Anatomy and approaches of the wrist

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Abstract

A thorough knowledge of the anatomy of the wrist is key to performing successful approaches to the complex tendon, ligament, neural and articular structures of the wrist. Several approaches have been described in the literature employing a range of anatomical planes. These approaches can be categorized into dorsal, volar and specialized approaches. Eight surgical approaches within the three categories are described in this article. The relevant anatomy for each approach is described, including details of vascular, neural, osseous, articular and ligamentous relations. This is followed by description of the surgical approaches to the distal radius, distal radio-ulnar joint, carpal tunnel, Guyon's canal, volar distal radius, volar scaphoid, dorsal scaphoid and de Quervain's release.

Keywords Carpal ligaments; carpal tunnel; distal radius; surgical approach; wrist anatomy; wrist approach; wrist replacement

Introduction

Wrist approaches vary in precise execution between surgeons and may depend on indication and surgeon preference. Several different skin incisions are commonly used, but approaches can be categorized into dorsal, volar and specialized approaches. The dorsal approach to the wrist joint is mainly used for treating arthritis and working on the bones of the carpus;[1] the volar approach is used primarily for exploring the carpal tunnel and its structures.[2] Specialized approaches include those to the trapezium, scaphoid, de Quervain's tendons and the ulnar nerve. In this article, the applied surgical anatomy of the wrist and surgical approaches are described.

Dorsal approach to the wrist

Applied anatomy of the dorsal approach

Two bony landmarks are crucial to this approach: the radial styloid process and Lister's tubercle. The brachioradialis muscle is attached to the radial styloid. The tendon of the extensor pollicis longus (EPL) muscle angles around the distal part of Lister's tubercle to change direction by 40–45°.[2] The skin around the dorsum of the wrist is loose and glides easily, allowing for longitudinal, straight incisions to be performed without risking joint contracture.

The extensor retinaculum is a narrow (2 cm), fibrous band that lies obliquely across the dorsal aspect of the wrist.[3] Its radial side is attached to the anterolateral border of the radius; its ulnar border is attached to the pisiform and triquetral bones. Twelve tendons pass under the extensor retinaculum, forming six compartments separated by fibrous septae (Table 1). The first compartment contains the abductor pollicis longus (APL) and extensor pollicis brevis (EPB). Extensor carpi radialis longus and brevis are in the second compartment on[4] the radial side of Lister's tubercle. The EPL tendon is in the third compartment on the ulnar side of Lister's tubercle. In the fourth compartment are found the extensor digitorum communis (EDC) and extensor indicis. The last two compartments contain one tendon each: the extensor digiti minimi (EDM) and extensor carpi ulnaris (ECU). The ECU tendon is contained in the subsheath and passes over the ulnar styloid process. Underneath the extensor compartments are the dorsal carpal ligaments.[2,3]

The dorsal carpal ligaments consist of the intrinsic and extrinsic ligaments (Table 2).[4] The dorsal extrinsic ligaments are detailed in Table 1. The surgically relevant ligaments include: 1) the dorsal radiocarpal ligament (radiocapitate, radiotriquetral, radiolunate and radioscaphoid); 2) the dorsal ulnotriquetral ligament; 3) the dorsal intercarpal ligament (originating from the triquetrum and extending radially and attached onto the lunate, inserted into the dorsal groove of the scaphoid and trapezium). The latter can be split in a dorsal approach to access the carpus. The intrinsic ligaments connect the adjacent carpal bones and they include: 1) the scapholunate interosseous ligament; 2) the lunotriquetral interosseous ligament; 3) the capitohamate, trapeziocapitate and trapeziotrapezoid ligaments.[4,5] The latter connects the bones of the distal row, making them move as one. Injury to the extrinsic dorsal radiocarpal ligament causes volar intercalated segment instability (VISI), while injury to the intrinsic scapholunate ligament can cause dorsal intercalated segment instability (DISI).[4,5]

Two nerves cross the wrist on the dorsal side and they can be at risk. The dorsal cutaneous branch of the ulnar nerve emerges

The extensor compartments

Compartment	Tendon	Pathology
1	EPB	De Quervain's tenosynovitis
	APL	
2	ECRL	Intersection syndrome
	ECRB	
3	EPL	Drummer's wrist
		Traumatic rupture
4	EIP	Extensor tenosynovitis
	EDC	
5	EDM	Vaughan–Jackson syndrome
6	ECU	Snapping ECU

APL, abductor pollicis longus; ECRB, extensor carpi radialis brevis; ECRL, extensor carpi radialis longus; ECU, extensor carpi ulnaris; EDC, extensor digitorum communis; EDM, extensor digiti minimi; EIP, extensor indicis proprius; EPB, extensor pollicis brevis; EPL, extensor pollicis longus.

Table 1

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Extrinsic and intrinsic ligaments of the wrist

Carpal ligaments	Subcategory	Ligament complex	Ligaments
Extrinsic	Proximal	Radial collateral	Radial collateral ligament
		Volar radiocarpal	Radioscaphocapitate
			Long radiolunate
			Radioscapholunate
			Short radiolunate
		Volar ulnocarpal	Ulnotriquetral
			Ulnolunate
			Ulnocapitate
		Dorsal radiocarpal	Radiocapitate
			Radiotriquetral
			Radiolunate
			Radioscaphoid
		Dorsal intercarpal (DIC)	Dorsal intercarpal ligament
		Ulnocarpal complex	Dorsal ulnotriquetral
			Triangular fibrocartilage
			Ulnolunate ligament
			Ulnar collateral ligament
	Distal	Carpometacarpal	
Intrinsic	Proximal row	Interosseous	Scapholunate interosseous
			Lunotriquetral interosseous
	Mid row	Volar midcarpal	Scaphotrapeziotrapezoid
			Scaphocapitate
			Triquetrocapitate
			Triquetrohamate
	Distal row	Volar intercarpal	Deltoid ligament
		Distal dorsal intercarpal	Capitohamate
			Trapeziocapitate
			Trapeziotrapezoid

Table 2

from the main trunk of the ulnar nerve proximal to the ulnar styloid and passes dorsally to innervate the skin of the little and ring fingers.[3] The superficial radial nerve emerges from beneath the brachioradialis, proximal to the radial styloid, to innervate skin over the dorsum of the first web space and most of the dorsum of the hand.

Universal dorsal approach to the wrist

The ideal dorsal wrist approach has to provide the best exposure whilst preserving sensitive dorsal nerve branches, dorsal veins, and skin integrity.[6] A longitudinal incision is commonly used in wrist surgery. Several authors have described a transverse dorsal approach, following Langer's lines,[7] but this is not commonly practised. The longitudinal dorsal approach described here allows access for scaphoid surgery, four-corner fusion, carpectomy, vascularization of the lunate, capitate fracture, dorsal capsulodesis and wrist replacement.[8,9]

Incision: a longitudinal incision on the dorsal aspect of the wrist, centred over Lister's tubercle, is made and the incision can be extended as necessary (Figure 1). The skin and subcutaneous fat flap are separated from the extensor retinaculum and elevated away with self-retaining retractors (Figure 2a and b).

Superficial dissection: the extensor retinaculum is defined and incised over the fourth compartment of the wrist. The EPL is exteriorized and the EDC and extensor indicis proprius (EIP) are mobilized off the compartment and lifted to the radial and ulnar sides respectively, exposing the distal radius and joint capsule (Figure 2c and d). This view can be expanded by dividing the fibrous pillars between compartments (second and third, third and fourth, fourth and fifth) which are divided transversely by sharp dissection at their base as they attach to the back of the radius. Retracting the retinaculum will expose the extensor carpi radialis longus (ECRL) and extensor carpi radialis brevis (ECRB) on the radial side and EDM on the ulnar side.

Deep dissection: the joint capsule is incised either longitudinally over the distal radius and carpal bones, or in an inverted-T shape fashion (Figure 2e and f). The dissection continues below the capsule (the dorsal radiocarpal ligament) towards the radial and ulnar sides of the radius to expose the entire distal end of the radius and carpal bones. Berger et al. described a radially-based anatomical dorsal capsulotomy to expose the radial aspect of the radiocarpal joint and entire midcarpal joint.[8,9] This is achieved by identifying the direction of the radioscaphoid, dorsal radiotriquetral and the dorsal intercarpal (DIC) ligaments then

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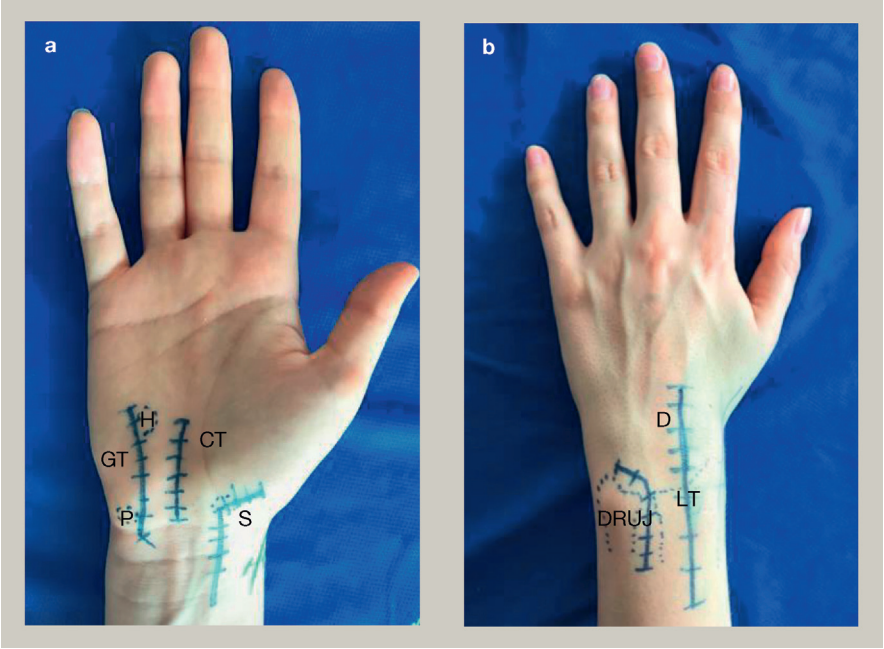

Figure 1 Skin marking of the volar and dorsal approaches. (**a**) Volar approaches. (**b**) Dorsal approaches. CT, carpal tunnel incision; D, dorsal incision; DRUJ, distal radioulnar joint; GT, Guyon's canal incision; H, hook of hamate; LT, Lister's tubercle; P, pisiform; S, scaphoid volar approach.

dividing the capsule along the tension lines of these ligaments (Figure 2). Carpal stability is achieved by leaving intact half of each capsular ligament (Figure 3).

Distal radioulnar joint

Distal radioulnar joint anatomy

The sigmoid notch of the radius articulates with the ulnar head and there is a different centre of rotation for each, leading to slight glide at the joint in the anteroposterior plane.[3–5] The distal radioulnar joint (DRUJ) articulates with the lunate and triquetrum *via* the triangular fibrocartilage complex (TFCC) (Figure 4a).[10] The ulnar height, in relation to the radius, varies in pronation (longer) and supination (shorter). Ulnar variance leads to changes in the applied load on the ulnocarpal or radiocarpal joints.[11,12]

The TFCC is a complex structure that acts as the major soft tissue stabilizer of the DRUJ. The components of the TFCC include: dorsal radioulnar ligament, volar radioulnar ligament, central disc, meniscus homologue, ulnar collateral ligament (UCL), ECU tendon sheath, origins of the ulnolunate and ulnotriquetral ligaments (Table 3) and (Figure 4a).[3,5] In addition to stabilizing the DRUJ, the TFCC allows the transmission of 20% of the load across the wrist (neutral ulnar variance). The periphery of the TFCC is well-vascularized, whereas the central radial portion remains relatively avascular.

The ECU acts as a secondary stabilizer of the DRUJ and resists dorsal and ulnar translation of the ulnar styloid.[3,4] It runs through a groove in the ulnar head and has its own sheath that forms a component of the TFCC. The retinaculum over the sixth compartment runs over the ulna towards the palmar side, blending into the anterior fascia and is separate from the ECU sheath. The flexor carpi ulnaris (FCU) inserts into the pisiform, hamate and base of the fifth metacarpal. With the pisiform acting as a pulley, the FCU ulnar deviates and flexes the wrist.[3,13]

Innervation of the DRUJ is mainly *via* branches of the ulnar nerve. Branches from the anterior interosseous nerve (AIN) are additionally found to innervate the volar DRUJ capsule.[14,15]

Distal radioulnar joint approaches

Five approaches to the DRUJ are described in the literature. The most commonly utilized approaches are the dorsal and dorsoulnar approaches. Ulnar, palmar, radio-ulno-carpal capsulotomy and radioulnar capsulotomy are less commonly used approaches.[16]

Indications include: open TFCC attachment, open wafer excision, TFCC anatomical reconstruction, ulnar head deletion (Darrach's, Sauvé-Kapandji and matched ulnar resection), ulnar head replacement and fracture reconstruction.[16]

Dorsoulnar approach

Bower's approach involves creating two retinacular flaps, one radially based and one ulnar based.[16,17]

Incision: an incision is made over the dorsum of the DRUJ (Figure 1), extending distally and slightly ulnarwards towards the styloid process of the fifth metacarpal (Figure 4b).[11,16,18] The dorsal branches of the ulnar nerve traverse this plane and should be protected.[14]

Superficial surgical dissection: the extensor retinaculum is divided longitudinally over the fifth compartment EDM and the tendon is retracted radially. The retinacular pillar is undermined and elevated over the ulna.

Deep surgical dissection: the DRUJ capsule is divided by a longitudinal capsulotomy, leaving sufficient cuff on the radial side for repair later. Care is taken not to disturb the ECU tendon sheath or to go more distal than the proximal edge of the dorsal radioulnar ligament. The ligament is identified between the ulnar head

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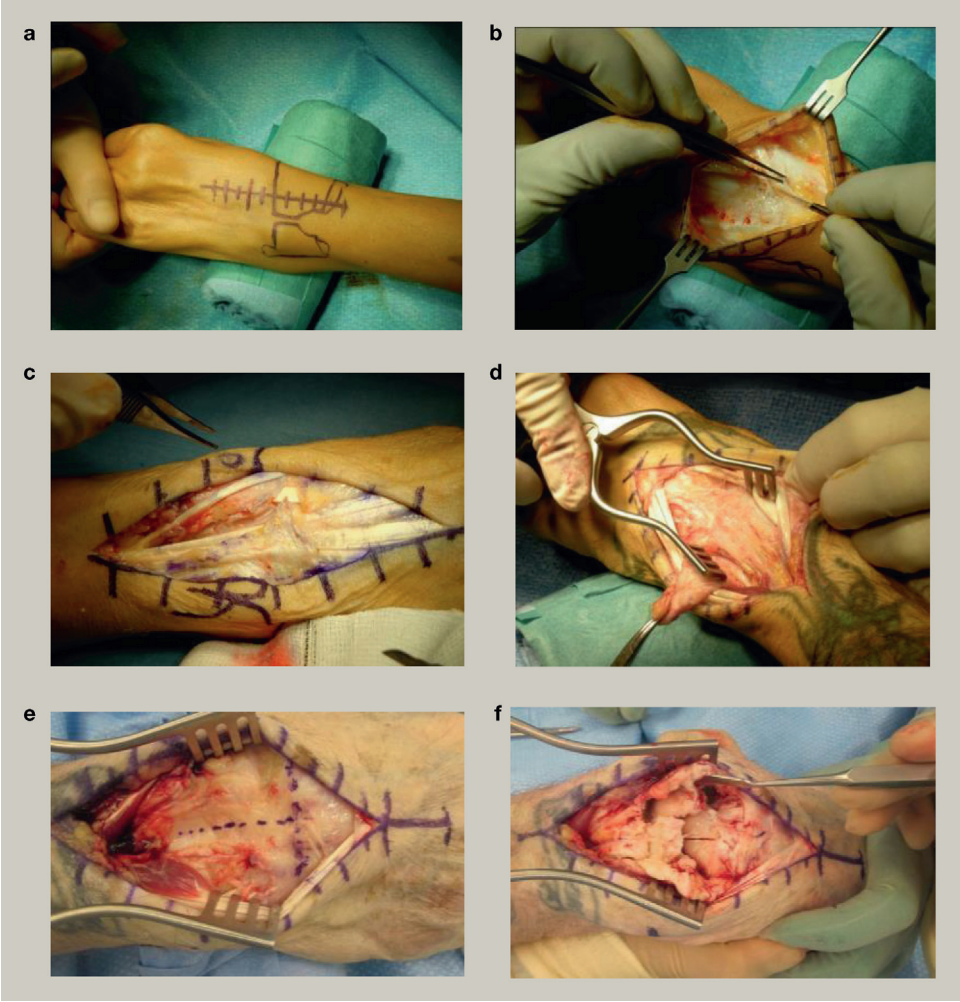

Figure 2 The dorsal approach for a wrist replacement procedure. (**a**) Landmarks and the proposed longitudinal incision are marked. (**b**) The skin and fat flap are separated from the extensor retinaculum and elevated. (**c**) The extensor pollicis longus (EPL) is exteriorized and retracted. (**d**) The EPL and extensor digitorum communis are retracted to expose the joint capsule. (**e**) An inverted T-shaped capsule incision is marked. (**f**) The capsule and dorsal ligaments are incised to expose the radiocarpal joint. (Images kindly provided by Mr Sumedh Talwalkar)

and the proximal edge of the lunotriquetral joint. A transverse incision can be made proximal to the ligament and up the radial edge of the ECU tendon sheath to create an inverted-L shaped incision (Figure 4b). To expose the distal attachment of the TFCC, an incision is made distal to the dorsal radioulnar ligament and up to the edge of ECU sheath. The ulnar head and ulnar neck are exposed by extending the capsulotomy incision proximally.

The Berger and Bishop technique utilizes an inverted-V capsulotomy based on the line of the dorsal radiotriquetral ligament and the edge of the sixth compartment. This approach visualizes the distal aspect of the TFCC and lunotriquetral joint and does not allow access to the proximal aspect of the TFCC or DRUJ.[18]

Volar approaches to the wrist

Volar approaches to the wrist include: carpal tunnel approach; Guyon tunnel approach, flexor carpi radialis (FCR) approach and flexor tendons approach.

Applied anatomy of the volar approach

The carpal tunnel is a fibro-osseous canal on the volar surface of the carpus. The four attachments of the flexor retinaculum (pisiform, hamate hook, ridge of trapezium and scaphoid tuberosity) all are palpable. The pisiform is a sesamoid bone within the tendon of the FCU. Slightly distal and radial is the hook of hamate.[19] The deep branch of the ulnar nerve lies on the hook. The ridge of trapezium is a prominence on the volar aspect of the trapezium. The scaphoid tuberosity is just distal to the radius and is palpable under the FCR tendon.[3]

One tendon and two nerves run on the surface of the flexor retinaculum: palmaris longus, palmar cutaneous branch of the median nerve and the ulnar nerve. The palmar cutaneous branch of the median nerve's course is variable.[20] Most commonly the nerve will branch off the median nerve around 5 cm proximal to the wrist and run along the ulnar border of the FCR before passing over the retinaculum and dividing into medial and lateral branches. The two branches may arise from the median nerve directly or the branch may arise within the carpal tunnel and pass through the flexor retinaculum. Rarely, the palmar branch is absent. The ulnar nerve runs down the volar surface of FCR muscle.[19] Just proximal to the wrist, the artery and nerve emerge from under the muscle to pass over the flexor retinaculum of the wrist in Guyon's canal. The canal boundaries are the pisiform,

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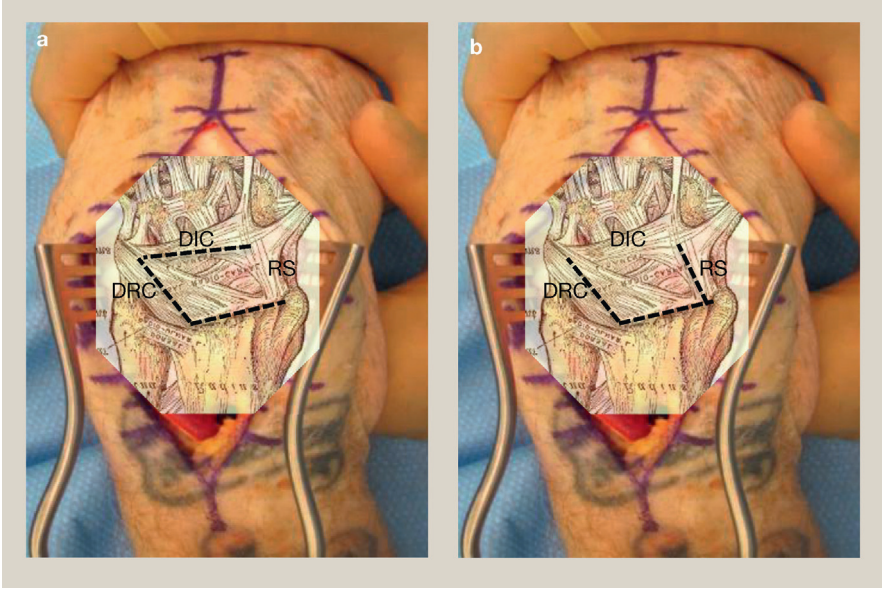

Figure 3 Schematic displaying radially-based anatomical dorsal capsulotomy (**a**) and distally-based capsulotomy (**b**). The radially-based capsulotomy is an anatomical capsulotomy with elevation of a radially-based flap to expose the radial aspect of the radiocarpal joint and entire midcarpal joint. Carpal stability is achieved by leaving intact half of each capsular ligament. The distally based capsulotomy allows similar access, but the flap is reflected distally. DIC, dorsal intercarpal ligament; DRC, dorsal radiocarpal ligament; RS, radioscaphoid ligament.

flexor retinaculum, hamate and volar carpal ligament. The ulnar artery is located at the radial side of the nerve.

The median nerve enters the carpal tunnel and lies superficial to the tendons of the flexor digitorum profundus (FDP) and flexor pollicis longus (FPL) muscles. While the flexor digitorum superficialis (FDS) tendons are toward the ulnar side of the nerve. The nerve divides into three branches: the medial cutaneous branch to the ring, middle and index fingers, the lateral cutaneous branches to the radial side of the index finger and to both sides of the thumb, the recurrent motor branch to the thenar eminence. Variations in the recurrent motor branch have been described including: the branch arises within the tunnel and hooks around the retinaculum, the branch arises within the tunnel and penetrates the retinaculum and the branch arises from the ulnar side of the nerve and hooks around to the radial side.[20,21]

The FDS tendons to the ring and middle finger are superficial to the index and little finger tendons. The FDP lies deeper to the FDS and they may be connected, while the FPL tendon is radial to the FDP.

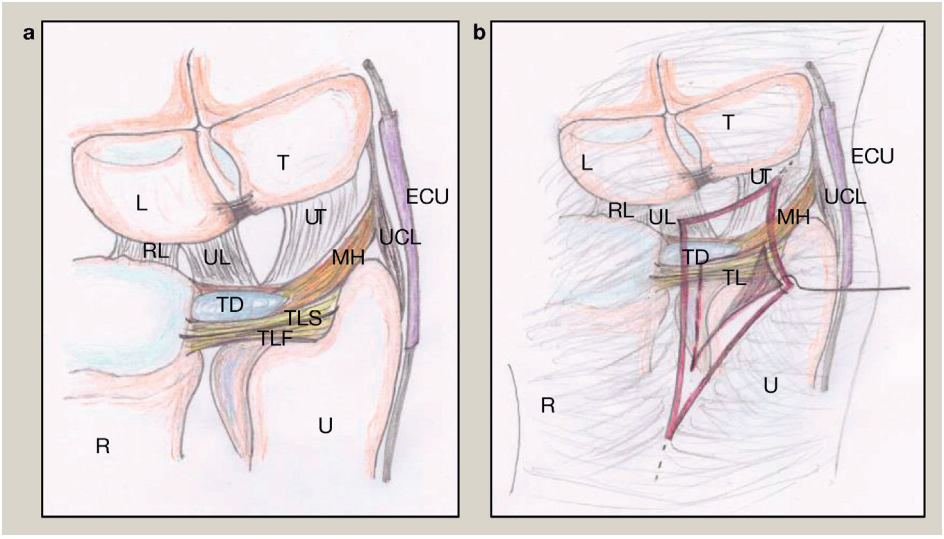

Figure 4 (**a**) Distal radioulnar joint (DRUJ) anatomy. The triangular fibrocartilage complex (see also Table 3) is made up of the ulnar collateral ligament (UCL), meniscus homologue (MH), triangular disk (TD) and the radioulnar ligaments formed of the triangular ligament styloid band (TLS) and the triangular ligament foveal band (TLF). (**b**) The DRUJ approach, showing skin incision location and capsular retraction to access the joint. ECU, extensor carpi ulnaris tendon and sheath; L, lunate; R, distal radius; RL, radiolunate ligament; T, triquetrum; U, ulnar styloid; UL, ulnolunate ligament; UT, ulnotriquetral ligament.

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Components of the triangular fibrocartilage complex

Component	Description
Dorsal radioulnar ligament	Triangular ligament styloid band Triangular ligament foveal band
Volar radioulnar ligament	Triangular ligament styloid band Triangular ligament foveal band
Central disc	Triangular fibrocartilage
Meniscus homologue	Oblique fibrocartilaginous structure merge into UCL
Ulnar collateral ligament (UCL)	Ulna styloid to triquetrum
Ulnolunate ligament	Volar ligament between ulna and lunate
Ulnotriquetral ligament	Volar ligament between ulna and lunate
Extensor carpi ulnaris (ECU) sheath	ECU in a separate sheath

Table 3

Carpal tunnel approach to the wrist

Incision: make the incision just to the ulnar side of the thenar crease (Figure 1). A line projected from the radial border of the ring finger can be used to guide the incision. Start about one-third of the way into the hand and continue just distal to the proximal crease.[1]

Superficial dissection: identify the palmar fascia and divide it carefully, after making sure the recurrent motor branch is not in the incision.[21]

Deep dissection: continue dividing the transverse carpal ligament gently to expose the nerve. Insert a McDonald over the nerve, between the retinaculum and nerve, to protect it and complete the incision in the retinaculum on the ulnar side of the nerve. The superficial palmar arch crosses the palm at the level of the distal end of the outstretched thumb and, therefore, division of the retinaculum should stop once the fat distal to the retinaculum is visible. The same is carried out proximally to reach the palmaris insertion into the retinaculum. The release is complete if the two ends of the retinaculum lie parallel to each other without tension.

Guyon's canal approach

Incision: make a curved incision following the radial border of the hypothenar eminence and crossing the wrist joint obliquely (Figure 1). Extend the incision onto the volar aspect of the distal forearm.[2]

Superficial dissection: deepen the incision through the volar carpal ligament and identify the FCU tendon in the proximal end of the wound.[16] Mobilize the tendon by incising the fascia on its radial border and retract the muscle and tendon in an ulnar direction to reveal the ulnar nerve. The artery is most at risk at the radial side of the nerve.

Deep dissection: follow the nerve and artery distally, incising the volar carpal ligament. During this procedure, take great care to protect the nerve and vessel. The ulnar nerve is now exposed across the wrist joint and decompressed.

FCR distal radius approach

The FCR approach is the most commonly used volar approach to distal radius fractures. The internervous plane is between the FCR (median nerve) and FPL (AIN).

Incision: the skin is incised over the FCR tendon (Figures 1 and 5), which is palpable just ulnar to the scaphoid tuberosity and extends distally for 6–8 cm. The subcutaneous fat is incised down to the FCR sheath. The incision can be extended over the wrist crease in a curved fashion.

Superficial dissection: the superficial sheath of the FCR tendon is incised in line with the tendon fibres. As the palmar cutaneous branch of the median nerve is almost always ulnar to the FCR tendon, the tendon is retracted ulnarwards. Recently, an aberrant variation of the palmar cutaneous branch has been described in which the nerve runs along the floor of the FCR sheath.[22] Therefore, careful dissection of the FCR deep sheath is recommended. Careful dissection should also be carried out near the proximal wrist crease, as the superficial branch of the radial artery crosses superficial to the sheath and runs from ulnar to radial.

Deep dissection: dissection is done between the radial fascia and the FPL muscle that runs deep to the fascia (Figure 5). The radial artery runs radial to the FCR tendon and superior to this fascia. Retracting the radial fascia will protect the artery. The FPL muscle belly and tendon are mobilized ulnarwards exposing the pronator quadratus muscle. The radial and distal borders of pronator quadratus are incised to bone, elevating the muscle off the volar radius and exposing the distal radius.

Scaphoid approaches

The scaphoid can be surgically approached from volar or dorsal aspects. The volar provides good exposure of the scaphoid bone whilst avoiding disturbance of the dorsal blood supply to the bone's proximal half.[23–25] However, the radial artery may be at risk as it transverses from volar to dorsal. The dorsal approach offers safe exposure of the scaphoid bone. The superficial branch of the radial nerve is at risk in this approach and it may also interfere with the dorsal blood supply of the scaphoid.[3]

Volar approach to the scaphoid

Incision: palpate the tuberosity of the scaphoid on the volar aspect of the wrist and the FCR tendon crossing the scaphoid before it inserts into the base of the second and third metacarpals.[2] The incision is a 2–3-cm vertical or curvilinear incision based on the scaphoid tuberosity and extending proximally between the FCR tendon and radial artery (Figure 1).[2,7]

Superficial dissection: the incision is deepened to the fascia until the radial artery is identified on the lateral side of the incision and retracted laterally. The flexor retinaculum portion over the FCR is incised to allow tendon retraction medially to expose the volar radial aspect of the wrist.

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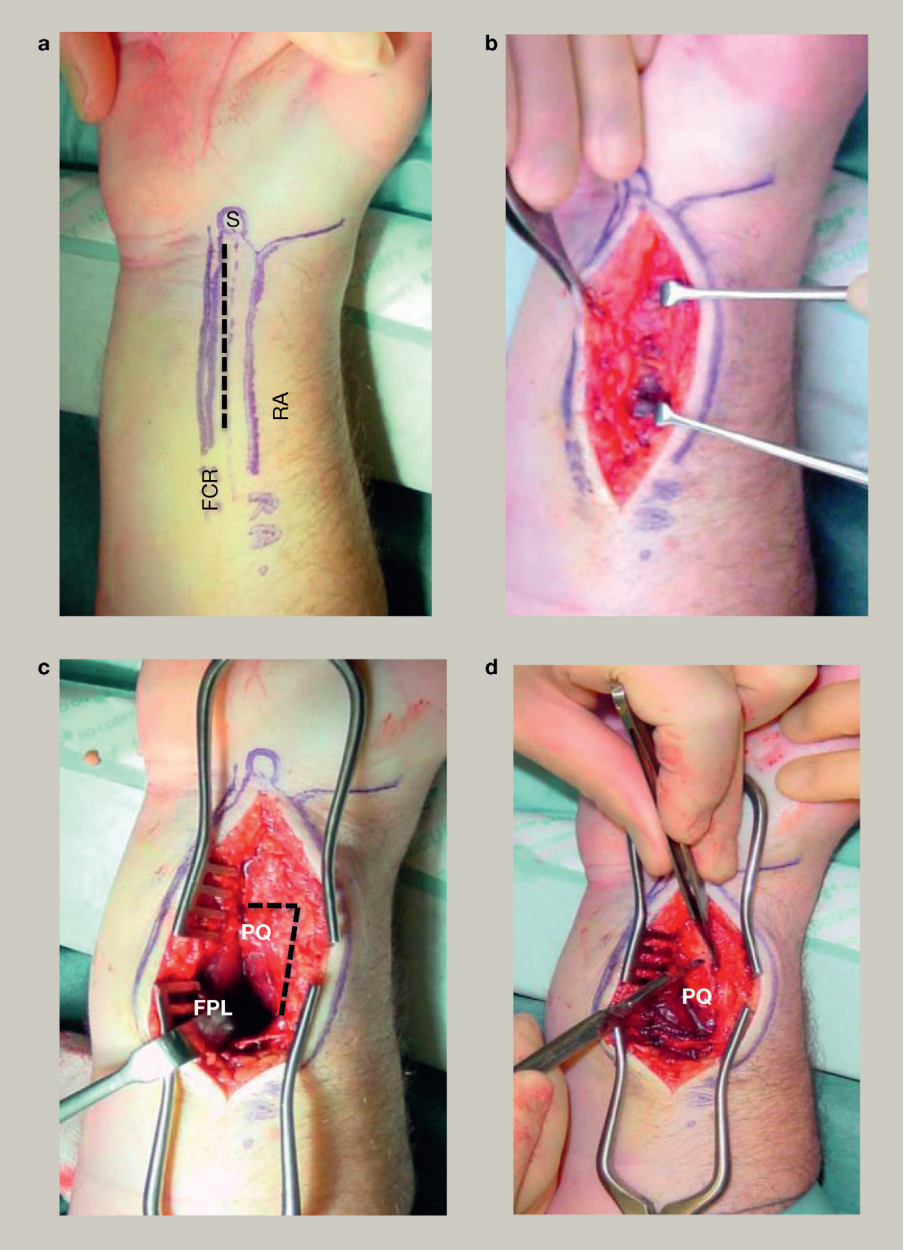

Figure 5 The flexor carpi radialis (FCR) approach. (**a**) The skin is marked to show the radial artery (RA), scaphoid tuberosity (S) and FCR tendon. (**b**) The FCR bed sheath is exposed and incised. (**c**) The flexor pollicis longus (FPL) is retraced ulnarly to show the pronator quadratus (PQ). The dotted line marks the PQ incision. (**d**) The PQ is incised distally and radially. (Images kindly provided by Mr Alfred Morris.)

Deep dissection: the capsule of the wrist over the scaphoid is incised to expose the distal two-thirds of the scaphoid. Dorsiflexion of the wrist will allow exposure of the proximal third of the scaphoid. The approach can be extended proximally along the FCR tendon and deeper to the lateral border of the pronator quadratus, which can be elevated to expose the distal radius.

Dorsal approach to the scaphoid

Incision: palpate the radial styloid process and anatomical snuffbox; the scaphoid lies in the floor of the snuffbox and will become more prominent when the wrist is moved into ulnar deviation. The radial artery is palpable in the floor of the snuffbox over the scaphoid.[8,26]

The incision is a slightly curved S-shaped incision, centred over the snuffbox and extending from the base of the first metacarpal to the radial styloid. The plane is between the EPL and EPB tendons, which are supplied proximally by the posterior interosseous nerve.

Superficial dissection: the EPL and EPB tendons are identified on the dorsal and volar sides of the incision. The fascia between the two tendons is incised whilst protecting the sensory branch of the superficial radial nerve. The radial nerve is usually divided into two or more branches at the interval between the two tendons.

The EPL is retracted dorsally and the EPB retracted volarwards. The radial artery is identified as it traverses at the

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proximal end of the incision over the bone and is protected with arterial sling.

Deep dissection: the ECRL tendon is identified at the dorsal aspect of the wrist capsule and retracted with the EPL dorsally. The capsule of the wrist is incised longitudinally and retracted to expose the radioscaphoid joint. Ulnar deviation will allow full exposure of the joint.

De Quervain's approach

This approach is used to release the first extensor compartment of the APL and EPL. It is a direct approach and is not extendable.

Incision: the landmarks on the radial side are the radial styloid, APL and EPB tendons. The skin only is incised for 2–3 cm in a transverse direction.

Superficial dissection: blunt dissection with scissors will allow the identification of the sensory branches of the radial nerve, which should be protected.

Deep dissection: the extensor retinaculum is identified and incised. The tendon sheath is opened proximally and distally. The APL tendon may have two strands at this level and should not be mistaken for the EPB.[27] Identifying both tendons and releasing both sheaths is crucial for successful decompression.

Conclusion

This article outlines the anatomy of the wrist and commonly used surgical approaches. Detailed knowledge of bony structures, ligament complexes, tendon anatomy, blood supply and nerve routes is crucial to achieve adequate surgical exposure. Determining the optimal approach is not just decided by the pathology being treated, but also by anatomical and functional restrictions. Careful planning of a suitable approach is fundamental to the success of the surgical intervention. ◆

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