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MR imaging of the metacarpophalangeal joints of the fingers: evaluation of 38 patients with chronic joint disability

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Abstract *Objective:* To report the MR imaging findings of painful injured metacarpophalangeal (MCP) joints of the fingers. *Design and patients:* MR imaging of 39 injured MCP joints in 38 patients was performed after a mean delay of 8.8 months. The MR images were obtained with the fingers in extended and flexed positions using T2-weighted and T1-weighted sequences before and after intravenous injection of a gadolinium compound. Ten patients were treated surgically. Mean clinical follow-up was 1.8 years. *Results:* Tears of the collateral ligaments were the most common lesion (30/39), most being radial in location. Contrast-enhanced axial T1-weighted images with the MCP joint in a flexed position showed these lesions optimally. Ten tears were partial and 20 were complete. In 13 patients, MR images showed 17 associated lesions including injuries of the extensor hood (10/17), interosseous tendon (3/17), palmar plate (3/17), and an osteochondral lesion (1/17). Sagittal MR images were essential to highlight palmar plate tears. *Conclusion:* Partial or complete tears of the collateral ligaments are prevalent MR imaging findings in patients with chronic disability resulting from injuries to the MCP joints. Although conservative treatment generally is sufficient for isolated injuries of the collateral ligaments, surgical repair is often required in cases of more extensive injuries. MR imaging may clearly delineate associated lesions of and about the MCP joints.

Keywords Extremities, MR · Extremities, injuries · Fingers and toes, injuries · Hand, MR

Introduction

Traumatic lesions of the metacarpophalangeal (MCP) joints of the fingers are uncommon compared with those of the thumb. The index and small fingers are injured mainly during forced twisting [1]. The clinical diagnosis is obvious when the tear is extensive and involves the collateral ligaments, the dorsal capsule, or the palmar plate. In these cases, spontaneous laxity of the injured finger may be depicted, sometimes with an associated rotational disturbance. However, the diagnosis is often missed initially when there is an isolated lesion of a collateral ligament. Residual pain may persist for months. Clinical testing of stability of the MCP joints of the middle and fourth fingers is difficult, because valgus and varus stress are not available [2]. There are classically three grades of joint sprain: (1) no instability indicates a sprain with collateral continuous ligament; (2) discrete instability and firm end-point indicates a partial tear of the collateral ligament; (3) gross instability without a firm end-point is indicative of a complete tear of the collateral ligament [1, 2, 3].

The treatment for collateral ligament lesions type 1 and 2 is conservative, with immobilization for 3 weeks in a cast and then rehabilitation in the case of type 1 lesions, followed by 3 weeks of immobilization in plus in the case of type 2 lesions. The treatment for type 3 lesions is conservative if possible (6 weeks) or surgery. An imaging method would be very useful to help to decide which treatment should be done. Conservative treatment with a cast is possible only when the free extremities of the torn ligament are very closed to each other. If the gap is significant, surgery should be performed. Association with another joint structure lesion would be an additional argument for surgery. Thus, it is clinically impossible to assess whether a case should be operated on or not [1, 2, 3].

Radiographs are not accurate in delineating many such traumatic lesions. Ultrasonography and MR imaging have proved to be diagnostically efficient in cases of Stener lesions of the MCP joint of the thumb [4, 5, 6, 7, 8, 9]. In a previous study, the usefulness of MR imaging was assessed in cases of dorsal tears of the extensor hood of the MCP joints [10]. Studies of MR imaging in cases of lesions of the collateral ligaments and the palmar plate of the MCP join of the fingers have not been published to our knowledge.

In our two previous studies we have evaluated MR anatomy of the normal MCP joint of the fingers of cadavers [11] and the accuracy of MR imaging in delineating simulated tears of the periarticular structures of these MCP joints [12]. In this investigation, we report the usefulness of MR imaging in cases of chronic disability of the MCP joint in a clinical series of 38 patients.

Materials and methods

Between May 1996 and June 2000, 38 patients (14 women, 24 men; mean age 45 years; age range 18–76 years) with chronic disability of a MCP joint (n=39) that occurred following an injury (sprain or direct blow) underwent MR imaging examination. The middle (n=14), small (n=12), and index fingers (n=10) were much more commonly injured than the fourth finger (n=3). The right hand (n=31) was more frequently involved. The mean delay between the initial injury and the MR examination was 8.8 months (range 2 months to 4 years). The clinical examination showed joint laxity (n=20), joint stiffness (n=16), and/or painful swelling (n=14). Three patients had had a previous ligamentoplasty. In the evaluation of the imaging findings, the gold standard was surgery (n=10) or clinical outcome (n=29; mean follow-up 1.8 years).

All patients underwent an MR imaging examination using a 1.5 T unit (Signa; GE Medical Systems, Milwaukee, Wis.) with a phased-array wrist coil or a home-built local gradient coil. The characteristics of this latest coil have been reported previously [12]. All sequences were performed with the following parameters: field of view of 3–4 cm in T1-weighted sequences and 6 cm in T2-weighted sequences; matrix of 256×128–160; section thickness of 1–3 mm; and 1–4 NEX.

Axial T1-weighted spin echo images (400–600/13–24 [repetition time, ms/echo time, ms]), and sagittal T1-weighted spin echo images (360–600/15–24) or sagittal three-dimensional spoiled gradient echo images (50/12; 40° flip angle) were obtained with the MCP joint in an extended position before and after intravenous injection of 0.1 mmol/kg gadolinium tetraazacyclododecanetetraacetic acid (DOTA; Dotarem; Laboratoires Guerbet, Aulnay-sous-bois, France). In 19 injured joints, contrast-enhanced axial and sagittal images were performed with fat suppression. After intravenous injection of the contrast agent and with the MCP joint in flexed position, axial T1-weighted spin echo images (400–600/13–24) were obtained in all patients and axial T2-weighted spin echo (2,000/72) images were performed in 26 patients.

The MR imaging studies were independently interpreted retrospectively in consensus by two experienced musculoskeletal radiologists who had knowledge of the clinical information. The images were assessed for collateral ligament injuries (partial or complete tear) and tears of the palmar plate (partial or complete). A partial tear was diagnosed when the ligament or palmar plate was continuous but irregular and flattened with thickened peripheral tissue. A complete tear was diagnosed when lack of visibility of the ligament or the palmar plate, or a focal gap at the proximal or distal insertion or at the midsubstance of either structure, was noted. Any associated injuries to the extensor hood (sagittal bands or transverse fibers of the interosseous muscles), osteochondral lesions, tendinosis, or bursitis were reported.

Results

Collateral ligament

A lesion of a collateral ligament was evident with MR images in 30 of 39 (77%) injured MCP joints. The radial collateral ligaments were the main site of injury (26/30, 87%) compared with the ulnar side (4/30, 13%). One third of these lesions (10/30) were partial tears. In these cases, the collateral ligament was thickened and showed variable increased signal intensity in contrast enhanced T1-weighted images and slightly increased signal intensity in T2-weighted images. The overlying sagittal bands were superficially displaced by the thickened ligaments. Dif-

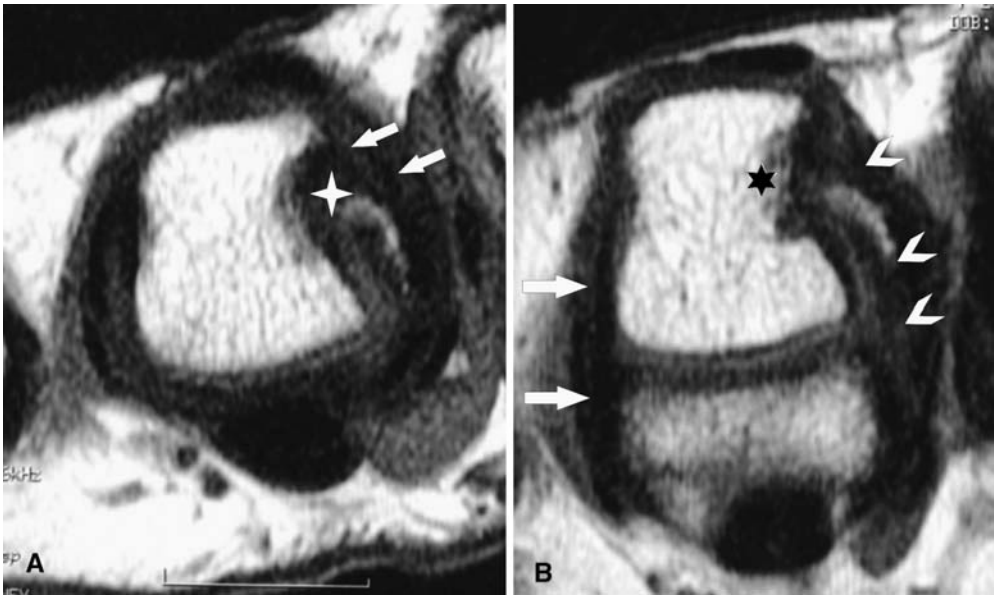

Fig. 1A, B MR images of a partial tear of the radial collateral ligament of the fourth right MCP joint. Axial T1-weighted (560/15) images of **A** the extended MCP joint and **B** the flexed MCP joint, the latter performed following intravenous contrast administration. In extension, the radial collateral ligament appears continuous but its proximal insertion is thickened (*white star*) and surrounded by scar tissue (*arrows*). In flexion, the ulnar collateral ligament is well-defined and taut (*arrows*) while the radial collateral ligament is relaxed (*arrowheads*). There is no significant enhancement of the ligament. Note the osteochondral lesion of the metacarpal head (*black star*)

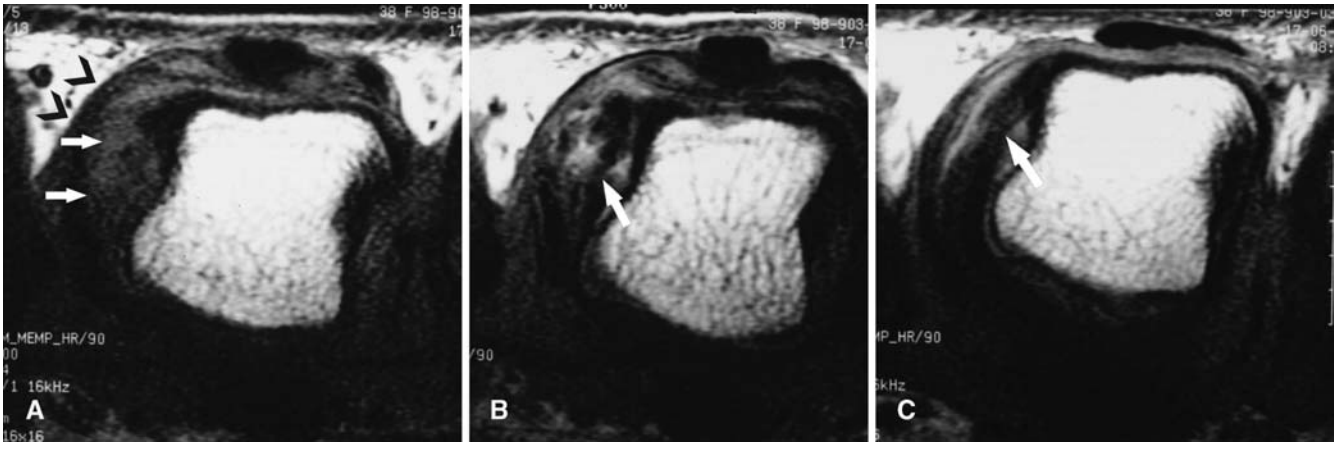

Fig. 2A—C MR images of a partial tear of the radial collateral ligament of the third left MCP joint. Axial T1-weighted (600/24) images of the extended joint **A** before and **B** after injection of gadolinium. Before injection, the radial collateral ligament is not visible and appears thickened (*arrows*) with displacement of the overlying sagittal band (*arrowheads*). After injection, the collateral ligament is better visualized and appears irregular (*arrow*) with strong peripheral enhancement. (**C**) The axial T1-weighted (600/24) contrast-enhanced image of the flexed MCP joint better shows the continuity of the ligament with a focal thinning in its midportion (*arrow*)

fuse enhancement of the peritendinous tissue was noted, and the ligament appeared continuous (Fig. 1). In six of the 10 partial tears, the ligament revealed a gap with focal enhancement on the axial images obtained with the MCP joint in an extended position; however, in the axial images with the MCP joint in the flexed position, the ligament appeared continuous (Fig. 2). In cases of a complete tear (20/30, 67%), postcontrast images of the extended joint were not useful in locating the site of ligamentous injury. However, after contrast enhancement, axial images in the flexed position accurately displayed the location of the ligamentous gap (Figs. 3, 4). The location of the ligament tear was proximal (8/20, 40%), in its midportion (2/20, 10%), or distal (1/20, 5%), and in the nine remaining

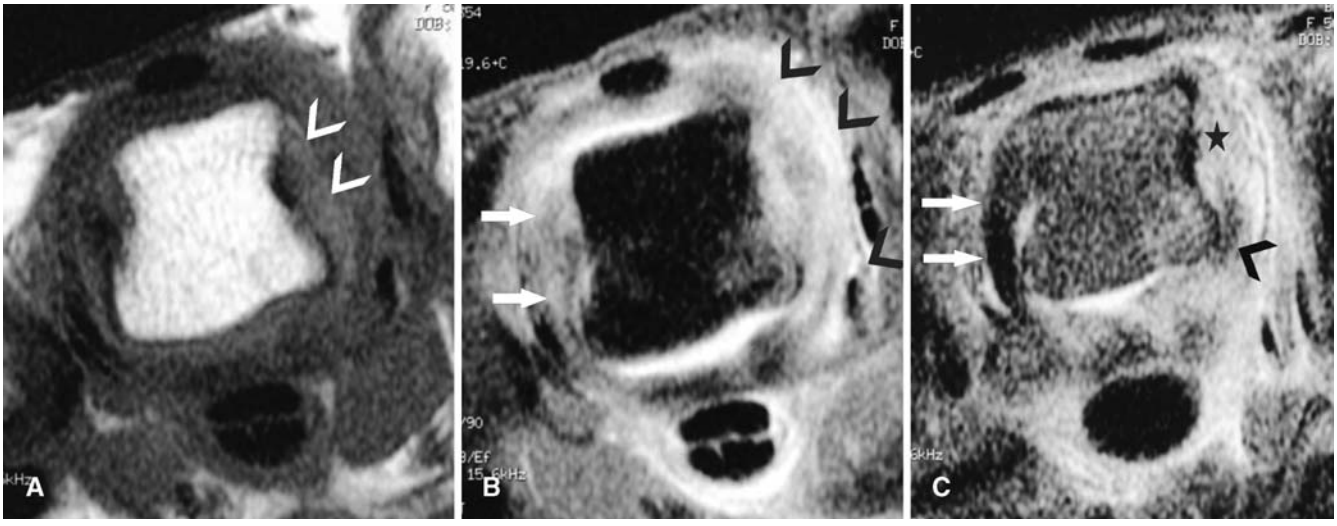

Fig. 3A—C MR images of a proximal complete tear of the radial collateral ligament of the fourth right MCP joint. Axial fat-suppressed T1-weighted (360–560/15) images of the extended joint **A** before and **B** after injection of gadolinium. Before contrast injection, the radial collateral ligament is not visible and appears thickened with slightly increased signal (*arrowheads*). After contrast injection, there is enhancement of the whole radial aspect of the joint (*arrowheads*) and the collateral ligament is not depicted. Note the difficulty in visualizing the normal ulnar collateral ligament (*arrows*). **C** Axial T1-weighted (560/15) fat-suppressed contrast-enhanced image of the flexed MCP joint. The normal ulnar collateral ligament is well depicted (*arrows*) while only the distal part of the radial collateral ligament is visible (*arrowhead*). The ligament is thickened and its proximal insertion is not visible (*star*)

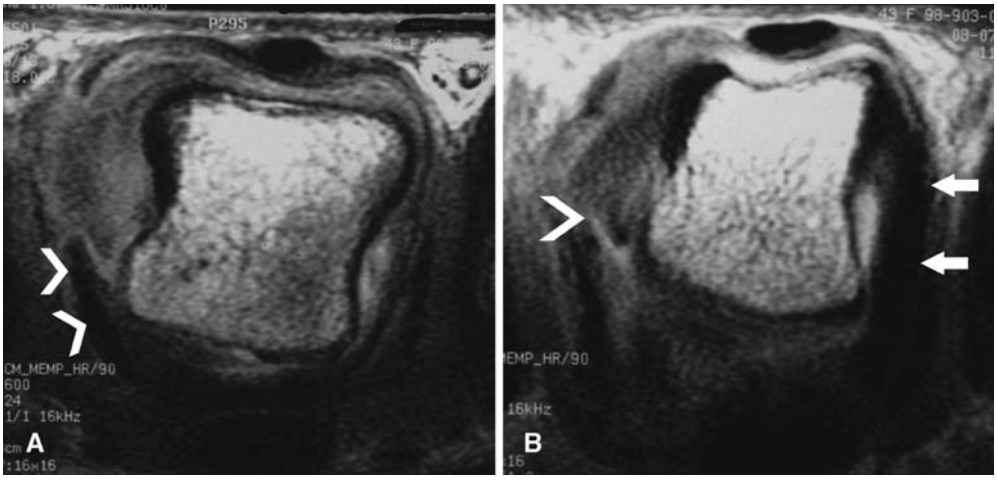

Fig. 4A, B MR images of a complete tear of the midportion of the radial collateral ligament of the third left MCP joint. Axial contrast-enhanced T1-weighted (600/24) images of **A** the extended and **B** the flexed joint. In the extended MCP joint, only the distal part of the radial collateral ligament is depicted (*arrowheads*), while the normal ulnar collateral ligament is not visible. In the flexed MCP joint, the gap between the two parts of the radial collateral ligament is better visualized (*arrowhead*). The normal contralateral ligament is well delineated (*arrows*)

cases (45%) the entire ligament showed signal abnormalities. It was not possible to determine accurately whether the injury was of the main or of the accessory collateral ligament, even when the different distal insertions of these ligaments were distinguished. T2-weighted images were performed in 26 cases. These 26 cases showed partial or complete ligament tears on postcontrast T1-weighted images. Only 12 ligament tears were visualized with the T2-weighted images of these 26 cases (46%). A fluid-filled tear with high signal intensity was noted only in five cases with T2-weighted images. A "pseudo-Stener" lesion was depicted in one case with retraction of the proximal ligament above the sagittal band. Axial T1-weighted images with the MCP joint in the extended position optimally showed the round retracted ligament (Fig. 5). Correlation of the MR imaging findings and those of surgery was excellent in all 10 cases.

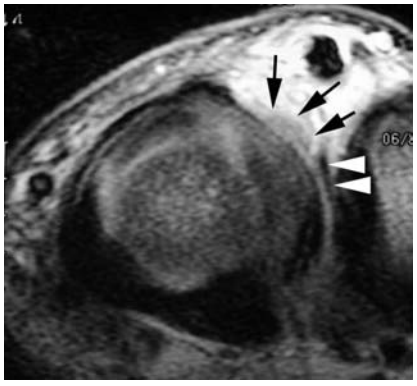

Fig. 5 "Pseudo-Stener" lesion of the radial collateral ligament of the fifth right MCP joint. Axial T1-weighted (600/24) contrast-enhanced image of the extended joint. Note the round proximally retracted ligament (*arrows*) overlying the sagittal band (*arrowheads*)

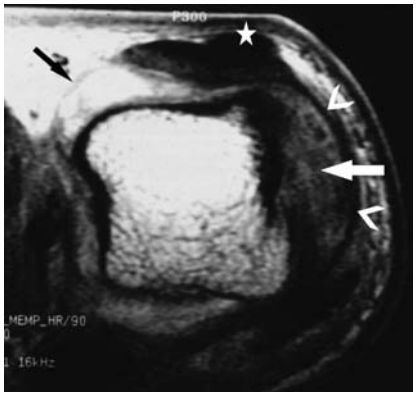

Fig. 6 MR image of a complete tear of the radial collateral ligament of the second right MCP joint associated with a tear of the ulnar sagittal band. Axial T1-weighted (600/24) contrast-enhanced image of the flexed MCP joint shows the thickened and enhanced radial collateral ligament (*white arrow*) with the displaced normal radial sagittal band (*arrowheads*). The ulnar sagittal band appears disrupted (*black arrow*) with subluxation of the extensor tendons (*star*) on the radial side

Seventeen complete or partial tears of the collateral ligaments were isolated abnormalities. Seventeen associated lesions were noted in the 13 remaining cases. These associated lesions included: injuries of the extensor hood (10/17) including six lesions at the level of the radial sagittal band (Fig. 6), two lesions at the level of the transverse fibers of the interosseous tendon, and dorsal bursitis in two cases; injuries of the interosseous tendons (3/17); tears of the palmar plate (3/17); and an osteochondral lesion (1/17).

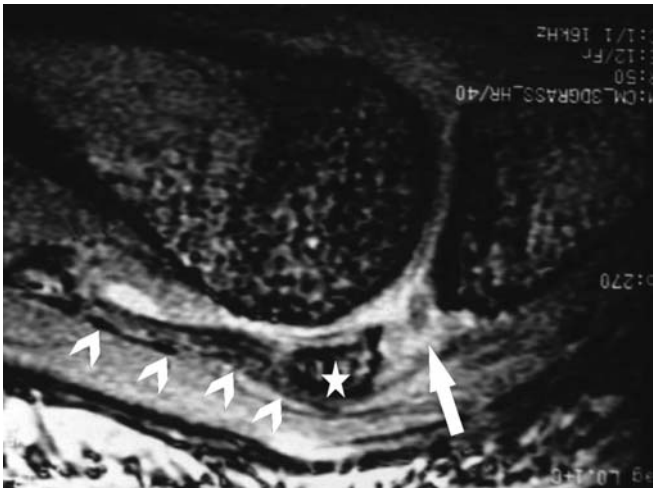

Fig. 7 MR image of a distal avulsion of the palmar plate of the fifth right MCP joint. The sagittal contrast-enhanced gradient echo (50/12/40°) image delineates a gap at the distal insertion of the palmar plate (*arrow*) which is too large for a synovial recess. The palmar plate is retracted (*arrowheads*) and the sesamoid bone is displaced proximally (*star*)

Palmar plate

MR images showed four lesions of the palmar plate: one partial and three complete tears. In one patient, the tear was an isolated finding. The three remaining patients had an associated tear of the radial collateral ligament, and in one case an osteochondral lesion of the phalangeal articular surface. In the case of the incomplete tear, the palmar plate appeared thickened with slight irregularities of its margins in the sagittal images. The flattened plate showed abnormal intermediate signal intensity in all sequences. The three complete tears were distal avulsions of the palmar plate. The distal gap was always visible in the sagittal images but never obvious in the axial images. The retracted palmar plate led to displacement of a sesamoid bone in two cases (index and small fingers) (Fig. 7).

Other lesions

Eight patients (8/39, 20%) did not have abnormalities of the collateral ligaments or the palmar plate. In most cases MR images demonstrated lesions of the extensor hood (6/8) including the radial sagittal bands (4/6) or the retinaculum between the extensor digiti minimi and the common extensor tendons (2/6). The two remaining patients had osteochondral lesions of the phalangeal articular surface of the MCP joint.

Discussion

Injuries of the MCP joints of the fingers are rare and involve mainly the radial collateral ligament due to a sudden ulnar deviation or a forced twisting of the finger [3,14, 15, 16]. Trauma with radial stress is even more unusual. Due to the lack of an adjacent finger on the radial side of the second finger, such stress produces injuries of the ulnar collateral ligament [16, 17]. Clinical diagnosis of collateral ligament tear may be difficult as the joint is minimally swollen and remains in the resting position with 30° of flexion. Ligament stability must be tested with the joint in the flexed position because in the extended position the joint is normally lax. Gross instability without a firm end-point is indicative of a complete tear of the collateral ligament [3].

Routine frontal and oblique radiographs are often normal in an emergency situation. A bony avulsion can rarely be depicted adjacent to the lateral edge of the base of the phalanx or on the lateral aspect of the metacarpal head [18]. The Brewerton view shows a large area of the metacarpal head and is recommended for detecting proximal avulsions of the collateral ligament [19, 20]. If there is no bone fragment, comparative views with lateral stress in a flexed joint can demonstrate a ligament rupture, but these are difficult to perform. Arthrography shows leakage of contrast agent at the level of the collateral ligament tear [16, 21]. A "pseudo-Stener" lesion was found in one case in our series, as described surgically by Schubiner and Mass or Ishizuki in the ulnar four digits [3, 16] or anatomically by Stener in thumb [22]. Ultrasonography may be an alternative imaging method with a relatively low cost; however, the MCP joints of the four ulnar digits are less accessible to ultrasonographic evaluation than that of the thumb, and the accuracy of ultrasonography in diagnosing collateral ligament injuries has not been demonstrated [23].

In chronic post-traumatic disability of the MCP joints, MR imaging appears useful in delineating abnormalities of the collateral ligaments and the palmar plate, which represented 80% of injuries in our series. Accurate imaging of the MCP joints may be obtained with a commercial phased-array wrist coil. A field of view as small as 4 cm is necessary to analyze these thin elements, however [24]. We did not use the coronal plane, as we have demonstrated that it is less efficient than the axial plane when the MCP joint in a flexed position for demonstrating the whole course of the collateral ligament [12]. It is very unusual to visualize the whole collateral ligament in the coronal plane in extended position [11]; in fact the best plane for the main collateral ligament in extension would be a coronal oblique plane. No study has yet compared these two planes. However, coronal oblique imaging is not routinely performed while the collateral ligament is slack and less clearly defined in extension. The images with the MCP joint in a flexed position also allowed assessment of the stability of the extensor tendon on the metacarpal head [10]. Axial T2-weighted images were less accurate than T1-weighted images in the depiction of collateral ligament tears because of the decreased signal-to-noise ratio. The soft tissue contrast in T2-weighted images was also poor in these chronic lesions owing to the presence of scar tissue. The presence of fluid in a ligament tear was uncommon in our series. Intravenous injection of a gadolinium-containing contrast agent increased the signal intensity and contrast of the images and was helpful in depiction of small ligament tears. MR arthrography has proved to be accurate in the assessment of the ulnar collateral ligament of the thumb [8], but articular puncture was not used in our study. Three-dimensional sequences in the sagittal plane were used to assess the palmar plate, but were not helpful in the assessment of the collateral ligaments, an opinion shared by Haramati and coworkers, who assessed injuries to the collateral ligaments of the thumb [5].

In our series MR imaging accurately depicted not only injuries of the collateral ligaments but also associated lesions (which were present in more than 40% in our series). An extensive tear to the dorsal capsule and the extensor hood or to the palmar aspect of the MCP joint with an avulsion of the palmar plate may require surgical repair. The palmar plate is rarely injured at the level of the MCP joint, compared with the level of the proximal interphalangeal joint [25]. The palmar plate is stretched in extension, and a distal avulsion can occur during hyperextension of the joint [26]. A small hematoma in the palmar aspect of the MCP joint may be noted. Manipulation or even skin pressure is painful. A bone avulsion of the palmar aspect of the base of the phalanx may be depicted on a lateral radiograph [19, 26]. A proximal avulsion is less common and is present only in cases of associated tear of the accessory collateral ligament [20]. Injury to the palmar plate is often missed clinically and results in antalgic flexion with a painful stiffness. In cases of palmar plate rupture, arthrography may show leakage of contrast agent into the flexor tendon sheath [25]. Palmar plate injuries heal easily and are associated with very little disability. A common synovial recess is present normally at the distal insertion of the palmar plate and must not be misdiagnosed as a distal avulsion of the palmar plate with MR imaging. However, the diagnosis of a complete tear of the palmar plate with an associated ligament tear may necessitate surgical intervention.

There are several limitations to this study. First, only 10 patients underwent surgery because most lesions are treated conservatively. The treatment plan was decided according to the clinical and MR imaging results as mentioned in Introduction. However, the mean clinical follow-up was 1.8 years. Second, the MR imaging protocol varied from one patient to another. The main diagnostic sequences (axial and sagittal T1-weighted images before and after contrast enhancement), however,

were always performed. Finally, MR images were performed with both a commercially available wrist coil and a home-built local gradient coil. Both coils provided similar visualization, except on T2-weighted imaging.

In conclusion, partial or complete tears of collateral ligaments are prevalent MR imaging findings in patients with chronic disability resulting from post-traumatic MCP joints. Although conservative treatment generally is sufficient for isolated injuries of the collateral ligaments, surgical repair is often required in cases of more extensive injuries. MR imaging may clearly depict the associated lesions of and about the MCP joints.

References

1. Raimbeau G, Cesari B. Ligament injuries of the metacarpophalangeal joints II—V (acute and chronic). In: Brüser P, Gilbert A, eds. Finger bone and joint injuries, 1st edn. London: Martin Dunitz, 1999:213–218.
2. Riederer S, Nagy L, Bücher U. Chronic post-traumatic radial instability of the metacarpophalangeal joint of the finger. J Hand Surg [Br] 1998; 13:503–506.
3. Schubiner JM, Mass DP. Operation for collateral ligament rupture of the metacarpophalangeal joint of the fingers. J Bone Joint Surg Br 1989; 71:338–339.
4. Hinke DH, Erickson SJ, Chamoy L, Timins ME. Ulnar collateral ligament of the thumb: MR findings in cadavers, volunteers, and patients with ligamentous injury (gamekeeper's thumb). AJR Am J Roentgenol 1994; 163:1431–1434.
5. Haramati N, Hiller N, Dowdle J, Jacobson M, Barax CN, Lieberfarb RI, Lester B, Kulick RG. MRI of the Stener lesion. Skeletal Radiol 1995; 24:515–518.
6. Harper MT, Chandnani VP, Spaeth J, Santangelo JR, Providence BC, Bagg MA. Gamekeeper thumb: diagnosis of ulnar collateral ligament injury using magnetic resonance imaging, magnetic resonance arthrography and stress radiography. J Magn Reson Imaging 1996; 6:322–328.
7. Hergan K, Mittler C, Oser W. Pitfalls in sonography of the gamekeeper's thumb. Eur Radiol 1997; 7:65–69.
8. Ahn JM, Sartoris DJ, Kang HS, Botte MJ, Trudell D, Haghighi P, Resnick D. Gamekeeper thumb: comparison of MR arthrography with conventional arthrography and MR imaging in cadavers. Radiology 1998; 206:737–744.
9. Plancher KD, Ho CP, Cofield SS, Viola R, Hawkins RJ. Role of MR imaging in the management of "skier's thumb" injuries. Magn Reson Imaging Clin North Am 1999; 7:73–84.
10. Drapé JL, Dubert T, Silbermann O, Thelen P, Thivet A, Benacerraf R. Acute trauma of the extensor hood of the metacarpophalangeal joint: MR imaging evaluation. Radiology 1994; 192:469–476.
11. Theumann NH, Pfirmann CWA, Drapé J-L, Trudell DJ, Resnick D. MR imaging of the metacarpophalangeal joints of the fingers. 1. Normal MR and MR arthrography findings in cadavers. Radiology 2002; 222:437–445.
12. Pfirmann CWA, Theumann NH, Botte MJ, Drapé J-L, Trudell DJ, Resnick D. MR imaging of the metacarpophalangeal joints of the fingers. 2. Detection of simulated injuries in cadavers. Radiology 2002; 222:447–452.
13. Drapé JL, Idy-Peretti I, Goettmann S, Wolfram-Gabel R, Dion E, Grossin M, Benacerraf R, Guerin-Surville H, Bittoun J. Subungual glomus tumors: evaluation with MR imaging. Radiology 1995; 195:507–515.
14. Dubousset JF. Les articulations métacarpophalangiennes. In: Tubiana R, ed. Chirurgie de la main. Paris: Masson 1980:227–234.
15. Nussbaum R, Sadler AH. An isolated, closed, complex dislocation of the metacarpophalangeal joint of the long finger: a unique case. J Hand Surg [Am] 1986; 11:558–561.
16. Ishizuki MD. Injury to collateral ligament of the metacarpophalangeal joint of a finger. J Hand Surg [Am] 1988; 13:456–460.
17. Doyle JR, Atkinson RE. Rupture of the radial collateral ligament of the metacarpophalangeal joint of the index finger: a report of three cases. J Hand Surg [Br] 1989; 14:248–250.
18. Gee TG, Pho RWH. Avulsion-fracture at the proximal attachment of the radial collateral ligament of the fifth metacarpophalangeal joint: a case report. J Hand Surg 1982; 7:526–527.
19. Zemel NP. Metacarpophalangeal joint injuries in the finger. Hand Clin 1992; 8:745–754.
20. Dray CG, Eaton RG. Dislocation in the digits. In: Green DP, ed. Operative hand surgery, 3rd edn. New York: Churchill Livingstone, 1993:779–785.
21. Engel J, Ganel A, Ditzian R, Militeanu J. Arthrography as a method of diagnosing tear of the ulnar collateral ligament of the metacarpophalangeal joint of the thumb ("gamekeeper's thumb"). J Trauma 1979; 19:106–109.
22. Stener B. Displacement of the ruptured collateral ligament of the metacarpophalangeal joint of the thumb: a clinical and anatomical study. J Bone Joint Surg Br 1962; 44:879.
23. Höglund M, Tordai P. Ultrasound. In: Gilula LA, Yin Y, eds. Imaging of the wrist and hand. Philadelphia: WB Saunders, 1996:479–498.
24. Masson JA, Golimbu CN, Grossman JA. MR imaging of the metacarpophalangeal joints. Magn Reson Imaging Clin North Am 1995; 3:313–325.
25. Gilbert A. Palmar fibrocartilage lesions. In: Brüser P, Gilbert A, eds. Finger bone and joint injuries. London: Martin Dunitz, 1999:241–244.
26. Stener B. Hyperextension injuries to the metacarpophalangeal joints of the thumb. Acta Chir Scand 1963; 125:275.