Primary Distal Radioulnar Joint Arthroplasty

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Introduction

The distal radioulnar joint (DRUJ) plays a key role for upper extremity function, including forearm rotation, forearm and wrist stability, and transmission of load across the wrist. The minimal osseous constraint provided by the sigmoid notch increases the risk for DRUJ instability and likely contributes to developing osteoarthrosis and post-traumatic arthrosis. Distal radius fractures often involve the sigmoid notch, which can disrupt joint conguity leading to instability and abnormal articular contact stresses. Madelung's deformity and other congenital conditions can severely affect the congruity and alignment of the joint leading to degenerative changes. Because the joint has robust synovium, it is also susceptible to inflammatory arthritis. A variety of surgical techniques are described for the treatment of arthritis, ranging from ablation using the Darrach procedure for low-demand patients to anatomic reconstruction with joint replacement to maintain a more natural function. The aim of this chapter is to review the role of primary arthroplasty in the management of DRUJ arthritis.

Anatomy

The sigmoid notch of the radius is shallow and has a much greater radius of curvature than the ulnar head, resulting in little inherent stability [1]. Joint geometry provides approximately 20% of the DRUJ stability, leaving the surrounding soft tissues responsible for the vast majority [2]. The triangular fibrocartilage complex (TFCC) is located between the carpus and distal ulna, being comprised of the radioulnar ligaments, articular disc, meniscus homolog, ulnocarpal ligaments, and the extensor carpi ulnaris (ECU) subsheath (Fig. 11.1). The TFCC provides both ligamentous functions for wrist and forearm stability and transmits substantial axial load between the carpus and forearm as well as sagittal loading during lifting [3].

DRUJ stabilizers can be described as extrinsic or intrinsic in relation to its capsule. Extrinsic stability is provided dynamically by the ECU tendon and pronator quadratus, while the distal interosseous membrane (IOM) and ECU subsheath provide static constraint [4]. The stout radioulnar ligaments, which comprise the volar and dorsal margins of the TFCC, are the most important intrinsic soft tissue stabilizers [5]. Each radioulnar ligament includes a superficial

Supplementary Information The online version of this chapter (https://doi.org/10.1007/978-3-030-68880-6_11) contains supplementary material, which is available to authorized users.

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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_11

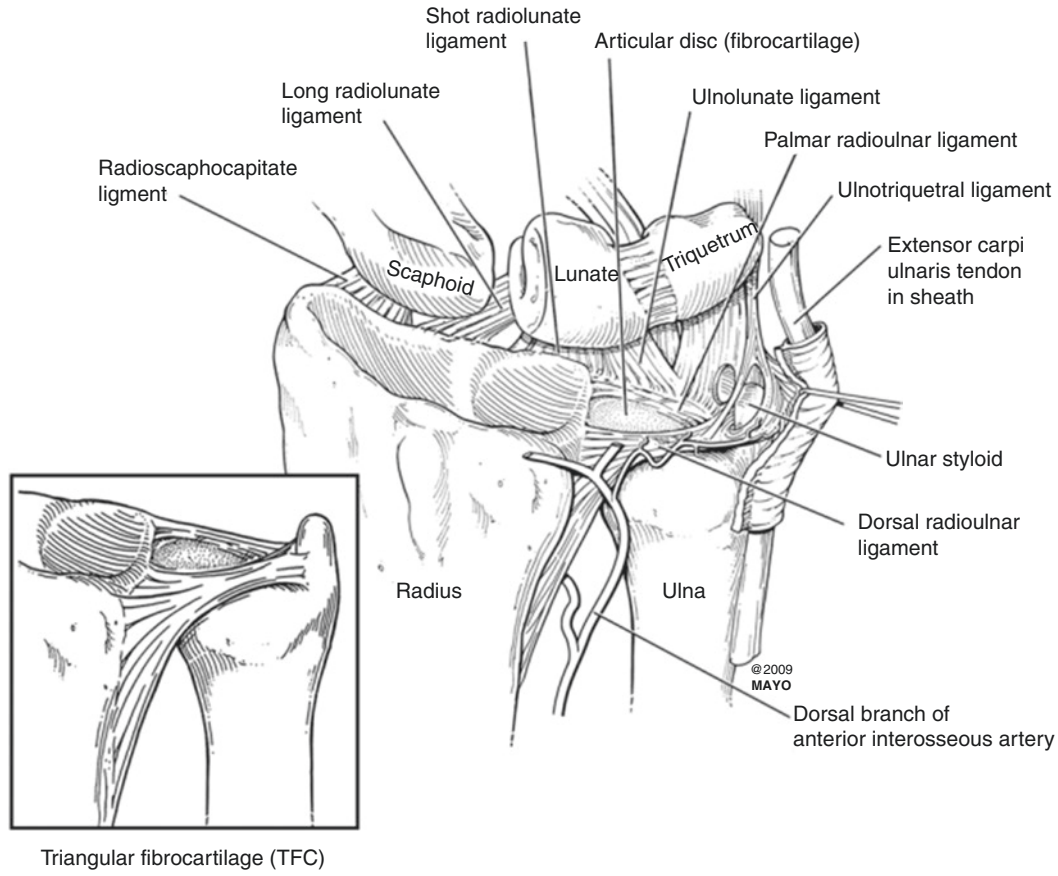

Fig. 11.1 Anatomy of the TFCC and soft tissue stabilizing structure: many operations involving the ulnar head sacrifice, stabilize, or preserve the structures of the TFCC. (Reproduced with permission from Carlsen et al. [31])

and deep component. The deep fibers (ligamentum subcruentum) attach to the fovea, through which the axis of forearm motion passes.

Causes of Arthritis

The DRUJ is susceptible to both osteoarthrosis and post-traumatic arthrosis. Distal radius fractures extending into the sigmoid notch can cause chondral damage or create an articular step-off resulting in degeneration. Malunion of either the distal radius or the ulna can substantially alter joint contact resulting in degeneration (Fig. 11.2). Similarly, forearm fractures in children can lead to growth disturbances and subsequent arthrosis. Congenital conditions, such as Madelung's deformity, may present with delayed arthrosis due to altered joint loading. The DRUJ is particularly susceptible to cartilage and ligamentous damage caused by chronic synovitis from rheumatoid arthritis and other inflammatory conditions.

Diagnosis (Physical Examination and X-ray)

The onset of symptoms caused by DRUJ arthrosis is often gradual over a course of years and may not be apparent until an aggravating injury or over-use event occurs. The physical examination starts with inspection of both wrists to detect asymmetry at resting posture. An asymmetrical, prominent ulna indicates possible instability, malunion, or inflammatory arthritis. Precise

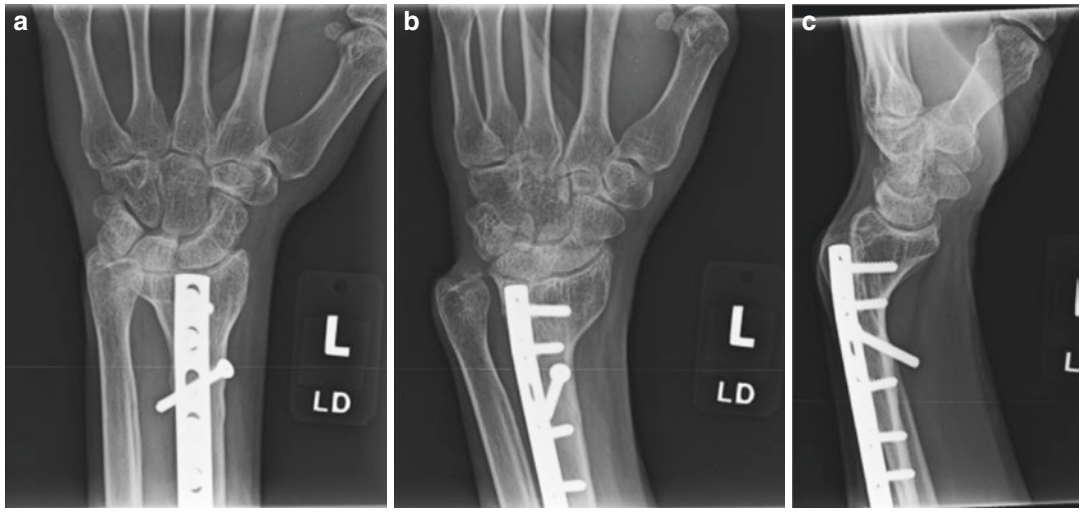

Fig. 11.2 Distal radius malunion following fixation showing DRUJ instability and arthritis. Lateral, oblique, and posteroanterior X-rays of the patient illustrated in Video 11.1

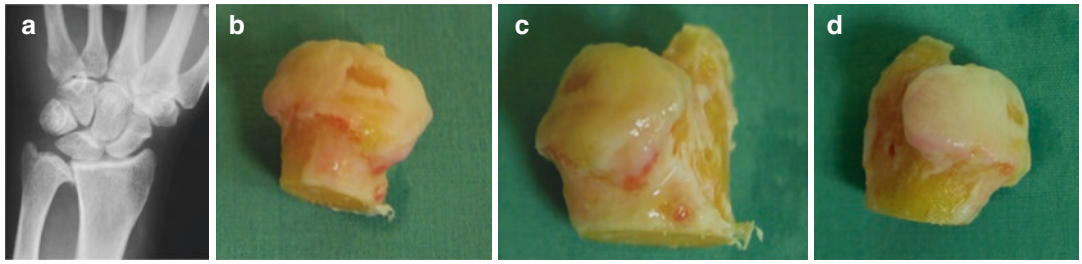

Fig. 11.3 Radiograph shows joint space narrowing, osteophytes, and sclerosis consistent with DRUJ arthritis. Clinical photographs show eburnation of cartilage and osteophytes of the ulnar head

palpation can isolate tenderness involving the ECU tendon sheath, the ulnar styloid, or the fovea. TFCC injury, ECU tendonitis or subluxation, and ulnar impaction are not mutually exclusive. Pain and crepitus are commonly elicited during rotation, especially when combined with manual joint compression. DRUJ instability is typically confirmed by finding increased translation of the ulna relative to the radius during manipulation of the joint in multiple positions; however, this must be compared to the contralateral side to confirm the laxity is pathologic. In performing this maneuver, the ulnar should be grasped proximal to the DRUJ to avoid misinterpreting joint pain for pain caused by joint translation. The modified press test described by Adams can demonstrate dynamic volar instability [6] (Video 11.1).

Imaging studies are an adjunct to a careful history and physical examination. Plain X-rays will show sequelae of arthrosis, such as joint space narrowing, sclerosis, subchondral cysts, and osteophytes (Fig. 11.3). Malunion, DRUJ subluxation, and other pathology may also be seen. CT will further delineate articular congruity, joint deformity, and arthrosis, which is most useful when including the contralateral wrist in mirrored and multiple positions. MRI is most useful for soft tissue pathology including TFCC integrity, but can also show signs of arthrosis and subluxation.

Treatment

Initial management can be nonsurgical, especially when instability, pain, and/or arthritis is mild, and includes activity modification, strengthening exercises, anti-inflammatory drugs, brace support, and possible limited or intermittent immobilization. While it is appropriate to begin with nonsurgical treatment, these methods typically have variable and often limited long-term success. There are three broad categories of surgical treatment, with technical variations in each category: partial or complete resection of the distal ulna (hemiresection with soft tissue interposition or the Darrach procedure), arthrodesis of the DRUJ with ulnar neck resection (Sauve-Kapandji procedure), and partial or complete arthroplasty (ulnar head replacement or total DRUJ replacement).

Surgical Exposure

Perhaps the most utilitarian approach to the DRUJ is dorsally through the fifth extensor compartment or between the fifth and sixth extensor compartments, with preservation of the radioulnar ligaments and other TFCC components. Alternatively, particularly for revision surgery or severe trauma, a lateral approach can be made in the interval between the ECU and flexor carpi ulnaris (FCU). In either approach, the dorsal sensory branch of the ulnar nerve is protected. For the dorsal approach, a 4–6 cm skin incision is made between the fifth and sixth extensor compartments, extending proximally from the level of the ulnar styloid (Fig. 11.4a). The fifth compartment is opened, except for its distal portion, and the extensor digiti minimi (EDM) tendon is retracted.

An ulnar-based rectangular-shaped flap is created in the DRUJ capsule, beginning just proximal and parallel to the dorsal radioulnar ligament, continuing along the dorsal rim of the sigmoid notch leaving a small cuff, and then extending over the ulnar neck (Fig. 11.4b). Care is taken not to cut the dorsal radioulnar ligament (Fig. 11.4c). Retraction of this flap exposes the articular surfaces of the distal radioulnar joint and the proximal surface of the TFCC (Fig. 11.4d). The integrity of the TFCC is assessed. Unless greater

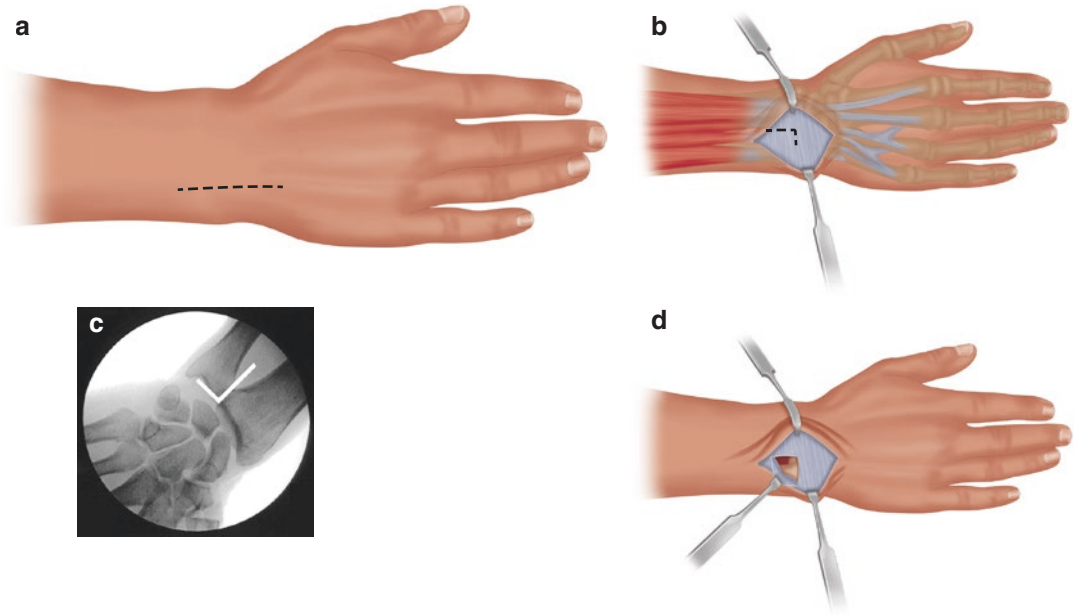

Fig. 11.4 Surgical exposure: (**a**) incision overlying the septum dividing the fourth and fifth extensor compartment. (**b**) An L-shaped or rectangular flap is designed in the DRUJ capsule. (**c**) The transverse limb of the capsular flap is proximal to the TFCC to preserve the radioulnar ligaments. (**d**) Retraction of the flap allows visualization of the DRUJ and ulnar head. (Reproduced with permission from Integra LifeSciences, Princeton, NJ)

exposure is needed, the ECU sheath should not be opened or elevated from the ulnar groove, as preserving the sheath will maintain its important stabilizing function for the ulnocarpal joint. At completion of the bony procedure, the dorsal DRUJ capsule and retinaculum are closed together with only slight imbrication to avoid loss of motion. The EDM is left subcutaneous. The technique for constrained total DRUJ replacement requires a more extensive exposure and dissection.

Surgical Treatment: Resection Arthroplasty

Distal Ulna Resection Arthroplasty (Darrach)

Distal ulna resection was described by Darrach in 1912 [7]. The procedure was widely used for chronic instability and arthrosis before the indications were refined. The entire ulnar head is removed while preserving the surrounding soft tissue envelope (Fig. 11.5). The ulnar head is resected just proximal to the sigmoid notch with a slightly angled osteotomy to help preserve more soft tissue. Sharp edges are removed with a file or rongeur to reduce potential adjacent tendon wear, particularly the ECU and EDM tendons. Prono-supination is performed to assess stump stability. The volar DRUJ capsule can be sutured to the ulnar stump using transosseous sutures and the dorsal capsule imbricated during closure to improve stability.

If the ulnar stump is prominent or demonstrates substantial instability during forearm rotation, then additional stabilizing techniques can be used. Common methods use strips of the ECU and FCU tendons secured to the ulna by means of bone tunnels or suture anchors [8]. Another technique uses the pronator quadratus (PQ) as an interposition and stabilizer by suturing it to the ulnar stump or dorsal capsule.

Tendon allograft interposition provides more bulk to reduce the problem of radioulnar impingement. One technique uses an Achilles tendon allograft that is folded to create a large buffer between the radius and ulna and sutured to each bone to add stability [9]. Long-term follow-up has shown satisfactory results, particularly as a salvage technique for failed distal ulna resections [10]. Tendon transfers and allografts have also been used to augment DRUJ stability during revision surgery for complications following ulnar resections and implant arthroplasty [11, 12].

Fig. 11.5 Ulnar head resection arthroplasty (Darrach): radioulnar convergence has resulted in impingement by the ulnar stump and scalloping of the adjacent radius

The Darrach procedure yields satisfactory results in the low-demand patients [13, 14]. Younger or more active patients may continue to have painful clicking, instability, and weakness that are associated with radioulnar convergence as evidenced by scalloping on X-rays (Fig. 11.5) [15].

Partial Distal Ulnar Head Resection (Hemiresection Arthroplasty)

The classic hemiresection arthroplasty procedure involves resection of the articular portion of the distal ulna with preservation of the surrounding soft tissues, including the TFCC, for stabilization. Bowers described resection of a portion of the head including the articular surface combined with tendon interposition and capsule reconstruction [16]. The technique is commonly referred to as the hemiresection interposition arthroplasty or HIT procedure. Although initially described for treatment of rheumatoid arthritis, the procedure has been used for all types of arthritis.

A rounded contouring of the distal ulna is done to match the obliquity of the sigmoid notch while preserving the TFCC attachment to the ulnar styloid (Fig. 11.6). Ulnocarpal impingement between the remaining ulnar styloid and the triquetrum can be a problem, particularly with positive ulnar variance; a shortening osteotomy through the remaining ulnar head may be necessary [17].

Sauve-Kapandji Procedure

When there is loss of the distal radioulnar articulation, the dynamic stabilizers are unopposed. This results in convergence of the radius and the ulna, slack in the static stabilizing structures, and progressive instability. The Suave-Kapandji procedure involves arthrodesis of the DRUJ and a proximal osteotomy to allow forearm rotation (Fig. 11.7). It is an attempt to correct the aforementioned complications related to resection arthroplasty.

Early complications were attributable to nonunion and radioulnar impingement. Tenuous

Fig. 11.6 Hemiresection interposition arthroplasty (HIT) with residual stylocarpal impingement due to preoperative positive ulnar variance

Fig. 11.7 Suave-Kapandji procedure with radioulnar convergence but no radiographic signs of impingement

single-point fixation and a large segment of bone resected led to these respective complications. Current techniques use two points of fixation, most commonly with cancellous screws in compression. Ten to fifteen millimeters is resected with interposition of the pronator to prevent ossification across the gap. Fujita et al. described a modified technique to improve stability and union rate [18]. A 30 mm distal ulna segment is rotated 90 degrees and inserted into a hole created in the sigmoid notch. The objectives are to improve union and prevent ulnar translation of the wrist. Many soft tissue stabilizing procedures have been described to prevent radioulnar impingement; however, the appropriate vector to maintain separation has not been achieved [19, 20].

Surgical Treatment: Implant Arthroplasty

Total Ulnar Head Arthroplasty

Total ulnar head arthroplasty replaces the entire ulnar head including the ulnar styloid with a stemmed implant (Fig. 11.8). The technique is most commonly used for a failed Darrach procedure, but has also been used for a failed HIT procedure, ulnar head fracture, and primary treatment for rheumatoid arthritis and osteoarthritis or even in extensive trauma. Like the Darrach procedure, all soft attachments to the distal ulnar must be released. The implant relies on the surrounding soft tissue envelope for joint stability. Although preoperative DRUJ instability is usually a contraindication for primary total ulnar head arthroplasty, if used after a failed resection arthroplasty due to radioulnar impingement, there will often be sufficient scar tissue that stabilizes the ulna after implantation [21]. Moreover, radiographic and clinical instability cannot consistently be correlated to clinical outcomes [22].

In the initial technique for a total ulnar head replacement, the sigmoid notch was deepened and contoured to match the radius of curvature of the implant head to improve joint stability; however, this technique is no longer commonly performed due to the increased risk of greater sigmoid notch erosion. In fact, sigmoid notch erosion is common even if the notch is not altered, but typically stabilizes by the second year and is not consistently symptomatic [22]. Resurfacing the sigmoid notch with an implant in an unconstrained fashion did not consistently improve outcomes and was associated with joint instability. Recently, Kakar et al. used lateral meniscal allograft to create a labrum to receive the ulnar

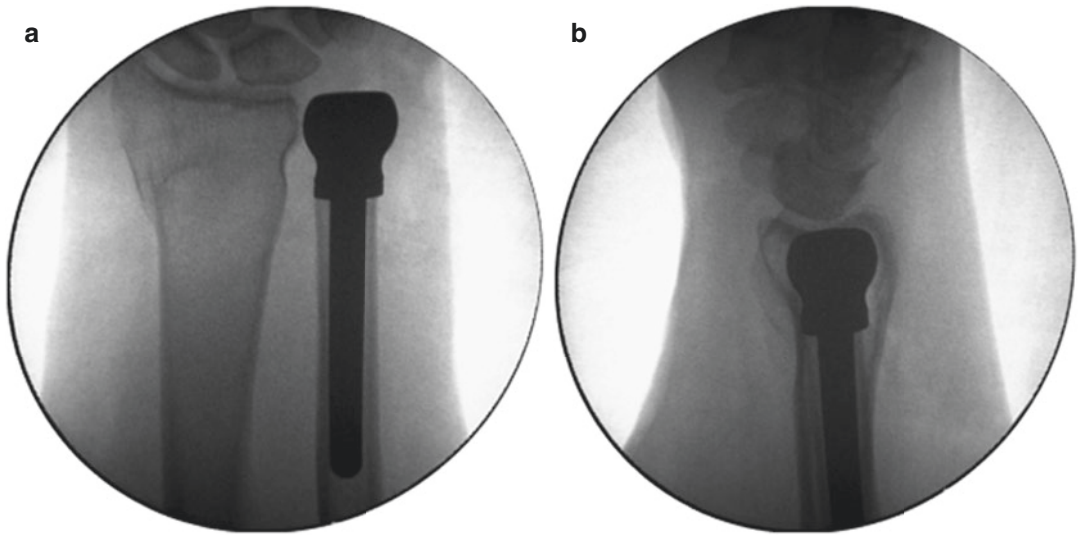

Fig. 11.8 Total ulnar head replacement

head implant [23]. While none of the four patients in this study were unstable postoperatively, only two had preoperative instability. Furthermore, the study lacked standardized outcomes, independent reviewers, objective measures of stability, patient numbers and was retrospective.

Ulnar neck resorption beneath the implant head is also common, which is likely caused by stress shielding, but this rarely causes implant loosening. Early implants with an extended collar showed higher rates of radiolucency, loosening, and subsequent failure [24]. This study also revealed that a pedestal at the proximal aspect of the implant stem results in a poor functional outcome.

Survivorship varies widely in definition, but is commonly defined as complications resulting in surgical removal. Sabo reported 90% survival in 74 patients at 5 and 15 years with an average follow-up of 7 years [25]. Patients in this study had improved patient-reported outcomes. In addition, the vast majority of patients would have the procedure again and recommend it to others. Interestingly, patients who had ulnar implant arthroplasty for post-traumatic conditions were less satisfied and had higher disability than patients who received the implant for arthritic conditions.

A systematic analysis that compiled over 150 wrists demonstrated high longevity and patient satisfaction [26]. Another systemic review found a low complication rate, and improved grip strength, pain, motion, and DASH scores [27]. While the data includes different implants from different manufacturers, implant designs are similar.

Partial Ulnar Head Arthroplasty

Isolated DRUJ arthritis without instability can be treated with a partial ulnar head replacement arthroplasty (Fig. 11.9a). The technique can be used as a primary treatment for osteoarthritis, a failed wafer resection, a failed HIT procedure, or a comminuted ulnar head fracture. Because only the articular portion of the head is resected, the kinematics of the joint are minimally altered [28]. Furthermore, modular partial head implant designs closely mimic the radiograph of an actual closely mimic the radiograph of an actual ulnar head in all dimensions. [29].

First Choice (Integra, Princeton, NJ) is the only partial ulnar head implant currently available in the USA (Fig. 11.9b–d). With this technique, the ECU tendon and its subsheath, TFCC attachment to the ulnar styloid, and ulnocarpal ligaments are preserved, which provide continued stability to the DRUJ. To insert the implant, the medullary canal is entered through the fovea and reamed to cortical contact for eventual press-fit implant fixation. A cutting jig is applied to the reamer to create a precise implant fit against the remaining head. This product is modular with three stem sizes and four head sizes.

Sigmoid notch erosion does occur, but is less than total ulnar head arthroplasty [21, 27]. Ulnar neck resorption also occurs, but did not result in implant loosening in a series of 18 patients with an average of 4.6 years of follow-up [21]. Partial ulnar head replacement lacks long-term data, but preliminary results are promising.

Semi-constrained Total DRUJ Arthroplasty

A semi-constrained, bipolar, modular DRUJ implant (Aptis Medical, Louisville, KY) was designed for the treatment of a failed Darrach procedure but later used for a variety of DRUJ conditions that include an unstable arthritic joint, particularly after failed surgery, and has also been used for primary treatment [3].

The Aptis arthroplasty replaces the DRUJ with a small ball-in-socket mechanism that provides intrinsic stability, which is supported by a radial plate and ulnar stem (Fig. 11.10). Preoperative planning estimates the size and location of the implant. A press-fit ulnar stem is selected based on the width of the medullary canal. The position of the articulation depends on

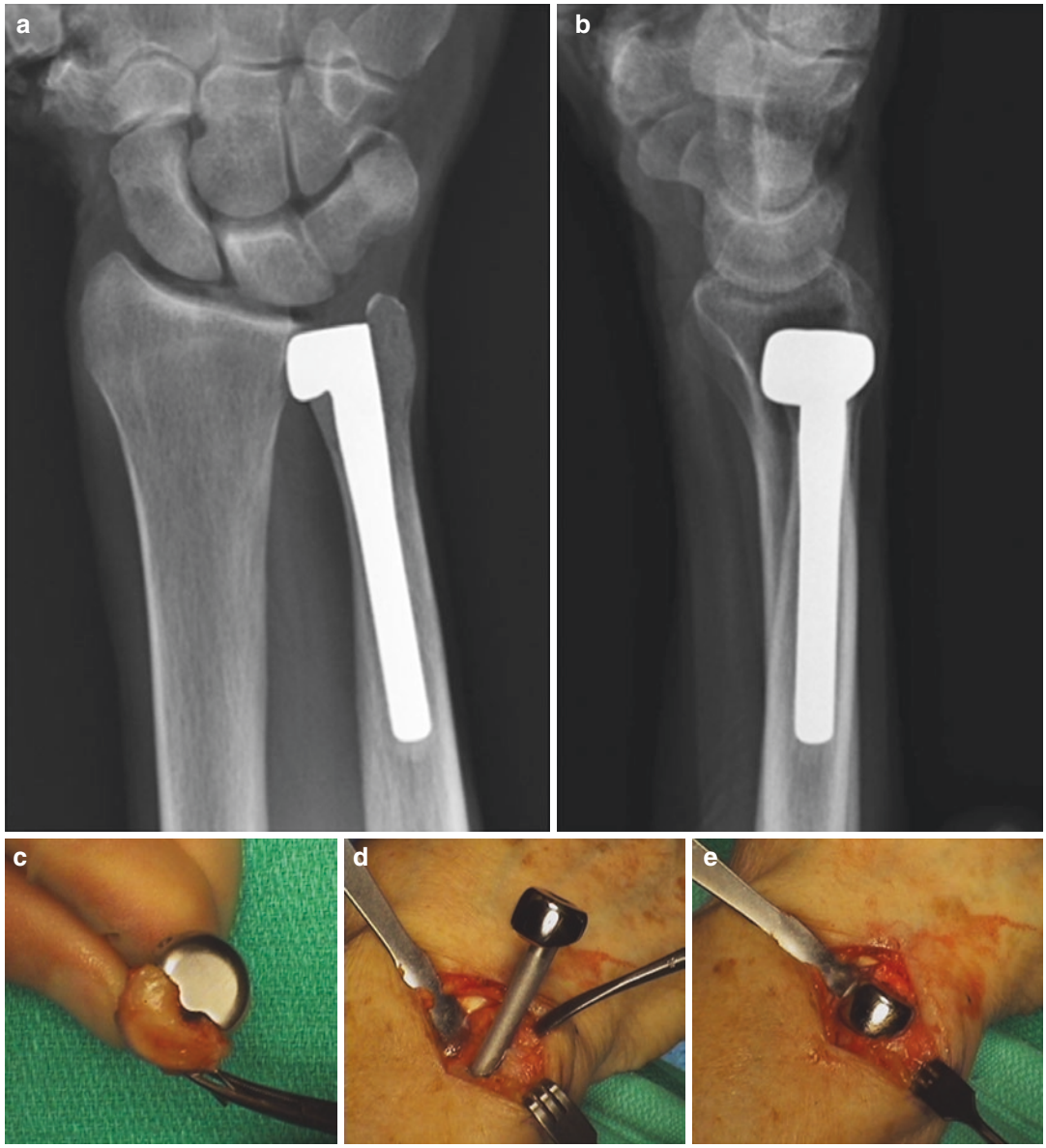

Fig. 11.9 (**a**–**e**) Partial ulnar head replacement

the condition being treated. Precise implantation is necessary to avoid potential mechanical problems and soft tissue irritation. In particular, the extensor tendons should be protected using a retinacular flap.

The majority of studies show improved motion with favorable patient-reported outcomes including pain scores [12, 27]. Because this implant is used mainly as a salvage procedure, wound healing and soft tissue complications are common [12], which are worse in patients with rheumatoid arthritis or immunosuppression. While successful in properly selected younger patients, with an implant survival rate of 96% at 5 years in one series, ECU tendonitis was a common complication [30].

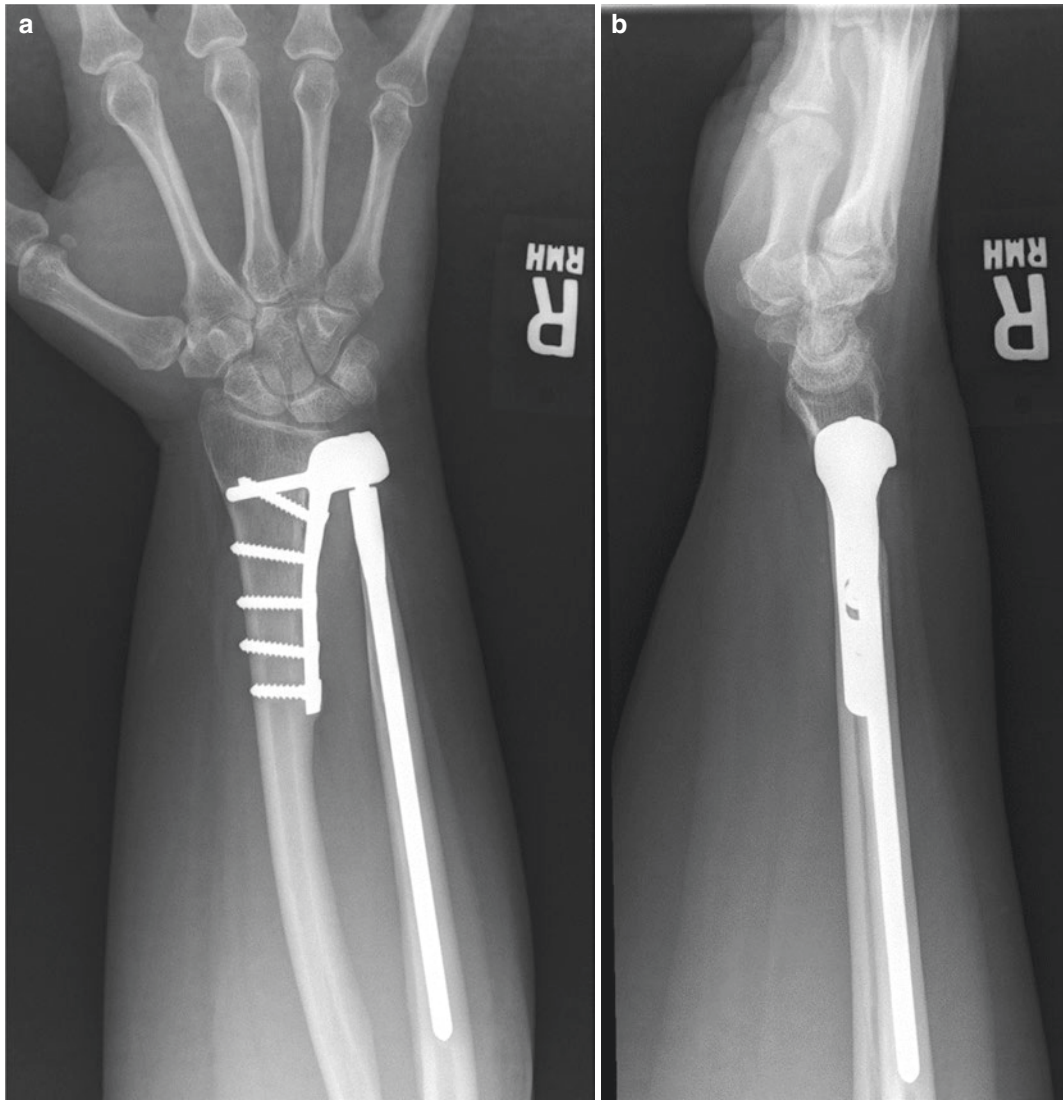

Fig. 11.10 Constrained arthroplasty

Conclusion

DRUJ arthritis can cause substantial pain and functional limitation. There are many surgical options available, ranging from resection arthroplasties to implant arthroplasties. Resection arthroplasties are complicated by instability that is most pronounced in active patients. Implant arthroplasties vary from partial ulnar head replacement to total joint replacement. Total ulnar head replacement has potentially broad indications, albeit achieving joint stability can be challenging. Partial ulnar head replacement maintains more natural joint kinetics, but has narrower indications. Total joint replacement obviates instability, but requires extensive dissection and results in more soft tissue complications. All techniques and implants have been used successfully for primary treatment and as a salvage operation.

References

1. af Ekenstam F, Hagert CG. Anatomical studies on the geometry and stability of the distal radio ulnar joint. Scand J Plast Reconstr Surg. 1985;19(1):17–25.
2. Stuart PR, Berger RA, Linscheid RL, An KN. The dorsopalmar stability of the distal radioulnar joint. J Hand Surg Am. 2000;25(4):689–99.
3. Scheker LR, Babb BA, Killion PE. Distal ulnar prosthetic replacement. Orthop Clin North Am. 2001;32(2):365–76, x.
4. Hotchkiss RN, An KN, Sowa DT, Basta S, Weiland AJ. An anatomic and mechanical study of the interosseous membrane of the forearm: pathomechanics of proximal migration of the radius. J Hand Surg Am. 1989;14(2 Pt 1):256–61.
5. Kleinman WB. Stability of the distal radioulnar joint: biomechanics, pathophysiology, physical diagnosis, and restoration of function what we have learned in 25 years. J Hand Surg Am. 2007;32(7):1086–106.
6. Adams BD. Anatomic reconstruction of the distal radioulnar ligaments for DRUJ instability. Tech Hand Up Extrem Surg. 2000;4(3):154–60.
7. Jupiter JB, Ring D. A comparison of early and late reconstruction of malunited fractures of the distal end of the radius. J Bone Joint Surg Am. 1996;78(5):739–48.
8. Breen TF, Jupiter JB. Extensor carpi ulnaris and flexor carpi ulnaris tenodesis of the unstable distal ulna. J Hand Surg Am. 1989;14(4):612–7.
9. Sotereanos DG, Göbel F, Vardakas DG, Sarris I. An allograft salvage technique for failure of the Darrach procedure: a report of four cases. J Hand Surg Br. 2002;27(4):317–21.
10. Sotereanos DG, Papatheodorou LK, Williams BG. Tendon allograft interposition for failed distal ulnar resection: 2- to 14-year follow-up. J Hand Surg Am. 2014;39(3):443–8.e1.
11. Allende C. Allograft tendon interposition and brachioradialis tendon stability augmentation in revision surgery for failed Darrach distal ulna resections. Tech Hand Up Extrem Surg. 2010;14(4):237–40.
12. DeGeorge BR, Berger RA, Shin AY. Constrained implant arthroplasty for distal radioulnar joint arthrosis: evaluation and management of soft tissue complications. J Hand Surg Am. 2019;44(7):614.e1–9.
13. Grawe B, Heincelman C, Stern P. Functional results of the Darrach procedure: a long-term outcome study. J Hand Surg Am. 2012;37(12) 2475–:80.e1–2.
14. Faucher GK, Zimmerman RM, Zimmerman NB. Instability and arthritis of the distal radioulnar joint: a critical analysis review. JBJS Rev. 2016;4(12):1–9
15. Field J, Majkowski RJ, Leslie IJ. Poor results of Darrach's procedure after wrist injuries. J Bone Joint Surg Br. 1993;75(1):53–7.
16. Bowers WH. Distal radioulnar joint arthroplasty: the hemiresection-interposition technique. J Hand Surg Am. 1985;10(2):169–78.
17. Glowacki KA. Hemiresection arthroplasty of the distal radioulnar joint. Hand Clin. 2005;21(4):591–601.
18. Fujita S, Masada K, Takeuchi E, Yasuda M, Komatsubara Y, Hashimoto H. Modified Sauvé-Kapandji procedure for disorders of the distal radioulnar joint in patients with rheumatoid arthritis. J Bone Joint Surg Am. 2005;87(1):134–9.
19. Sauerbier M, Berger RA, Fujita M, Hahn ME. Radioulnar convergence after distal ulnar resection: mechanical performance of two commonly used soft tissue stabilizing procedures. Acta Orthop Scand. 2003;74(4):420–8.
20. Bieber EJ, Linscheid RL, Dobyns JH, Beckenbaugh RD. Failed distal ulna resections. J Hand Surg Am. 1988;13(2):193–200.
21. Adams BD, Gaffey JL. Non-constrained implant arthroplasty for the distal radioulnar joint. J Hand Surg Eur Vol. 2017;42(4):415–21.
22. Axelsson P, Sollerman C, Kärrholm J. Ulnar head replacement: 21 cases; mean follow-up, 7.5 years. J Hand Surg Am. 2015;40(9):1731–8.
23. Kakar S, Noureldin M, Elhassan B. Ulnar head replacement and sigmoid notch resurfacing arthroplasty with a lateral meniscal allograft: 'calamari procedure'. J Hand Surg Eur Vol. 2017;42(6):567–72.
24. Kakar S, Swann RP, Perry KI, Wood-Wentz CM, Shin AY, Moran SL. Functional and radiographic outcomes following distal ulna implant arthroplasty. J Hand Surg Am. 2012;37(7):1364–71.
25. Sabo MT, Talwalkar S, Hayton M, Watts A, Trail IA, Stanley JK. Intermediate outcomes of ulnar head arthroplasty. J Hand Surg Am. 2014;39(12):2405–11.e1.
26. Calcagni M, Giesen T. Distal radioulnar joint arthroplasty with implants: a systematic review. EFORT Open Rev. 2016;1(5):191–6.
27. Moulton LS, Giddins GEB. Distal radio-ulnar implant arthroplasty: a systematic review. J Hand Surg Eur Vol. 2017;42(8):827–38.
28. Garcia-Elias M. Eclypse: partial ulnar head replacement for the isolated distal radio-ulnar joint arthrosis. Tech Hand Up Extrem Surg. 2007;11(1):121–8.
29. Conaway DA, Kuhl TL, Adams BD. Comparison of the native ulnar head and a partial ulnar head resurfacing implant. J Hand Surg Am. 2009;34(6):1056–62.
30. Rampazzo A, Gharb BB, Brock G, Scheker LR. Functional outcomes of the Aptis-Scheker distal radioulnar joint replacement in patients under 40 years old. J Hand Surg Am. 2015;40(7):1397–403.e3.
31. Carlsen BT, Rizzo M, Moran SL. Soft-tissue injuries associated with distal radius fractures. Oper Tech Orthop. 2009;19(2):107–18. https://doi.org/10.1053/j.oto.2009.05.003.