.

Concerning the use of these implants in primary disease, however, whether in inflammatory arthritis, osteoarthritis or secondary to trauma, this remains controversial. We have no doubt that they will be rolled out for treatment of these diagnoses and as such, with time, the answer to these questions will be known. Whether the results will be any better than a Darrach’s procedure in the older patient with inflammatory arthritis or, indeed, a Sauvé Kapandji procedure in the younger age group is unknown. At this time, therefore, we would recommend that any patient with these diagnoses undergoing this procedure is counselled carefully before surgery is undertaken, since they will need long-term supervision and, possibly, further surgery.

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References


Further reading – Trail IA, Arthroplasty of the Hand and Wrist, published by Lawrencekirk UK.