Index Radial Collateral Ligament Repair with Titanium Mini-Suture Anchor: Osteolysis Complication of an Underreported Injury

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Abstract We are reporting on a case of an index radial collateral ligament tear repaired with a titanium Mitek bone suture anchor. The development of cystic radiographic changes and increased pain and weakness led to suture anchor removal at 10 months post-repair. Periprosthetic osteolysis due to titanium-induced osteoclastogenesis and micromotion was suspected to be the cause. This case report provides a dual focus by stressing the importance of the diagnosis and treatment of this underreported ligament tear and highlighting our osteolysis complication via the mechanism of titanium-induced osteoclastogenesis for future therapeutic preventive measures.

Keywords Cystic changes · Index metacarpophalangeal joint · Osteolysis · Radial collateral ligament · Titanium-induced osteoclastogenesis

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Introduction

Collateral ligament injuries of the metacarpophalangeal (MCP) joint of the fingers are particularly uncommon when compared to those of the thumb [16]. Among the other fingers, the incidence of radial collateral ligament (RCL) injuries was reported to be about 7 of 10,000 hand injuries examined in an emergency room over a 2-year period [6]. In this time period, the least commonly reported was a RCL injury of the index MCP joint of which no cases were reported. In full review of the literature, only 32 patients have been reported with this specific injury of the index finger; three patients have been reported in a case study in 1989, three more in a larger study of RCL injuries to all digits in 1998, 14 additional patients in an index RCL study in 2006, and a final 12 patients in a similar report of index RCL injuries in 2007 [7, 10, 17, 30]. The early diagnosis of these injuries is important due to the less successful outcomes seen with late treatment [10].

Osteolysis is well documented in the orthopedic literature [5, 20, 23, 28], but there are few, if any reports, following the use of a non-absorbable implant for soft tissue repair in the hand. When metal is used as the implantable device, osteolysis can be caused by wear particles that activate an inflammatory cascade, resulting in increased osteoclastogenesis and thus increased bone resorption [5, 20, 22, 23, 28]. The cause of the osteolysis in the report was suspected to be a combination of both titanium-induced osteoclastogenesis and micromotion. Although suture anchor removal successfully treated the symptoms of the osteolysis complication, preventive therapeutic agents of osteolysis will have major implications not only in the knee, shoulder, and hip but also the hand.

Case Report

A 34-year-old right-handed white male fell at work onto his left shoulder and hand. Prior to presenting to the office, the shoulder was treated surgically and then the hand and index finger were treated conservatively with a cortisone injection and buddy splinting. Approximately 17 months after the work-related injury, the patient was referred to our office for examination. The patient complained of pain on the radial aspect of the left index finger at the MCP joint. The constant pain was described as moderate in intensity with aggravation from gripping, pulling, buttoning, and twisting. The physical exam revealed laxity of the RCL with no endpoint, tenderness at the MCP joint, and slight ulnar deviation and pronation of the index finger. X-ray and FluoroScan confirmed that there was laxity of the RCL (Fig. 1). MRI revealed that the ulnar collateral ligament was intact and that there was a tear of the RCL at the index MCP joint.

The patient was indicated for surgery to repair the torn ligament. Exploration revealed a proximal rupture of the RCL from its attachment to the metacarpal head. A Mitek MiniQuick Anchor Plus (DePuy Mitek Inc., Raynham, MA) was used along with reinforcement from 3–0 Dexon interrupted sutures. The joint was stabilized with a 0.045" Kirschner wire directed obliquely from the ulnar to the radial side (Fig. 2). The patient was fitted into a soft fluff dressing with a plaster hand-based index finger splint and was left in good condition.

In the early postoperative period, complaints of pain in the dorsal aspect of the hand revealed hypersensitivity and cutaneous allodynia. These symptoms resolved over a 2-week period status post-treatment with Lyrica (Pfizer Global Pharmaceuticals, New York, NY) and removal of the K-wire. Immobilization of the index finger in radial deviation was maintained.

Figure 1 Pre-operative X-ray of radial collateral ligament tear.

Figure 2 Postoperative X-ray with pin and suture anchor fixation.

At 4 weeks post-surgery, the patient was referred to an occupational therapist for fabrication of a custom hand-based/radially deviated index finger splint. Occupational therapy originated with proximal and distal interphalangeal joint range of motion (ROM) and progressed at 6 weeks to active ROM of the MCP joint with continued splinting and a home exercise program. By 8 weeks, the splint was discontinued and passive ROM and strengthening had commenced. Sixteen weeks post-surgery, index finger total active motion was 268° and total passive motion 295°. When compared to the non-injured side, grip strength was 39 of 106, lateral pinch 11 of 33, and precision pinch 7 of 13 lb.

At 20 weeks post-surgery, the patient complained of restriction with stretching distal to the radial MCP joint that increased over a 2-week period to moderate pain radiating from the MCP joint to the PIP joint. Comparing the evaluation at 16 to 20 weeks revealed a notable decrease in grip strength from 31 to 8 lb. ROM was unchanged, but X-rays revealed that there were cystic changes around the bone suture anchor. Anti-inflammatory drugs were administered, and within 10 days, the patient reported minimal pain.

Although conservative management with nonsteroidal anti-inflammatory drugs and rest provided some degree of relief, the pain persisted with tenderness in the area of the anchor. At 8 months post-op, there were clearly defined cystic changes seen on X-ray (Fig. 3). We suspected a foreign body reaction. A MRI revealed a subtle finding on proton density weight fat-saturated images and T2-weighted images that reportedly could reflect inflammation in the area of the RCL and periarticular soft tissues. We

Figure 3 X-ray 8 months post-repair of the radial collateral ligament (RCL).

suspected that the suture or anchor could be causing a bioreaction, and therefore at 10 months post-surgery, all hardware was removed. There was no foreign body granulation found at the site of the anchor.

Post-removal of the bone suture anchor, the patient showed excellent ROM and reported less pain. At 2 months post-removal and 1 year from the initial RCL repair, the patient resumed full activities. On final evaluation at 1 year post-removal, the patient showed index MCP flexion and extension of 0° to 78° and recovered 65%, 80%, and 67% of the contralateral gross grasp, lateral pinch, and precision pinch strength, respectively. Final examination X-rays compared to previous X-rays revealed less defined cystic changes around where the anchor had been (Fig. 4). The patient left with normal joint stability and no persisting pain.

Discussion

Collateral ligament injuries of the fingers and specifically RCL tears of the index finger are not as rare as previously

Figure 4 X-ray 1 year post-removal of anchor and suture showing a lesser degree of cystic changes.

believed [10, 16]. They are becoming more reported in recent literature, but their overall relatively low incident rate could be attributed to their great degree of stabilization from the three adjacent digits, their relaxed state in the neutral position, or their radial support from the first dorsal interosseous muscle [16, 25]. In addition, the RCL is less inclined to disrupt due to its ligamentous ability [8, 9]. However, the index finger has its vulnerability in that it is a border digit, and forces toward the ulnar and dorsal side (as was seen in this case) will provide a force capable of tearing the ligament [8, 9].

A variety of treatment plans for collateral ligament tears of the digits have been supported [7–9, 14, 15, 33]. When focusing strictly on index RCL tears of the MCP joint, Doyle and Atkinson [7] suggest that complete tears should be managed in similar ways than the thumb ulnar collateral ligament, thus indicating surgical intervention. Gatson et al. [10] and Kang et al. [17] further advise early surgical repair for cases of gross instability of the joint.

Of great significance is the early diagnosis and treatment of RCL injuries of the digits. Gatson et al. [10] proposed a grading system by extrapolating from similar systems for the proximal interphalangeal joint and the thumb MCP joint (Table 1). They hypothesized that a less severe grade (I or II) may progress into a grade III without proper immobilization. Gatson et al. [10] reported poor results in patients with a mean late treatment of 9 months (range, 4–24 m). In our case, the patient presented to our office about 17 months post-injury, and therefore, it is possible that the outcome was partially compromised due to this delay.

The late presentation of a grade III injury removed the opportunity for an early intervention, but the patient did undergo surgery within 7 weeks of presenting to our office. Due to the delay, we thought that reconstruction with a tendon graft was necessary. Fortunately, repair was possible because there was no Stener-type lesion and enough substance of the ligament remained. A similar observation was found in a 12-patient study of index RCL tears of the MCP joint with no presence of Stener-type lesions, with mean duration from injury to surgery of 7 months (range, 0.5–37.5 m) [17]. This study and our case both suggest that good results may be attainable despite late repairs. In spite

Table 1 Gatson's grading system.

Grade 1	Tenderness to palpation over the RCL No laxity ^a compared with the contralateral digit
Grade 2	Laxity ^a greater than the contralateral digit but with a definite firm endpoint
Grade 3	No discernable endpoint to ulnarly applied stress

This grading system has been published in the text of Gatson et al. [4]

^a Laxity was measured by testing the involved index finger in full flexion with ulnar directed stress and comparing it to the contralateral digit

of this result, we continue to advocate the need for an early diagnosis and treatment to allow for a better outcome [10].

The RCL rupture was repaired with a Mitek bone suture anchor, which has been used in previous cases of repair of the collateral ligaments [10, 17, 18, 21, 24, 29, 37]. This anchor is a titanium alloy with its prongs composed of titanium and nickel [16]. The Ethibond suture that was used is composed of polyethylene terephthalate, which is a polyester derivative.

Post-repair of the ligament, the osteolysis prolonged the recovery of the patient and added a new element to this reportedly uncommon case of a RCL injury of the index MCP joint. Upon surgical exploration of the index finger, the anchor was found to be loosened and was removed from the osteolytic cavity. After removal, an almost immediate relief (10 days) of signs and symptoms were noted. We first suspected that the titanium anchor or polyester suture was causing irritation of the tissues and a foreign body reaction.

The pathologic examination of tissue around the bone suture anchor failed to confirm our hypothesis. No multinucleated giant cells, plasmacytes, or histiocytes were found. We surmised that a foreign body reaction to the metal or suture was unlikely to be the cause.

Several other hypotheses were considered. It was unlikely that the drill hole was too big or too hot to loosen the suture anchor because the drill used was not a high-speed drill and every precaution was taken to prevent burning of the bone. The cystic changes seen around the implant on radiographs were not characteristic of what one would typically observe when bone is burnt. The steroid injection prior to the surgery was also discounted as a likely cause because it was administered several months prior to the surgery. We then postulated that osteolysis may have resulted from mechanical stress. Mechanical motion has been shown to improve osteoclast survival and play a role in prosthesis failure [20, 23].

The mechanism for osteolysis is important when theorizing how to apply therapeutic preventive measures. Factors such as pro-inflammatory cytokines activate receptor activator of nuclear factor κ B (RANK) and RANK ligand (RANKL). RANKL is a membrane protein expressed by osteoblasts and marrow stromal cells, whereas RANK is present on macrophages [11, 12, 32]. The binding of these osteoclastogenic molecules leads to cell differentiation into mature osteoclasts, allowing bone resorption [2–4, 11, 26, 27]. In a mouse marrow system, mechanical stimulation with titanium particles had been shown to induce an earlier expression of RANKL, thus indicating a greater potential for bone resorption and osteolysis [23].

Nuclear factor of activated T cells (NFAT) is a transcription factor that acts downstream of RANKL, and thus inactivation of one of NFAT's members, NFATc1, by

11R-VIVIT peptide seems encouraging when determining therapeutic methods to suppress titanium particle-induced osteoclastogenesis [22]. Alendronate has also been shown to be an antiresorptive agent, and a 29-patient study with 20 controls and a 6-year follow-up after total hip arthroplasty has suggested that the alendronate group had significantly less bone loss than the 20-person control group [1]. The research on various inhibitors of the pathway of osteoclastogenesis is widespread [1, 13, 19, 22, 31, 34–36, 38], and future investigations with large populations and long follow-up periods may result in a preventive treatment of periprosthetic bone loss.

Tears of the index RCL may have the best results when diagnosed and treated early. However, this case report suggests that a good outcome may still be possible with late repair. Like index RCL tears, osteolysis is a significant issue in orthopedics, and further research on the clinical success of therapeutic agents that prevent titanium-induced osteoclastogenesis is warranted.

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