VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 70, No. 3, pp. 204–210

ISSN 0015–5659
www.fm.viamedica.pl

Antero-medial approach to the wrist: anatomic basis and new application in cases of fracture of the lunate facet

A.-P. Uzel[1, 2], A. Bulla[1], M. Laurent-Joye[2], P. Caix[2]

[1]*Service d'Orthopédie et Traumatologie, CHU Pointe-à-Pitre, Guadeloupe*
[2]*Laboratoire d'Anatomie Médico-Chirurgicale Appliquée, Université Bordeaux 2 Victor Ségalen, Bordeaux CEDEX, France*

[Received 21 March 2011; Accepted 18 May 2011]

The Henry approach is the classical anterolateral surgical exposure of the volar aspect of the distal radius. This approach does not allow good access to the medial side of the volar distal radius (lunate facet) and the distal radio-ulnar joint, unless it is extended proximally, retracting the tendons and the median nerve medially, which can cause some trauma. The purpose of our study was to investigate the anatomic basis and to outline the advantages of the unusual anteromedial approach, reporting our experience in the treatment of 4 distal radius fractures, with a 90° or 180° twist of the lunate facet, and 10 wrist dissections on cadavers. The average follow-up was 68.8 months (range 18 to 115 months). In our series, this approach did not cause any nerve injuries or any sensory loss of the distal forearm and the palm. All the fractures of the lunate facet and of the radial styloid process healed. One patient with an ulnar styloid process fracture associated showed pseudarthrosis, but with no instability of the distal radio-ulnar joint or pain on the ulnar side. Using the criteria of Green and O'Brien, modified by Cooney, the results were: excellent in two cases, good in one case, and average in another. The evaluation of arthritis according to Knirk and Jupiter's classification showed grade 0 in three cases and grade 3 in one case with osteochondral sclerosis. We showed that the anteromedial approach is reliable and convenient in the case of fractures situated in the antero-medial portion of the radius, for the double objective of reducing the fracture under direct control and checking the congruence of the distal radio-ulnar joint. (Folia Morphol 2011; 70, 3: 204–210)

Key words: articular fracture, distal radio-ulnar joint, ligamentous

INTRODUCTION

The Henry approach [15] is the classical anterolateral surgical exposure of the volar aspect of the distal radius. Actually, this approach does not allow good access to the medial side of the volar distal radius and the distal radio-ulnar joint unless it is extended proximally, retracting the tendons and the median nerve medially. In case of fractures of the lunate facet, it seems that the anteromedial approach between the flexor muscles on the radial side and the ulnar neurovascular bundle on the medial side could provide a better visualisation. The purpose of our study is to investigate the anatomic basis and to outline the advantages of this approach, reporting our experience in the treatment of 4 distal radius fractures and 10 wrist dissections on cada-

Address for correspondence: A.P. Uzel, Service d'Orthopédie-Traumatologie, CHU Pointe-à-Pitre, Route de Chauvel, 97159 Pointe-à-Pitre Cédex, Guadeloupe, tel: 05 90 89 14 66, 05 90 89 10 10, ext. 3461, fax: 05 90 89 17 44, e-mail: andre-pierre.uzel@wanadoo.fr; maxuzel@hotmail.com

vers. To our knowledge, this approach has never been described before for this indication.

MATERIAL AND METHODS

Patients

Our study was performed on four young adult male patients with fractures of the distal radius (Fig. 1). All patients were informed of the study and their consent obtained. The patients' average age at the time of injury was 27 years (range 19–43 years). In two cases, the fractures were caused by road traffic accidents and in the other two, by a fall from a roof (3 m and 6 m in height). Standard X-ray and computed tomography (CT) scan confirmed the diagnosis. In each case, the radiological findings showed Melone type 4 fractures [27] with rotation of the lunate facet (a 90° twist in two fractures and a 180° twist in the other two fractures) and fractures of the radial styloid process, associated with a partial dislocation of the radio-carpal joint. Furthermore, one of the patients had a fracture of the ulnar styloid process, and another had a fracture of the lower ulnar diaphysis with distal radio-ulnar joint dislocation and scapholunate diastasis.

Cadavers

The anteromedial approach to the distal radius was performed on ten wrists from five adult fresh cadavers. Of these, 3 were males and 2 were females, and they ranged in age from 38 to 103 years (mean 79 years).

Surgical technique

A longitudinal palmar skin incision was carried out along the axis of the ring finger just medial to the palmaris longus tendon, extending for 5 cm. The antebrachial fascia was opened, allowing access to the distal portion of the anterior forearm compartment. The dissection was carried out between the flexor digitorum (superficialis and profondus) tendons and the ulnar neurovascular bundle. The flexor tendons were retracted radially, so that the fascia of the pronator quadrates muscle could be visible. The pronator quadrates muscle was minimally elevated from its distal extremity, which made it possible to keep its ulnar and radial insertions intact. In our series, it has not been necessary to incise and elevate the pronator quadrates muscle on its ulnar border. The articular surface of the lunate facet was reduced and checked, and the congruity of the distal radio-ulnar joint was verified. Osteosynthesis of the lunate facet fragment was performed through direct pinning in three cases (Fig. 2). In one case pinning was performed through a short posterior approach. In all cases the radial styloid process fracture was treated by intrafocal or trans-styloid pinning by means of a 5 mm cutaneous incision and soft tissue dissection. In one case osteosynthesis of the ulnar styloid process fracture was carried out by dorsomedial pinning and the scapholunate diastasis was not treated because of a lateral cutaneous lesion. The wound was sutured

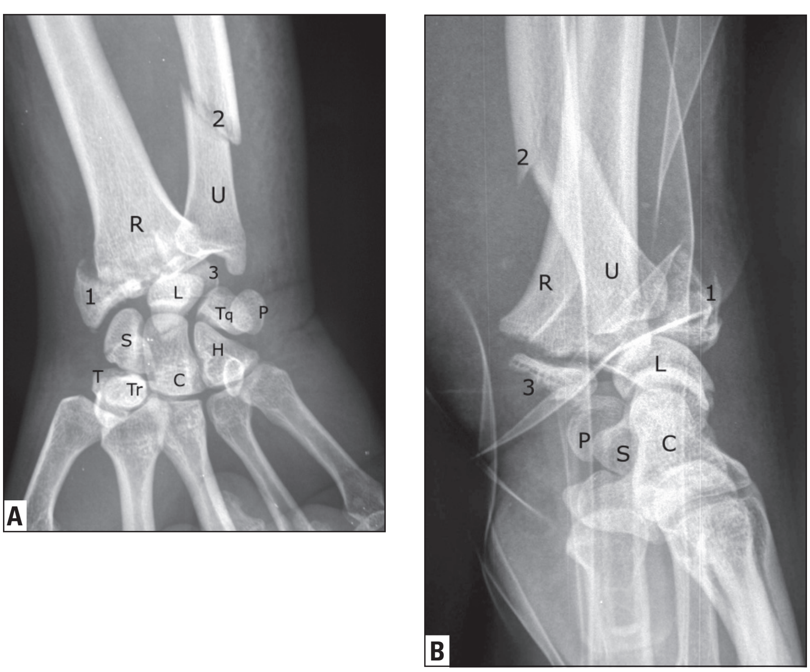

Figure 1. A. Antero-posterior radiograph showing a Melone type 4 fracture of the distal radius and fracture of the ulnar diaphysis; **B.** Lateral radiograph showing 180° rotation of the lunate facet and subluxation of the wrist; R — radius; U — ulna; S — scaphoid; L — lunatum; Tq — triquetrum; P — pisiform; T — trapezium; Tr — trapezoid; C — capitatum; H — hamatum; 1 — fracture of the radial styloid process; 2 — fracture of the ulnar diaphysis; 3 — fracture of the lunate facet of the radius.

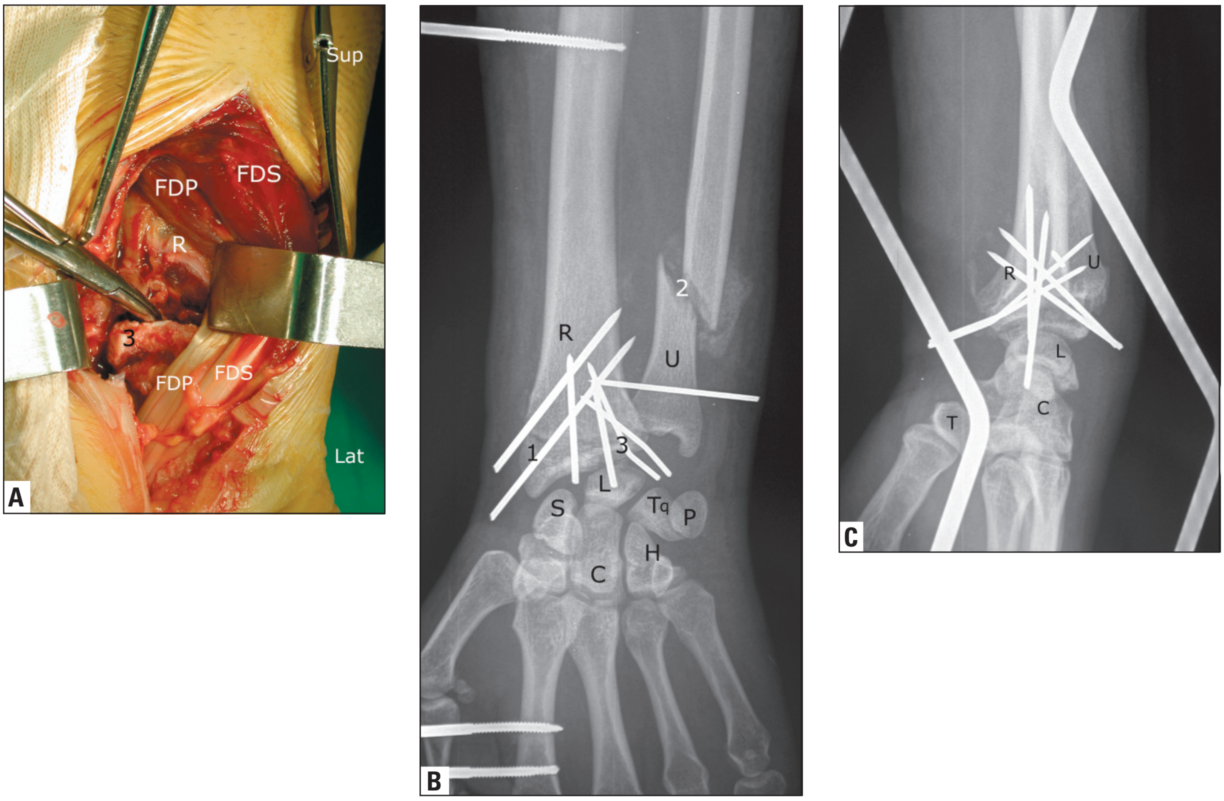

Figure 2. A. Peri-operative view showing the lunate facet twist; **B, C.** Antero-posterior and lateral radiograph showing osteosynthesis of the lunate facet fragment performed through direct pinning and the distal radius osteosynthesis by intrafocal and trans-styloid pinning. An external fixation without distraction completes the osteosynthesis. The scapholunate diastasis was not treated because of a lateral cutaneous lesion; R — radius; U — ulna; S — scaphoid; L — lunatum; Tq — triquetrum; P — pisiform; T — trapezium; C — capitatum; H — hamatum; FDP — flexor digitorum profondus; FDS — flexor digitorum superficialis; 1 — fracture of the radial styloid process; 2 — fracture of the ulnar diaphysis; 3 — fracture of the lunate facet of the radius; Sup — superior; Lat — lateral.

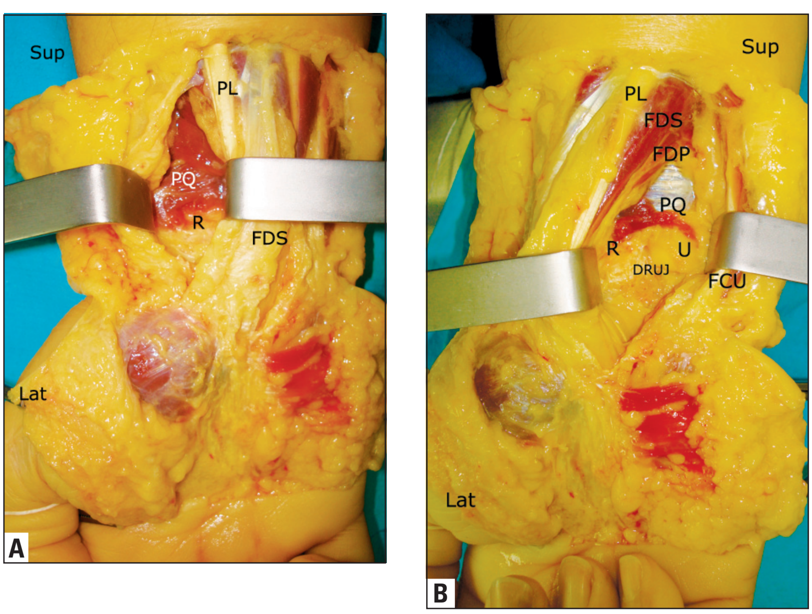

Figure 3. The inadequate view of the medial part of the distal radius (**A**) and the distal radio-ulnar joint by the Henry approach (**B**) on the contrary by the anteromedial approach the view on the lunate fossa and on the distal radio-ulnar joint is excellent; R — radius; U — ulna; DRUJ — distal radio-ulnar joint; FDP — flexor digitorum profondus; FDS — flexor digitorum superficialis; PL — palmaris longus; PQ — pronator quadratus; FCU — flexor carpi ulnaris; Sup — superior; Lat — lateral.

in layers. The pronator quadrates muscle repair was followed by subcutaneous and cutaneous sutures. In two cases an external fixation was used, and in two others cases an arm cast was kept for 6 weeks.

Cadaver dissections

In order to confirm its safety and ease to practice, the anteromedial exposure was subsequently performed on 10 wrists from 5 fresh cadavers which had undergone no previous surgery. The anatomical protocol included the realization of two fasciocutaneous lateral and medial flaps opposite the axis of the ring finger, medially to the palmaris longus tendon. The dissection was performed up to the pronator quadrates muscle. All the flexor tendons were retracted laterally and the neurovascular bundle medially. The inferior part of the pronator quadrates muscle was retracted superiorly in order to analyse the lunate fossa, the distal radio-ulnar joint, and the short radiolunate ligament.

RESULTS

This approach allowed us to carry out an anatomic reduction and osteosynthesis of the fragment of the twisted lunate facet under direct control. Moreover, we were able to appreciate the congruence of the distal radio-ulnar joint. The average follow-up was 68.8 months (range 18 to 115 months). In our series, this approach did not cause any nerve injuries or any sensory loss of the distal forearm or the palm. All the fractures of the lunate facet healed without complications. The ulnar styloid process fracture showed pseudarthrosis, but without any instability of the distal radio-ulnar joint or pain on the ulnar side. Using the criteria of Green and O'Brien, modified by Cooney et al. [7], the results were: excellent in two cases, good in one case, and average in another. The evaluation of arthritis according to Knirk and Jupiter's classification [19] showed grade 0 in three cases and grade 3 in one case, with osteochondral sclerosis.

In one of the 10 dissected wrists we found an accessory belly of the abductor digiti minimi muscle, which was inserted into the tendon of the palmaris longus. It was necessary to retract the belly superiorly in order to perform our approach. We did not find any nerve between the ulnar vascular bundle and the flexor tendons. In our experience, analysing the lunate fossa and the distal radio-ulnar joint with this approach was easier than with the Henry approach (Fig. 3) [15].

DISCUSSION

The Henry approach [15] easily allows for exposure of the lateral two thirds of the distal radius. However, accessing the medial aspect of the distal radius and the distal radio-ulnar joint is made difficult by the obstacle constituted by the flexor tendons and the median nerve. As the tendons have an important volume and tonus, access to the medial aspect through the classic approach requires extensive exposure of their proximal part. Furthermore, excessive traction on the tendons and on the median nerve could lead to neuropraxia of this nerve and of its thenar muscular branch linked to certain thenar eminence muscles. Moreover, the median nerve and the flexor tendons are distally fixed by the flexor retinaculum. To overcome the limitations of the Henry approach we propose here the application of the anteromedial approach to the medial aspect of the distal radius, the lunate facet, and the distal radio-ulnar joint through an incision located between the flexor digitorum (superficialis and profondus) tendons and the ulnar neurovascular bundle. Generally this approach is used for volar fasciotomy and complex carpal dislocations, often combined with a carpal tunnel release. Recent studies [21] have stated that the midline approach is associated with an increased rate of median nerve irritation when compared to the classic Henry approach [15] as applied to the exposure of the lateral side of the radius, due to the excessive traction on the nerve.

Nevertheless, our approach, as described above, in the case of lunate facet fracture can give adequate exposure with low risk because it is not necessary to mobilise the median nerve.

The anatomy of the anterior parts of the wrist and of the hand is well known but there are some variations. For the safe practice of the anteromedial approach, some anatomic considerations are important.

The palmar cutaneous branch of the median nerve

The palmar cutaneous branch of the median nerve is the distal collateral branch of the median nerve in the forearm [4]. It emerges on its radial side, on average 44.3 mm before the bistyloid line [6]. It courses in line with the third finger and perforates the antebrachial aponeurosis about 5.7 mm from the bistyloid line [6]. The nerve typically courses ulnar to the flexor carpi radialis tendon, deep into the antebrachial fascia between the tendons of the flexor carpi radialis, and palmaris longus [4, 5, 23, 25]. This emergence can be located in the palm, where the nerve can be injured, if the incision is performed in line with the third finger [6] during surgical treatment of carpal tunnel syndrome, for example. Our approach in line with the ring finger, within the palmaris longus tendon when present, is safe for the palmar cutaneous branch of the median nerve. If prolongation of the incision distally to the hand for carpal tunnel release is necessary, it is possible, as recommended by Da Silva et al. [8], to perform an incision in line with the ring finger. This is the best solution, but some branches will be damaged. In the series of dissections carried out by Matloub et al. [25], this would result in injury for 25% of the specimens.

The palmar cutaneous branch of the ulnar nerve

The palmar cutaneous branch of the ulnar nerve origins from the ulnar nerve 5 to 11 cm distal to the medial epicondyle of the humerus and divides into its terminal branches in the distal forearm [3]. In our approach, it is at risk of injury. In a series of 52 human cadaveric upper extremity dissections, Balogh et al. [3] found that in 30 cases (58%) the nerve was well defined, and that in 22 cases (42%) its origin from the ulnar nerve was not identifiable. Balogh et al. [3] established four distribution patterns for the nerve of the palmar cutaneous branch of the ulnar nerve: radial, ulnar, radioulnar, and vessel-related.

Anastomoses between the median and ulnar nerves

In his anatomical study, Kazakos et al. [18] showed anastomoses between the median and ulnar nerves in 10 out of 100 specimens. The average length of the anastomosis was 6.4 cm [18]. On average, its origin was 6.8 cm distal to the medial epicondyle, and its connections to the ulnar nerve were on average 11.0 cm distal to the medial epicondyle [18]. With the anteromedial approach these anastomoses can be injured but their locations are higher than our approach.

The medial antebrachial cutaneous nerve

The medial antebrachial cutaneous nerve is a branch from the medial cord of the brachial plexus consisting of sensory fibres from the first thoracic root ganglion [31]. The nerve splits into anterior and posterior branches in the distal third of the arm. The anterior branch supplies sensitivity to the volar aspect of the forearm including the antecubital fossa and proximal anterior aspect of the forearm [24, 31]. These branches lie proximally to the anteromedial incision.

The lateral antebrachial cutaneous nerve

The lateral antebrachial cutaneous nerve is the distal sensory division of the musculocutaneous nerve which supplies the lateral part to the volar aspect of the forearm. Its course is lateral to the flexor carpi radialis tendon. Therefore, it is not affected by the anteromedial approach.

The anterior interosseous nerve

The anterior interosseous nerve arises from the median nerve as it passes between the two heads of the pronator teres muscle and accompanies the anterior interosseous artery up to the anterior surface of the interosseous membrane in the forearm. Here, it lies in the interval between the flexor pollicis longus tendon and the flexor digitorum profundus tendon. At the inferior part of the pronator quadrates muscle it divides into several branches that reach the anterior aspect of the radiocarpal capsule [3]. The anterior interosseous nerve branches, which are always very thin, spread out unevenly over the width of the radial epiphysis [3]. Anterior approach to the radial epiphysis, with distal elevation of the pronator quadratus muscle, causes section of the anterior interosseous nerve [10].

Palmaris longus muscle

The palmaris longus tendon constitutes the lateral landmark for the anteromedial approach. A more lateral approach could cause a lesion of the median nerve that courses superficially between the flexor carpi radialis tendon laterally and the palmaris longus tendon medially. Nonetheless, there are wide anatomical variations among different ethnic groups. The overall rate of palmaris longus muscle absence in Caucasian populations (European and North American) has been reported to be between 5.5 and 24% [12, 32, 39–42]. However, the overall rate of palmaris longus muscle absence in Asian populations (Chinese, Indian, Japanese, Korean, Malaysian) has been reported to be between 0.6% and 17.2% [1, 16, 17, 33, 35, 36]. Among the Turkish population, Ceyhan and Mavt [5] noted an absence rate of 63.9%, while Kose et al. [20] reported a rate of 26.6%. Several techniques have been described to demonstrate the presence of the palmaris longus muscle on clinical examination [22, 28–30]. Schaeffer et al. [34] described a well-known manoeuver that involves flexing the wrist with the thumb and little finger opposed. Mishra [28] has described two other techniques. For Kose et al. [20], Mishra's second test is more effective than Schaeffer's in demonstrating the presence or absence of the palmaris longus tendon. Thompson's test [39] and Pushpakumar's "two-finger sign" [30] have also been proposed. The absence of the palmaris longus tendon was statistically more common in women than in men [20]. Bilateral absence of the palmaris longus muscle was statistically more frequent than unilateral absence [20], but the opposite was reported by Erić et al. [11]

Anomalous abductor digiti minimi muscle

Accessory origins of the abductor digiti minimi muscle from the palmaris longus tendon have been reported by various studies in approximately 22% to 35% [9, 11, 14, 43] of hands. Their courses are oblique and cross over the Guyon's canal. When the volar antero-medial approach is used, it will be necessary to retract or cut this accessory belly. This accessory belly was found in one of the ten wrists that were dissected.

The pronator quadrates muscle

Based on the Sotereanos et al. [38] study, the pronator quadratus muscle occupies a distinct forearm space without intermuscular communication. The pronator quadratus muscle is a dynamic extrinsic stabiliser of the distal radio-ulnar joint. In the Henry approach the muscular insertion of the pronator quadratus muscle to the radius is necessarily sectioned. In our series, we only used partial elevation of the distal part of the pronator quadratus muscle. The repair of the pronator quadratus muscle, when detached from the radius or to the ulna, is difficult to perform.

Lunate facet and ligaments

The lunate facet surface area (53%) was found to be slightly larger than the scaphoid facet surface area (47%) [26]. The protrusion of the volar part of the lunate facet anterior to the volar metaphyseal cortex was studied by Andermahr et al. [2] on 48 three-dimensional CT scans. The height and width of the volar extension of the lunate facet were 3 ± 1 mm and 19 ± 4 mm, respectively, and the average height of the lunate facet was 19 ± 3 mm [2]. The short radiolunate ligament originates from the lunate facet and penetrates the radial side of the lunate. The reported lesions occurred during high-energy trauma. A global posterior displacement of the distal epiphysis of the radius causes the lunate facet to turn around and be pulled out, due to insertions of the short radiolunate ligament. Injury of the distal radio-ulnar joint and of the triangular fibrocartilage complex is possible because the articular disc and the ventral and dorsal distal radioulnar ligament are inserted into the cartilage of the sigmoid notch.

Vascularisation

The distal radius is supplied by the radial and interosseous arteries, and particularly by the palmar radiocarpal arch, located just proximal to the radiocarpal joint. It courses within the palmar wrist capsule and connects with the palmar anterior interosseous artery and the ulnar artery. The palmar radiocarpal arch is subdivided into radial and ulnar components by the palmar anterior interosseous artery forming the T-anastomosis described by Haerle et al. [13] The radial palmar radiocarpal arch gives off multiple branches to the distal radius periosteum supplying cortical and cancellous bone [37].

Extension of the incision to the palm

The anteromedial approach can be extended to the palm, crossing the wrist flexion creases in a z-shape, on the axis of the ring finger, which is the neural watershed of the medio-ulnar sensitive areas of the palm. In this way one can avoid lesions of the palmar cutaneous nerves, branching out from the ulnar and median nerves running on both sides of the fourth radius in the subcutaneous cell tissue. Although according to Martin et al. [23], there is no true "internervous plane" in the palm, through which the carpal canal can be reached; this extension can facilitate the opening of the flexor retinaculum.

CONCLUSIONS

The anatomic reduction of the distal radio-ulnar joint is essential to ensure the integrity of the pronosupination. We showed that the anteromedial approach is reliable and convenient in cases of fractures situated in the antero-medial portion of the radius, for the double objective of reducing the fracture under direct control and checking the congruence of the distal radio-ulnar joint. In all our cases the radial styloid process fractures were treated by direct pinning, and additional exposure was not necessary.

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