Rotatory Radiocarpal Instability

J.-L. Roux

1 Introduction

Radiocarpal rotatory instability is defined as the increase in longitudinal rotation between the forearm bones and the carpal condyle.

This rotational laxity in the transverse plane constantly provoked by pronosupination is frequently forgotten in clinical and biomechanical studies of carpal stability.

Longitudinal rotation between forearm bones and carpal condyle has nevertheless been described by several authors.

The first was Cyriax [1] in 1917, who showed that an important passive rotation existed between forearm bones and carpal condyle. He emphasized that this rotation cannot be produced actively. He evaluated it clinically at 45°, whereas in a cadaver it was only at 19°.

In 1980, Gagey [2] evaluated intracarpal and radiocarpal rotation at 50° in completely relaxed patients under general anaesthesia in theatre.

In 1991, Kapandji [3] defined ‘rotational drift’ between the radius and the base of the metacarpals. He measured it in his own wrist under tomodensitometry at 45° in free pronosupination.

In 1992 [4, 5], we clinically measured radiometacarpal rotation RMR, which is the rotation that occurs between the forearm bones fixed in midpronation and the base of the metacarpals. We used a special device that measures simultaneously the RMR, the grip force and the pronosupinator moment arm exerted distally to show that this passive rotation varied for the same moment arm force according to the grip strength. A first measurement was recorded with the wrist relaxed (force less than 5 N), exerting a distal rotation moment arm of 2 Nm in supination and 0.5 Nm in pronation. In these conditions, the RMR was 42°. A second measurement was taken

J.-L. Roux
Hand Surgery Unit, Institut Montpelliérain de la Main,
25, rue Clémentville, 34070 Montpellier, France
e-mail: jlroux.imm@wanadoo.fr

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with closed wrist (grip force between 80 and 100 N) with distal moment arm of rotation of 1 Nm in pronation and in supination. The RMR was 33°. This decrease in RMR with a distal moment arm almost tripled defines the wrist locking. We used this test to assess 100 healthy wrists.

2 Radiocarpal Rotatory Stability

We have shown in a cadaveric anatomic study that there are radiocarpal and intracarpal ligament structures limiting the passive longitudinal rotation in pronation as well as in supination. We described a 'double ligamentary pronosupinator helix' (Fig. 1) [5, 6].

The pronator helix is activated by active pronation against resistance or passive carpal supination. It originates on the posterior border of the radius and joins the posterior border of the triquetrum ulnarly and is composed mainly of the dorsal radiotriquetral ligament. It is prolonged palmarly by the triquetrocapitate ligament then by the thick capitotrapeziotrapezoidal complex. The supinator helix is activated by active supination against resistance or passive carpal pronation. It originates on the anterolateral border of the radius with the radioscaphocapitate ligament, prolonged by the palmar capitotriquetral ligament. On the dorsal aspect of the carpus, it is continuous with the transverse dorsal carpal ligament by a ligament band

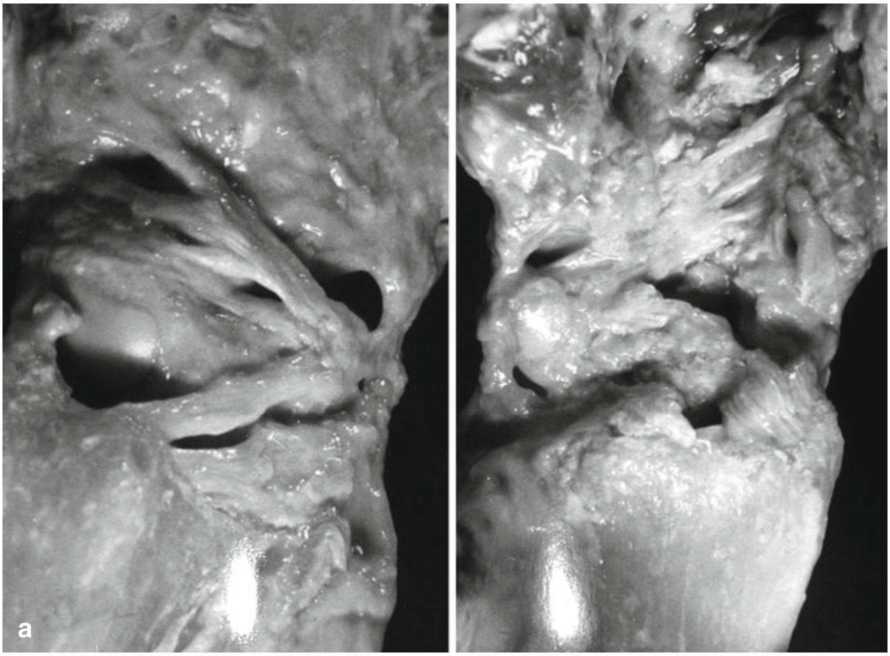


Fig. 1 (**a**, **b**) Extrinsic ligaments form a double pronosupinator helix. This helix is particularly apparent on pronosupination against resistance

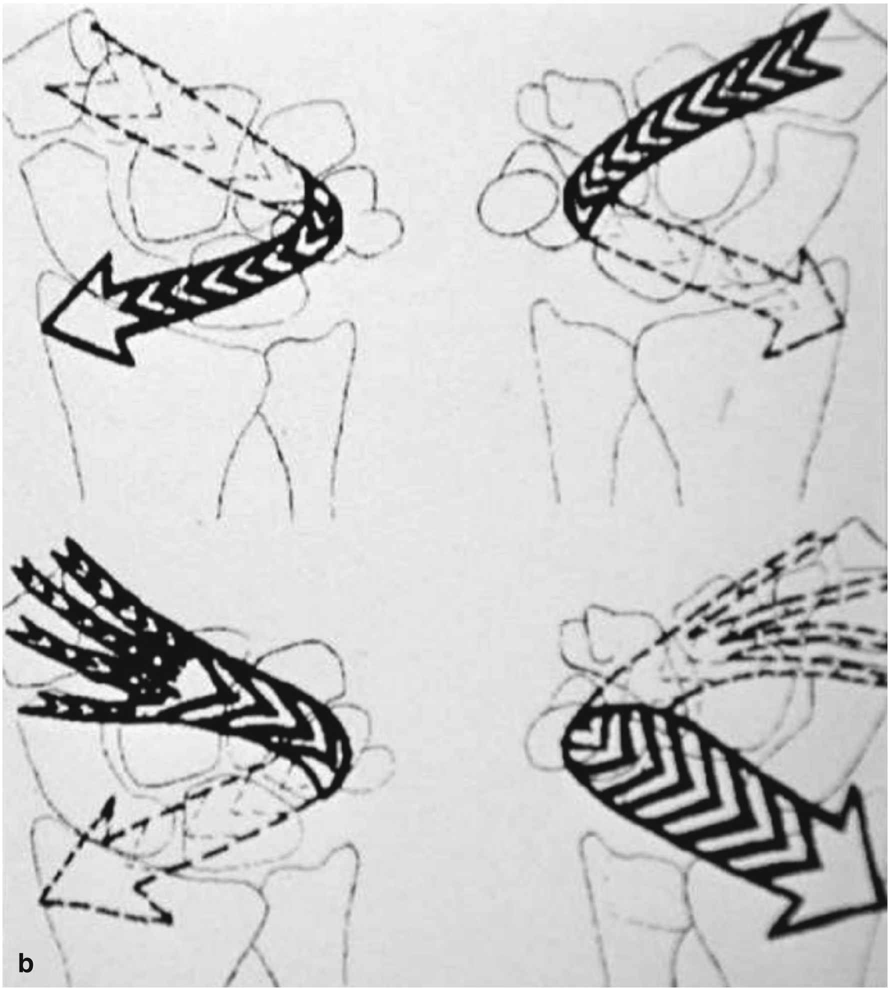


Fig. 1 (continued)

that joins the triquetrum to the trapezoid. This band is more apparent on active supination against resistance.

In a 1995 cadaveric study, Ritt et al. [7] resumed the previous work to study the rotational carpal stability with respect to the radius. He released the anatomic structures activated by a rotational radiocarpal moment arm. When a pronatory moment arm is exerted at the carpal condyle, the radioscaphocapitate ligament is the first to be solicited.

The long and short radiolunate ligaments play a secondary role.

The dorsal radiocarpal ligament is the principal ligament to oppose carpal supination.

Ritt emphasizes that the action of these ligaments depends on the position of the forearm in pronosupination. The ligaments originating from the ulna can be activated by radiocarpal rotation depending on the position of the forearm in pronosupination.

Such is the case for the palmar ulnolunate ligament which essentially resists carpal supination but its action varies according to the pronosupination of the forearm.

The work of Ritt [7, 8] and ours [4–6] show the adaptation of the entire radiocarpal and intracarpal ligamentous structure to the pronosupinator forces the wrist is subjected to.

3 Clinical Test

Since 1992, we use a simple clinical test that activates the previously described ligaments [4–6]. It consists of exerting a distal passive pronosupination force while maintaining midpronation of both forearm bones (Fig. 2).

This test has become systematic for clinical examination of wrist ‘sprains’. Palmar pain provoked by passive pronation of the carpus suggests a radioscaphoid ligament lesion. This test is also positive in scaphoid fractures. Verdan used a similar test holding the hand while the patient tries to actively supinate the forearm. Palmar and palmar radial wrist pain evoked corresponds to the radioscaphocapitate ligament pressing on the fracture site. It suggests a scaphoid fracture.

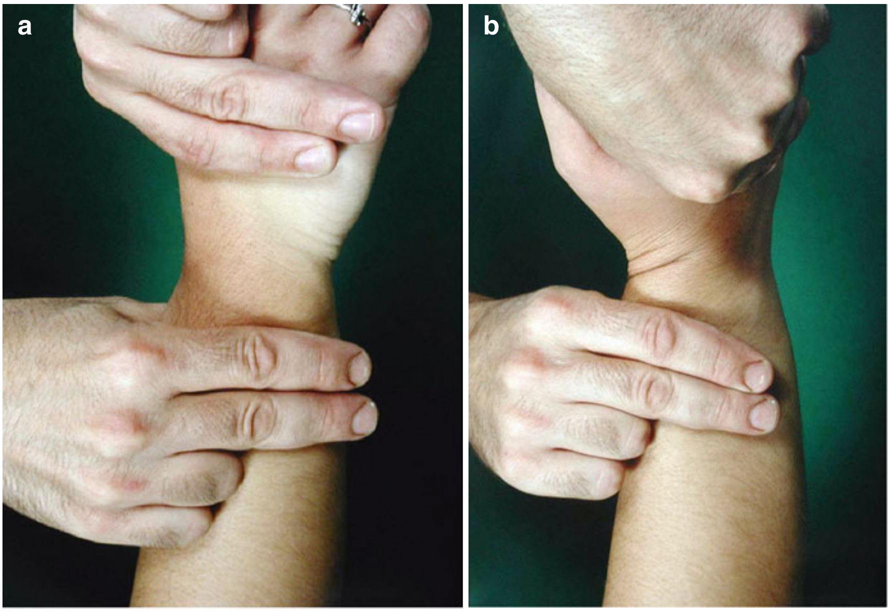


Fig. 2 The test for evaluation of radiometacarpal rotation is a systematic part of our clinical wrist examination, particularly useful if an extrinsic capsular ligament sprain is suspected. (**a**) The forearm is held in midpronation with one hand while the other hand is used to rotate the carpal condyle longitudinally into pronation. (**b**) In supination

The passive carpal supination activates dorsal radiotriquetral ligament and is positive in case of radiotriquetral sprain.

Clinical experience led us to consider results of this test during wrist immobilization [9]. In function of results of this test, we suggest immobilization in slight carpal supination or pronation. This position is independent of the pronosupination of the forearm. We have used this principle for the orthopaedic/closed treatment of dorsal flake triquetral fractures. These fractures are the equivalent of sprain of the dorsal radiotriquetral ligament when this test is positive – this is almost always the case in our experience. For scaphoid fractures and palmar sprains painful in carpal pronation, we place the wrist in mild supination.

4 Radiocarpal Rotatory Instability in Supination

Radiocarpal rotatory instability in supination is defined by increased rotation of the carpal condyle over the distal radius compared to the other side. The clinical test is done symmetrically with one hand holding the forearm in midpronation while the other hand exerts longitudinal rotation in supination at the carpal condyle. In certain cases, simple observation of the wrist shows carpal supination on the distal radius (Fig. 3).

5 Anatomical Reminder

The dorsal radiotriquetral ligament inserts onto the dorsal distal surface of the radius (Fig. 4). Exactly at the dorsal border of the articular surface of the radius, extending from the tubercle of Lister to the sigmoid fossa. It has an oblique pathway passing ulnarly over the posterior horn of the lunate where its deep fibres are attached. These fibres are the reason why the name dorsal radiocarpal ligament is preferred to radiotriquetral. They strengthen the dorsal portion of the lunotriquetral ligament and insert distally on the dorsum of the triquetrum where the ligament merges with the insertion of the dorsal intercarpal ligament. Viegas et al. [10] described the anatomic variations of this ligament but the radiotriquetral fibres are constant.

6 Clinical Experience

Since 1998, we have operated four patients for rotatory radiocarpal instability in supination. To us, this is synonymous with dorsal radiotriquetral ligament insufficiency. We have treated this instability by reconstructing this ligament using extensor retinaculum.

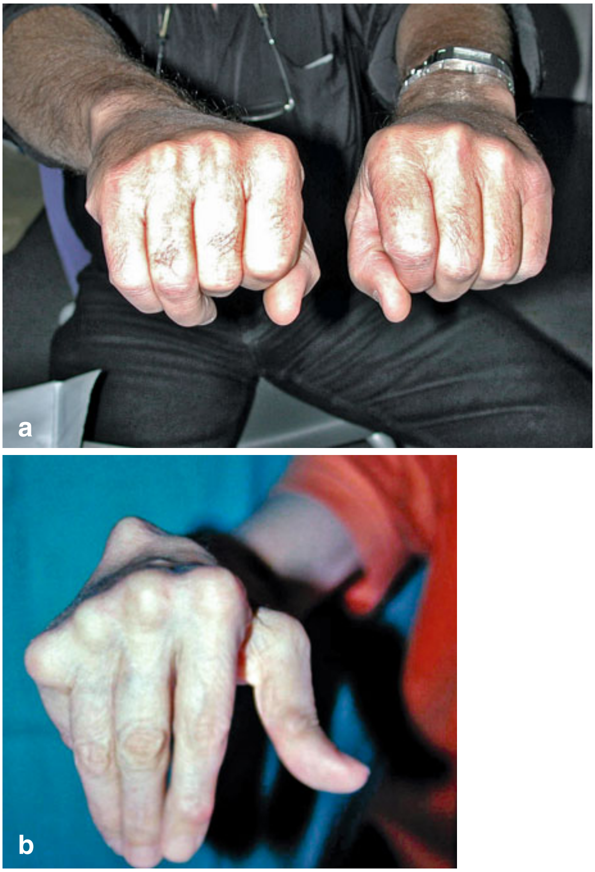


Fig. 3 (**a**) Carpal supination is difficult to observe in case of isolated rupture of the dorsal radiotriquetral ligament. This patient presents with a mild carpal supination of the right wrist following radiotriquetral ligament rupture. (**b**) The carpal supination deformity is apparent in rheumatoid affection or when rupture of ulnocarpal ligaments is associated. Palmar dislocation of the radius with respect to the ulna exacerbates the supination deformity of the carpus

The series includes four men with wrist trauma after a fall. In three cases, the fall was backwards with torsion and supination of the carpus in one case. All cases had posttraumatic oedema. Three patients had radiograms and immobilization, two in a plaster for 3 weeks and one in resin for 1 month. One patient had ignored his initial trauma.

The four patients presented with ulnar wrist pain and acute tenderness on the posterior triquetrum. The radiometacarpal rotation test was positive with pain which increased on carpal supination. In three cases, there was increased radiocarpal rotation in supination compared to the contralateral side. In one case the test was equivocal but the pain sharp. There was no lunotriquetral instability clinically. The radiolunate joint was free with complete pronosupination of the wrist, and normal ROM in other planes with tenderness at extremes of range of motion being the reason for consultation. Patients also complained of a loss of grip strength, measured at 65 % of the contralateral side.

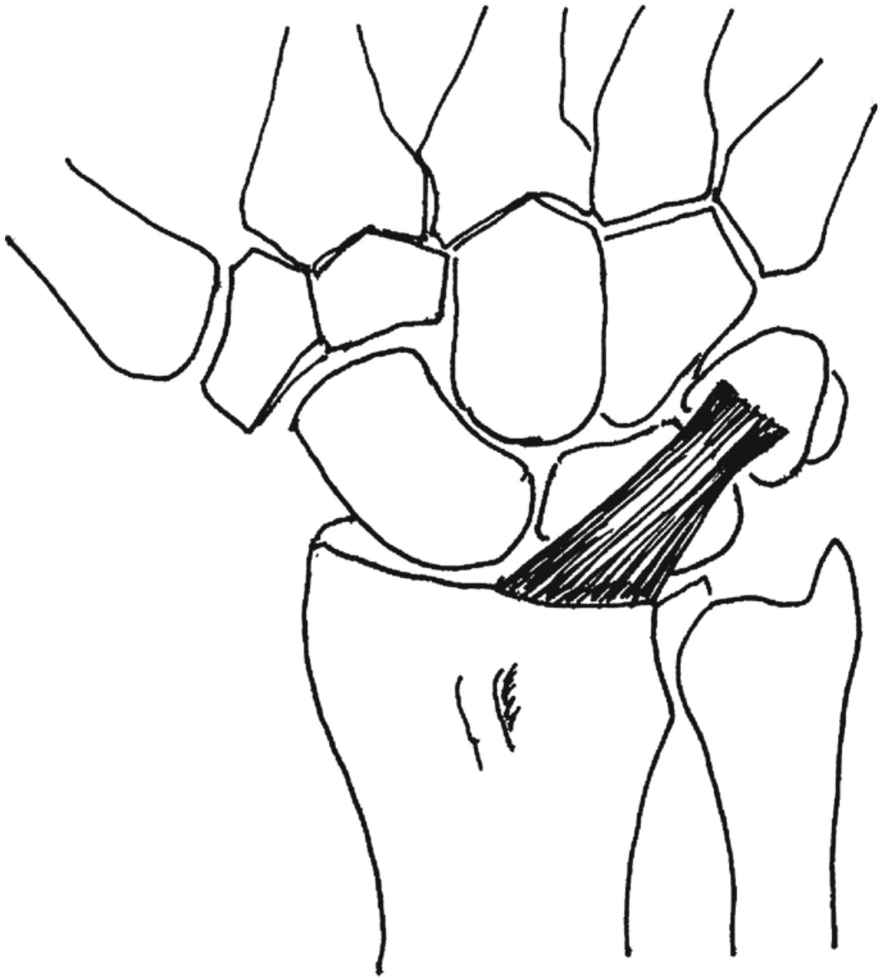


Fig. 4 Dorsal radiotriquetral ligament resists carpal supination. According to Viegas, the radiotriquetral fibres are constant, and in 99 % of cases some fibres terminate on the lunate

In three cases, x-rays showed dorsal avulsion of the ligament off the triquetrum (Fig. 5). There was no ulnar drift of the carpus. The dynamic views showed no disruption of the Gilula lines.

Arthrogram was done in all cases; in two cases there was lunotriquetral incompetence, TFCC was intact in all cases. In one case, a scapholunate ligament lesion without diastasis was found.

Scintigraphy was done in two cases showing isolated ulnar fixation.

Patients were operated at 12–30 months from the initial trauma.

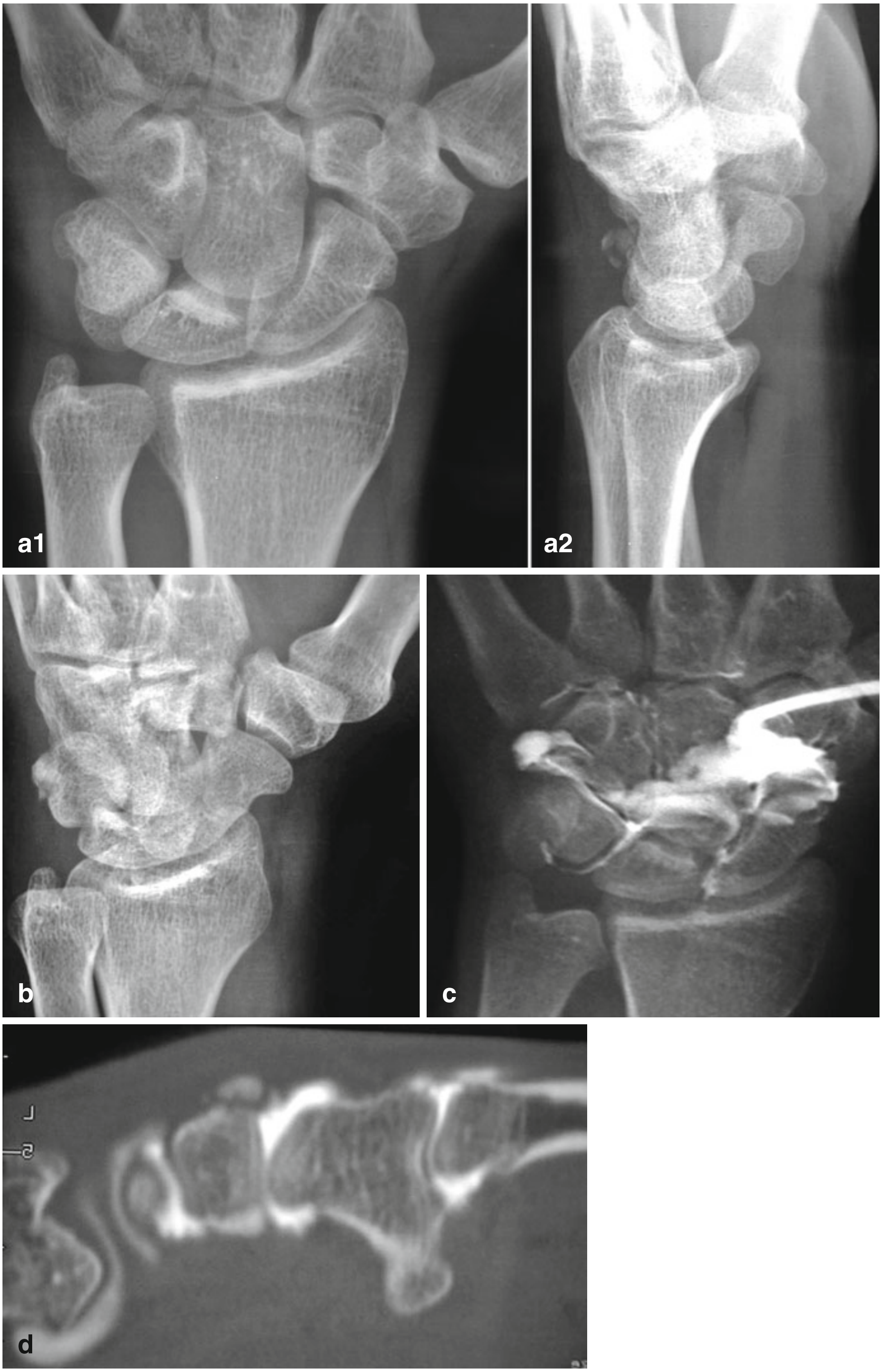


Fig. 5 (**a1**, **a2**) A 32-year-old patient presents with dorsal avulsion of the triquetrum on x-ray where the fragment is seen on the lateral view. (**b**) The oblique view shows the dorsal surface of the triquetrum. (**c**) Arthrogram shows a leak through the lunotriquetral ligament. (**d**) Sagittal cut through the triquetrum of the arthrogram shows the avulsed dorsal fragment

7 Operative Technique

7.1 Reconstruction of the Radiotriquetral Ligament

The operation is performed under general anaesthesia with a tourniquet at the upper arm through a dorsal longitudinal incision in the axis of the third ray medial to the tubercle of Lister. The dorsal extensor retinaculum is identified and the tubercle located. A flap of retinaculum is drawn 6–8 mm wide parallel to its fibres (Fig. 6a). This flap needs to be long enough to reach the dorsal surface of the triquetrum. The retinaculum is incised parallel to its fibres taking care of the extensor tendons beneath (Fig. 6b). Once the flap is harvested, the retinaculum is then opened longitudinally and distally. We identify the dorsal radiocarpal interval and identify the radiotriquetral ligament. In four cases, we found substantial fibrosis and the ligament was difficult to isolate. In three cases, a bony fragment was found on the dorsal

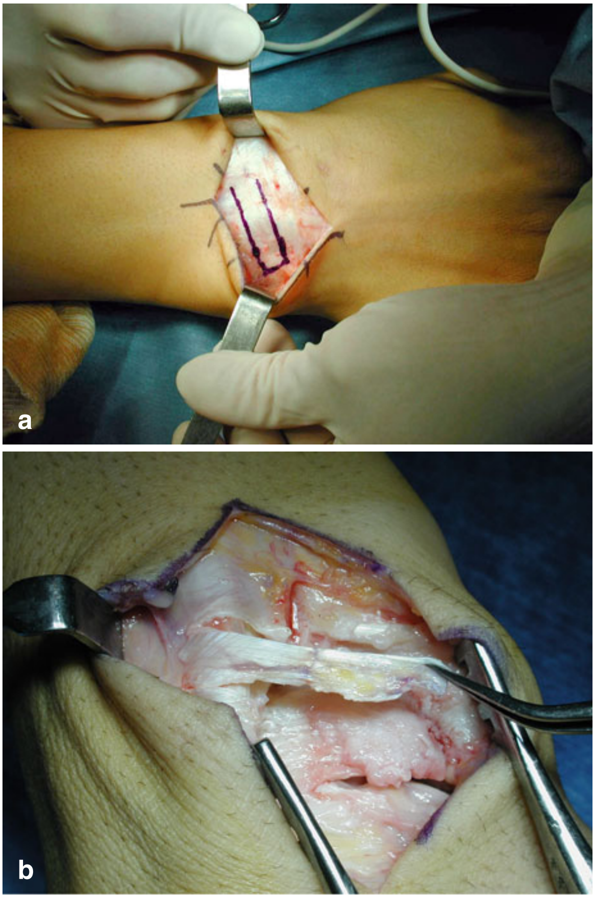
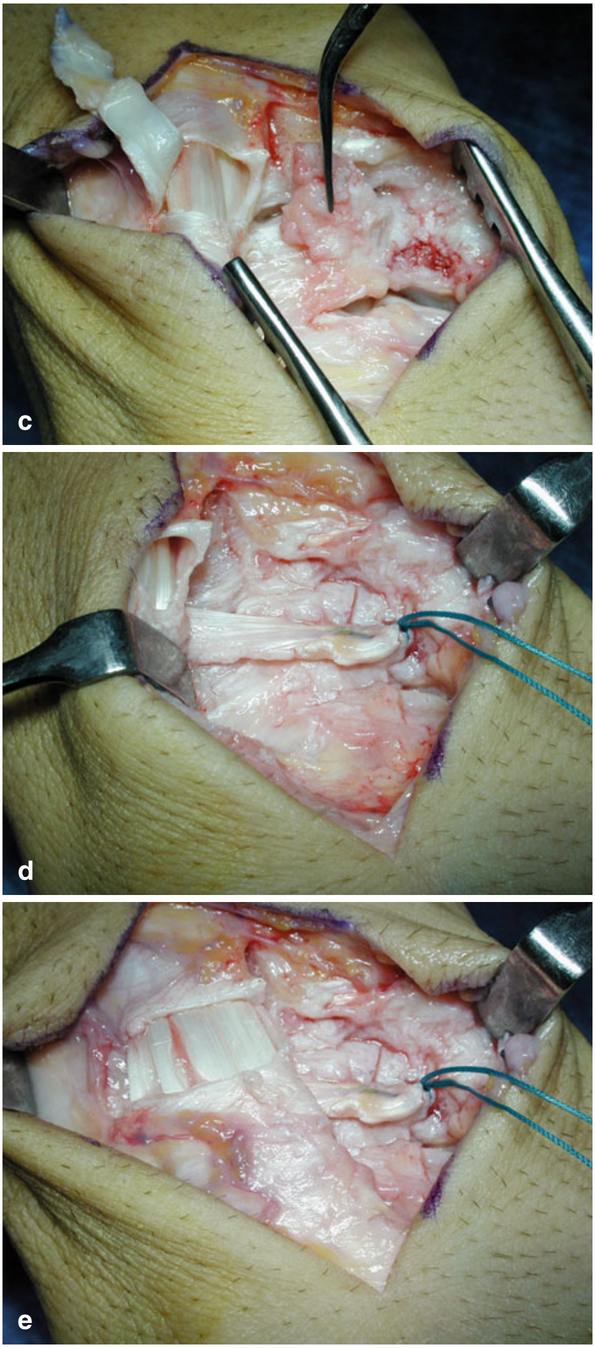


Fig. 6 Operative technique for radiotriquetral ligament reconstruction: (**a**) Right wrist: plane of the extensor retinaculum after longitudinal incision in the axis of the third ray. (**b**) Left wrist: harvesting the retinacular flap; its insertion on the tubercle of Lister is preserved. (**c**) Left wrist: removal of a fragment of the avulsed triquetrum and reaming the radiotriquetral ligament insertion zone. (**d**) Left wrist: fixation of the ligamentoplasty, the carpus is placed in pronation over the radius. (**e**) Left wrist: the extensors resume their position onto the ligamentoplasty. (**f**) Postoperative immobilization using a malleable splint holding the carpus in pronation to the radius

Fig. 6 (continued)



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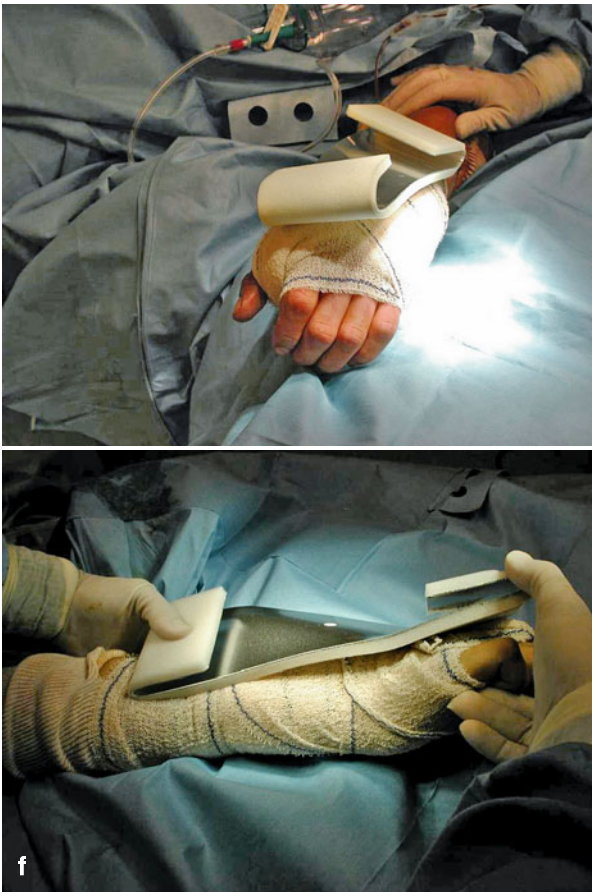

aspect of the triquetrum in the midst of fibrous tissue with difficulty to identify the ligament fibres (Fig. 6c). The ulnocarpal interval was explored and partial minute insignificant lesions of the lunotriquetral ligament were found in three cases without instability. Nothing was done for the lunotriquetral. In one case we sutured the scapholunate ligament which was partially ruptured.

The dorsal aspect of the triquetrum is reamed at the ligament insertion. The retinacular flap is passed under the extensor tendons; its tension is adjusted and fixed onto the dorsal triquetrum using an anchor with the carpus held in maximum pronation to the forearm (Fig. 6d, e). The dorsal retinaculum is resutured so as to re-establish the extensor gliding plane and the continuity of the ligament curtain that resists the carpal supination. A drain is inserted. The hand and forearm are immobilized on a malleable splint maintaining the carpus pronated with respect to the radius (Fig. 6f). At 48 h postoperative, the drain is removed and a resin splint is used to keep the carpal pronation. This splint is renewed at suture removal at 15–20 days and is kept for a total of 45 days.

8 Results

The four patients were reviewed with a final follow-up of at least 1 year. Pain was improved in all four patients. One patient suffered from pain on strength grip, the other three had no pain.

Pronosupination was complete, and extension recovered. In all cases there remained a residual flexion deficit of about 20 % compared to the contralateral side as well as a radial inclination. An increase of force was recorded at 90 % of the contralateral side.

9 Radiocarpal Rotatory Instability in Pronation

The radiocarpal rotatory instability in pronation is defined as the increase in carpal rotation on the distal radius in pronation compared to the contralateral side. Testing is done symmetrically, with one hand maintaining the forearm in midpronation while the other hand exerts a longitudinal rotation at the carpal condyle in pronation.

This clinical test is systematic for us in traumatic wrist examination. We did not find a frank asymmetry of rotation as in the test in supination. This test is positive if painful. Pain is felt on the palmar and radial aspects of the wrist; direct pressure on the wrist between flexor carpi radialis and abductor pollicis longus reproduces this pain. We attribute this pain to a radioscaphocapitate sprain or a scaphoid fracture.

We exclude scaphoid rotatory instability in the setting of scapholunate dissociation. In case of scapholunate dissociation, scaphoid instability occurs in pronation but it involves the scaphoid and not the carpal condyle. This is associated with dissociative intracarpal instability: scapholunate instability.

Radioscaphoid ligamentoplasty as described by Blatt aims to correct the rotator instability between the radius and the scaphoid. Some clinical results are good despite an absent scapholunate ligament. These observations related to our analysis of radiocarpal instability lead us to question: Can dissociative scapholunate instability be secondary to a primary lesion of the radioscaphocapitate ligament?

10 Discussion

Radiocarpal rotatory stability is necessary to transmit pronosupination from the forearm to the hand [6]. The role of the wrist ligaments in the transverse plane is seldom studied. It is in this plane that pronosupination is exerted.

For over a century, radiography has led us to analyse the stability of the carpus in the frontal and sagittal planes while masking the transverse plane.

The advent of CT and MRI that offered a view of the transverse plane in multiple cuts was very conducive to the study of instability, and the 3-D reconstructions facilitate the interpretation of the relative position of the bones.

For the study of instability of ligamentous origin, the available imaging today remains inadequate. The visualization of the interosseous ligaments is good but that of the capsular ligaments is still mediocre. Arthroscopy shows the wrist ligaments directly, and visualization of the radiocarpal capsular ligaments that can be put under tension by pronosupination emphasizes the importance of the transverse plane in carpal stabilization.

Slutsky [11, 12] studied the dorsal radiotriquetral ligament arthroscopically using a palmar radiocarpal portal. This work showed the frequency of lesions of this ligament. Unfortunately, the test of passive carpal supination to detect radiotriquetral ligament lesions did not correlate with the findings of Slutsky. This work showed the frequent association of this lesion with other ligament lesions: scapholunate, lunotriquetral or TFCC. No association of triquetral fracture seems to have been found.

Three of the four patients operated presented with avulsion of the dorsal fragment of the triquetrum. Arthroscopy was not done for these patients. It would have shown the bony fragments found on operation on the distal part of the ligament. We think the lesions we describe are different from those intraligamentous ones reported by Slutsky. Ours were primary lesions of the radiotriquetral ligament; isolated or associated with nonsignificant lesions of the interosseous ligaments. In one case we sutured the scapholunate interosseous ligament.

On the other hand, lesions identified by Slutsky are frequently associated with interosseous ligament lesions. They could be secondary ligament lesions as their diagnosis was very remote from the initial trauma. They could be microtraumatic due to excessive use in case of rupture of the interosseous ligaments. These findings lead us to think that capsular ligament lesions activated by the rotatory pronosupination force are often the site of 'adaptative' secondary lesions. This is what we define as secondary or 'adaptative' rotatory instability. With this instability, the fine radiotriquetral ligament is vulnerable, which may explain the frequent lesions found by Slutsky.

This secondary rotatory instability is probably the cause of the difficulties encountered in the treatment of interosseous ligament injuries – a theory that correlates well with the known evolution pattern of the scapholunate ligament injury. In an initially isolated SL ligament injury, the so-called secondary stabilizers will progressively be affected [13]. At surgery, all the ligaments should be repaired if possible [14].

We think that most primary ligament lesions are acute result of trauma in extension mainly, less frequently in flexion, and the secondary chronic ligament lesions are the result of repeated pronosupination against resistance.

When the wrist is relaxed, pronosupination force induces radiocarpal rotation which places the radiocarpal ligaments under tension. If the force increases, rupture will occur which will, in turn, increase the radiocarpal rotation [15].

Rarely, torsion can induce carpal rotation on the radius and cause acute lesions such as the avulsion of the triquetral insertion of the dorsal radiotriquetral ligament.

The exact mechanism of these fractures is debated between the advocates of avulsion and those of triquetrum impaction against the ulnar styloid [16]. Practically, both mechanisms are probably involved. The four radiotriquetral avulsion patients treated were asked about the trauma. Only one reported torsion with carpal supination, while the other three reported a fall backwards with impaction of the hypothenar eminence in extension. In this case the forearm is pushed behind and the carpal supination may be secondary to forearm pronation; ulnar styloid impaction onto the triquetrum is also possible.

Carpal supination is marked in rheumatoid deformity and palmar ulnocarpal lesions are most probably associated with a radiotriquetral ligament lesion [7].

This idea is reinforced by the distal radioulnar instability and palmar subluxation of the radius. In rheumatoid polyarthritis, rotatory instability in rotation is associated with ulnar drift of the carpus. This drift was never found in our patients. In rheumatoid, the deformity is often treated by tendon transfers of ECRL on to ECU which reproduces the course of the radiotriquetral ligament. In more advanced affection, partial arthrodesis (radiolunate or radioscapholunate) is done for stabilization, to correct supination and ulnar shift of the carpus.

11 Conclusion

Radiocarpal rotatory instability has to draw our attention on the transverse plane, plane of pronosupination, plane where imaging is still deficient.

Only an accurate account of the ligament lesions can provide basis for efficient ligament reconstruction. We thus think that acute posttraumatic ligament lesions are complicated by secondary 'adaptative' lesions that need to be diagnosed and treated.

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