12 Revision/Failed Distal Radioulnar Joint Arthroplasty

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Introduction

A painful, dysfunctional, or severely arthritic distal radioulnar joint (DRUJ) can be reconstructed by fusion, resection arthroplasty with or without soft tissue interposition, or prosthetic joint arthroplasty [1–4]. Unfortunately, patients may still develop persistent dysfunction following these procedures due to the inherent stresses on across the DRUJ during functional motion of the forearm and wrist [1, 3]. The loss of the bony buttress on the ulnar side of the wrist and/or failure to recreate that support with an appropriately positioned and tensioned arthroplasty alters loading across the DRUJ and allows for convergence of the radius and ulna with contraction of the pronator quadratus, abductor pollicis longus, and extensor pollicis brevis [5, 6].

Failures of previous arthroplasty procedures represent a difficult problem in a particularly complex patient population. Typically, these patients are encountered after several prior surgeries with complaints such as persistent pain, instability, and general wrist dysfunction. Treatment and patient education about expected outcomes are a further challenge given the limited body of evidence on managing complications or failure of DRUJ arthroplasty. The larger published series assessing outcomes following DRUJ arthroplasty include 30–50 patients, the largest published to date including just 52 total patients. Complication rates in these cohorts ranged from 30% to 40%, with limited description of patient evaluation and treatment of these complications [7–12]. Further contributing to the paucity of data is the limited number of providers who have the experience and willingness to tackle these complex problems. Given the inherent heterogeneity of this population in addition to the previously described factors, application of the evidence is prone to subjectivity. As such, this review stems from a compilation of available evidence and nearly four decades of experience in treating these patients at tertiary referral centers.

In presenting their approach to the challenging problem of ulnar-sided wrist pain, Kakar and Garcia-Elias define pathology from four interrelated zones, each associated with treatments specific to that zone [3]. Identifying the involved zone(s) and applying appropriate treatment while remaining respectful of the potential for interrelated problems is essential to successful resolution of primary DRUJ pathology. We propose that the concept of using a mental algorithm for processing interrelated pathology on the ulnar side of the wrist can also be adapted to failed DRUJ arthroplasty. In this setting, the zones are unique as while there is no longer a TFCC, articular

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G. J. W. King, M. Rizzo (eds.), *Arthroplasty of the Upper Extremity*,
https://doi.org/10.1007/978-3-030-68880-6_12

surface, or cartilage interface, there exists the potential for new pathology related to the prior operation(s).

Previous authors have identified multiple potential sources of pain and dysfunction following procedures for resection of the distal ulna, including neurogenic pain, tendinitis, tenosynovitis, and radiocarpal arthritis [13]. By expanding and regrouping those potential pain generators, we propose six interrelated zones to frame evaluation of the failed DRUJ arthroplasty. The zones are nerve, tendon, adjacent arthritis, impingement, implant complication/instability, and infection. Applying the useful framework proposed by Kakar and Garcia-Elias [3], the four-leaf clover becomes a multi-petal flower, distilling complex problems into discrete arenas with succinct and specific solutions (Fig. 12.1). Each of these zones should be individually considered when evaluating a new patient with a failed DRUJ arthroplasty and each zone specifically interrogated to gain a comprehensive understanding of pathology, such that targeted and comprehensive treatment can be determined and performed.

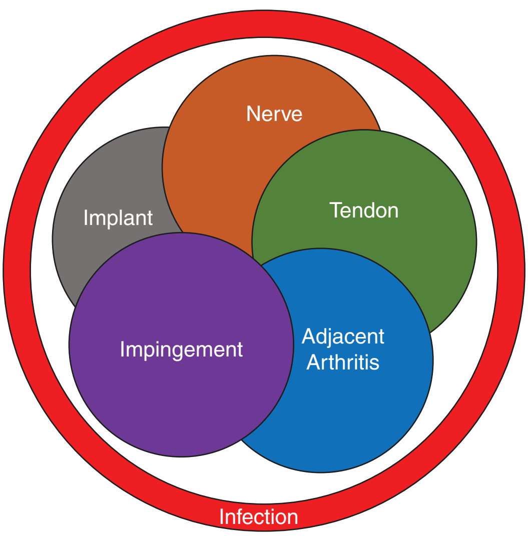

Fig. 12.1 Six zone algorithm for evaluating potential sources of pain and dysfunction following DRUJ arthroplasty

Clinical Presentation

Patient History

Each patient requires holistic review, avoiding the temptation to focus on the most recent procedure. This entails a thorough history and physical with special emphasis on the unique functional demands specific to each patient, including a review of previous pathology and procedures on the extremity. The critical information to glean is the connection between the patient's symptoms prior to an intervention and how the intervention changed those symptoms. The time course is important as problems that developed insidiously following intervention suggest a different etiology than problems which preceded or developed abruptly following intervention. Another critical point is confirming that physical and radiological exam findings are in fact representative of the specific complaints that affect the patient in their day-to-day life. For example, all distal ulnar resections will have convergence, but this finding may not correlate with the pain which limits function and prompted presentation to clinic [13, 14].

Physical Examination

The physical examination begins with a general inspection of traumatic and surgical scars, obvious deformity such as subluxated tendons, and the defect created by the absence of the ulnar head.

Range of motion of the shoulder, elbow, and hand is assessed. A cursory way to confirm a functional range of motion of the shoulder and elbow is to ask the patient to place their hands to their mouth, to their ear, to the back of their head, and behind their back in the region of the lumbar spine. This simulates self-cares and basic functional needs, including performing personal hygiene, feeding independently, and using a cell phone. Wrist flexion and extension are measured with the elbow flexed to 90° and resting on the exam table. The contralateral side is similarly measured and recorded for comparison. Digit range of motion is assessed by asking the patient to transition from holding their digits in full extension to full composite flexion ("make a fist"). This confirms the presence or absence of hand pathology that may need to be addressed in conjunction with the DRUJ. Pain and crepitus with range of motion of the radiocarpal joint, the hand, elbow, or shoulder may direct more thorough evaluations of these joints to identify adjacent joint arthritis that may contribute to DRUJ dysfunction or be exacerbated by any intervention to the DRUJ.

Palpation of adjacent joints is critical, as active range of motion may be insufficient to reveal pathology. The radiocarpal joint is palpated, first by identifying Lister's tubercle and rolling the examiner's thumb distal to the radiocarpal articulation. Pain more radially over the radial styloid may suggest underlying arthritic changes, while pain more proximally may suggest either tenosynovitis or prominent radial hardware in the setting of a previous constrained arthroplasty. A shearing compressive force at the pisotriquetral joint also suggests an arthritic joint (Fig. 12.2).

A complete peripheral nerve examination is performed with objective measures of motor strength and sensibility recorded. Special attention is paid to the dorsal cutaneous branch of the ulnar (DCBrUN) which can be injured by traction or transected in a dorsally based approach to the DRUJ. Each nerve distribution, especially the DCBrUN, should be palpated to assess hypersensitivity. Tinel's sign can be assessed to elucidate and pinpoint an area of maximal tenderness that may correlate with neuroma formation from a prior procedure. Compressive provocative testing can also quickly and easily be performed to confirm the baseline function of the median nerve at the wrist and the ulnar nerve at the elbow and Guyon's canal. Sensibility is objectively recorded by measuring static two-point discrimination on the radial and ulnar aspect of each digit as well as monofilament testing in the same distribution. Strength is evaluated by testing of grip, appositional ("key") pinch and oppositional pinch.

Having completed the above, the DRUJ is assessed. The patient's arm is placed by their side with the elbow flexed 90° to limit shoulder motion. The patient is asked to move the forearm from maximum supination to maximum pronation and describe the amount and quality of pain that is occurring at the distal end of the ulna. If the motion is pain-free, then the patient is asked to hold a 5 kg weight, repeat the pronation supina-

Fig. 12.2 Clinical and radiographical evaluation of the pisotriquetral joint with arthritic changes suggestive of pisotriquetral arthrosis

tion action, and describe any accompanied pain. Translation is assessed with the patient's elbow resting on the exam table. The examiner translates the ulna in a volar-dorsal direction while stabilizing the radius. This is performed in neutral, full pronation and full supination. Finally, a compression test is performed with a grasping maneuver that pushes the end of the ulna against the radius while pronating and supinating the forearm. This latter examination can be quite uncomfortable and should be performed gently and discontinued if particularly painful (Fig. 12.3).

Maneuvers designed to identify irritation of the flexor carpi ulnaris (FCU) and irritation or subluxation of the extensor carpi ulnaris (ECU) are performed. With the patient's elbow flexed and resting on the exam table, the patient is asked to maintain a neutral position while the examiner applies a gentle extension force. This causes tension and prominence of the FCU, which can then be palpated from the mid forearm into the base of the palm, where it envelops the pisiform, before inserting into the base of the fifth metacarpal. Swelling and tenderness along the FCU tendon may be noted.

Examining the ECU has been described with various maneuvers that reveal the tendon perching or subluxating from the sixth dorsal extensor compartment. In the setting of failed DRUJ surgery, tendon subluxation is not subtle. The subluxation can be presented by placing the wrist in extension and rotating the forearm through a complete range of pronation and supination while palpating the sixth dorsal extensor compartment at the ulnar head. The maneuver is then repeated with the wrist in flexion and again in extension. The subluxation can be exaggerated by having the patient resist counter pressure placed on the wrist by the examiner, relying on the principle of co-contraction of the ECU and FCU to maintain neutral wrist position in the face of directional force. It has been argued that this maneuver also stresses the TFCC, LT ligament, and ulnocarpal articulation and may be less specific for ECU pathology. Thus, we also routinely perform the "synergy test" to specifically assess ECU tendonitis, as elegantly described by Ruland and Hogan (Fig. 12.4) [15]. This is performed with the patient's elbow flexed and resting on the exam table, the wrist positioned in neutral and maximal supination, and the digits fully extended. The examiner attempts to compress the patient's thumb and long finger while the patient resists this effort. A positive test elicits characteristic pain at the sixth dorsal extensor compartment radiating along the ECU tendon proximally and/or palpable subluxation of the ECU tendon. This can be especially helpful in elucidating a potential cause of mild pain over the

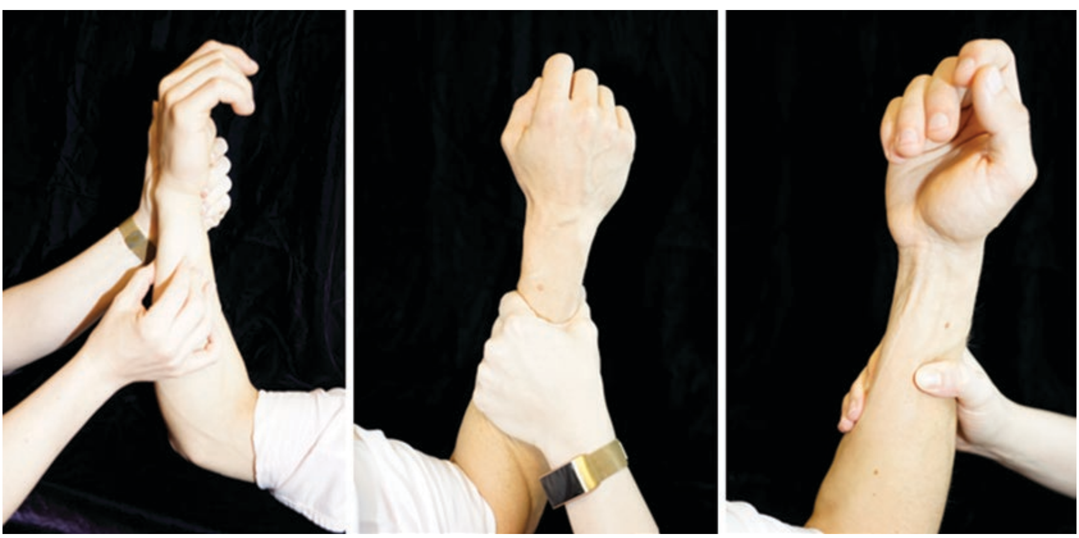

Fig. 12.3 Provocative testing of DRUJ pain: translation, compression in pronation, compression in supination

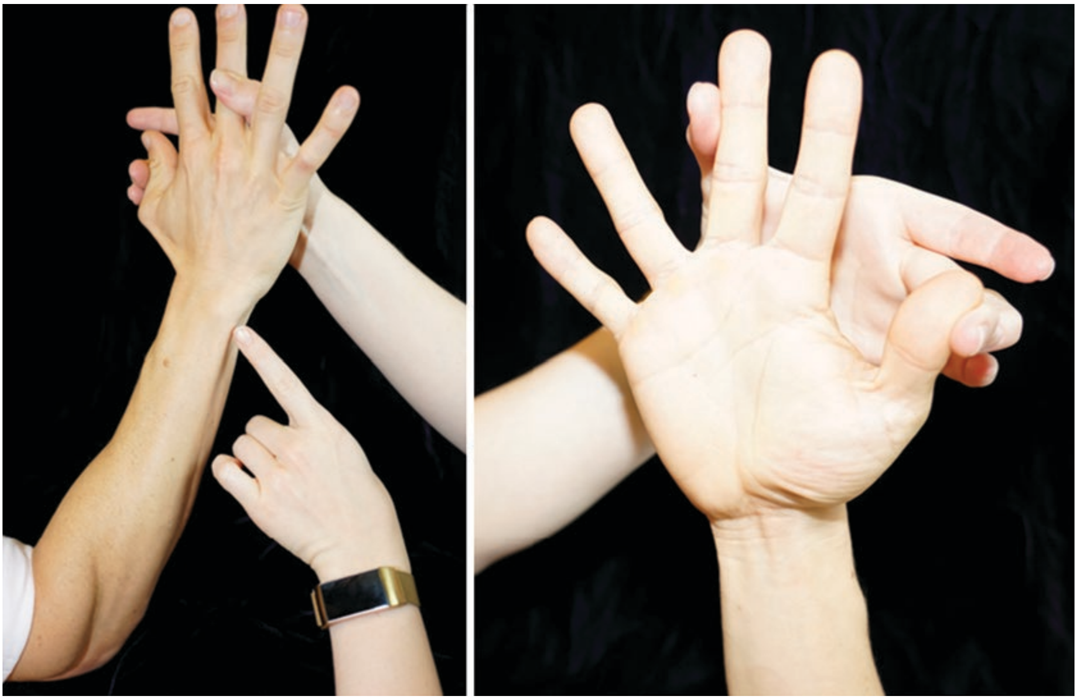

Fig. 12.4 Provocative testing for ECU subluxation using the "synergy" test

prominence of a metallic implant in an otherwise stable DRUJ after reconstruction.

Diagnostic Studies

Radiographs of the elbow, forearm, and wrist should be taken in posteroanterior (PA), lateral, and oblique projections, including an oblique view of the proximal radioulnar joint (PRUJ). As the majority of these patients have undergone some sort of ulnar head resection, the ECU sulcus cannot be used to determine a true PA projection of the DRUJ as previously described [16]. Thus, a PA will need to be approximated by abducting the shoulder to 90°, flexing the elbow to 90° and positioning the forearm in neutral with the forearm and hand flat on the cassette. A true lateral of the wrist can be obtained without the ulnar head, and the accuracy of the projection is confirmed by using the scaphopisocapitate (SPC) alignment criteria described by Yang et al. [17]. This image is essential for assessing the correct placement of constrained metallic arthroplasties.

The radiographs are scrutinized for adjacent joint osteoarthritis, fractures, and carpal malalignment. Radiographs of the elbow are used to predict the potential exacerbation of arthritic conditions upon correction and increased used of the limb after DRUJ reconstruction. In some cases, DRUJ and PRUJ pathology will need to be addressed simultaneously. In the setting of ulnar head arthroplasty, the ulnar cortex of the radius is assessed for signs of scalloping suggesting erosion from contact with the distal end of the ulna. Implant arthroplasties are assessed for alignment and cortical erosion, lucent lines around the implant, and stress reaction, which may suggest underlying or impending stress fracture or indolent infection.In the setting of previous ulnar head resection arthroplasty, special radiographs to assess for radioulnar instability are indicated. As described by Lees and Scheker, the image is obtained with the patient's arm at their side, elbow flexed to 90°, and forearm in neutral. A cassette is placed between the forearm and the body, while the patient holds a 2.2 Kg (5 lb) weight. The beam of the radiograph is directed perpendicular to the forearm in the coronal plane [13]. The radiograph will reflect the amount of convergence that is associated with resection of the ulnar head. The degree of impingement can be further augmented by having the patient rotate the forearm in the most uncomfortable position that was identified on physical examination and again directing the beam perpendicular to the coronal axis of the arm to visualize the narrowing of the interosseous space.

Advanced imaging studies are occasionally indicated after comprehensive exam and routine imaging studies. Ultrasound may be useful in the identification of dynamic ECU subluxation and tenosynovitis, but its role in dealing with this specific population is not well defined in the literature. Computed tomography (CT) and magnetic resonance imaging (MRI), which are essential contributors to the differential diagnosis of DRUJ pain and instability before operative intervention, play a more limited role after an arthroplasty procedure. CT and MRI after arthroplasty can be used to define the integrity of the medullary canals of the forearm bones, document the extent of static displacement of the remaining ulna, and help delineate the role of tenosynovitis, carpal necrosis, intercarpal arthrosis, implant loosening, and infection, although artifact can limit interpretation of these studies. If physical examination reveals decreased sensibility and grip strength weakness that is suggestive of pathology more substantial than pain limitation, electrodiagnostic testing will help identify the extent and location of any nerve injury, as well as help differentiate weakness secondary to nerve injury.

Principles of Management

The overall treatment of a failed DRUJ arthroplasty must be inclusive of all pathology and comprehensive in addressing each specific pathology. The six zones (nerve, tendon, adjacent arthritis, impingement, implant complication/instability, and infection) allow a formulaic pattern of examination and framework for thoughtful treatment of this patient population. The final intervention should incorporate treatment targeted at each contributing pathology. Except for isolated tendon or nerve problems, there are limited surgical options for revision arthroplasty. Functional status and physical demands are the critical factors in formulating and suggesting treatment plans to the patient.

For low-demand patients, our first option is always nonoperative treatment. We use mild analgesics, bracing that limits forearm motion and accommodative strategies to palliate pain. In particular, we teach patients to avoid pronation and supination movements while holding anything heavier than a 2-kilogram weight, as this is the most common instigator of pain. Revision DRUJ procedures, although possible, are discouraged in low-demand patients because of the associated loss of independence during recovery, especially activities of daily living, as well as the increased risk of immediate postoperative complications necessitating prolonged immobilization.

In general, higher-demand patients are more clinically challenging secondary to the higher expectations and anticipated ongoing use of the extremity. In higher-demand patients with a failed ulnar head resection, options include further ulnar shortening or soft tissue interposition arthroplasty. Wolfe et al. advocated further shortening of the ulna to minimize distal impingement. In their study, they reported substantial pain relief, though admittedly with persistent proximal impingement and volar-dorsal translation [18]. Garcia-Elias et al. have suggested that extensive ulnar resection risks further destabilization of the ulna by further resecting the interosseous ligament and increasing reliance on dynamic secondary stabilizers [19]. Perhaps for this reason, further reports of wide resection of the ulna have not been repeated in the literature. Soft tissue interposition arthroplasty as advocated by and eponymously named for Sotereanos, which entails complete ulnar head resection and placement of allograft between the radius and ulna, has been advocated as a method to provide a physical barrier between the radius and ulna which simultaneously tensions the interosseous ligaments conferring increased stability to the ulna [20]. As a primary intervention, this procedure is effective in alleviating pain, with greater than 80% of patients reporting significant reduction in pain related to impingement in the early postoperative period [21–24]. However, results in the setting of previous resection arthroplasty demonstrate less reliable pain relief and improvement of overall function [23, 24].

In the setting of high-demand patients with failed previous arthroplasty, one would anticipate simple resection arthroplasty and procedures which do not recreate the stability of the distal radioulnar joint DRUJ to be prone to failure. Regardless, we always discuss nonoperative management. Depending on the degree of dysfunction and the patient's specific goals for functional improvement, satisfying expectations may not be possible. This can be a difficult discussion of realistic goals, and the treating provider has a responsibility to clarify and temper appropriate expectations. We often encourage patients in this population to think critically about their willingness to curtail activities that place high demands on the extremity and prolong nonoperative management for as long possible. We often do our best to remember and convey that there is no situation which cannot be made worse with operative intervention.

Admittedly, this high-demand group is often resistant to living with dysfunction and unwilling to make dramatic, lifelong changes in activities or occupation. There are two procedures that we consider in this setting. The first is the previously described Sotereanos procedure, which uses a large interposition allograft as a spacer and interosseous membrane (IOM) tensioning device [20]. In this procedure, a large bulk allograft is secured with suture anchors placed between the radius and the ulna. With a 14-year follow-up, the initial reports presented by Sotereanos et al. are promising [24]. We use this technique in young patients with the anticipation that when it fails, the procedure can be repeated or revised with a semi-constrained arthroplasty. It is tempting to envision interposition arthroplasty as "no bridges burned," but additional surgeries always carry potential for complications. The durability of interposition arthroplasty in the setting of previously performed and now failed arthroplasty is not well-known, yet this remains a consideration for appropriately selected patients who may be very young or unwilling to accept an arthroplasty procedure.

The second procedure considered for high-demand patients with failed previous arthroplasty is revision to semi-constrained arthroplasty as advocated by Scheker [11]. Revision to a semi-constrained arthroplasty is the preferred definitive intervention as it most closely recreates the normal dynamic motion of the forearm. Patients report a forearm that feels essentially normal to them [10, 11]. While the manufacturer recommends restrictive life-long weight limits and activity restrictions, patients routinely exceed these and use the extremity normally [7, 8, 11]. This surgical option is highly attractive to patients who have been severely limited and for whom expectations include returning to vocations and hobbies that require dynamic pronation and supination of both hands. Technically this is accomplished with revision utilizing longer ulnar stems or impaction grafting for bone loss in the ulnar diaphysis (Fig. 12.5).

For cases in which there is extensive bone loss, deformity that cannot be corrected, an infection that cannot be cleared, or an occupation that places heavy load on the extremity, we recommend creation of a single bone forearm (Fig. 12.6). This is particularly suited for the patient who presents with pain throughout the range of motion of the DRUJ and has gross multiplanar instability and an occupation or geographic location that precludes the necessary therapy, follow-up, or restrictions associated with interposition or semi-constrained arthroplasty. As such, the only option for pain relief is a one bone forearm. This is a hyper-select group of patients which is definitively not well captured in the literature. In general, patient function after creation of a one-bone forearm is adequate and satisfaction only moderate [7, 25]. However, our experience suggests that for the appropriately selected patient, this is a very reliable option that is well tolerated with acceptable outcome from the perspective of both patient and physician.

Fig. 12.5 Revision of a prior failed ulnar head hemiarthroplasty to a semi-constrained Aptis-Scheker arthroplasty with 8 years of follow-up

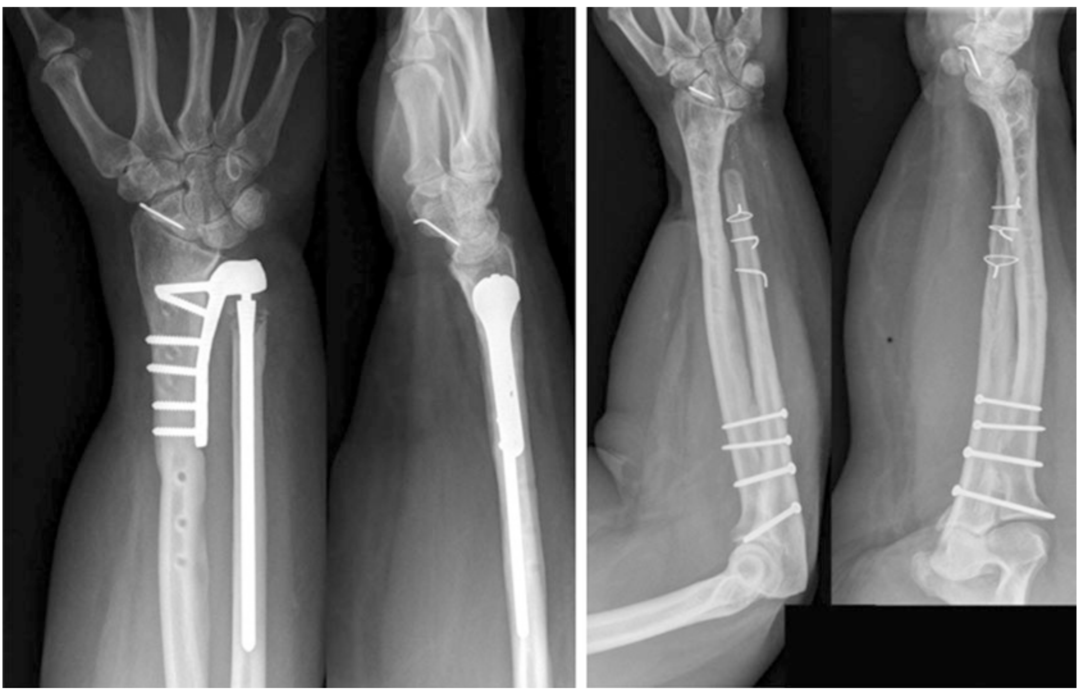

Fig. 12.6 Creation of a single bone forearm in the setting of bone loss and infection

Treatment Algorithm by Zone of DRUJ Pathology

Zone 1: Nerve

Nerve injury and the resultant neurogenic pain can negate an otherwise acceptable DRUJ arthroplasty and result in profound dysfunction. The DCBrUN travels in the subcutaneous tissue as it traverses the ulnar neck and head from proximal volar to distal dorsal. This passage makes it prone to transection when the DRUJ is approached through a skin incision along the subcutaneous border of distal ulna, as well as by traction injury when the dorsal skin flaps are elevated to expose the DRUJ. The incidence of nerve injury with this approach is not well defined. While the original descriptions of DRUJ approaches for reconstruction do not mention neurologic injury, recent articles have reported a frequency of nerve complications that is not insignificant [7, 26–28].

Palliating neurogenic pain may be all that is needed to salvage a "failed reconstruction." If present, it is critical to address neurogenic pain to optimize outcome even in the setting of other contributing pain generators. The relative contribution of an injured nerve to the patient's pain can be estimated using a diagnostic injection of local anesthetic. The response to injection should be assessed with regard to pain as well as functional improvement. If the diagnostic injection is accompanied by return to normal function, however transient, then addressing the nerve injury alone may be sufficient. If not, then the additional causes of pain must be addressed. If the pain is significantly improved with the injection, then directed treatment is first predicated upon the length of time from injury. Observation should be recommended if the patient presents within 3 months of their last procedure or time of nerve injury, as many nerve-related symptoms in this time period are neuropraxic in nature and will resolve spontaneously [8]. Additionally, nonoperative management in the form of structured and supervised desensitization should be undertaken. If the injury is greater than 3 months old and nonoperative desensitization has failed to improve symptoms, then operative intervention is warranted.

Operative intervention for DCBrUN dysfunction entails thorough neurolysis and consideration of nerve wrapping with vein grafts, collagen conduits, or silicone sleeves. These wraps are well described in treatment of peripheral neuritis and treatment of neuromas in continuity. However, benefits specific to traumatic neuritis of the DCBrUN have not been reported, and our personal experience has not demonstrated appreciable benefit [7]. Our preferred treatment is neurolysis and neurectomy, with implantation of the transected free nerve end into an adjacent muscle belly, namely, the ECU or FCU, as has been described for painful neuromas of the sensory branch of the radial nerve (Fig. 12.7) [29].

Zone 2: Tendon

Tendon-related problems can include tenosynovitis, tendonitis, adhesions, and tendon subluxation. Resection of the ulnar head can be associated with irritation of the ECU, though it has been noted infrequently after placement of a bipolar, semi-constrained, modular implant such as the Aptis DRUJ prosthesis (Aptis Medical, Glenview, KY) [7, 10, 26, 27]. The discomfort can be substantial and sufficient to compromise an otherwise good result. The common clinical finding is a painful ECU tendon as it translates over ulnar head component of the prosthesis. Swelling of the ECU tendon may be noted but a fulminant tenosynovitis rarely occurs. The diagnosis is readily confirmed with relief after injection of local anesthetic adjacent to the tendon

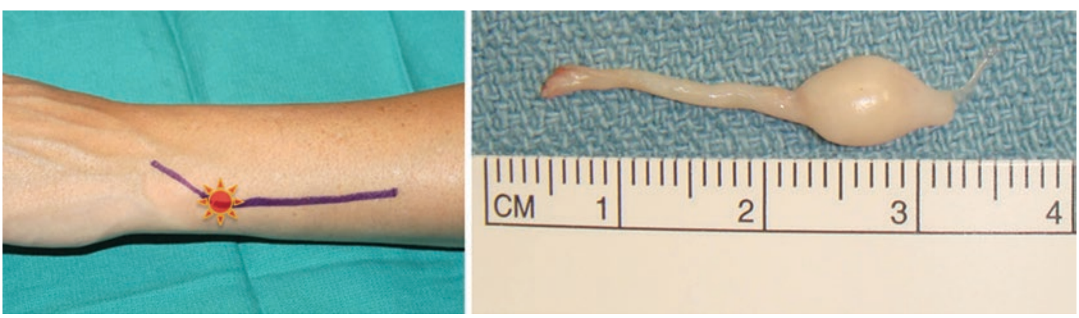

Fig. 12.7 Painful neuroma of the dorsal cutaneous branch of the ulnar nerve that was treated with neurolysis, neurectomy, and implantation of the free nerve ending into the adjacent muscle belly

and ulnar head component. Ultrasound may also be helpful in demonstrating inflammation about the tendon and/or subtle subluxation. Treatment is surgical with stabilization of the ECU with capsular interposition to prevent the ECU tendon from gliding over the bare metal of the ulnar head component (Fig. 12.8). Despite this direct irritation of the ECU, tendon rupture has not been reported.

The developers of this implant recognized this potential problem and recommend that an ulnar based flap of extensor retinaculum be elevated in the exposure of the joint and then placed between the ulnar head component and the ECU tendon at the time of initial arthroplasty. When this device is being used to salvage a previous DRUJ resection, the scar formed by prior surgery may prevent the retinacular flap from being raised [27]. In this case, the DRUJ is reconstructed with the Aptis prosthesis, tenolysis of the ECU is performed, and a dermoadipose graft is harvested from the groin and interposed between the prosthesis and the tendon (Fig. 12.8).

Tenosynovitis of the extensor digiti communis (EDC) tendons has been reported after successful DRUJ reconstruction with the Aptis prosthetic. The frequency of this complication is unknown. In one such case, fascia lata allograft was interposed with resolution of symptoms [26].

Zone 3: Adjacent Joint Arthritis

The wrist includes numerous local articulations with propensity for degenerative change which can complicate the evaluation of a painful DRUJ. The radiocarpal, midcarpal, and pisotriquetral joints are not uncommonly degenerative, especially in situations where the degree of degeneration and dysfunction of the DRUJ has

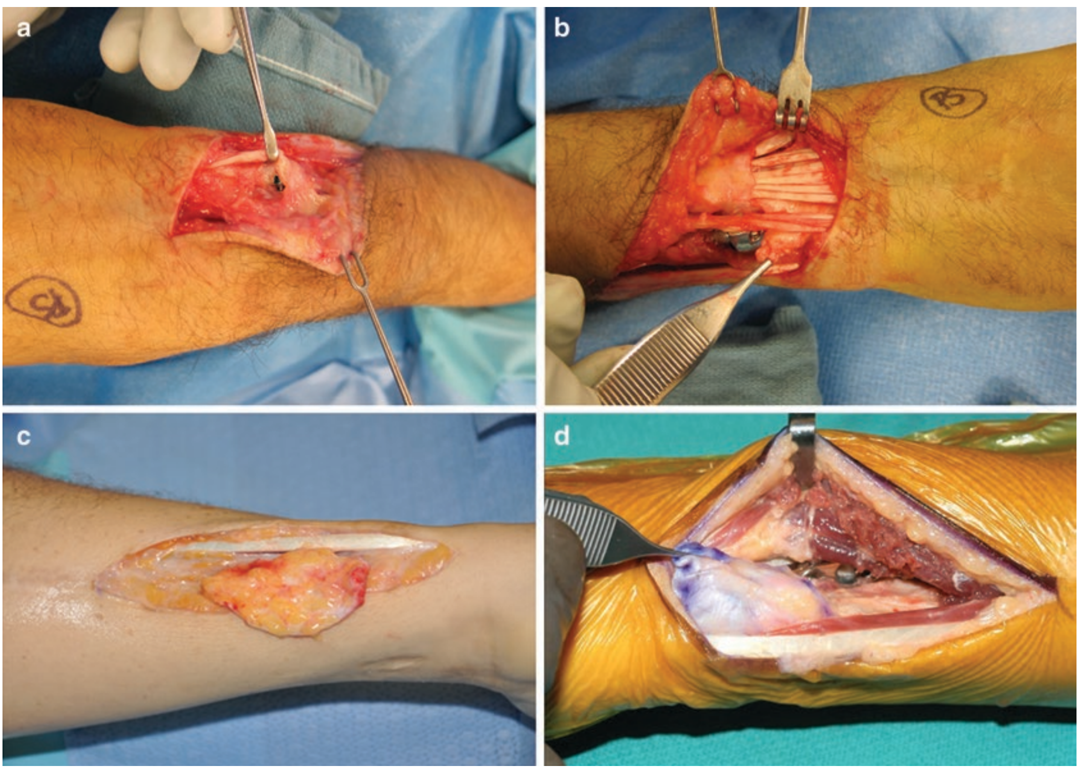

Fig. 12.8 The ECU tendon can glide over the bare metal of the ulnar head component (**a**). In these cases, this can be treated with an ulnar-based flap of the extensor retinaculum (**b**) or a dermoadipose graft (**c**). It is currently recommended to use an ulnar-based extensor retinaculum flap at the primary operation (**d**)

become so severe as to necessitate at least one if not multiple arthroplasty attempts. It underscores the critical need to assess the specific pain complaints of the patient and correlate that pain to both in the history and physical exam.

Radiocarpal arthritis is often diagnosed with localization of pain to the radial side of the wrist and reproduction of pain with wrist flexion and extension. This can be managed in similar fashion to radiocarpal arthritis in the absence of a DRUJ arthroplasty. A similar approach can be undertaken with midcarpal arthritis. With regard to pisotriquetral arthritis, compression of this joint is painful on exam, and tangential shearing force reproduces discomfort that is limiting for the patient. This can be addressed with pisiform excision with reliable relief of pain [27].

Elbow arthritis, specifically with involvement of the PRUJ, can play a role in upper extremity limitation and pain. Physical exam of the elbow and proximal localization of pain with attempted pronation and supination can identify potential contributing pathology from these proximal articulations. Treatment is indicated in similar fashion to patients without DRUJ arthritis, but it remains critical to appreciate the role that these limitations can play on overall dysfunction of the extremity, especially in consideration of radial head resection.

Zone 4: Impingement

Impingement can occur in the dorsal-volar direction, often described as translational, as well as in the radial-ulnar direction, described as impingement. Impingement of the radius and ulna after resection is inevitable with the loss of the distal radioulnar articulation, as in the setting of resection arthroplasty [18, 22, 30]. However, this impingement does not always translate to pain and dysfunction, emphasizing the importance of correlating physical exam and imaging findings with clinical complaints. Common complaints include the inability to perform gripping activities or lift anything with the hand of the affected extremity. Often these patients report using their forearm as a hook to carry objects such as grocery bags to avoid compressive forces across the DRUJ. They may also report performing activities with the wrist locked in full pronation or full supination. The degree of pathology can easily be identified with weighted radiographic evaluation, but this must be correlated with replication of pain and dysfunction with compression on physical exam [13, 14, 22].

Treatment of impingement is targeted at supporting the resected ulnar stump. Numerous procedures have been described to support the distal ulna and resist translational instability, often involving use of slips of the ECU or FCU for dynamic support and recreation of forces resisting excessive motion in the sagittal plane. Unfortunately, these procedures have not demonstrated durable long-term correction of ulnar stump instability, and recurrent translation or impingement occurs in the majority of cases when followed for greater than 5 years [31, 32].

Direct support of the ulnar stump can be accomplished with a physical barrier between the two bones which resists direct compression of the ulnar head against the radius and additionally tensions the interosseous ligaments supporting the translation of the ulnar stump in all planes in the form of a Sotereanos procedure [21, 22, 24]. However, the definitive treatment for instability in both the volar-dorsal and radioulnar planes is recreation of the distal radioulnar joint articulation by insertion of a semi-constrained implant [11]. This stabilizes the ulnar stump and prevents painful impingement by buttressing the ulnar diaphysis against the ulnar cortex of the radius.

Zone 5: Implant Complications

A well-functioning DRUJ prosthesis is dependent on numerous aspects of implantation technique as well as design of the implant itself. Older generation implants suffered from significant flaws that led to progressive loosening or disengagement of the radial plate from the ulnar head [11]. Modern implants appear to have solved these early design flaws, and results demonstrate revision-free survival of greater than 95% at 5 years [7, 10, 28].

The technique of implantation is dependent on appropriate imaging as the primary determinant of alignment and center of rotation. Inappropriately aligned implants (with center of rotation deviated from the true center of the previous ulnar head) lead to continuous translational force and painful stress along the ulnar implant and the radioulnar articulation. This can lead to progressive loosening, cortical erosion, or stress reaction along either the ulnar cortex or radial plate [7]. In addition to stress reaction related to inappropriate alignment, the rigidity of the implant itself can lead to stress risers and potential stress fracture. The rigid medullary canal filling implant which abruptly ends in the middle of the ulnar diaphysis and rigid radial plate ending in the diaphysis of the radius represent stress risers. With significant impact loading, radial stress fractures may occur as early as within the first 6 weeks of the primary procedure, even when the proximal most screw is deliberately unicortical to minimize the stress riser [7].These can be treated with compression plating (Fig. 12.9).

Zone 6: Infection

In the setting of multiple surgeries and certainly with implant arthroplasty, infection must always be a consideration. The highly vascular nature of the upper extremity relative to other privileged joint sites potentially makes upper extremity arthroplasty more vulnerable to hematogenous spread [7]. For this reason, we routinely recommend prophylaxis to patients with DRUJ arthroplasty undergoing invasive or dental procedures for their lifetime, similar to multiply revised lower extremity arthroplasties [33].

When examining a previous arthroplasty, the soft tissues and images are thoroughly scrutinized for reactive changes suggestive of infection. The interview is aimed at a thorough understanding of any delayed healing or postoperative wound complications that could suggest indolent infection. If any lucency, erosion, or widening around the implant is noted on the images, especially if there is a history of wound complications or concerns with the soft tissue exam such as erythema or chronic swelling or there is unexplained pain in the setting of an implant which is localized to the DRUJ, then screening labs are obtained. We routinely obtain a complete blood count with differential, erythrocyte sedimentation rate, and C-reactive protein. If the serologic exam is abnormal, clinical exam or history is highly suggestive, or no other explanation for ongoing pain can be found, we perform open tissue biopsy. This is performed as an independent procedure such that chance for propagating low-grade infection to revision implants is minimized.

Treatment is dependent on function, level of pain, and patient-specific factors. Resection of implants with antibiotic spacer placement and a 6-week course of intravenous antibiotics is the

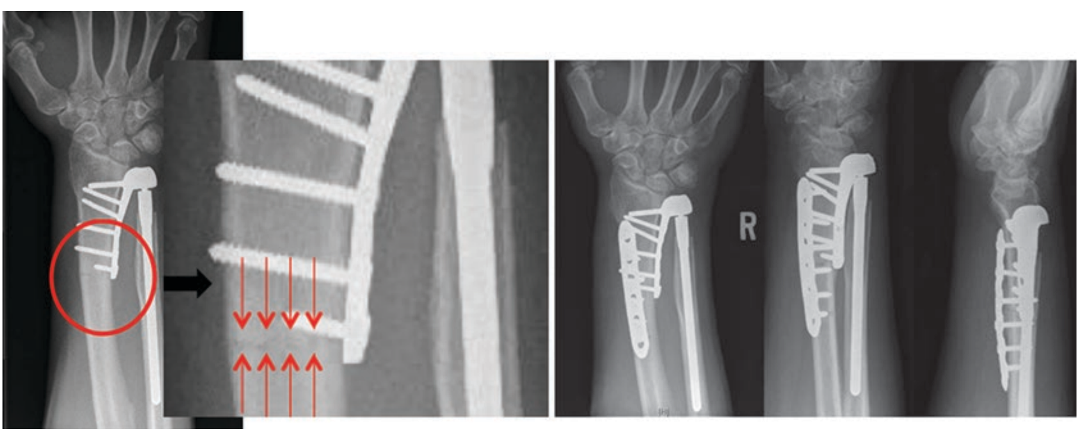

Fig. 12.9 Radius stress fractures can occur with impact loading and can be treated with compression plating

Fig. 12.10 Case example of a DRUJ arthroplasty that became infected after a routine dental procedure. The patient was treated with implant resection and antibiotic spacer placement with a six-week course of intravenous antibiotics, followed by revision implantation

standard of care for an acute infection. Revision to new constrained implant can be considered once infection has been thoroughly treated (Fig. 12.10). Lifelong suppression with antibiotics can also be considered for those patients who cannot undergo a two-stage procedure related to underlying medical status, soft tissue, and/or bone stock concerns.

Conclusion

DRUJ dysfunction alone is a challenging problem to address. Patients with previous DRUJ arthroplasty and persistent pain and dysfunction are a complex patient population with limited options for management. A thorough and holistic evaluation of all aspects of the patient and extremity are critical for successful treatment. We propose framing this evaluation in six interrelated zones to identify less obvious potentially contributing pathology. Treatment is then designed based on patient-specific factors such as level of demand and the quality of the tissues, with mindfulness to include all relevant pathology identified in careful consideration of each of the six zones. The outcomes for this group are difficult to articulate due to the extreme heterogeneity and rarity of these patient encounters, even at tertiary referral centers. However, careful evaluation and cognizance of patient goals with grounded and realistic management of expectations can yield high patient satisfaction despite the enormous challenge of tackling these complex clinical scenarios.

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