8 Hand and Wrist Implants

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The development of arthroplasty in the hand and wrist lags behind that of the larger joints, and as yet, there is no clear consensus on the best overall material or configuration for most joint replacements. As a result, there is a proliferation of replacements on the market, most of which have only short-term results available. This chapter is, therefore, not a comprehensive atlas of all replacements but endeavors to provide an idea of radiological appearances. Some specialized fusions have been included as well.

The Hand

Replacements in the small joints of the hand consist of either resurfacing arthroplasty, or spacers, which are usually made of silicone. The arthroplasties are very dependent on the availability of bone stock for implant fixation and soft tissue integrity for joint stability, which are commonly both destroyed in the inflammatory arthropathies. Arthroplasty is therefore generally reserved for posttraumatic or osteoarthritis. To date, the available evidence suggests that resurfacing arthroplasties provide pain relief but do not improve range of motion. Both metal and pyrocarbon resurfacing arthoplasties exist. The biomechanical properties of pyrocarbon mimic that of cortical bone more closely and thus theoretically should lead to less stress shielding and therefore less loosening of the implant. However, a non-progressive lucent line is frequently noted around these implants.

In the presence of an inflammatory or post-infective arthritis, where there is significant bone loss or loss of soft tissue integrity, resurfacing arthroplasty is contraindicated and a choice must be made between a silicone spacer or fusion of the joint. When making this decision, the functional requirements of the different parts of the hand should be considered. In general terms, the radial half of the hand is used for pinch, tripod, and key grip. This involves holding the digits in slight extension, with significant lateral loading, so fusion of the index and middle fingers provides strength and stability with limited effect on function. Similarly, the thumb can be considered a stable post that the fingers grip against, and fusion of the thumb is usually tolerated well. The ulnar half of the hand, however, is used predominantly for power grip, and this relies on the ability to curl the fingers into deep flexion. Fusion of the ring and little fingers is therefore much less tolerated, and silicone spacers should be considered.

In general, no replacement in the hand allows the patient to regain much in the way of movement, and in the presence of an already stiff, but painful joint, fusion is a more reliable long-term option than replacement. However, in very

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mobile but painful proximal inter phalangeal joints (PIPJ) or metacarpophalangeal joints (MCPJ), the patient will find it hard to adapt to the loss of movement, and arthroplasty should be considered.

Metacarpophalangeal Joints

The history of MCPJ replacement dates back to the 1950s, when initially, metal hinges were used. These rapidly loosened, with bone erosion and metal debris abounding. Following the success of the early hip replacements, a similar design was used for the MCPJ, incorporating a metal head within a high-density polyethylene cup. Again, breakage and erosion were problematic. Interest then moved to the silicone spacer, and a variety of metal/silicone devices were developed. Of these, the Swanson [1] has proved the most durable and is still in use today. The principle of Swanson's joint replacement is a flexible silicone spacer which is inserted into the medullary canal of the bone on either side of the joint, following resection of the articular surfaces. This acts as a constrained prosthesis to maintain joint alignment, but the combination of the implant flexibility and the ability of the tapered stems to piston in and out of the medullary canal permits the joint to maintain range. The silicone promotes the formation of a fibrous capsule, thus increasing the joint stability (Fig. 8.1).

These spacers do not, however, replicate the normal rotating and gliding action of the MCPJ and thus do not restore normal function. They also have a tendency to fracture at the hinge over time (although fracture does not invariably

Fig. 8.1 Silicone metacarpophalangeal joint replacements in the middle, ring, and little fingers of the right hand. The flat cut of the resected joint surfaces is noted, compared to the irregular erosions on the index finger MCPJ. The silicone spacer is not visible on X-ray. The metal components are cuffs, called grommets, which sit just within the medullary canal, around the neck of the spacer, and were originally designed to strengthen the implant. Their use has been largely abandoned as they offer no protection against implant fracture of the silicone

necessitate revision) and, although still the most commonly used type of implant, are now generally reserved for lower-demand patients.

The motion of the MCPJ varies depending on its position. In flexion, it moves predominantly in the sagittal plane, but in extension, some adduction and abduction in the coronal plane are permitted. This complex action is best replicated by two separate articulating components. For these to function as a joint, there must be sufficient soft tissue stability to maintain the alignment of the components throughout their range of motion.

Cobalt-chrome and ultrahigh molecular weight polyethylene (UHMWPE) MCPJ replacements have been designed to replicate the three-dimension shape of the native anatomy [2]. They consist of a proximal cobalt-chrome head and a distal polyethylene cup. They are cemented in situ, and this makes revision difficult due to subsequent loss of bone stock. Results are equivalent to those for silicone arthroplasty. They are highly dependent on intact soft tissue for stability and coverage.

More commonly used, but still with relatively short-term follow-up, are pyrocarbon resurfacing arthroplasties. These consist of two, uncemented (press fit) pyrocarbon implants, which are designed to replicate the native anatomy. They rely on intact soft tissues for stability, but the absence of cement makes revision easier, as bone stock is preserved (Fig. 8.2). They seem to provide reasonable

Fig. 8.2 Pyrocarbon metacarpophalangeal joint replacement of the left index finger. The pyrocarbon is a similar density to cortical bone on X-ray, as distinct from ceramic or metal, which look completely white. The area which has been reamed to allow the press fit of the components can be seen as a halo around the implants. It should be noted that the metacarpal head component has not been inserted centrally, but instead, replicates the load bearing articulation of the native joint

Fig. 8.3 Lysis around the pyrocarbon MCPJ replacement. Subsequent X-rays of the same patient show a clear area of lysis around the implants. The edges of this lysis are clearly defined and well demarcated, with no surrounding erosions or bone reaction. This is commonly seen in these joint replacements and should be followed up radiographically. A nonprogressive lytic region of up to 1 mm surrounding the prosthesis is not considered pathological

pain relief and, in the MCPJ, a slight increase in range of movement of about 10°. Evidence of nonprogressive lysis around the components is common, as is subsidence (Fig. 8.3). In asymptomatic patients, these radiographic changes do not necessitate revision. Stability of these implants relies on adequate soft tissues (Fig. 8.4). If these joints are revised, they are usually exchanged for a silicone arthroplasty. Most studies report average follow-up of 5 years, with reasonable patient satisfaction [3–5].

Proximal Interphalangeal Joint

The development of proximal interphalangeal joint replacements has followed a similar path to the MCPJ, with silicone spacers remaining the gold standard. However, the even smaller size of the joint, and the complex soft tissue balancing, often on a background of degenerate soft tissues preoperatively, means that results have been less satisfactory overall. The joints have to withstand large loads, particularly during pinch grip, and the surgical approach requires release and subse-

Fig. 8.4 Dislocated pyrocarbon MCPJ replacement. In this X-ray, the index and middle MCPJ have been replaced with pyrocarbon resurfacing components. Alignment of the index MCPJ is maintained, but the middle MCPJ has dislocated. There is no inherent stability to the resurfacing arthroplasty, and joint congruency is entirely dependent on the soft tissue constraints. These are often damaged by the underlying pathology preoperatively (such as soft tissue erosions from rheumatoid arthritis), and the extensive surgical approach weakens them still further. Dislocation is a common complication and is usually managed with revision to a silastic implant. In common with Fig. 8.3, a narrow lytic line can be seen surrounding the components. Note also the areas of heterotopic ossifications surrounding the prosthesis

quent repair of the collateral ligaments. Failure of these often leads to unsatisfactory results.

The silicone spacers, by necessity being smaller, are less stiff and less able to resist lateral loading. Particularly in the radial digits, fracture rate of the implant is high and they are very intolerant of pre-existing deformity (such as swan neck deformity). They do not show any increase in range of motion from preoperative measurements, but in selected patients, satisfaction is generally good [6].

Pyrocarbon resurfacing of the PIPJ replicates the anatomy of the native joint, and because of the bicondylar design, it provides more lateral stability than the silicone spacers. The surgical approach, however, is similarly unforgiving, and good soft tissue structure preoperatively is a necessity. Numerous studies have shown that preoperative range of motion is preserved, but not increased, following pyrocarbon joint replacement [7], and significant bone erosion and implant subsidence have been demonstrated radiographically. This latter phenomenon is thought to cause a gradual loss of range in these joints but doesn't appear to be associated with

Fig. 8.5 Pyrocarbon proximal interphalangeal joint replacement. The size of the components in the PIPJ is determined by the size of the medullary canal. In this case, it can be seen that the joint surface has expanded in response to the osteoarthritis, and the surface replacements look undersized. However, the stems of the components are well fixed and centrally located in the medullary canal, and it would not have been possible to insert a larger component. The cerclage wire around the middle phalanx has been placed there intraoperatively to treat a split in the cortex which occurred during reaming. When managed in this way, these splits usually go on to unite, as in this case, without resulting in instability of the components

either pain or dissatisfaction (Fig. 8.5). A slightly unusual complaint is an audible squeak from the joint, which has not been fully explained. Revision is sometimes requested for this! Titanium semiconstrained implants have a

Fig. 8.6 Failure of the titanium semiconstrained PIPJ replacement. The LPM PIPJ replacement was introduced in 2000. The two titanium implants are constrained by a central hinge. Nearly 50% were showing signs of failure within 6 years. In this image, massive lysis around the components can be seen. Unlike the well-demarcated lysis seen in Fig. 8.3, the cortices here are being eroded and there is significant subsidence of the components

high failure rate due to extensive osteolysis and consequent loosening (Fig. 8.6).

Distal Interphalangeal Joint

There are no resurfacing arthroplasties available for the distal interphalangeal joint (DIPJ), but there are Swanson's silicone spacers in use. Radiographic appearances are similar to other silicone spacers. However, fusion of the DIPJ remains the gold standard and by far the most commonly used surgical treatment for arthritis of this joint.

Carpometacarpal Joint of the Thumb

The carpometacarpal joint of the thumb (CMCJ) is the most commonly operated on joint for arthritis in the hand. It has an incredibly complex articular shape, often described as “saddle shaped,” with two arcs of curvature which enable circumduction of the thumb metacarpal. The combination of high load on gripping and flexibility of the surrounding soft tissues leads to a high rate of arthritis in this joint (30% of women and 12% of men).

The gold standard for surgical treatment of arthritis in the thumb CMCJ remains excision of the trapezium. Soft tissue stabilization procedures at the same time are popular, but have not been found to lead to superior results [8]. Satisfaction is generally high, but some patients complain of weakened grip strength, and in patients with ongoing pain following trapeziectomy (15%), there are few salvage options.

For these reasons, the search for an acceptable joint replacement has been ongoing. The unique articular shape of the CMCJ has proved challenging to replicate, and numerous articulations have been trialed, some with more success than others. Two implant types will be discussed, the total joint replacement and the interposition arthroplasty.

Interposition arthroplasty is appealing, as it has the potential to maintain thumb length and grip strength, with minimal surgical exposure and limited bone resection, thus facilitating subsequent revision. Implants are commonly made of pyrocarbon and are usually either spherical or disc shaped. They most frequently fail by dislocation. The disc-shaped implants have a hole through the center to allow a ligamentous constraint to be passed through, with the aim of preventing this. As yet, they have not been shown to have superior clinical results to simple trapeziectomy (Fig. 8.7).

There has been more success with joint replacements, but the design of these still has its

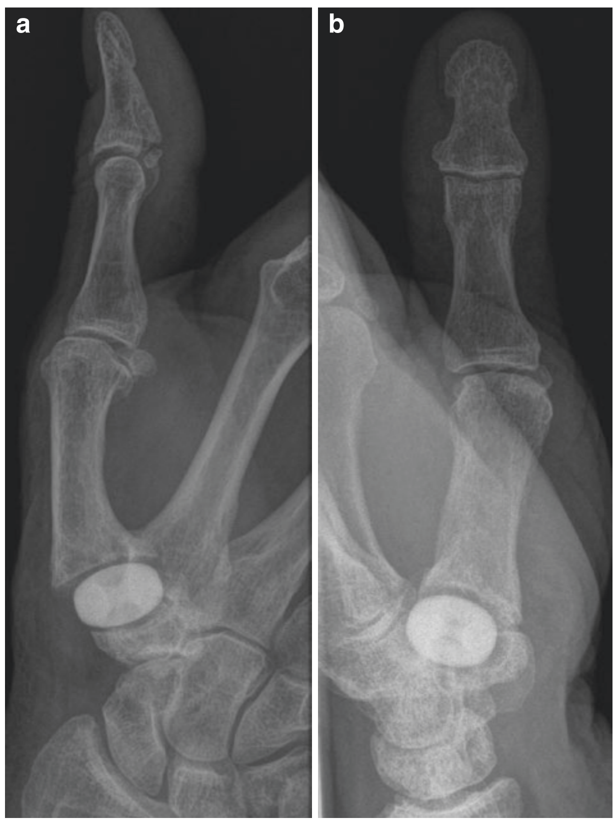

Fig. 8.7 Pyrodisc thumb carpometacarpal joint interposition prosthesis. This pyrocarbon prosthesis is shaped like a doughnut, with a central hole. This allows a section of tendon to be passed through to hold the prosthesis within the resected joint space. The curved resections of the base of the thumb metacarpal and trapezium match the surface contours of the pyrodisc. Height of the thumb metacarpal (and thus length of the thumb) has been maintained. There has been only limited bony resection required. Results of implant arthroplasty of the thumb CMCJ remain mixed. AP (**a**) and lateral (**b**) view

limitations. The older designs consist of monoblock "spacers," with stems inserted into the thumb metacarpal. These can either be silastic or titanium. More recent designs usually consist of a stemmed ball, fitted into the thumb metacarpal, and a screw-fit hydroxyapatite-coated socket in the trapezium. The articulation of these implants is usually a cobalt-chrome metal on metal design and is unconstrained (Fig. 8.8). Nineteen different types have been recorded, none of which have shown superior results to trapeziectomy [9]. A review of total arthroplasties from the Norwegian Joint Registry found a total of five different implants used, with an average survival rate of 91% at 5 years and 90% at 10 years. However, they stress that survival was defined as not having been revised and did not necessarily imply that the implants were functioning well [10]. Implants fail by dislocation, loosening, or periprosthetic fracture. In those implants that survive, however, patients report good pain relief, range of motion, grip strength and high satisfaction [11].

It is clear that CMCJ arthroplasty requires considerable development before it can match simple trapeziectomy in efficacy; however, the more recent designs have promising early results, and they may become more popular in the future.

Fig. 8.8 The Elektra thumb CMCJ prosthesis. The proximal thumb metacarpal has been resected and a modular stemmed head has been inserted. In the trapezium, a hydroxyapatite-coated threaded cup has been impacted. There is little mechanical constraint to this prosthesis and the small bone size means that periprosthetic fracture is a risk. It can be seen that the height of the thumb metacarpal has been maintained, and the axis of the thumb articulation is well aligned, meaning that subsequent Z deformity should not occur

The Wrist

The wrist consists of three separate articulations, the midcarpal joint, the radio and ulnar carpal joint, and the distal radioulnar joint (DRUJ). A discussion regarding the biomechanics and the consequent effects of arthroplasty of these joints is beyond the scope of this chapter, but some examples will be illustrated.

The midcarpal and radioulnar carpal joints are primarily responsible for flexion and extension of the wrist, approximately 50% of the range coming from each articulation. The radioulnar carpal joint is largely responsible for radial and ulnar deviation of the wrist. The distal radioulnar joint (DRUJ), the proximal radioulnar joint, and the diaphysis of each bone, held by the interosseous membrane, in combination, permit pronosupination of the forearm. The DRUJ should therefore be considered separate from the wrist, although it is often involved in wrist joint pathology.

Radio Carpal and Midcarpal Joints

Arthritis of the midcarpal and radio carpal joints is most commonly treated with fusion of the affected joints. Numerous implants exist to fuse the small joints in isolation, but they can also be fused using headless compression screws or simple k-wires. Non-union is becoming less common as locking implant technology allows greater compression and stability but should be considered in a patient with ongoing pain.

Fusion across either the radio carpal joint or the midcarpal joint will sacrifice 50% of the flexion-extension range but is well tolerated (Fig. 8.9).

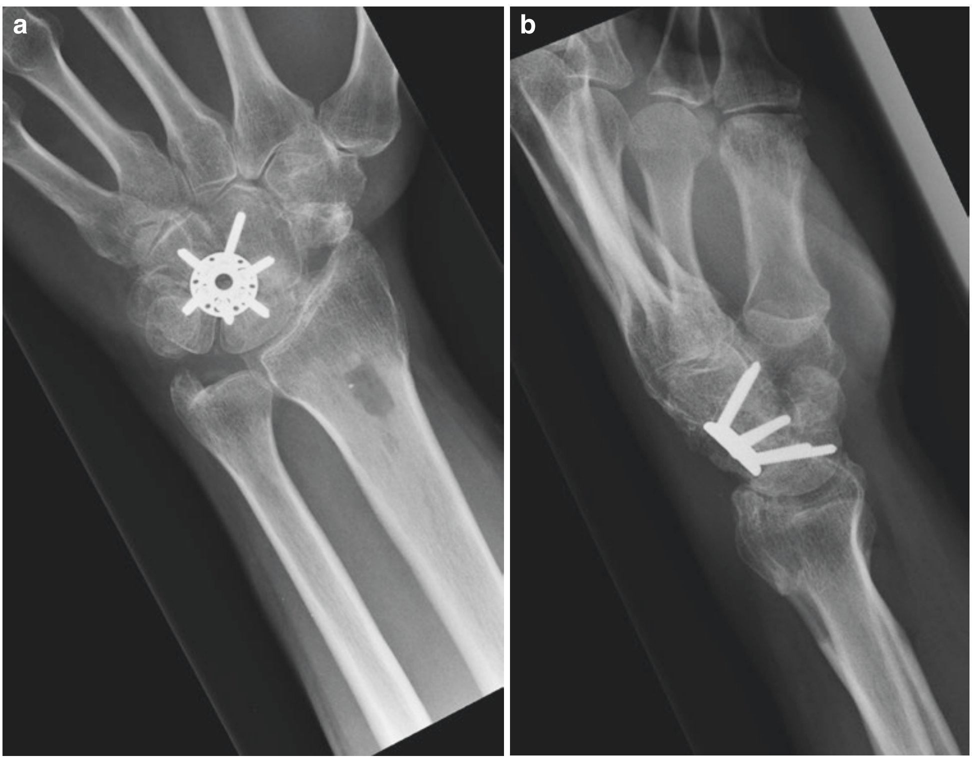

Fig. 8.9 The four-corner fusion. This plate has locking screw holes to allow rigid fixation of the midcarpal, lunotriquetral, and capitohamate joints. The scaphoid has been excised to treat either a non-union, AVN, or radioscaphoid osteoarthritis, and the remainder of the carpus have been fused to prevent collapse of the carpal height. The defect in the distal radial metaphysis is iatrogenic and is the site where bone graft has been taken to fill the intercarpal spaces. AP (**a**) and lateral (**b**) view

Total wrist arthrodesis spans the radio carpal, midcarpal, and usually the third carpometacarpal (CMCJ) joints. It abolishes all flexion and extension and radial and ulnar deviation at the wrist but provides excellent long-term pain relief and good strength. The wrist is usually fused in 15° of extension, to facilitate power grip (Figs. 8.10 and 8.11). Unilateral wrist arthrodesis is well tolerated, but lack of flexion is disabling when bilateral wrist arthrodesis is performed. Non-union of the third CMCJ is common, and more recent plate designs abolish the need to span this joint.

Total wrist replacement is predominantly used for low demand patients, often with a contralateral wrist fusion. The indication is pain relief where some preservation of movement is required [12]. It is typically used in patients with rheumatoid arthritis.

Fig. 8.10 Wrist fusion using a Steinman pin. This patient with severe erosive arthritis from rheumatoid disease has had a wrist fusion using a Steinman pin to stabilize the carpus onto the distal radius. The Steinman pin can also be inserted through the head of the third metacarpal. AP (**a**) and lateral (**b**) view

Fig. 8.11 The Synthes wrist fusion plate. This patient with osteoarthritis and well-preserved carpal height has had a dorsal wrist plate, spanning the radius, carpus, and third metacarpal. The third carpometacarpal and lunotriquetral joints have not been excised. The radioscaphoid and scapholunocapitate joints have fused. Note that the wrist is fixed in slight extension to enable power grip

Early wrist replacements have developed along similar lines to the hand arthroplasties. The earliest examples are Swanson's silastic spacers. These demonstrated considerable problems with instability of the hand, implant breakage, and synovitis and have now been abandoned. In the 1970s, cemented prostheses with a ball and socket design were introduced. These have also been abandoned due to poor soft tissue balancing, loosening, and periprosthetic fracture. More recent designs utilize an offset articulation to mimic the dual plane of motion of the wrist and to preserve the soft tissue balancing. Further developments have reduced the amount of bone resection required, thus making subsequent revision or fusion more feasible. The current generation of total wrist replacements is coated with hydroxyapatite and relies on osseous integration in the proximal component and screw and peg fixation with osseous integration distally. The majority employ a metal on polyethylene bearing and are designed to replicate the anatomical shape of the distal radius and proximal carpal row. A modular design allows different thicknesses of polyethylene to be selected to enable better soft tissue balancing. These designs allow flexion and extension and radial and ulnar deviation at the wrist but permit only very limited or no pronosupination at the carpus, which many rheumatoid patients rely on for function (Figs. 8.12 and 8.13).

A recent review of the evidence for total wrist replacement looked at the results for seven different manufacturers. Follow-up was reported up to 10.8 years (for the Universal). Survivorship ranged from 50% at 7.3 (5–10.8) years to 100% at 5.5 (3–9) years. All prostheses demonstrated improved pain scores postoperatively, although when compared to arthrodesis, pain scores do not improve as much. Only one,

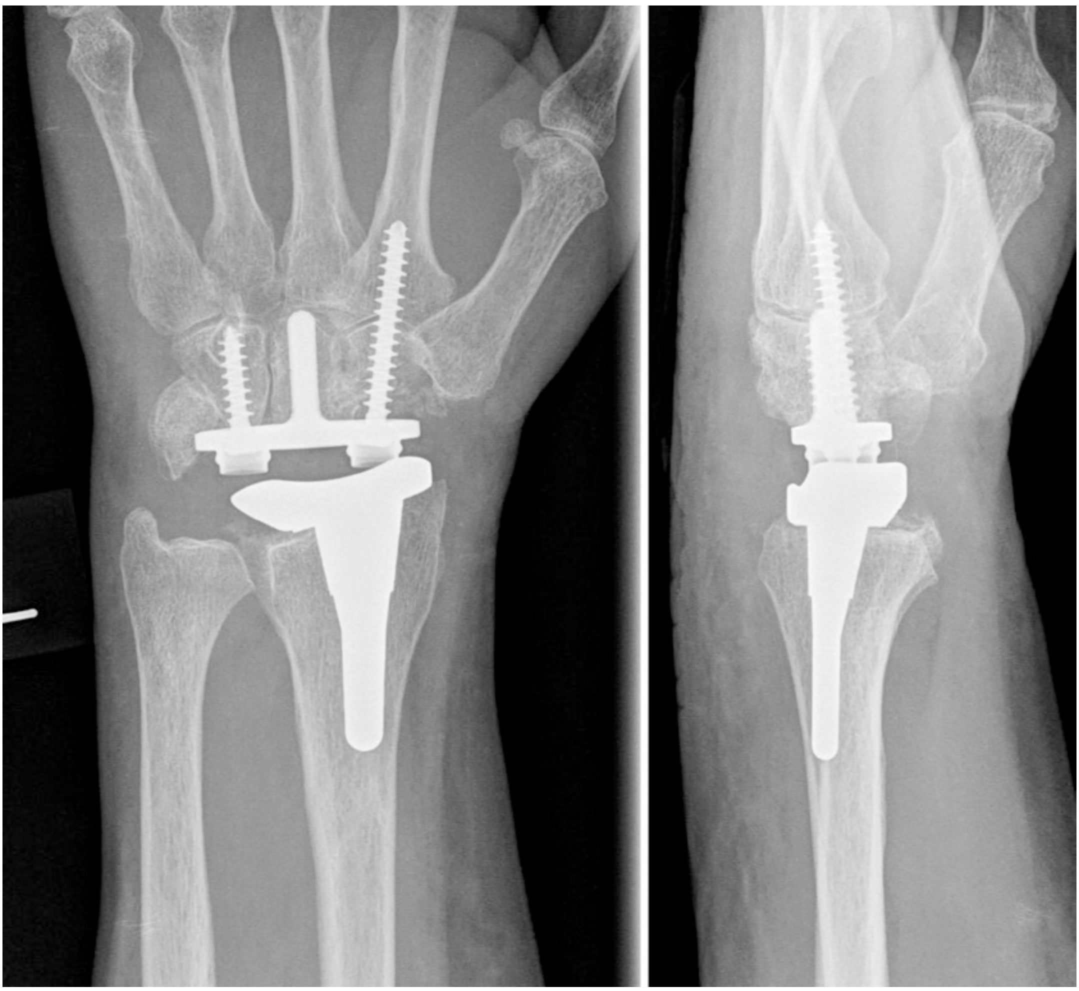

Fig. 8.12 Total wrist replacement. The proximal carpal row has been excised and an oblique cut has been made at the distal radius. The proximal part of the prosthesis is coated with hydroxyapatite and impacted into the shaft of the radius. The distal part is held in place with a hydroxyapatite-coated peg and two screws, one into the hamate and one crossing into the index metacarpal. Between the two cobalt-chrome prostheses, there is a polymer-bearing surface which fixes onto the distal component and articulates with the proximal component. The curvature of the articulating surfaces copies the normal articular dynamics of the radiocarpal joint. AP (left) and lateral (right) view

Fig. 8.13 Comparing these images with Fig. 8.12, lysis has developed around the distal component. The screws and pegs have areas of bone loss around them, and the component has subsided into the distal carpal row. The proximal component remains well fixed, with trabecular bone extending up to the metal-bone interface

the Maestro, demonstrated a functional range of motion. The remainder tended to show that the preoperative range of motion was preserved but not improved. Data for grip strength was insufficient [13]. It is clear that total wrist replacement currently lags significantly behind that of larger joints in its efficacy, and fusion remains the gold standard.

The Distal Radioulnar Joint

The distal radioulnar joint (DRUJ) has a complex gliding and rolling motion with stability largely provided by the soft tissue constraints of the triangular fibrocartilaginous complex (TFCC) and the tension in the interosseous membrane. Pathology of the DRUJ consists of either arthritis, leading to pain and loss of forearm rotation, or instability, which can cause pain and loss of grip strength and a feeling of "giving way."

Traditional approaches to management of DRUJ pathology were to either excise the distal ulna (Darrach's procedure) or to fuse the DRUJ and perform an osteotomy proximal to the DRUJ articulation to allow forearm rotation (Sauve-Kapandji procedure). Both of these procedures can lead to instability of the ulnar stump and painful abutment between the ulna and radius (Fig. 8.14). The salvage options for these patients are a soft tissue stabilization procedure, arthroplasty, or a one-bone forearm,

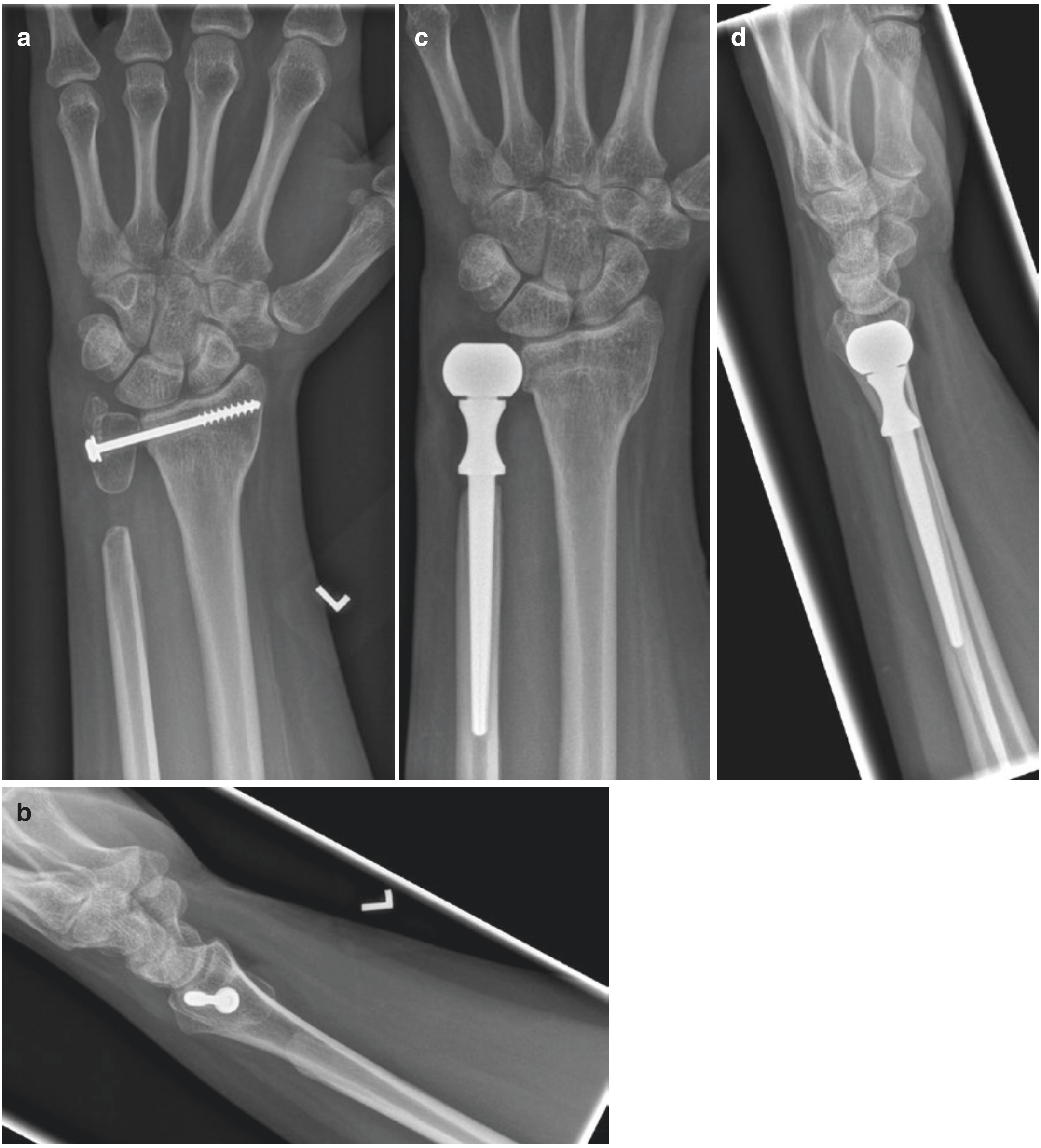

Fig. 8.14 Postoperative images of a Sauve-Kapandji procedure, revised to a Herbert distal ulna prosthesis. Remodeling of the ulnar border of the distal radial metaphysis can be seen in response to abutment of the unstable ulnar stump. The Herbert distal ulna prosthesis is modular, consisting of a press-fit titanium stem, variable neck lengths to allow for differing levels of ulna resection, and a ceramic head which replicates the anatomy of the native distal ulna. It relies on ECU function for DRUJ stability as the TFCC attachments are excised. AP (**a**) and lateral (**b**) view of Sauve-Kapanji procedure. AP (**c**) and lateral (**d**) of Herbert distal ulna replacement

where the radius and ulna are fused in the mid-diaphysis.

Arthroplasties can be divided into ulnar head replacements or DRUJ total arthroplasty.

Ulnar head replacement designs are either a monoblock or modular design, usually consisting of a metal stem and either metal, ceramic, or pyrocarbon articulation. The modular design allows for an extended neck, which can be useful when revising a Sauve-Kapandji procedure, where the osteotomy site is often too proximal for a standard prosthesis (Fig. 8.15).

DRUJ total arthroplasties can again be subdivided into two categories, constrained and semiconstrained. They are considered in patients who have erosion of the sigmoid notch, either at presentation or following distal ulna replacement. Semiconstrained prostheses (Fig. 8.16) have the theoretical advantage of allowing the normal gliding and rolling action of the DRUJ, whereas constrained prostheses permit rotation only. There is, however, only short-term follow-up of small numbers for these prostheses and as yet no conclusions as to which is superior in the long term.

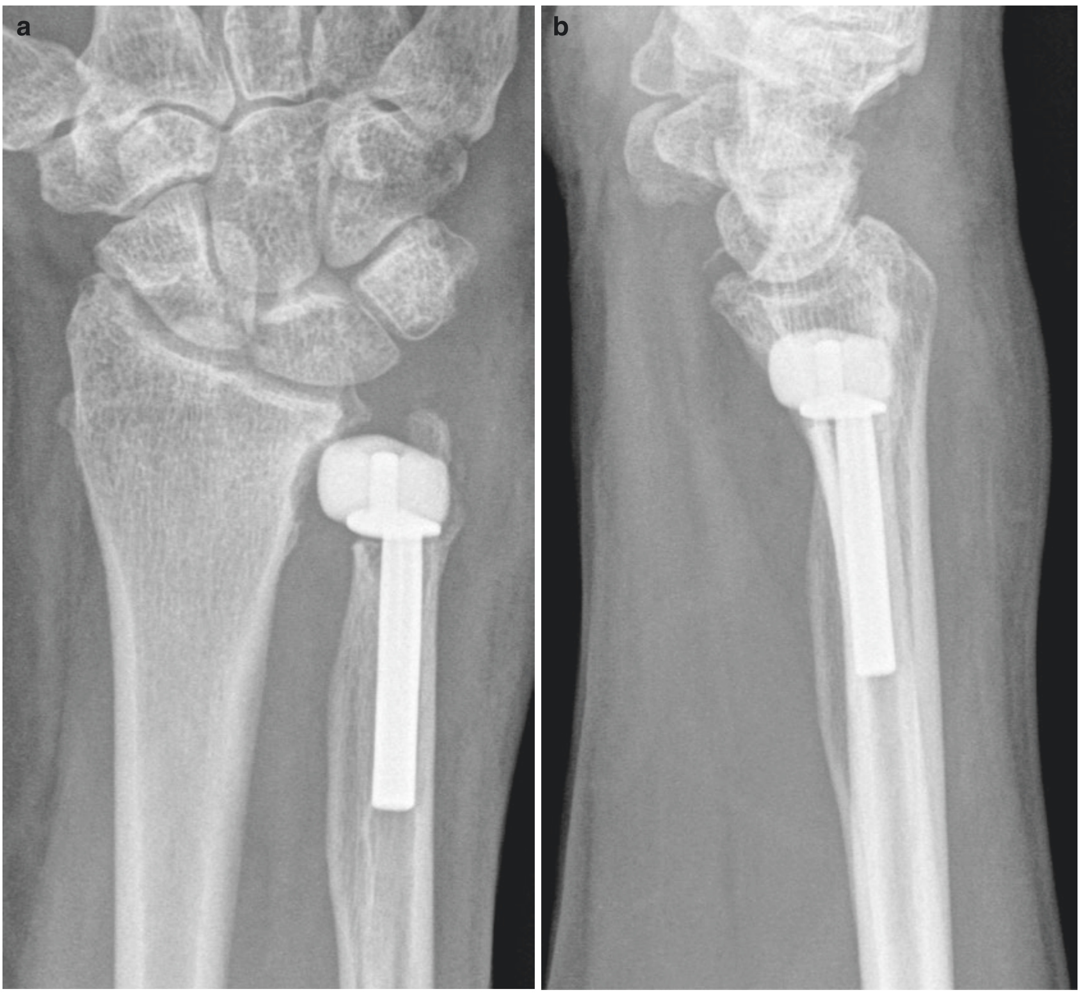

Fig. 8.15 Eclypse ulnar head replacement. This is a modular prosthesis. With a titanium press fit (uncemented) stem and pyrocarbon head. It is designed to replicate the ulnar head. Mobility between the cylindrical peg and the pyrocarbon spacer allows some rotation and proximo-distal translation, and it can be inserted without detaching the normal soft tissue stabilizers of the DRUJ, thus maintaining the normal dynamics of the joint. AP (**a**) and lateral (**b**) view

Fig. 8.16 The Scheker (Aptis), semiconstrained total distal radioulnar joint prosthesis. This is used for arthritis of the distal radioulnar joint with instability or following distal ulna resection with stump instability. The constrained design means that stability is maintained even in the absence of the normal soft tissue constraints. Replacement of the sigmoid notch overcomes the problem of notch erosion, and the Scheker can be used as a revision prosthesis. A cobalt-chrome plate is attached to the distal radial metaphysis using a peg and screw fixation. A socket protrudes from this. A cobalt-chrome peg is inserted into the ulnar shaft. This has a highly polished stem distally, onto which is inserted a polyethylene ball. This ball articulates with the cobalt-chrome socket on the radial plate

In summary, arthroplasty for the joints in the hand and wrist is in its infancy when compared to the advances that have been made in larger joints. The prostheses tend to have only short-term follow-up, and a consensus on the best designs has yet to be reached.

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