THE INTEROSSEOUS MEMBRANE AND ITS INFLUENCE ON THE DISTAL RADIOULNAR JOINT

An anatomical investigation of the distal tract

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From the interosseous membrane of the forearm a tract extends to the dorsal capsule of the distal radioulnar joint. The structure and function of this tract have been investigated. The tract originates from the radius 22 mm proximal to the distal dorsal corner of the sigmoid notch. Central fibres are attached there with fibrous cartilage and superficial bundles mix with the periosteum. The tract is 8 mm wide, 31 mm long and 1 mm thick. Distally it inserts at the capsule of the distal radioulnar joint between the tendon sheaths of extensor digiti minimi and extensor carpi ulnaris. Deep fibres insert directly at the triangular fibrocartilage. The tract of the interosseous membrane is taut in pronation and loose in supination. It strengthens the dorsal capsule of the distal radioulnar joint. During pronation the tract protects the ulnar head in a sling. Its attachment at the triangular fibrocartilage influences the distal radioulnar joint. Its insertion at the triangular fibrocartilage and the support of the weakest part of the dorsal capsule are of interest.

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During forearm rotation the radius, ulna, interosseous membrane (IM) and proximal radioulnar joint (PRUJ) interact with the distal radioulnar joint (DRUJ) (Platzer, 1975). Stability of the DRUJ is maintained by the triangular fibrocartilage complex (TFCC) (Palmer and Werner, 1981), the ulnocarpal ligaments, the pronator quadratus muscle (Johnson and Shrewsbury, 1976), the dorsal ligamentous complex (Bowers, 1993), the interosseous membrane (Lanz and Wachsmuth, 1935), the forearm muscles crossing the supination/pronation axis and by the bony architecture.

At the DRUJ the cartilaginous surfaces of the sigmoid notch and of the ulnar head have different diameters. The DRUJ is incongruent.

All structures affecting the DRUJ have to be analysed carefully to establish the cause of instability of the DRUJ. The purpose of this study was to investigate the anatomy, histology and function of the distal tract of the IM and its influence on the DRUJ.

MATERIAL AND METHODS

Forty-five cadaver wrists were investigated (mean age, 73 years, range 69–82). All specimens were fixed in alcohol and glycerin. Another four specimens were investigated osteologically. The upper limb was amputated above the elbow joint. The forearm fascia and the extensor retinaculum were excised through a midline longitudinal dorsal incision extending from the elbow to the carpus. The extensor tendons were dissected at the MP joints and were retracted with their muscle bellies to their proximal origin. From the proximal forearm the IM and the distal tract to the DRUJ were exposed. After investigation of the distal tract the hand was amputated at the radiocarpal joint (RCJ).

The following investigations were performed with the forearm in neutral position.

Radial attachment: The distance between the distal insertion at the radius and the distal/dorsal edge of the sigmoid notch was measured.

Width was assessed at the distal insertion of the tract at the radius at right angles to its direction.

Length was measured along the proximal border of the tract.

Insertion at the DRUJ was classified into a radial type (beneath the EDM), a central type and an ulnar type (beneath the ECU). The capsule of the DRUJ was studied with loupes to locate the insertion.

Osteology: Two bony sections were made in the sagittal plane, and two along the plane of the tract. The specimens were embedded in methylmethacrylate and cuts of 5 micrometres were made with a microtome. The slices were stained with Giemsa. The structure of the tract and its pattern of insertion were investigated under polarized light. The thickness of the tract was measured under the microscope.

Function: The tension of the tract was assessed before amputation at the RCJ. It was investigated in neutral forearm position, in maximal pronation and in maximal supination. The tract was considered to be taut when the fibres were oriented parallel and loose when the fibres were folded.

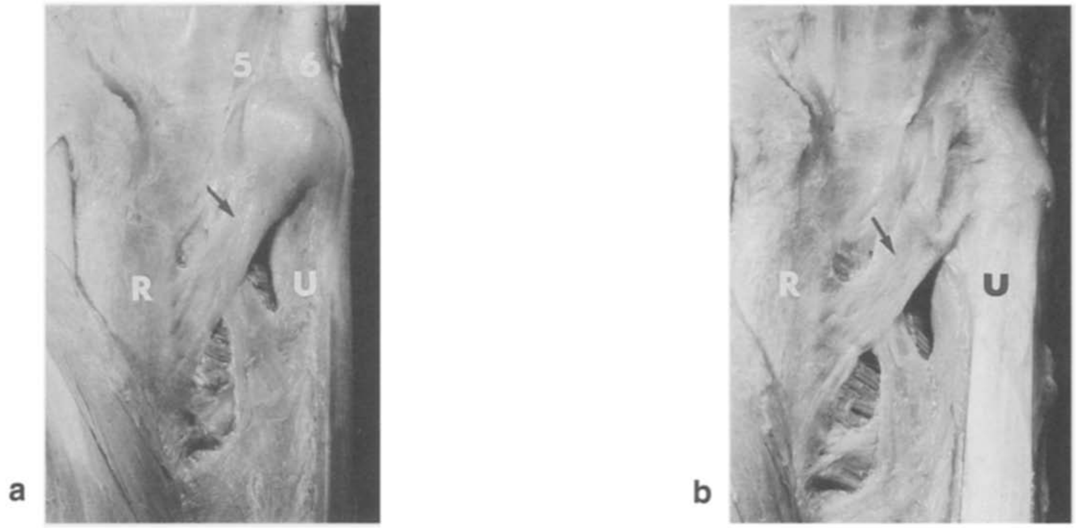


Fig 1 Dorsal view of DRUJ: Tract of the interosseous membrane extending from the distal radius to the DRUJ (between ECU and EDM). (a) The tract is taut in pronation. (b) The tract is loose (folded) in supination. Arrow, distal tract of the IM; R, radius; U, ulnar; 5,6..location of EDM and ECU tendons

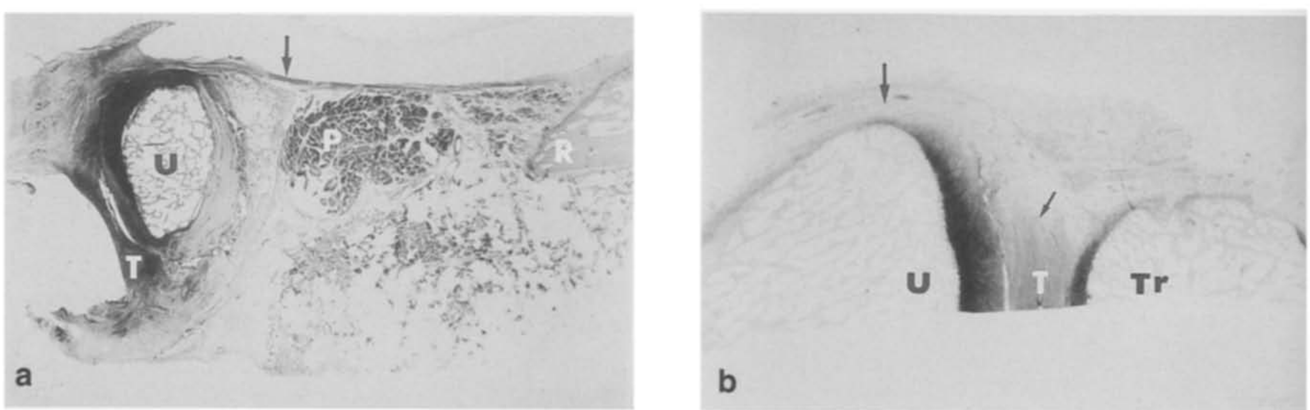


Fig 2 Osteology of the distal tract of the IM. (a) Insertion (Radius, DRUJ) and tract (section along its course); Giemsa staining, 2.5× original magnification. Arrow, distal tract of the IM; R, radius; P, pronator quadratus muscle; U, ulna; T, TFC. (b) Collagen fibres at insertion at the DRUJ (saggital section) Giemsa staining; 2.5× original magnification. Arrow, course of the distal tract of the IM around the ulnar head and its insertion at the TFC; U, ulnar; T, TFC; Tr, triquetrum.

RESULTS

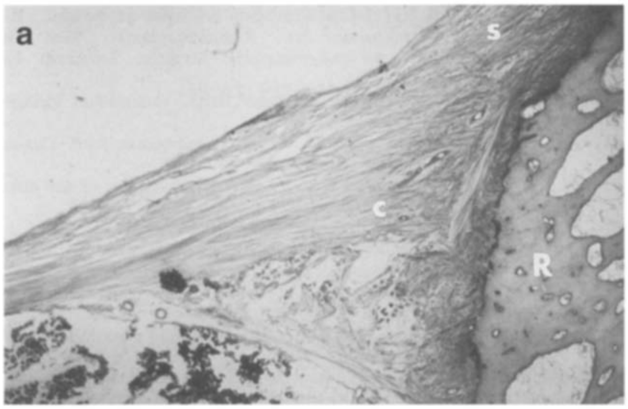
In all specimens the tract of the IM extended proximally from the radius distally to the ulna (Fig 1). It inserted constantly at the DRUJ and was covered palmarly by the pronator quadratus muscle (Fig 2).

The attachment at the radius was 34 mm (range 20–50 mm) proximal to the dorsal rim of the sigmoid notch. Macroscopically the fibres of the tract were attached in a semicircular pattern at the periosteum of the distal radius. The distal end of the attachment to the radius was 22 mm (range 15–35 mm) proximal to the distal and dorsal edge of the sigmoid notch (Fig 1). In all specimens central fibres of the tract were attached to the radius with fibrous cartilage whereas superficial fibres intermingled with the periosteum (Fig 3).

The tract was 8 mm wide (range, 4–12 mm), 31 mm long (range, 25–50 mm) and 1.0 mm thick (range, 0.6–1.3 mm). Collagen fibres showed wavy bundles and were oriented mainly in one direction. Fibrocytes were flattened and spindle-shaped. Reticular tissue was attached dorsal and palmar to the tract.

Distally an ulnar type of insertion was observed in 10% and a middle type insertion was seen in 90%. In this area magnification revealed an inner synovial and two superficial collagen layers of the dorsal capsule. Insertion of the tract at one of the layers could not be verified by the use of loupes. Bony studies revealed fibres of the tract inserting directly at the TFC and others inserting superficially at the capsule (Fig 2).

The fibres of the tract were aligned parallel and taut in maximal pronation, folded and loose in maximal



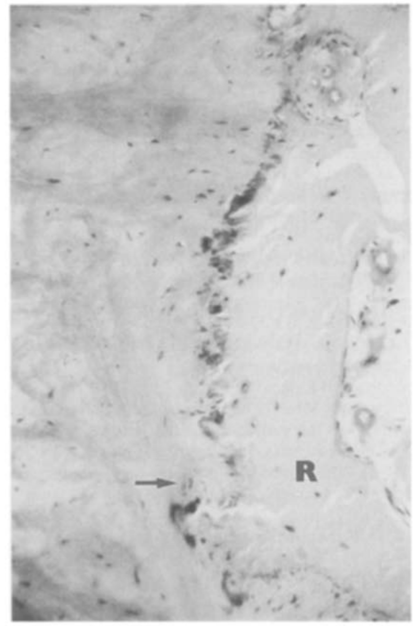


Fig 3 Radial insertion of the tract. (a) s, superficial fibres interweaving with the periosteum; c, central fibres inserting into bone; 5× original magnification. (b) Attachment of central bundles with fibrous cartilage – metachromatic effect due to mucopolysaccharide acid staining in chondral differentiated cells; 25× original magnification. R, radius; s, superficial fibres; c, central fibres; arrow, chondrocytes.

supination (Fig 1). In the neutral position of the forearm the tract was loose. The capsule was not folded and the fibres were aligned parallel. Tension and parallel alignment increased with increasing pronation.

DISCUSSION

Ulnar variance seems to influence the conformation of the DRUJ. The shape of the ulnar head corresponds to the inclination of the sigmoid notch (Förstner, 1987). The different diameters of the sigmoid notch and of the ulnar head limit the area of joint contact (Olerud et al, 1988). Rotation of the forearm is combined with translation in a dorsopalmar direction and with translation from distal to proximal. In pronation joint contact at the sigmoid notch changes to dorsal and proximal, and in supination it changes to palmar and distal. The joint has the closest fit in the neutral position of the forearm (af Ekenstam and Hagert, 1985; Kauer, 1992; Linscheid, 1992; Schmidt and Lanz, 1992; Schuind et al, 1991).

The incongruent DRUJ is stabilized by static and dynamic forces. The triangular fibrocartilage (TFC), the ulnar carpal ligaments and the tendon sheath of the ECU are the major units of the stabilizing triangular fibrocartilage complex (TFCC) (Fick, 1911; Palmer and Werner, 1981). Additional static stabilizers are the extensor retinaculum, the dorsal carpal ligament complex and the IM (Bowers, 1993). Dynamic stability is provided by the pronator quadratus muscle and the ECU (Johnson and Shrewsbury, 1976; Spinner and Kaplan, 1970). Only the proximal and middle third of the IM are considered as relevant structures influencing forearm rotation.

The distal part of the IM has been little discussed (Kapandji, 1984; Küsswetter and Schmid, 1979; Lanz and Wachsmuth, 1935). The IM contributes only a little to forearm stability. All fibres are oriented to accept the distal pull of the attached muscles (Hollister et al, 1994). The distal IM has been variably described. Küsswetter and Schmid (1979) described thin horizontal fibres between the ulna and radius inserting into the periosteum. Lanz and Wachsmuth (1935) and Kapandji (1984) described a tract of the distal IM extending from the distal radius proximally to the ulna. In contrast, the tract we studied extends from a proximal attachment on the radius to the DRUJ. It reinforces the capsule of the DRUJ between the tendon sheaths of ECU and EDM. This insertion increases the coverage of the ulna head during pronation. It also inserts directly into the TFC, one of the major units of the stabilizing TFCC. The reinforcement of the tract at the radius with fibrous cartilage and periosteum can be interpreted as a mixed pattern of attachment. This kind of attachment is seen when higher tension forces are applied to ligaments. Ligaments with low functional importance insert only into the periosteum (Küsswetter and Schmid, 1979). Furthermore, the orientation of the collagen fibres provide insight into the stress applied to the tract (Chidgey, 1995). The tract is a functional structure. It is loose in supination and taut in pronation. When the ulnar head becomes prominent in pronation, the tract extends from the palmarly located TFC around the prominent ulnar head to its palmar attachment at the radius. The ulnar head is protected in a "pronation sling". The tract can be considered as an additional stabilizer of the DRUJ. It supports the ulna head during pronation where the stabilizing ECU and EDM do not cover the DRUJ.

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