Osteoarthritis of the Wrist

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Summary: This article reviews pathogenesis and treatment of wrist osteoarthritis. Because there is no cure for osteoarthritis, treatment is directed at symptomatic relief. Surgical treatment is reserved for patients who have failed nonoperative modalities. This article reviews the surgical treatment of wrist osteoarthritis with an emphasis on selection of the appropriate procedure. Literature guiding surgical treatment with patient outcomes is reviewed. (*Plast. Reconstr. Surg.* 133: 605, 2014.)

Osteoarthritis is considered synonymous with aging. Osteoarthritis in the wrist is often traced to a traumatic insult such as fracture, dislocation, or ligament injury.[1] In 1984, Watson and Ballet described a predictable pattern of wrist degeneration following scapholunate ligament injury, termed scapholunate advanced collapse wrist. Scapholunate advanced collapse wrist is one of the most common patterns seen in adult patients.[2] A similar disease progression follows scaphoid fracture nonunion, termed scaphoid nonunion advanced collapse wrist.[3] Less common causes of wrist osteoarthritis include distal radius malunion or articular stepoff,[4] avascular necrosis of the scaphoid (Preiser disease) or lunate (Kienböck disease),[5,6] and congenital abnormalities such as Madelung deformity.[7,8]

The landmark publication by Watson and Ballet reviewed over 200 wrist radiographs with arthrosis. The cause in the majority (57 percent) of cases of wrist osteoarthritis was scapholunate advanced collapse.[9] A staging system that notes the progression of disease was described, with stage I representing early degenerative changes (narrowing/sclerosis) that are confined to the radial styloid. As the disease progresses, degenerative changes are seen in the entire scaphoid fossa (stage II), followed by midcarpal arthritis at the capitolunate joint (stage III) (Fig. 1).[10] A fourth stage was added by other authors, for pancarpal arthritis with diffuse involvement of the radiocarpal and midcarpal joints with or without involvement of the distal radioulnar joint.[11–13] The radiolunate joint is typically spared in the scapholunate advanced collapse wrist.[11–16] However, a recent publication by Lane et al. suggests that in a minority of cases (5 to 6 percent of scapholunate advanced collapse wrists), the lunate fossa may be arthritic as well.[17] The presence of lunate fossa arthritis has important implications for surgical treatment, as often this joint is not addressed (Fig. 2).

Like scapholunate advanced collapse wrist, scaphoid nonunion may lead to a pattern of carpal instability[18] and osteoarthritis in most (if not all) cases if left untreated, and is termed scaphoid nonunion advanced collapse.[16,19–21] The cause of scaphoid nonunion advanced collapse is trauma, leading to scaphoid fracture and subsequent nonunion and resulting in abnormal joint kinematics. Scaphoid nonunion leads to a sequence of arthritic degeneration similar to that in scapholunate advanced collapse wrist. The difference is the loss of tether linking lunate and scaphoid motion is within the scaphoid bone rather than the scapholunate ligament. The spherical proximal scaphoid fragment that is tethered to the lunate by means of an intact scapholunate ligament is typically spared from arthritic changes.[22]

Distal radius fracture with nonunion can also lead to wrist osteoarthritis.[23,24] In a classic report of intraarticular distal radius fractures, Knirk and Jupiter reported a 91 percent incidence of arthritis at late follow-up if there was any degree of articular stepoff after fracture reduction, and a 100 percent incidence of arthritis (eight of eight) if there was a greater than 2-mm stepoff of the articular surface.[25] Only 11 percent of those wrists with a congruent articular reduction developed arthritis at late follow-up. A recent long-term (mean, 38 years) follow-up study by Forward et al. demonstrated much lower rates of arthritis

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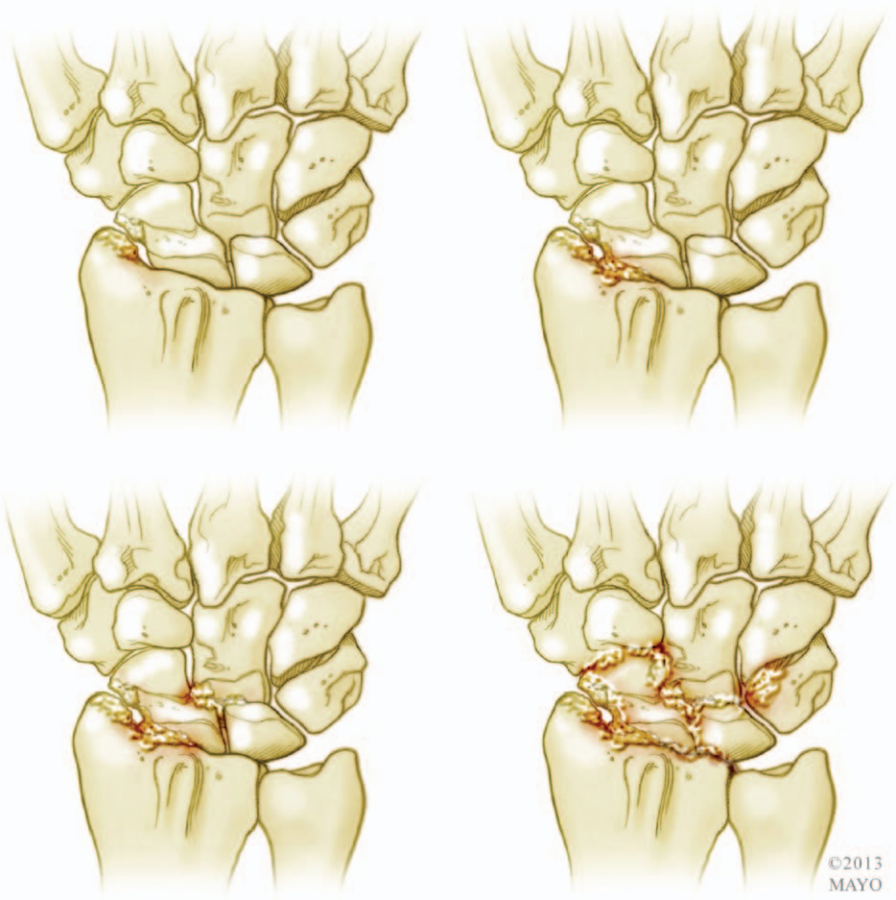

Fig. 1. Progressive osteoarthritis that occurs with both chronic scapholunate ligament injury and scaphoid nonunions. (*Above*, *left*) Stage I, affecting the radial styloid–scaphoid junction. (*Above*, *right*) Stage II, affecting the entire radioscaphoid joint. (*Below*, *left*) Stage III, affecting the entire radioscaphoid joint and the capitolunate articulation. (*Below*, *right*) Stage IV, affecting the entire radiocarpal and midcarpal joints and may involve the distal radioulnar joint. (Used with permission of Mayo Foundation for Medical Education and Research.)

(a 43 percent increase in osteoarthritis changes on the injured wrist) despite a significant number of patients with malunion and intraarticular fractures.[26] More compelling is that Disabilities of the Arm, Shoulder, and Hand scores were no different than population norms, grip strength was only modestly reduced (89 percent of uninjured side), and no patients required a salvage procedure.

PATIENT EVALUATION

Symptoms of wrist osteoarthritis include pain, stiffness, and instability. However, there is great variability in symptom severity and, in fact, not all patients will experience pain. In a classic study looking at arthritis among miners in their forties, Kellgren and Lawrence found that only 24 percent of miners with radiographic osteoarthritis had pain, and 8 percent of radiographically normal joints had pain,[27] thus suggesting that osteoarthritis in the knee does not always hurt, and that knee pain does not imply the presence of osteoarthritis.

A careful history of the patient's symptoms is essential, with attention to exacerbating and alleviating factors and how these symptoms are interfering with daily life including work, hobbies, athletics, and pastimes. Each articulation is palpated carefully to identify the areas of tenderness, or crepitus. It is important to get a sense of the degree to which the pain is affecting the patient's lifestyle and work, as this will dictate the decision to treat with nonoperative methods or proceed to more definitive reconstruction. This is an important consideration, as the reconstruction may require a significant investment by the patient, such as time off work because of immobilization

Fig. 2. Scapholunate advanced collapse arthritis involving radial styloid–scaphoid articulation with the unusual finding of radiolunate degeneration.

and a potential loss of motion, which for some individuals may be more burdensome than the original osteoarthritis symptoms.

A critical evaluation of posteroanterior and lateral wrist radiographs is essential. One must note which articulations are involved. Involvement of the lunocapitate articulation should give one pause before proceeding with a proximal row carpectomy reconstruction, as this will leave an arthritic capitate head behind to articulate with the lunate fossa. In this situation, a midcarpal fusion, such as a scaphoidectomy and four-corner fusion, may be more appropriate. Further imaging such as computed tomographic scanning, magnetic resonance imaging, or bone scanning is not part of the routine evaluation but may be indicated in select situations.

NONOPERATIVE TREATMENT

Because there is no way to reverse the pathophysiologic process of osteoarthritis and there is no cure, treatment is directed at alleviating symptoms and enabling patients to return to their desired lifestyle. Nonsurgical treatment can be effective for patients with wrist osteoarthritis. The options for nonsurgical treatment are splint or cast immobilization, nonsteroidal antiinflammatory medications, and selective intraarticular injections of corticosteroids, which may provide patients with improved function and decreased pain. In patients with more advanced disease, however, the pain relief granted by nonsurgical methods is limited.

SURGICAL TREATMENT

Surgery is directed at elimination of pain at the arthritic joint through débridement (radial styloidectomy), denervation (neurectomy), arthroplasty, or partial or total wrist arthrodesis. The specific treatment is selected carefully based on the patient's symptoms, expectations, pattern of arthritis, and functional demands. Biomechanical data are available to help predict the range of motion that may be predicted with proximal row carpectomy, midcarpal joint fusion, and radiocarpal joint fusion.[28,29] Based on these studies, midcarpal fusion will provide motion 50 to 67 percent that of the contralateral side, and radiocarpal fusion will provide 33 to 40 percent that of contralateral motion unless the scaphoid distal pole is removed, and in which case an additional 15 to 20 percent of motion is possible.[12] Proximal row carpectomy results in wrist motion that is 50 to 75 percent that of the contralateral side.[12] The surgical approach to the wrist should account for the future likelihood of additional procedures should the current treatment fail.

Neurectomy

Total denervation of the wrist is associated with improved pain without loss of motion and with minimal morbidity and convalescence.[30–32] Partial denervation of the anterior interosseous nerve and posterior interosseous nerve is possible through a single dorsal incision (Fig. 3).[33] This procedure has been shown to provide partial relief of wrist pain in cases of radiocarpal arthritis with chronic wrist pain at an average of 31 months after surgery.[34] In that study, three of 20 patients required additional procedures for pain relief. Most patients continue to have some wrist pain, but the majority (90 percent) experience symptomatic improvement. Before proceeding with neurectomy, the patient should undergo a trial, whereby both the anterior and posterior interosseous nerves are injected with a trial of a long-acting anesthetic. This allows the patient a period of hours after the injection to assess the level of relief that may be expected from the denervation procedure, and an improvement in grip strength can be assessed in the surgeon's office.[35] A study by Bell et al. demonstrates how pain relief can improve grip strength in patients with wrist abnormality.[36] Subjects had lidocaine (with or without corticosteroid) injected into the midcarpal joint. Patients with chronic wrist pain had improvement of grip

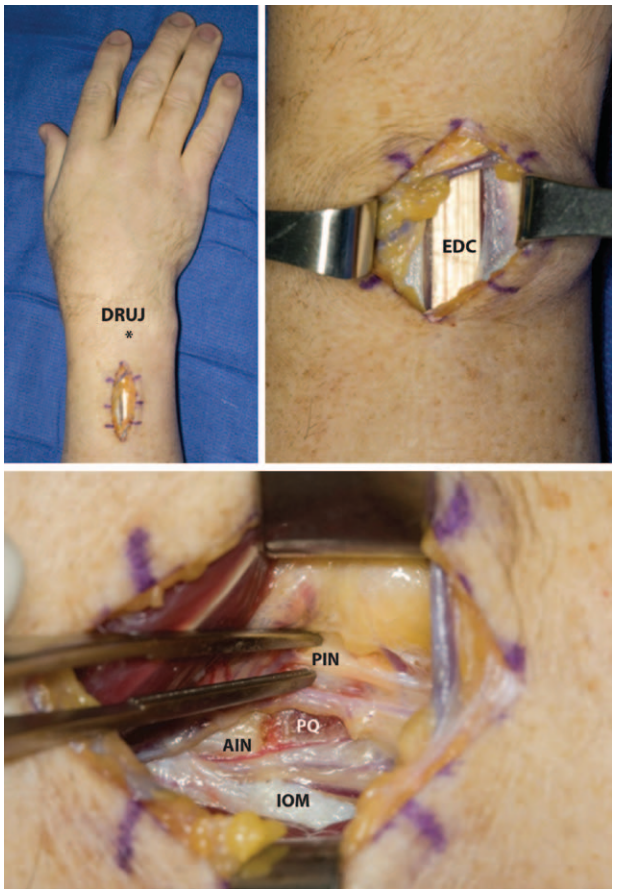

Fig. 3. (*Above*, *left*) Dorsal approach for anterior and posterior interosseous neurectomies. A dorsal skin incision is made beginning one fingerbreadth proximal to the ulnar head/distal radioulnar joint and extending for 3 to 4 cm. (*Above*, *right*) The deep fascia is incised, exposing the extensor digitorum communis tendons. The tendons are retracted and the distal interosseous membrane is exposed. (*Below*) The posterior interosseous nerve is visualized and a segment is resected. The interosseus membrane is divided to expose the anterior interosseous nerve coursing along the dorsal surface of the pronator quadratus muscle. A segment is excised with care to preserve the proximal motor branch to the pronator quadratus muscle. *AIN*, anterior interosseous nerve; *EDC*, extensor digitorum communis; *IOM*, interosseous membrane; *PIN*, posterior interosseous nerve; *PQ*, pronator quadratus; *DRUJ*, distal radioulnar joint.

strength following the injections. Normal volunteers, in contrast, had a reduction in grip strength after midcarpal injection. The relationship of pain relief from the injection and improvement of grip strength were compared with the presence of intracarpal abnormality as confirmed by wrist arthroscopy. Improvement in grip strength of 6 kg (28 percent) after midcarpal lidocaine injection had a 73 percent sensitivity and a 70 percent specificity ($p = 0.02$) of having intracarpal abnormality at the time of arthroscopy.

Radial Styloidectomy

Radial styloidectomy can be performed as a conservative palliative procedure, most commonly for patients with early scapholunate advanced collapse or scaphoid nonunion advanced collapse wrist where arthritis is confined to the radial styloid. Radial styloidectomy can be performed either in isolation or in combination with other another procedure. It is usually performed subperiosteally through the anatomical snuffbox but may also be performed arthroscopically[37] as a palliative procedure. It is important to preserve the volar radial ligament attachments (i.e., the radioscaphocapitate ligament). If more than 6 to 10 mm of styloid is removed, the radioscaphocapitate ligament origin will be significantly compromised, possibly resulting in ulnar translation of the carpus.[38–40]

Proximal Row Carpectomy

Proximal row carpectomy involves excision of the scaphoid, lunate, and triquetrum. It is a good salvage option for the wrist with considerable radioscaphoid arthritis and preserved proximal capitate and lunate fossa of the radius articular surfaces. Proximal row carpectomy entails removal of the entire proximal carpal row (i.e., scaphoid, lunate, and triquetrum) and results in the wrist functioning as a simple hinge joint. After the proximal row carpectomy, the distal carpal row migrates proximally, so that the capitate articulates with the lunate facet of the radius. The radius of curvature of the lunate fossa is larger than that of the capitate head, and there is resultant incongruity between the radius and capitate that, with time, can lead to arthritis.[41–44]

The technique for proximal row carpectomy has been described previously in the literature,[45] although an arthroscopic technique has been proposed.[46–48] In the standard open approach, the exposure of the carpus is performed, and the articular surfaces are inspected for suitability of the procedure. Scaphoid, lunate, and triquetrum are removed. When excising the scaphoid, it is critically important to preserve the radioscaphocapitate ligament to prevent ulnar subluxation of the wrist after proximal row carpectomy. The capitate is then allowed to rest in the lunate fossa of the radius (Fig. 4).

One important advantage of proximal row carpectomy over intercarpal fusion is that it does not require a lengthy period of immobilization for an arthrodesis to heal. The procedure has been used even in young active persons, with good functional and clinical results.[49–52] Krakauer et al. have compared proximal row carpectomy with intercarpal

Fig. 4. Proximal row carpectomy for stage IV scapholunate advanced collapse wrist with degeneration at the midcarpal joint and radiolunate articulation. Because there was minimal degeneration at the radiolunate articulation, and because the patient had a strong desire to preserve motion and refused total wrist fusion, a proximal row carpectomy was performed. Note that some fragments of the scaphoid bone remain, as is common with careful preservation of the radioscaphocapitate ligament. (*Left*) Preoperative and (*right*) postoperative anteroposterior (*above*) and lateral (*below*) views.

fusion.[53] They found that carpectomy preserved better motion, an average arc of 71 degrees versus 54 degrees for limited arthrodesis. Both procedures preserved reasonable strength and reduced pain.

The data on long-term outcomes after proximal row carpectomy are limited. In one study of 20 patients treated with proximal row carpectomy for various degrees of wrist osteoarthritis, two patients required radiocapitate arthrodesis for persistent pain after proximal row carpectomy. The remaining 18 patients were evaluated at an average of 13.1 years after surgery. The average wrist range of motion was 63 percent that of the opposite side, and the average maximal grip strength was 83 percent that of the opposite extremity. Sixteen of the 18 patients had returned to their previous employment. Flattening of the capitate was present in 33 percent ($n = 6$) of patients, and 20 percent ($n = 4$) of patients had some evidence of moderate to

severe radiocapitate arthrosis. However, this finding did not correlate with patient satisfaction, wrist pain, or function.[54]

Scaphoidectomy and Four-Corner Fusion

Scaphoidectomy and four-corner fusion involves complete excision of the scaphoid with preservation of the radioscaphocapitate ligament and fusion of the remaining midcarpal joint (i.e., lunate, capitate, triquetrum, and hamate) as a unit. Variations in the technique have been described, which mainly involve the type of hardware used to provide fixation. Although the technique classically includes arthrodesis of four bones (i.e., lunate, triquetrum, capitate, and hamate), actually only lunocapitate arthrodesis is required for wrist stability.[55] Additional joint fusion between the triquetrum and hamate is performed to improve the union rate by increasing the surface area of fusion. Reducing the lunate to restore the normal anatomical relationship between it and the radius is a critical step. This is performed by flexing the wrist and bringing the extended lunate into neutral alignment relative to the long axis of the radius under lateral view fluoroscopy (Fig. 5). Autologous bone is preferred over allograft or other bone substitutes. It can be harvested from the anterior iliac crest or from the distal radius metaphysis. Although there is some evidence that iliac crest bone is biologically superior to distal radius bone for use as a bone graft,[56] harvest from the distal radius does not require a second surgical site and avoids the pain and morbidity associated with iliac crest bone graft harvest. Bone fixation can be performed by a variety of methods, including Kirschner wires, compression screws, and a circular plate (Fig. 6).

For circular plate fixation, a depression is created for the circular dorsal plate using a circular reamer. The plate is placed in position and rotated to maximize the number of screws in each bone (ideally, two screws per bone). It is crucial to accurately measure drill-hole depth and screw length, particularly with triquetral screws. Excessive screw length can lead to pisotriquetral joint impingement, pain, and arthrosis. A 30-degree supinated view can bring the pisotriquetral joint into clear view and confirm that a screw does not penetrate the joint. At the conclusion of fixation, the radiocarpal joint should be ranged passively, to ensure that there is no impingement of the plate with the wrist in extension.

This procedure represents an option of salvage with preservation of motion in the osteoarthritic wrist. Because it does not require preservation of the lunocapitate articulation, it may therefore be appropriate in more advanced stages of the scapholunate advanced collapse/scaphoid nonunion advanced collapse wrist. It does require preservation of the radiolunate articulation, which is rarely affected in this pattern of arthritis.[17] In 1984, Watson and Ballet presented outcomes of their "scapholunate advanced collapse procedure" for the scapholunate advanced collapse wrist.[9] Although this scapholunate advanced collapse wrist procedure was initially proposed to be used with a silicone scaphoid implant, scaphoid excision without an implant works equally well and avoids the long-term risk of silicone synovitis.[57–59] Potential advantages of four-corner fusion over proximal row carpectomy include the retention of the radiolunate interface and preservation of carpal height, which arguably maintains the resting muscle tension across the wrist, preserving grip strength.[10,60]

Functional outcome following four-corner fusion have been analyzed in several studies.[53,61–64]

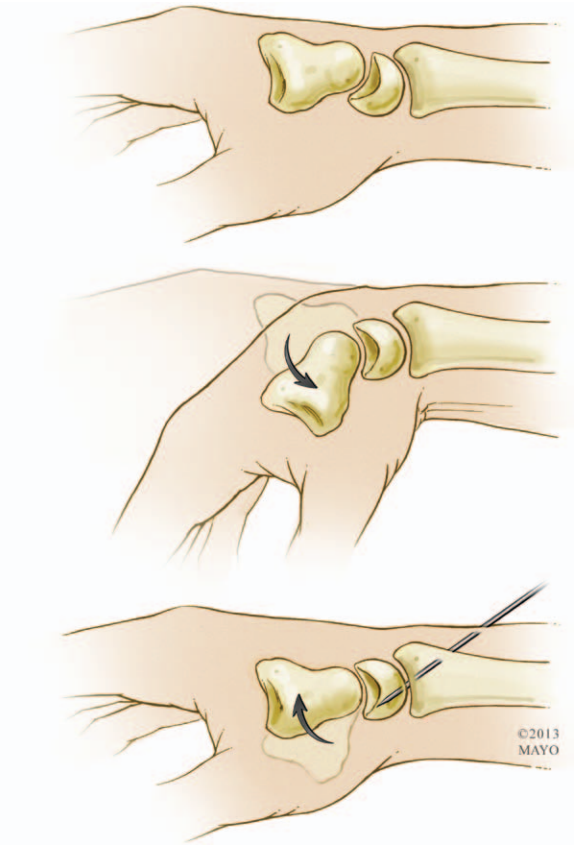

Fig. 5. Wrist flexion reduces the lunate from its extended position. A temporary Kirschner wire holds the lunate in this position while the midcarpal articulation is fused. (Used with permission of the Mayo Foundation for Medical Education and Research.)

Fig. 6. Postoperative film following scaphoidectomy and four-corner fusion with radiolucent circular plate. (*Left*) Anteroposterior and (*right*) lateral views.

One of the largest series belongs to Ashmead et al., who reported on 100 cases. In this series, nonunion occurred in only 3 percent of patients. Also, 51 percent of patients had total resolution of wrist pain, whereas 15 percent continued to have pain with daily activities or at rest. Final wrist flexion-extension arc averaged 53 percent that of the contralateral side and final grip strength averaged 80 percent that of the contralateral side.[61] Ozyurekoglu et al.[65] evaluated the functional and radiographic outcomes of the four-corner fusion technique using percutaneous headless compression screws.[66] Thirty-three patients were treated with scaphoidectomy and four-corner fusion for scapholunate advanced collapse ($n = 19$), scaphoid nonunion advanced collapse ($n = 12$), midcarpal instability ($n = 1$), and Preiser disease ($n = 1$). The capitolunate fixation was achieved with a percutaneous transmetacarpal Acutrak screw (Acumed, Hillsboro, Ore.), and triquetrohamate fixation was performed with a percutaneous screw. Scaphoid was used as a bone graft. At an average follow-up of 8 months (range, 6 to 64 months), union occurred in 31 of 33 wrists (94 percent). The percentage of grip strength improved from 41 percent before surgery to 80 percent after surgery. Twenty-five of 33 patients were completely pain free. The average postoperative Mayo wrist score was 74, a significant improvement over the preoperative average of 40. Final Disabilities of the Arm, Shoulder, and Hand scores averaged 13. The authors achieved results that were comparable to or better than results of previously published techniques, exploiting the theoretical advantages of strong compression between carpals and avoiding a screw head–size hole in the lunate articular cartilage and preserving the dorsal capsular ligament attachments to the triquetrum.

Failure to correct lunate position can lead to limited wrist extension, hardware abutment, and pain.[61,62] Neither use of bone graft nor hardware choice has been shown to clearly correlate with fusion rates.[67] In a study by Vance et al., hardware complications have been noted.[68] In their series, nonunion and impingement occurred in 48 percent of cases treated with circular plate fixation, in comparison with a 6 percent rate with traditional fixation (Kirschner wires, staples, or compression screws). Plate fixation was also associated with a higher rate of patient dissatisfaction.[68] Implant-related complications are lowered with new-generation circular plates, which are less bulky. Rhee and Shin[69] reported their series in which 22 patients and 23 wrists underwent four-corner fusion using a locking, dorsal circular fusion plate made from polyether ether ketone (Xpode; Biotech International, Salon de Province, France). Union was achieved in 22 of 23 wrists at a mean time of 3 months (range, 1 to 12 months). There was one partial union that underwent successful revision arthrodesis. There were no cases of plate breakage or screw pullout. Four broken screws (two wrists) within a solid fusion mass not requiring removal were observed. Rhee and Shin have concluded that the use of a radiolucent plate allowed for more accurate assessment

of union with the biomechanical advantages of a fixed angle construct.[70] Similarly high union (22 of 24) rates and low implant-related complications were reported by Luegmair and Houvet for the Xpode cup.[70]

Total Wrist Arthroplasty and Total Wrist Arthrodesis

In advanced arthritis where longstanding dorsal intercalated segmental instability deformity may have resulted in arthritic changes within the lunate fossa, wrist arthrodesis and wrist arthroplasty may be the only options for wrist salvage. Total wrist arthroplasty may be an enticing option because of the potential for motion preservation. Because many of the activities of daily living are made considerably easier with some wrist motion,[66] total wrist arthroplasty has become an increasingly attractive surgical alternative in lower demand individuals who have debilitating pancarpal osteoarthritis. It is often preferable to fusion when both wrists are arthritic.[71] The normal wrist functions through complicated interactions at multiple articulations across the wrist joints. It is impossible for a prosthesis to duplicate this complexity of motion and strength. Therefore, there is a compromise that occurs for motion at the expense of strength, and total wrist arthroplasty should be selected for only those patients with low-demand wrists.[72,73] The first total wrist arthroplasty implant was made of silicone and provided good pain relief. Long-term follow-up data have shown a high incidence of implant failure,[74–77] and issues regarding reactive synovitis and secondary osteolysis have been reported.[78,79] A new generation of articulated wrists were designed to improve on previous implants and provided an enhanced arc of motion, but suffered from instability problems.[80] Through innovative research and by learning from past mistakes, total wrist designs have since become increasingly sophisticated, with attempts made to optimize component fixation and their articulating geometry.[75,75,78,81]

Total wrist arthrodesis represents the ultimate salvage of wrist arthritis, and it has become the standard surgical treatment for patients with severe pancarpal degenerative joint disease who still wish to undertake considerable heavy labor.[82,83] Generally, good function occurs after surgery, although patients report trouble with personal hygiene and working in tight spaces.[84,85] Reasonable outcomes are possible after total wrist arthroplasty.[86] Although the literature is rather consistent in showing an outstanding fusion rate with current techniques, reports of the ability of total wrist arthrodesis to successfully relieve pain are a bit more variable.[85,87,88] This procedure is typically performed with the use of a dorsal wrist fusion plate.[89,90] Specialized precontoured dorsal plates have become ubiquitous and decrease the need for long-term postoperative immobilization[91] (Fig. 7). Nagy and Buchler compared the

Fig. 7. Total wrist arthrodesis and ulnar head replacement for advanced pancarpal arthritis with distal radioulnar joint involvement. Note that proximal row carpectomy was performed at the time of wrist fusion to eliminate the need for consolidation of a second articulation. (*Left*) Anteroposterior and (*right*) lateral views.

outcomes of AO-wrist arthrodesis, with or without arthrodesis of the third carpometacarpal joint. Their study revealed decreased complications by simply bridging the third carpometacarpal joint without attempting fusion.[92]

SUMMARY

Wrist osteoarthritis commonly results from ligamentous injury that leads to a predictable pathway and sequence of degeneration. Successful treatment of the osteoarthritic wrist is possible and largely dependent on the individual patient's symptoms and impairment balanced against the risks and benefits of any particular treatment. As there is no cure for osteoarthritis, treatment is directed at symptomatic improvement. Therefore, treatment should be stepwise, starting with the least invasive and risky options (e.g., lifestyle modification, rest, and steroid injection). When these treatments fail, more invasive procedures may be indicated, such as proximal row carpectomy and partial or total wrist fusion procedures. The literature is lacking in regard to definitive, level I evidence to guide treatment. Level I comparative studies with long-term follow-up are needed to guide future treatment.

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