Total wrist arthroplasty: A review

Indranil Chakrabarti

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Abstract Total wrist arthroplasty was first performed over a hundred years ago. However, it did not prove a viable option until the late 1960s with the advent of the Swanson implant. Since then there have been many advances. The changes in design, and their rationale, are discussed in this article. The latest implants, the advances made and the indications for surgery are addressed.

Keywords Wrist · arthroplasty · wrist · replacement · rheumatoid · universal 2.

Introduction

Wrist pain can be debilitating. Its causes are manifold and it is essential, when presented with a patient complaining of such pain, to establish the source of the discomfort, its cause and the extent of the functional limitation that arises from this. It is vital to ascertain whether the pain is in the radiocarpal articulation, the distal radio-ulnar joint, the midcarpal joint or a combination of two or more of these sites. In most cases this is achieved by clinical examination and with the aid of plain radiographs. When it has been established that the pathology involves the radiocarpal joint (and that pain and limitation of function are major features) treatment needs to be tailored accordingly. Failure of conservative treatment may necessitate surgery; the whole gamut of surgical options being considered, from the least invasive (denervation) to the most restrictive (fusion). The underlying cause of the pain must also be considered.

If total wrist fusion is thought to be a reasonable surgical option for a particular patient it is now possible also to consider total wrist replacement. The former is effective in relieving pain and results in remarkably little loss of function in many cases. However, if the disease is bilateral, fusion of both wrists can be severely limiting, especially in relation to personal hygiene and in those patients whose occupation involves manual dexterity. Replacement then becomes a serious alternative.

A recent meta-analysis of 500 wrist replacements (18 studies) compared with 800 wrist fusions (20 studies) [1] suggested that fusion provided equally good results and was therefore more cost-effective. However, the arthroplasty papers represented a disparate group of implants with variable results. A variety of functional scores were used and it is therefore difficult to reach any firm conclusions.

Indications

The commonest indication for total wrist replacement in the UK is rheumatoid disease. Often, both wrists are

Indranil Chakrabarti (✉)
Consultant Orthopaedic and Hand Surgeon,
'D' Floor, Rotherham General Hospital
Moorgate Road, Rotherham
South Yorkshire, S60 2UD, UK
Honorary Clinical Senior Lecturer
University of Sheffield Medical School
Sheffield, South Yorkshire, UK.

e-mail: ichakrabarti@doctors.org.uk

involved. Replacement of one side (the dominant) and fusion of the other has been recommended by some. However, this is an arbitrary choice and it may be argued that the dominant hand is stronger, transmits greater forces than the non-dominant and should therefore be the one to be fused. It is also the case that some patients prefer not to have a fusion on either side and therefore bilateral wrist replacement may be considered. However, to my knowledge, there has been no published data in this regard and the reported results are largely anecdotal.

It is generally agreed that this operation is contraindicated in those with poor bone stock and severe deformity. As with all joint replacements, the key to success is soft tissue balance. When there is bone loss with ulnar/volar subluxation and fixed supination of the carpus, soft-tissue balance is very difficult to achieve and complications are more likely; in particular, dislocation.

Rupture of the long flexors and finger extensors is a relative contraindication. If the wrist is otherwise well-balanced (with preservation of the wrist flexors and extensors) it is my personal belief that extensor or flexor tendon rupture do not necessarily preclude replacement though tendon reconstruction may have to be considered either at the same time or later.

Previous or underlying infection is a serious problem in joint replacement and, in such cases, is contra-indicated.

History/background

The first total wrist replacement was thought to have been performed by Themistocles Gluck [2]. In the 1880 and 1890s he performed a number of joint replacements for tuberculosis. One of these (in 1890) was a total wrist replacement made of ivory and cemented in. It is thought the implant was still functioning in 1891 but the final outcome remains unknown. After this, nothing much happened in regard to wrist replacement surgery until the 1960s when Swanson made the next big step forward. Since then, advances in design have followed a somewhat predictable course.

Design and development

We are doomed to re-invent the wheel. It has been shown time and again (first with the knee, then the shoulder, the elbow and now the wrist) that constrained implant designs fail. Those that are closest in design to the normal anatomy of the joint are the ones most likely to succeed. Whilst this has become a reality for other joints, it is very much a 'tall order' in the case of wrist arthroplasty. How does one design an implant that simulates the complex anatomy and kinematics of the carpus? Faced with this difficulty a logical (though, on the face of it, somewhat contrary) option is to design exactly the opposite – a sim-

ple, one-piece implant made of a forgiving, malleable yet robust material: the Swanson Silastic wrist replacement.

As with the other silastic implants designed by Swanson, it was not a true joint replacement, rather a spacer; an interpositional arthroplasty. In 1982 Allieu et al reported the results of the use of these implants in 19 patients with a 21–54 month follow-up [3]. They stated that the outcome was 'fair' with good pain relief but limited movement. Longer-term results (a minimum of 10 years) were reported by Kistler et al. in 2005 [4] in 16 patients who underwent the procedure for rheumatoid disease. The majority had 'good' or 'very good' results in terms of pain relief but with only limited movement and with evidence of silicone synovitis. Ulnar translocation of the carpus tended to recur and carpal height was lost. It was felt that the prosthesis was still a good option in patients with low demand.

In order to avoid some of these problems and improve longevity a number of different designs appeared. The Mueli [5, 6] and Volz [7] prostheses were developed in the 1970s and were designed with distal prongs that crossed the carpometacarpal joints and inserted into the metacarpals. This was also the case with the 'CFV' (Clayton, Ferlic and Volz) [8] and Trispherical implants. However, constraint was a feature and the fact that the prongs crossed mobile carpometacarpal joints meant that abnormal stresses at these joints were inevitable, resulting in loosening and metacarpal fracture with cut-out of the distal component. Soft-tissue balance was a particular problem with the Volz. Overall, results have been variable, follow-up limited and complication rates high [9–12]. The Mueli prosthesis was modified [13] but results, once again, were equivocal.

Other implants include the Destot [14] and the RWS [15]. Again, short-term results appear to be reasonable, with very good pain relief in the majority of cases but loosening is high in the case of the RWS (11/29) and 4/28 of the Destot implants had poor results. However, in this series, patients with scapholunate advanced collapse were included. The conclusion was that the implant should only be used in low-demand patients over the age of 50.

The Guèpar prosthesis [16] was a step forward. The metal carpal component, though, was fixed to the second and third metacarpals with screws and the proximal (radial) component was made of polyethylene and cemented in. The results remained less than ideal [17].

Beckenbaugh, Linscheid and Cooney developed the Biaxial wrist replacement which came into use in 1983. They reported the results of 57 cases with a minimum 5-year follow-up and 83% survivorship [18]. It comprised a press-fit, porous-coated radial component of cobalt-chrome with a concave polyethylene liner and a convex distal component made of cobalt-chrome and with a central peg going into the middle metacarpal. It had another small peg designed to fit into the capitate and provide

rotational fixation. Initially, it was thought that both components would be uncemented but it quickly became established that the distal fixation required cement. Although some authors reported equivocal results with this implant, the biggest series was reported by Takwale et al. [19]. They looked at 76 of these replacements with a mean follow-up of 52 months. With revision as the end point, the 8-year survivorship was calculated at 83%. Subsidence of the distal component and its malposition (ie. not within the middle metacarpal) correlated with a greater degree of loosening.

Kretschmer and Fansa, however, [20] abandoned the use of this implant because of a high complication rate.

Because of the mixed results, and despite the re-design of the distal component to incorporate a longer peg (with results at least as good as before at an average of 6 years postop) [21], the device was made unavailable in 2004.

By this stage it had become apparent that the way forward was to design an implant that had minimal constraint, did not require cement and had a distal (carpal) component that was fixed with screws that did not transgress the ulnar, more mobile carpometacarpal joints. This is where the Universal wrist replacement designed by Menon [22] came in. It comprised a press-fit Cobalt/Chrome radial component with porous coating and a Titanium carpal implant fixed with two screws and a central peg. The articulation was provided by a toroidal polyethylene insert. Menon reported a series of 37 replacements with an average of 6.7 years follow-up and survivorship of nearly 90%. He stressed the importance of obtaining fusion of the distal carpal row ('coalition') but pointed out the high dislocation rate associated with the lack of constraint. The complication rate was quite high (32%) but the majority (75%) were treatable and settled. As a result, the prosthesis was modified, the toroidal insert changed to an ellipsoid shape, the radial component surface adjusted accordingly and the Universal 2 born. Long-term results are awaited though the early results appear promising [23].

Present situation

The most recent design to emerge is the 'Remotion' wrist developed by Gupta and the Mayo clinic [24]. It is also uncemented, is made of cobalt-chrome with a titanium coating and has fixation of the carpal component with a central peg into the capitate and two screws, but differs from the Universal 2 in several ways. First, the carpal base plate is curved so as to prevent flattening of the distal row thereby preventing tendonitis and neuritis in the carpal tunnel. Secondly a unique feature of this implant is that the polyethylene insert rotates on the base plate through about 10 degrees in order to allow for the 'dart thrower's' action of the wrist. Finally, the press-fit radial component does not require resection of the distal radius.

This preserves the dorsal and palmar carpal ligament origins on the distal radius and maintains innervation of the wrist capsule, preserving proprioception.

How successful this will be, only time will tell.

Conclusions

Certain principles have become clear. Some of them are true for all joint replacement surgery; namely, minimal constraint, osseointegration and anatomical or near-anatomical design. There is also a very important consideration unique to the wrist: the carpal component needs to be fixed into an 'Os Carpus.' In other words, the distal row of carpal bones should be arthodesed in order to form a solid mass into which the implant can be incorporated. Failure to achieve this predisposes to loosening.

Total Wrist Replacement has come a long way in a relatively short period of time. Although fusion has stood the test of time, patients now expect more. Advances in technology have meant that newer materials together with a better understanding of biomechanics, kinematics and the biology of osseointegration allow us to aim higher. There is no doubt that patients prefer a painless mobile wrist to a painless stiff wrist. It is the difference between 'excellent' function and merely 'good' function. We therefore strive for the former rather than the latter.

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