The radioulnar joint in distal radial fractures

A review

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ABSTRACT – We searched The Cochrane Library and Medline regarding the radioulnar joint in distal radial fractures and found no randomized or controlled studies. This review presents the descriptive literature by summarizing accepted views and controversies. There is only weak support for the commonly accepted treatments. Current research has shown that distal radial fractures are often associated with ligament injuries not seen on radiographs. These injuries can lead to laxity of the DRU-joint and subsequent worse outcome, which indicates that we must have a complete diagnosis including ligament injuries if we want to understand better the fracture and its sequelae. Randomized studies should be done before advocating surgical treatment of these unforeseen injuries.

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What's the problem?

Distal radial fractures are estimated to amount to one sixth of all fractures seen in emergency departments (Hollingsworth and Morris 1976). Many authors report good long-term results (Lidström 1959, Stewart et al. 1985, Altissimi et al. 1986, Kopylov et al. 1993, Warwick et al. 1993), but overall complications occur in one third of the patients (Cooney et al. 1980). The commonest complaint after distal radial fractures is ulnar-sided wrist pain (Frykman 1967, Cooney et al. 1980, Altissimi et al. 1986, Solgaard 1988, Tsukazaki and Iwasaki 1993), found in every fifth patient (Frykman 1967), which affects the end-result adversely (Frykman 1967, Hollingsworth and Morris 1976, Jupiter et al. 1992, Stoffelen et al. 1998). Such pain has been attributed mainly to malunion of the distal radius (Lidström 1959, Frykman 1967, Hollingsworth and Morris 1976, van der Linden and Ericson 1981, Villar et al. 1987, Kopylov et al. 1993, Warwick et al. 1993, Hove et al. 1995, Stoffelen 1997) thus creating an imbalance distally, which may lead to both ulnocarpal abutment (Bowers 1999), as well as incongruency (Kihara et al. 1995) and osteoarthrosis of the distal radioulnar (DRU) joint (Fernandez 1993). It has recently been suggested that in many cases common distal radial fractures are complicated by ligament injuries, found on wrist arthroscopy (Geissler et al. 1996a, Lindau et al. 1997, Richards et al. 1997). This might explain some of the DRU-joint problems as in other forearm injuries—e.g. Galeazzi fractures—where the DRU-joint is frequently injured in conjunction with the more obvious fracture (Goldberg et al. 1992). In this review, we summarize views concerning the association between distal radial fractures and the DRU-joint at the present time.

The current literature is mainly descriptive

We searched The Cochrane Library in the beginning of 2000 and found only one review regarding distal radial fractures or distal radioulnar joints. This review (Handoll and Madhok 2000) evaluated 50 randomized trials comparing treatment options for distal radial fractures and concluded that the poor quality and heterogeneity of the studies rendered further meta-analyses meaningless. We had previously done a Medline search and requested all subheadings for "Colles' fracture" and "radius fracture" with "distal" as the truncated word and "not explode child" thereby to exclude fractures in

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Table 1. 811 articles were found in a Medline search, and classified according to the scientific method. Search words were all subheadings for "Colles' fracture" and "radius fracture" with "distal" as the truncated word and "not explode child" to exclude fractures in children. The classification was then based on the search words randomized, control and prospective

Type of study	Distal radius	DRU-joint
Randomized	34	0
Control group	20	0
Uncontrolled	721	36
Total	775	36

Table 2. Classification of 36 uncontrolled studies dealing with the association between distal radial fractures and the DRU-joint

Type of article	Topic	Total
Descriptive	Specifically about the DRU-joint	10
	General survey	4
	Diagnostics	7
Treatment	Posttraumatic conditions	14
	Acute injuries	1
Total		36

children. There were 1033 original articles since 1966. Papers in languages other than English, German or French (90) were excluded as also were letters (41), articles regarding fractures other than Colles' (35), single case reports (30) and veterinary papers (26), leaving 811 original articles to analyze. The first author read all abstracts and divided the articles into 2 groups, one with articles dealing mainly with the distal radial fracture itself and the other mainly with DRU-joint-related issues. These studies were classified as randomized, with control groups and without controls, according to the current opinion on good scientific standard (Table 1). This is best done by prospective, randomized studies, preferably blinded as regards assessment of outcome. The study becomes weaker if there is only a non-randomized control group or if it is retrospective. However, it must be emphasized that although these standards are applicable to studies of treatment, research to understand a disease or condition may be done equally well in uncontrolled, descriptive studies, which can be prospective or retrospective. The data can be collected without a hypothesis to generate questions, hypotheses and sometimes general understanding.

We found no article concerning the association between distal radial fractures and the DRU-joint that had randomization or control groups among the 811 in the Medline search (Table 1). One prospective, randomized study gave the impression of dealing with treatment of DRU-joint injuries in relation to the end-result (af Ekenstam et al. 1989). However, the premise of the study that repair of the triangular ligament and the ulnar styloid fracture would prevent redislocation of the distal radial fracture was not confirmed. It was therefore placed in the radius group, leaving us with 36 studies regarding DRU-joint-related issues (Table 1), of which 21 were descriptive and 15 about treatment of various DRU-joint conditions; all were uncontrolled (Table 2). This review is based on the findings from the Medline search and other literature in the field.

Understanding the DRU-joint

Depending on our definition of a "good scientific standard", we can say that we found no satisfactory article (randomization or control group) with the Medline search (Table 1), or accept descriptive studies, although analyzed differently than studies about treatment. By applying an inductive, hypothesis-generating approach, we may find useful knowledge regarding functional anatomy, diagnostics, pathological conditions and treatment of the DRU-joint. This is discussed under the headings of "accepted views" or subject of "controversy".

Functional anatomy–Ligaments are important stabilizers

Accepted views. The radius rotates around the ulnar head during pro-supination of the forearm through the DRU-joint (Hagert 1992, Hagert 1996; Figure 1). This joint is also connected to the carpus with a ligament apparatus (Figure 1) and transmits forces to the hand (Hagert 1996). The stability of the DRU-joint is provided by bony congruity between the sigmoid notch of the radius and the ulnar head, which are held together by ligaments (Hagert 1996, Garcia-Elias 1998, Bowers 1999; Figure 1).

The spheres of the two articular surfaces differ, i.e., the curvature of the ulnar head has a shorter

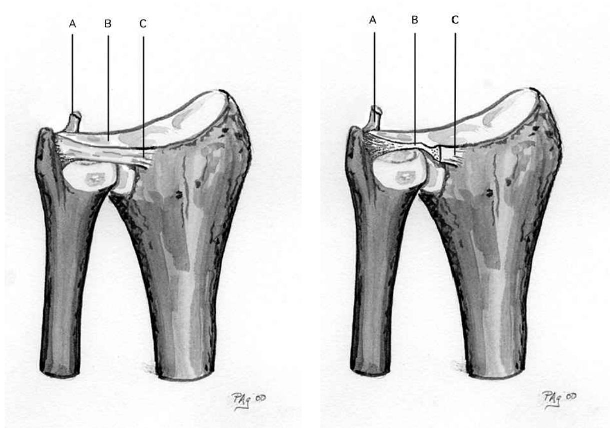


Figure 1. Ligaments are important stabilizers. This schematic drawing shows the triangular fb rocartilage complex (TFCC), the major stabilizer of the DRU-joint (Palmer and Werner 1981, af Ekenstam and Hagert 1985a, b, Palmer 1989, Schuind et al. 1991, Hagert 1992, Garcia-Elias 1998, Bowers 1999). The TFCC is cut open (right) to show that the central disc is membranous and provides no additional stability between the ulna and radius.

A. The ulnocarpal ligament is the palmar, distal part of the TFCC. It arises from the fovea of the ulna and inserts the palmar aspect of the triquetrum.
B. The central articular disc.
C. The dorsal and palmar ulnoradial ligaments stabilize the DRU-joint.

radius, but the curvature of the sigmoid notch has a longer one. This means that in the neutral forearm position, only about 60% of the joint surfaces are in contact, and in full pronation and supination, only 10% (Johnson 1976, af Ekenstam and Hagert 1985a,b, Tolat et al. 1996, Garcia-Elias 1998). The sigmoid notch is more often flat than C-shaped (Tolat et al. 1996), which places a high load on the ligamentous support. The various shapes of the notch explain why malalignment of the distal radius causes laxity of the DRU-joint in some cases, and not in others.

The major stabilizers of the DRU-joint are the ulnoradial ligaments, which represent the transverse, peripheral part of the triangular fibrocartilage complex (TFCC) (Palmer and Werner 1981, af Ekenstam and Hagert 1985a,b, Palmer 1989, Hagert 1995, Hagert 1996, Garcia-Elias 1998, Bowers 1999). The ligaments pass from the fovea of the ulnar head and the base of the ulnar styloid to the dorsal and palmar edges of the distal radius (Palmer and Werner 1981, af Ekenstam and Hagert 1985a,b, Palmer 1989, Chidgey et al. 1991). The periphery is well-vascularized (Bednar 1991, Chidgey et al. 1991), which suggests that peripheral tears may heal. The TFCC includes a central articular disc and the ulnocarpal ligament (Figure 1). The articular disc bears a compressive load and acts like an ulnocarpal cushion, but gives no stability to the DRU-joint (Palmer 1981, 1989, af Ekenstam and Hagert 1985a,b, Chidgey et al. 1991, Hagert 1995, 1996, Garcia-Elias 1998, Bowers 1999). It is cartilaginous and avascular (Bednar et al. 1991, Chidgey et al. 1991). The ulnocarpal ligament arises from the fovea of the ulnar head and inserts on the palmar surface of the triquetrum (King et al. 1986, Hagert 1995, 1996, Wiesner, 1996, Garcia-Elias 1998). It may partly contribute to the stability of the DRU-joint (King et al. 1986, Wiesner et al. 1996, Garcia-Elias 1998).

It is generally accepted that, in addition to the TFCC, stability is achieved by various degrees of contribution from the extensor carpi ulnaris tendon (Garcia-Elias 1998), the pronator quadratus muscle (Johnson and Shrewsbury 1976) and the radioulnar interosseous membrane (Hotchkiss et al. 1989).

Controversies. During recent years it has been debated whether the dorsal or palmar radioulnar ligaments stabilize the DRU-joint. Cadaveric studies have shown that during maximum pronation, the small joint surface contact the palmar aspect is stabilized by taut deep ligament fibers on the dorsal aspect of the joint, but at the same time, there is some passive tautness in the more superficial fibers on the palmar aspect (af Ekenstam and Hagert 1985b, Hagert 1992). Som authors of other cadaveric studies have asserted that it is only the palmar ligaments that are taut during pronation, with consequent generation of stability (Schuind et al. 1991, Adams and Holley 1993, Kihara et al. 1995). The controversy reflects the problem of determining which fibers stabilize the joint and which are taut by passive distension. Both superficial and deep fibers of the palmar and dorsal ligaments probably have to be intact for complete stability of the joint throughout the whole range of forearm rotation, as suggested by Garcia-Elias (1998).

Imaging of the DRU-joint is best done with arthroscopy

Accepted views. Incongruence of the DRU-joint is best diagnosed with CT, which also shows rotational deformities of the malaligned distal radius (Mino et al. 1985, Frahm et al. 1989, Metz and Gilula 1993, Neuman and Langer 1996). TFCC tears can be detected with arthrography (Mohanti and Kar 1980, Fontes et al. 1992), but specificity, although improved by MRI, is best with wrist arthroscopy (Cooney and Berger 1993, Schers and van Heusden 1995, Weiss et al. 1996).

Impairment of DRU-joint function has a worse outcome

Accepted views. It is generally accepted that impaired function of the DRU-joint adversely affects the end-result after distal radial fractures (Frykman 1967, Hollingsworth and Morris 1976, Jupiter et al. 1992, Stoffelen et al. 1998, Lindau et al. 2000a,b, 2002). Axial shortening of the radius may cause this impairment (Bade and Lobeck 1991, Adams 1993), especially if it is accompanied by dorsal angulation of the articular surface (Kihara et al. 1993). This leads to incongruence of the DRU-joint and changes the load distribution in the wrist, where the load on the distal ulna is increased from 1/5 to 2/3 (Short et al. 1987). The increase in ulnar load distribution causes central degenerative attrition of the articular disc in the TFCC, due to impingement between the ulnar head and the lunate, a condition called ulnocarpal abutment syndrome (Bowers 1999). If untreated, it eventually leads to localized osteoarthrosis of the ulnar head and/or the lunate (Geissler et al. 1996b, Bowers 1999).

It has been increasingly accepted that fractures of the distal radius in patients below the usual age for osteoporosis are associated with tears of the TFCC (Geissler et al. 1996a, Lindau et al. 1997, Richards et al. 1997). These ligament tears have been found on wrist arthroscopy and occur with or without fractures of the ulnar styloid (Geissler et al. 1996a, Lindau et al. 1997, Richards et al. 1997). This implies that distal radial fractures in younger patients are frequently complicated by injuries that can not be seen on radiographs.

Controversies. Malunion, with axial shortening of the distal radius, is generally associated with a worse outcome (Lidström 1959, Frykman 1967, Hollingsworth and Morris 1976, van der Linden and Ericson 1981, Villar et al. 1987, Kopylov et al. 1993, Warwick et al. 1993, Hove et al. 1995, Stoffelen 1997). However, a few authors have reported patients with malunion who are asymptomatic; they concluded that the anatomical end-result does not matter (Dias et al. 1987, Tsukazaki et al. 1993).

The importance of ulnar styloid fractures, which have been associated with a worse outcome (Lidström 1959, Frykman 1967, Stewart et al. 1985, Stoffelen et al. 1998), is also disputed. This is partly why Frykman's classification (1967) used each fracture type (extraarticular = I, radiocarpal = III, radioulnar = V, radiocarpal and radioulnar = VII) with a worse counterpart when the ulnar styloid was fractured (types II, IV, VI and VIII). However, the usefulness of Frykman's classification has been questioned (Andersen et al. 1996), since others have reported no correlation between this classification and outcome (Flinkkilä et al. 1998). Furthermore, several studies have found no correlation between ulnar styloid fractures and the end-result (Villar et al. 1987, af Ekenstam et al. 1989, Aro and Koivonen 1991, Tsukazaki et al. 1993, Warwick et al. 1993, Poirier 1994, Lindau et al. 2000a). This may be because in previously described reports, acute TFCC-tears can occur without ulnar styloid fractures (Geissler et al. 1996a, Lindau et al. 1997, Richards et al. 1997). The outcome is probably correlated to ulnar-sided conditions other than fracture of the ulnar styloid.

Treatment is based on descriptive reports

As regards treatment, the lack of controlled studies obliges us to examine the current literature from an inductive, hypothesis-generating point of view to find areas for future randomized studies.

Acute peripheral TFCC-tears may need sutures. The results after acute management of DRU-joint injuries have been reported in only a few uncontrolled studies and these have been reasonably good with both open and arthroscopic treatment in selected patients (Geissler et al. 1996b, Fellinger et al. 1997). On the other hand, the natural course of untreated peripheral TFCC-tears is fairly good, according to the Gartland and Werley score (Lindau et al. 2000a). A warning should be noted

Table 3. Verified and suggested causes of DRU-joint-related symptoms, with one main reference for each cause

Verified causes	
Ulnocarpal abutment	Bowers 1999
DRU-joint laxity	Lindau et al. 2000b
Radiographic osteoarthrosis	Fernandez 1993
Incongruence of the sigmoid notch	Kihara et al. 1995
Nonunion of hypertrophic ulnar styloid	Burgess and Watson 1988
Arthrofibrosis	Bert et al. 1980
Suggested causes	
Tears of the TFCC	Tsukazaki and Iwasaki 1993
Tenosynovitis of the ECU	Tsukazaki and Iwasaki 1993

DRU distal radioulnar joint
TFCC triangular fibrocartilage complex
ECU extensor carpi ulnaris

before embarking on surgical treatment: isolated fractures of the lateral malleolus of the ankle (SE II fractures) have generally been treated with a plaster cast, but there has been a trend to perform surgery more often. However, surgery has no effect (Bauer et al. 1985) and even better results are achieved by immediate mobilization without plaster (Ryd and Bengtsson 1992). Thus, by abandoning surgery, both the patient and the health service have benefited. Bearing this in mind, we must admit that only prospective, randomized studies can show whether surgical treatment of DRU-joint injuries is of any value, especially if we take into account the possible morbidity of surgery itself.

Many treatments have been recommended for late DRU-joint laxity. Wrist pain after distal radial fractures may be caused by many different DRU-joint related conditions (Table 3). Various surgical procedures can be considered depending on the clinical and radiographic findings.

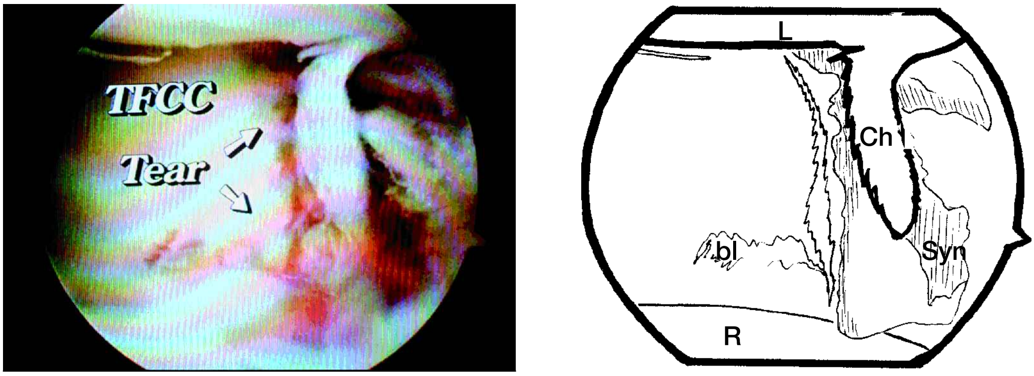
Patients with symptomatic malunion of the distal radius mainly have symptoms secondary to the relatively longer ulna causing an ulna abutment syndrome. By doing a radial osteotomy with a bone graft (Campbell 1937, Fernandez 1982, af Ekenstam et al. 1985), the distal radius can be realigned as regards axial shortening and dorsal angulation. The lengthening osteotomy rebalances the load distribution in the wrist, thereby decompressing the ulna abutment. This abutment can also be decompressed by ulnar shortening osteotomies (Milch 1941, Cantero 1977, Geissler et al. 1996b), Sauvé-Kapandji arthrodesis of the DRU-joint (Kapandji 1986, Preisser et al. 1991, Zilch and Kauschke 1996, Mikkelsen et al. 1997) or ulnar head arthroplasties (Imbriglia and Matthews 1993). The arthroplasty may be done as an arthroscopic (Osterman et al. 1990, Geissler et al. 1996b) or an open procedure (Bowers 1999).

In many cases, the radial osteotomy also changes the sigmoid notch, which may improve the range of pro-supination and create bony stability of the DRU-joint (Fernandez 1982). However, this procedure does not yield stability in all cases. Some authors assert that additional ligament stabilizing procedures may be necessary in almost half the cases (Posner and Ambrose 1991, Fernandez 1993, Hove and Molster 1994), but af Ekenstam et al. (1985) did not find this advantageous. Since ulnar styloid fixation was regarded as a ligament-stabilizing procedure, these contradictory results may be due to recent findings that the stabilizing ulnoradial ligaments can be torn without fracturing the ulnar styloid (Lindau et al. 1997). Moreover, ligament rupture may cause laxity of the DRU-joint, even without malunion (Lindau et al. 2000b). Consequently, we can not reinsert the ulnar styloid alone when we try to stabilize the DRU-joint in conjunction with a radial osteotomy, but should treat the soft tissues completely.

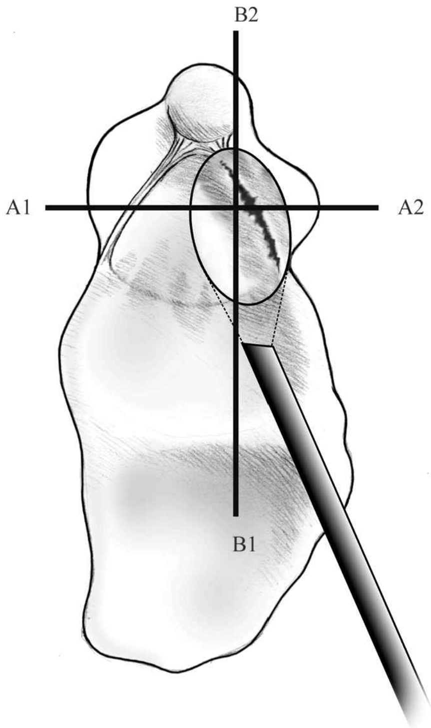
Laxity of the DRU-joint without malunion of the radius is mainly treated with ligamentoplasties (Bowers 1999). The wide variety of techniques (Bowers 1999) probably attest to the lack of a good one. At present, the most attractive reconstruction technique uses a tendon graft to constrain the joint by passing the graft in a tunnel parallel to the sigmoid notch of the radius and reinserting both ends in the fovea through a tunnel of the ulnar head (Adams 1998). This pulls the radius towards the ulna like the reigns of a horse. Although it is an interesting approach, no study has shown that it is better than any other.

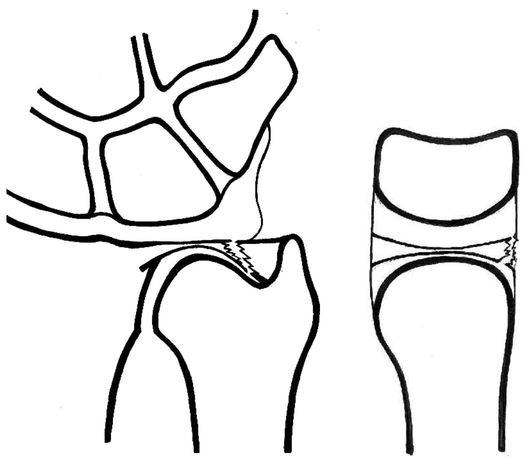
These treatments appear acceptable and the authors report good results with most of them. However, there is no proof that they are better than no surgery at all.

Figure 2. Peripheral TFCC-tears cause laxity of the DRU-joint.



An arthroscopic view (left) and a schematic drawing (right) of a dorsal ulnar avulsion tear of the ulnoradial ligament of the TFCC (right wrist with dorsum to the right). The lunate (L) is above with a chondral flake (Ch) hanging down. The dorsoulnar peripheral tear creates a rough longitudinal line from the lunate facet of the radius {R} below going all the way towards the ulnar styloid, which can not be seen arthroscopically. The synovium (syn) is imbedded by a hematoma on the right and there is blood on the central disc (bl).





A schematic drawing (left) indicates the position of the arthroscope, showing the dorsoulnar aspect of the radiocarpal joint. The sagittal line A1-A2 and the transverse line B1-B2 show the cuts.

These above figures suggest the way in which a pathoanatomical continuation of the arthroscopically-demonstrated peripheral avulsion tear occurs. The sagittal (A1-A2) cut is on the right and posterior, the triquetrum above and the ulnar head below the dorsally-avulsed ligament. The transverse (B1–B2) cut shows how the peripheral tear penetrates deep into the ligament and probably injures the ligament's insertion in the fovea of the ulnar head.

Detailed knowledge may improve treatment in the future

It recently became clear that we should distinguish osteoporotic patients and younger ones. Fractures in the former group are due to moderate trauma (Mallmin and Ljunghall 1992) and are mainly extra-articular (Schmalholz 1988). Those in younger, non-osteoporotic patients are due to higher-energy trauma and are mainly intra-articular (Lindau et al. 1999). The elderly are also more willing to accept persistent deformity so long as function is adequate (Porter and Stockley 1987), but one third of patients below the osteoporotic age are dissatisfied with their hand function 2 years after the fracture (Lindau et al. 2000b). The impaired hand function in younger patients is associated with DRU-joint laxity, which shows no correlation to radiographic changes at the time of fracture or at follow-up (Lindau et al. 2000a,b). This indicates that associated ligament injuries play an important role. Dislocated distal radial fractures in these patients, examined with wrist arthroscopy, have frequently been found to have ligament injuries, usually TFCC-tears (Lindau et al. 1997). Their better bone quality probably causes the ligaments to rupture before the bone breaks. This is similar to a valgus trauma to the knee, which tends to cause a rupture of the collateral ligament in a young adult and a condylar fracture in an elderly osteoporotic patient.

Of the ligament ruptures that were found in the wrist, peripheral tears of the ulnoradial ligament (ulnar avulsion, distal avulsion and radial avulsion, using Palmer's classification (1989), Figure 2), were associated with the development of laxity of the DRU-joint (Lindau et al. 2000a). Presence of laxity worsened the outcome (Lindau et al. 2000a,b). There are no radiological markers in patients with peripheral TFCC-tears (Lindau et al. 1997, 2000a) or laxity of the DRU-joint (Lindau et al. 2000a, b). This is consistent with previous studies where outcome showed no correlation with fracture classification (Flinkkilä et al. 1998) or fracture of the ulnar styloid (Villar et al. 1987, Aro and Koivonen 1991, Tsukazaki et al. 1993, Warwick et al. 1993, Poirier 1994).

The observation that ligament tears (Figure 2), rather than malunion of the distal radius, cause DRU-joint laxity in patients without osteoporosis creates problems regarding diagnosis and treatment. So far, no radiological markers are available that correlate ulnoradial tears (peripheral TFCC-tears) with a distal radial fracture. The first aim should therefore be to find such markers in order to select fractures with possibly severe ligament tears. We could then try—e.g., to suture ulnoradial (peripheral TFCC) tears via arthroscopy—to improve the outcome, bearing in mind that the distal radial fracture must be anatomically restored to avoid bony incongruence of the sigmoid notch. However, the patients, with or without secondary conditions after a fracture, do fairly well in any case (Lidström 1959, Stewart et al. 1985, Altissimi et al. 1986, Warwick et al. 1993, Lindau et al. 2000a, b), indicating that current management is reasonably satisfactory. Hence, before advocating any new technique to prevent posttraumatic DRU-joint laxity, we must show, in prospective randomized studies, that surgery does more good than harm.

Another problem is that DRU-joint laxity is not associated with objective findings, such as a reduction in isometric grip strength (Lindau et al. 2000 b,c) or even strength during supination and pronation (Lindau et al. 2002). Instead, laxity is associated with worse subjective functional scores (Lindau et al. 2000a,b, 2002) and worse performance of everyday activities (Lindau et al. 2002). This shows that DRU-joint stability is needed for a broad range of hand functions, in which symptoms can develop when sudden motions are not offset by muscular support, like the give-away phenomenon in knees with anterior cruciate ligament injuries. These findings reflect the importance of evaluating clinical end-results by combining traditional objective parameters with patient-related outcome questionnaires (Amadio et al. 1996).

Conclusion—randomized studies are needed

Our Medline search found no randomized or controlled study, which indicates that we still do not know how best to treat the DRU-joint condition that was described 200 years ago by Abraham Colles (1814). The lack of controlled studies means that we can not advocate any specific treatment for acute or late DRU-joint-related conditions. Recent studies have shown differences between osteoporotic and other fractures and that we can not ignore the relation with ligament injuries, especially in patients below the osteoporotic age. These ligament injuries (Figure 2) cause posttraumatic DRU-joint laxity, which is associated with a worse outcome. Neither the initial ligament injury nor the posttraumatic laxity can be detected by radiographic methods, which creates challenges regarding diagnosis and treatment. To improve the overall outcome of distal radial fractures, future studies must be randomized, or at least have control groups.

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