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ORIGINAL PAPER

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Stabilization of the ulna stump after Darrach's procedure at the wrist

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Abstract We studied the outcome of patients with chronic distal radioulnar joint symptoms who were treated with excision of the distal ulna and reconstruction using the flexor carpi ulnaris tendon. Twelve patients with 14 wrists were assessed. Ten patients were posttraumatic, and two had bilateral surgery for rheumatoid arthritis. Average age was 37 years at time of operation. Follow-up averaged 20 months (9 months to 4 years). All patients except one reported improvement in pain symptoms. Grip strength of the operated hand as measured by dynamometer readings was 67% of the strength of the normal hand with five wrists achieving an excellent result in grip strength. Eleven patients reported a subjective improvement in functional activities. An improved range of motion was obtained in all patients. We discuss the importance and basis for ligamentous reconstruction following excision of the distal ulna and review the literature for other previously described procedures.

Résumé Nous avons étudié le résultat de malades souffrant de symptômes chroniques de l'articulation radio-ulnaire distale qui ont été traité par excision du cubitus distal et reconstruction avec le tendon du fléchisseur carpien ulnaire. Un total de douze malades avec quatorze poignets ont été étudiés. Dix étaient post traumatiques et deux ont eu une chirurgie bilatérale pour polyarthrite rhumatoïde. L'âge moyen était de 37 ans à l'opération. Le suivi moyen était de 20 mois (neuf mois à quatre années). Tous les malades sauf un ont eu une amélioration de la douleur. La force de préhension, mesurée par dynamomètre, était de 67% de celle de la main normale et 5 des 14 poignets ont obtenus une force de très bonne qualité. Une amélioration de la mobilité a été obtenue chez tous les patients. Onze des douze malades ont rapporté une amélioration subjective dans les activités quotidiennes. Les auteurs discutent l'importance de la reconstruction ligamentaire après résection distale du cubitus.

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Introduction

Altered biomechanics, injury, and inflammation involving the distal radius and ulna have profound effects on the distal radioulnar joint (DRUJ) leading to deformity and degenerative changes [10]. As a result, patients suffer from pain, reduction in range of motion, and weakness of grip strength. Treatment by excision of distal ulna as described by Darrach [5] has enjoyed wider acceptance over other bony and soft-tissue procedures [20]. However, the procedure has also been criticized because of reported complications resulting from an unstable distal ulna [9], ulnocarpal translocation, ulnar impingement [7], and decreased grip strength, especially in the younger age group who frequently subject the wrist to more stressful activities [1, 15].

Other methods have been developed to improve upon Darrach's procedure. These include matched ulnar resection [11, 22], hemiresection arthroplasty [2], replacement arthroplasty using an ulnar head prosthesis [21], and fusion of the DRUJ with the creation of a proximal pseudoarthrosis [17]—all of which have shown variable results.

There is now an increasing number of surgeons who believe that the number of failed Darrach's procedures could be minimized and the postoperative function improved by incorporating a distally or proximally based tenodesis. Most surgeons have used extensor carpi ulnaris (ECU) slips for this purpose [14]. One previous author has described the incorporation of an extensor and an ad-

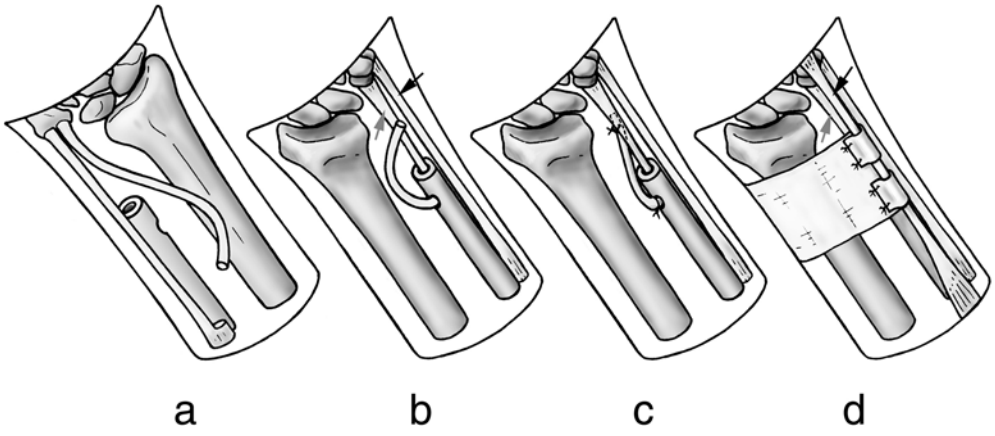

Fig. 1 **a** Diagrammatic representation of distal flexor carpi ulnaris (FCU) split with dorsoradial drill hole in ulnar stump. **b, c** FCU threaded through the hole and stitched onto itself. **d** Extensor retinacular flaps are wound around the tendon and stitched to reinforce it in its canal. *Gray arrow* represents FCU and *black arrow* represents extensor carpi ulnaris (ECU)

ditional flexor tendon slip to impart further stability in posttraumatic patients undergoing Darrach's procedure [4]. Furthermore, Klienman and Greenberg [12] used the ECU to control the impingement and transferred the ulnar insertion of the pronator quadratus to the dorsal aspect of the distal ulna to retard the dorsal translation of the stump. The flexor carpi ulnaris (FCU) has also been used to stabilize the distal ulna after Darrach procedures [18] and in combination with Sauve-Kapandji procedures [13].

We present our results using a modification of the Darrach's procedure with a distally based slip of the FCU tendon and rerouting the ECU tendon to stabilize the ulnar stump.

Materials and methods

We did a retrospective analysis of 12 patients with 14 procedures (two bilateral cases) carried out between 1997 and 2000. All procedures were carried out by the senior author (RB). There were ten women and two men with a mean age of 37 (range 24–59) years at time of operation. Average follow-up was 20 months (9 months to 4 years). Ten patients had developed wrist symptoms after suffering distal radial fractures; the dominant wrist was involved in seven of these ten patients. The two patients who underwent bilateral surgery were suffering from rheumatoid arthritis (RA). Preoperatively, the main complaints were severe-to-moderate pain, pronation and supination limitation, and grip-strength weakness.

Both subjective and objective assessments were carried out during outpatient reviews. Preoperative data obtained from medical notes was confirmed with each patient. Pain was assessed according to a questionnaire using a visual analogue score of 1–10, along with daily analgesic requirement and painful restriction of daily activities. We rated pain as mild if it did not interfere with daily activities, moderate if it interfered with heavy duties, and severe if it restricted simple daily activities or required constant analgesia. The presence of clicking on forearm rotation was evaluated with its relation to pain. Weakness was assessed together with overall ability to carry out daily functional activities. The ability to return to work was assessed postoperatively.

Objective assessment was carried out on the affected wrist and compared with the uninvolved side wherever possible. Range of movement in flexion and extension, pronation and supination were measured using a goniometer. Grip strength was measured using a JAMAR dynamometer.

Preoperative and postoperative anterior-posterior radiographs were studied. Measurements were made for amount of ulna resection and radio-ulnar distance. Observations were also made for postoperative radial notching and for scalloping, pencilling, and sclerosis of the resected ulna.

Surgical technique

An incision is made on the flexor aspect of the wrist to locate the FCU tendon. The dorsal cutaneous sensory branch of the ulnar nerve is identified and protected because of its close proximity to the radial side of the tendon. Prophylactic release of Guyon's canal is undertaken at this stage. The FCU tendon is then split one third longitudinally and divided on its radial side at the musculotendinous junction and freed up to its pisiform insertion, forming a nearly 10-cm-long distally based slip.

The wrist is pronated, and a second longitudinal incision is made on the dorsoulnar aspect of the wrist overlying the ECU tendon. The extensor retinaculum is identified, and a dorsally based lateral flap is prepared for a future sling for the ECU. The distal ulna is exposed, and a resection is carried out with an electric saw and then trimmed back by bone nibblers until there is no bony contact with the radius in all positions of supination and pronation. The amount of ulna taken is thus dictated by the clearance required between the remaining stump and the radius. We try to remain conservative in our excision. In our experience, the triangular fibrocartilage complex is usually completely worn out or unrecognizable with advanced stages of degenerative changes, especially in posttraumatic cases, and is largely ignored.

A drill hole in the ulnar stump, approximately 0.5–1 cm proximal to the level of the ulnar resection, is made on its dorsal-radial aspect (Fig. 1a). The dorsal-radial position of the hole ensures that the resultant vector of the tenodesis is in an ulnar-volar direction, minimizing the potential of ulnar impingement and dorsal displacement. The FCU tendon is threaded from the flexor to the dorsal aspect of the wrist, taking care to pass this tendon strip deep to the dorsal branch of the ulnar nerve and ulnar to the main ulnar nerve (Fig. 1b). The tendon is then inserted into the medullary cavity of the ulna, pulled through the radially-based hole, and stitched back onto itself as a loop with nonabsorbable sutures (Fig. 1c). It is important that the wrist be held in about 30° of flexion when the FCU tenodesis is pulled taut to ensure there is an even greater degree of tension on the tenodesis when the wrist is later extended. This provides extra grip strength (Fig. 2a and b). Supination and pronation is then performed with the wrist in flexion to ensure an adequate space between the radius and ulna.

Following that, the extensor retinaculum flap previously created is passed under and around the ECU tendon and sutured onto itself dorsally, thus acting as a sling to maintain the ECU in its dorsal position relative to the remaining ulna stump (Fig. 1d). Postoperatively, the wrist is maintained in the flexed position for 6 weeks with a dorsal slab, which extends above the elbow to prevent supination and pronation. This is followed by progressive physiotherapy.

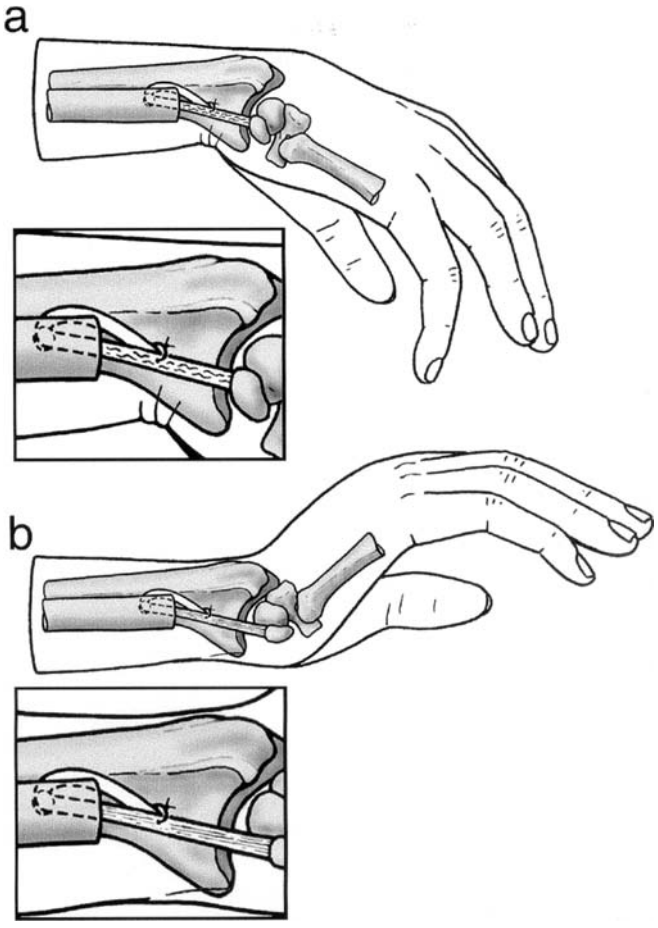

Fig. 2a, b Flexor carpi ulnaris (FCU) tenodesis in 30°of flexion with increased tension within its substance on bringing wrist into extension

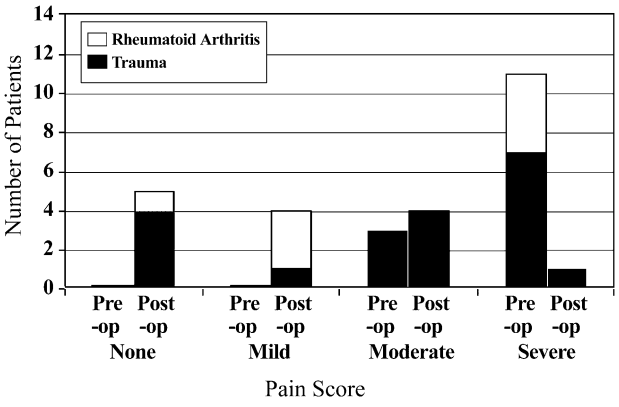

Fig. 3 Assessment of preoperative and postoperative pain

Results

Preoperative and postoperative pain assessment results are shown in Fig. 3. Pain grading using the VAS showed that the average pain score was reduced from 7.5 preoperatively to 3 postoperatively. Pain symptoms improved in all but one patient.

Eight patients (trauma group) with eight wrists were working before the injury; four managed to return to full-time employment with unrestricted use of their hands, two returned to restricted employment, and two were unable to return to work. Four of the original 12 patients were unemployed, including two of the trauma group. Of these patients, two reported unrestricted use of hands following surgery and two reported continued restrictions of activities. All except two patients reported a definite subjective improvement in grip strength compared to the preoperative state. Popping and clicking were reported in two patients only, without the association of pain and weakness. Five patients reported excellent satisfaction following the operation; five were very satisfied; one satisfied; and one—with a postoperative pain score of 6—was unhappy with her results, reporting limitations with daily activities and continued weakness of her hands.

Table 1 shows the average range of wrist motion. Preoperative ranges of movements were compared with the postoperative measurements. Mean flexion improved from 25.5° to 52°, and mean extension improved from 26° to 38.7°. The most marked improvement was seen however, in supination and pronation, with the mean supination range improving from 18.3° to 80° and the pronation range recovering from 28.3° to 82°.

Grip strength was compared with the normal wrist in ten patients. Surgery was performed on both wrists in two patients. Disregarding dominance, five of the operated wrists achieved more than 80% of the strength of the normal hand. The average grip strength of the operated hand was 18.8 (8–36) kg compared to 27.6 (20–48) kg on the nonoperated side. Overall, average grip strength at final follow-up was 68% (range 54–84%) of the normal side.

Radiographic evaluation

Both preoperative and postoperative radiographs were reviewed. Comparative measurements revealed an average ulnar resection of 17 (range 6–28) mm. Pencilling was noted in ten distal ulna, while radial notching was observed in four distal radii. Average ulnoradial distance at the distal forearm narrowed from 8.7 mm to 5.3 mm on radiographs at final analysis. The distance was narrowed in nine wrists and remained unchanged in four.

Discussion

The most common indications for excision of distal ulna include bony and ligamentous disruption of the DRUJ, ulnar head instability, RA, radio-ulnar osteoarthritis, ulnar impingement, and disorders of triangular fibrocartilage complex (TFCC). These conditions not only cause persistent pain and discomfort but also restrict motion at the wrist joint.

The proximal and DRU joints are the two bony points of contact, providing stability to the soft tissues of forearm. The distal ulna transmits 20% of the force to the carpus while the rest passes through the radius in the neutral position [15]. Once the DRUJ is removed, all the force is transmitted through the radiocarpal joint, making the joint prone to osteoarthritic changes. At the same time, loss of the distal ulna promotes radial convergence and impingement of the ulnar stump brought on by the deforming forces of the muscles of the first dorsal compartment, namely the extensor pollicis brevis, abductor pollicis longus, and also the pronator quadratus during pronation and supination. These muscles converge to the base of the thumb from the ulna in a radial direction across the interosseous space, causing stump impingement and instability [1].

Distal ulnar resection, while leaving intact the soft tissue attachments, was originally described by Darrach [5] for chronic traumatic palmar dislocation of the DRUJ. Since then it has become the standard treatment for a number of painful conditions around the wrist joint. Numerous earlier publications supported the procedure with good to excellent results regarding pain, maintenance of grip strength, and without range of motion loss [3, 6]. However, these results could not be replicated in later studies that showed increased numbers of failures due to persistent pain, ulnar stump instability, mechanical impingement, and loss of grip strength by up to 25–50% [7, 8, 11]. One explanation of these poor results was thought to be the use of the procedure on much younger patients, therefore exposing the operated wrist to more demanding and vigorous activities. Another reason suggested was the inability to meticulously follow the technique [20]. Bell [1] even suggested that this procedure should not be performed in younger patients because of a high complication rate, a practice supported by Palmer and Werner [15] and Talesnik [17].

Various soft-tissue procedures have been used as modifications to Darrach's procedure to improve results by conferring stability to the carpus and the resected ulnar stump. Goldner and Hayes used a proximally based slip of ECU tendon while Tsai [19] used a distally based ECU tendon slip for a similar group of patients. Breen and Jupiter [4] combined a distally based FCU and a proximally based ECU tenodesis to stabilize the unstable ulna.

We believe from clinical experience that the TFCC is either torn or nonexistent in the group under consideration and therefore its repair is impossible. We therefore confined our stabilization methods of the resected ulna to tenodesis procedures. In choosing the tendon for tenodesis, we would agree with Spinner and Kaplan [16] that it is the ECU that confers the most stability to the distal ulna following removal of all bony and soft-tissue support, including the TFCC complex. The ECU runs in its own fibroosseous tunnel with the extensor retinaculum swinging around it to attach to the pisiform bone without having any connections with it. Even with all ligaments and the TFCC divided with the ECU maintained in its dorsal compartment, the DRUJ remains dorsally stable. We therefore splinted the ECU tendon in its dorsal position using a sling of extensor retinaculum and did not use it for tenodesis. Instead, we preferred the FCU for this purpose.

A flexor carpi ulnaris tenodesis has sound biomechanical principles. The tenodesis is suspended from the pisiform in the axis of the ulna, thereby reproducing the function of the ulnar collateral ligament in allowing a transmission of load from the ulna to the wrist. This also provides a checkrein for ulnocarpal translocation by counteracting the dynamic deforming forces of the first compartment muscles and producing an ulnar deviation wrist posture.

In harvesting the tendon, we use the radial half of the tendon, as this is usually less muscular and therefore allows a longer slip to be detached from the main tendon. By positioning the wrist in 30° of flexion while reconstructing the tenodesis, a shortened working arm is produced when the wrist goes into natural extension for power grip. It is the senior author's experience that the main trunk of the ulnar nerve is at risk of compression in Guyon's canal in DRUJ-related disorders, and therefore the canal should be released as an integral part of the operation.

In our study, nearly all the patients' pain scores, range of motion, grip strength, and ability to perform activities of daily living improved. Overall return to employment remained satisfactory with only 25% unable to return to their previous employment. An overall improvement in patient satisfaction with the operation was also noted.

In this study, the average ulnar resection was 17 (range 6–28) mm. We found no correlation between amount of ulnar resection and patient satisfaction. Tsai et al. [20] reported that patients in whom less than 11 mm ulna was resected were more satisfied. Other radiological observations such as pencilling of distal ulna, radial notching, and reduced ulnoradial distance following surgery were unrelated to the subjective or objective results.

In the younger age group and the physically active group of patients we recommend that plans for a Darrach's procedure should be accompanied by a soft-tissue tenodesis to reduce complications and improve grip strength. From our series, we feel that the FCU tendon is effective in reproducing the role of the ulnar collateral ligament and also recommend that the ECU tendon be maintained in its dorsal position over the ulna to confer dorsal-ulnar stability.

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