Outcomes after repair of subacute-to-chronic grade III metacarpophalangeal joint collateral ligament injuries in fingers are suboptimal

Justin C. Wong · Kevin F. Lutsky · Pedro K. Beredjiklian

Published online: 24 December 2013
© American Association for Hand Surgery 2013

Abstract

Purpose Although injury to the collateral ligaments of the metacarpophalangeal joint (MPJ) of the fingers is less common than corresponding injuries in the thumb, similar disability may result from chronic untreated injuries. We evaluated injury characteristics and the outcome after primary repair of subacute to chronic grade III collateral ligament injuries of the MPJs of the fingers.

Methods We retrospectively reviewed all patients who underwent primary repair of a finger MPJ collateral ligament over a 3-year period. Twenty-five digits in 23 patients with subacute to chronic injuries were identified, all of which had complete MPJ collateral ligament tear. Postoperatively, we assessed disability using DASH scores and evaluated joint stability, range of motion, and grip strength. These measures were compared to preoperative data to assess results. Post hoc analysis was used to compare the level of disability between index and small radial collateral ligaments and other finger CL injuries.

Results Intraoperative findings revealed complete tears in all cases and all ligaments were of sufficient quality to permit primary repair using a suture anchor. The average preoperative DASH score was 40 (range 17–77) in 7 patients (nine fingers) where this was available. Postoperative DASH scores were available in 19 patients (21 fingers). The average postoperative

DASH score was 19 (range 0–65). In the subgroup of patients with preoperative and postoperative DASH scores, there was no statistically significant difference after surgery (preop DASH 39.1 vs. postop DASH 23.8, $p=0.17$). The average grip strength as a percentage of the contralateral hand was 68 % (range 32–100 %). The average postoperative MPJ arc of motion was 75° (range 50–90°). Post hoc analysis showed statistically significant higher postoperative DASH scores among small finger RCL repairs compared to other finger CL repairs ($p=0.007$).

Discussion Primary repair of complete MPJ collateral ligament injuries of the fingers may be performed in the subacute to chronic setting. Although joint stability was restored, patients continued to have decreased grip strength and residual disability.

Keywords Collateral ligament · Finger · Metacarpophalangeal joint

Introduction

Injuries to the collateral ligaments of the metacarpophalangeal joints (MPJ) of the fingers are reported to occur with less frequency than their counterparts in the thumb. It has been reported that 1 in 1,000 hand injuries involve MPJ collateral ligaments; 39 % of these involve the fingers and the remainder involve the thumb [6]. It may be the true incidence is underreported or under-recognized [17]. Partial ligament injuries can be treated nonoperatively and managed successfully with a period of immobilization [10]. However, there is little data to guide the management of complete tears, with most reports focusing on the radial collateral ligament (RCL) of the index finger. When nonoperative treatment of complete tears is unsuccessful and symptomatic, patients may require surgical treatment.

Level of Evidence: IV, Therapeutic study, retrospective case series

J. C. Wong (✉)
Department of Orthopedic Surgery, Thomas Jefferson University,
1020 Walnut Street, College Building Rm 516, Philadelphia,
PA 19107, USA
e-mail: jcwong330@gmail.com

K. F. Lutsky · P. K. Beredjiklian
Rothman Institute, Department of Orthopedic Surgery, Thomas
Jefferson University, Philadelphia, PA, USA

Chronic injuries to the collateral ligament are defined as presenting after 4–6 weeks from the time of injury, or those that fail treatment with immobilization after a similar timeframe [10, 16, 21]. Patients may demonstrate persistent instability and choose to bypass the injured digit, especially in radial collateral ligament injuries of the index finger [10]. Direct repair can be used for surgical treatment of chronic collateral ligament injuries if the ligament is of sufficient quality. In this circumstance, and when the ligament has avulsed from its origin or insertion, repair is commonly performed with a suture anchor [1, 10, 16]. If the ligament cannot be repaired primarily, reconstruction with autograft can be performed [21]. The outcomes of surgical treatment of chronic injuries are varied, with some authors achieving good outcomes with either repair or reconstruction [8, 16, 21] and others reporting persistent stiffness or requirement for MPJ fusion [10].

The purpose of this study is to evaluate the characteristics of finger collateral ligament injuries and report on the results of primary repair of collateral ligament tears in patients with subacute to chronic injuries.

Methods

Patients

All consecutive patients who underwent surgical repair of a finger MPJ collateral ligament tear between January 2010 and December 2012 were identified by review of the senior author's case logs. Primary repair of the collateral ligament was the preferred intervention because of the senior author's experience that the remnant collateral ligament always remains despite chronic injury. Patients who failed a period of at least 4 weeks of immobilization with casting or splinting and remained symptomatic were treated surgically and were included in the study. Those with associated avulsion fractures were excluded because we felt that bone-to-bone healing represents a different clinical scenario than ligament to bone healing. Information including patient demographics (such as patient age and gender), injury mechanism, hand dominance, preoperative disability of the arm, shoulder, and hand (DASH) scores, results of magnetic resonance imaging (MRI) of the affected digit, and time to surgery were obtained (Table 1). Preoperative radiographs were reviewed to determine the presence or absence of a collateral ligament avulsion fracture. Postoperative outcome measures included joint stability, DASH outcome measure scores, MPJ range of motion, and grip strength compared to the contralateral hand (Table 2).

A total of 23 patients (9 male, 14 female) sustaining injury to 25 fingers underwent primary repair of subacute to chronic finger MCP collateral ligament injury after failing nonoperative treatment. The diagnosis of MPJ collateral ligament tear

was based upon patient history and physical exam demonstrating laxity or instability of finger MPJ when held in 60° of flexion and stressed compared with the contralateral hand, as described by Kang et al. [16]. Pain or tenderness to palpation on the side of collateral ligament injury was present in 22 patients (24 fingers). Radiographs of the hand in some cases demonstrated static MPJ instability and joint incongruity, although this was not required for the diagnosis of MPJ collateral ligament injury, (Fig. 1). Non-contrast MRI was obtained of the affected digit to confirm the diagnosis of MPJ collateral ligament tear in most cases (Fig. 2). For 22 digits in 20 patients, MRI of the affected hand was obtained at the discretion of the senior author. In the remaining three digits in three patients, either gross instability was present and MRI was not deemed necessary for the diagnosis of complete MPJ collateral ligament tear or the patient was unable to undergo MRI testing. Similar to Kang et al., indications for surgery included persistent discomfort and laxity at the MPJ after a trial of immobilization or in the absence of pain, and evidence of symptomatic finger MPJ instability [16].

Injury Characteristics

The average patient age was 47 years (range 17–67 years) (Table 1). The mechanism of injury involved hitting the hand against a fixed object for six fingers, fall onto outstretched hand for seven fingers, ball sports for six fingers, motor vehicle accident for three fingers, and was unknown for three fingers. Six of the 23 patients were involved in worker's compensation claims. The dominant hand was involved in 20 of 25 (80 %) finger injuries. The average time from injury to surgery was 14 weeks (range 6–52 weeks). The most commonly injured ligaments involved the border digits (index finger and small finger), which represented 60 % of injuries (Table 1). The average preoperative DASH score was 40 (range 17–77) in the seven patients (nine fingers) where this was available (Table 2).

Surgical Outcomes

A postoperative DASH score was available for six of the seven patients who had a preoperative DASH score. This subgroup of six patients (eight fingers) was utilized to determine the effect of surgery on patient DASH score using a paired Student *t* test. Patient demographics and postoperative DASH scores in the subgroup of patients with preoperative and postoperative DASH scores was compared to the 13 patients in whom only postoperative DASH scores were available to determine if the subgroup was representative of the entire cohort of patients. Unpaired *t* test was used to compare continuous data such as age, time from injury to surgery, and postoperative DASH scores. Fisher's exact test was used to analyze the noncontinuous data such as patient gender and type of injury.

Table 1 Patient demographics and outcomes

Pt ID	Age (gender)	WC (Y/N)	Dominant hand/injured hand	Mechanism	Injured finger	RCL/UCL	Time from injury to surgery (weeks)	Site of CL avulsion (P1, MC or both)
1	55 (F)	N	R/R	Unknown	Index	RCL	20	P1
2	51 (F)	N	R/L	Fall	Index	RCL	16	MC
3	52 (F)	Y	R/R	Hit hand on railing	Index	RCL	6	MC
4	57 (F)	N	R/R	Fall	Index	RCL	12	P1
5	53 (F)	Y	R/R	Hit hand on car	Index	UCL	32	P1
6	54 (F)	N	R/R	Unknown	Index	UCL	52	MC
7	17 (M)	N	R/R	Ball sports	Index	UCL	16	P1
8	55 (M)	N	R/R	Golf cart crash	Ring	RCL	12	P1
			R/R		Small	RCL	12	P1
9	34 (M)	N	R/R	Ball sports	Small	RCL	20	P1
10	33 (M)	N	R/R	Punched object	Small	RCL	16	P1
11	42 (F)	N	R/R	Hit on car	Small	RCL	6	P1
12	48 (F)	N	R/R	Hit wall	Small	RCL	12	P1
13	42 (F)	Y	R/R	Hit hand on railing	Small	RCL	8	P1
14	49 (F)	Y	R/L	Fall	Small	RCL	6	P1
15	50 (M)	Y	R/L	MVA	Small	RCL	16	MC
16	55 (F)	N	R/R	Unknown	Long	RCL	12	P1
17	54 (F)	N	R/L	Fall	Long	RCL	8	P1
18	67 (M)	N	R/L	Fall	Long	RCL	12	Both
19	25 (M)	N	R/R	Ball sports	Long	RCL	6	P1
			R/R		Ring	RCL	6	P1
20	53 (F)	N	R/R	Fall	Long	UCL	16	P1
21	45 (M)	Y	R/R	Ball sports	Long	UCL	10	P1
22	48 (F)	N	R/L	Ball sports	Ring	RCL	16	P1
23	58 (M)	N	R/R	Fall	Ring	RCL	6	P1

MVA motor vehicle accident, *RCL* radial collateral ligament, *UCL* ulnar collateral ligament, *CL* collateral ligament, *P1* proximal phalanx, *MC* metacarpal, *DASH* disabilities of arm, shoulder, and hand, *WC* worker's compensation

Disability of Index and Small RCL Injuries Compared to Other Finger CL

The small finger RCL is potentially subjected to increased ulnar-directed stress as a border digit without a buttressing digit. The index finger RCL is also similarly subjected to increased ulnar-directed stress due to its role in providing stability of the index finger MPJ during pinch grip. We performed post hoc analysis of postoperative DASH scores with unpaired *t* test to determine if statistically significant differences were observed between these at-risk CL repairs and other CL repairs. At-risk CL injuries were defined as the RCL of the index and small fingers. Other CL injuries were defined as the RCL or UCL of the long and ring finger as well as the UCL of the index and small fingers. The two patients with double-digit injuries were excluded from this comparison to maintain injury homogeneity. We separately compared postoperative DASH scores between index RCL and other CL injuries and small RCL and other CL injuries.

Surgical Technique

All surgical procedures were performed by one surgeon, under sedation and local anesthesia. A longitudinal dorsal skin incision was utilized over the MPJ. A longitudinal incision bisecting the extensor tendon was made, providing access to the dorsal joint capsule. The dorsal joint capsule was incised longitudinally, revealing the metacarpal head and base of the proximal phalanx. The avulsed collateral ligament was identified, assessed, and confirmed to be amenable to direct repair. The collateral ligament avulsion site was identified and pre-drilled with a 2.1-mm drill, followed by placement of a suture anchor (MiTek Worldwide Inc., Norwood, MA). The avulsed end of the collateral ligament was then secured using the anchor with the joint held in 60° of flexion. Restoration of joint stability was confirmed intraoperatively by stressing the repaired ligament. The longitudinal incision on the tendon was not repaired to decrease scar tissue formation. The joint capsule and skin

Table 2 Postoperative outcomes

Pt ID	Injured finger	RCL/UCL	Grip strength (%)	MPJ extension (deg)	MPJ flexion (deg)	MPJ Arc of motion (deg)	DPC (cm)	Preop DASH	Postop DASH
1	Index	RCL	84	6	80	74	2	—	1.7
2	Index	RCL	—	5	85	80	0	—	5
3	Index	RCL	—	0	70	70	2	16.7	35
4	Index	RCL	39	15	78	63	2	—	45
5	Index	UCL	99	0	75	75	1	—	2.5
6	Index	UCL	100	0	70	70	—	—	19
7	Index	UCL	—	0	80	80	0	—	2
8	Ring	RCL	65	17	88	71	2	77	65
	Small	RCL	—	18	71	53	2	—	—
9	Small	RCL	—	0	85	85	1	30	10
10	Small	RCL	—	—	—	—	—	48.3	—
11	Small	RCL	92	0	65	65	—	19.1	21
12	Small	RCL	93	0	82	82	—	—	45
13	Small	RCL	57	0	75	75	0	—	—
14	Small	RCL	75	0	85	85	—	—	65
15	Small	RCL	—	—	—	—	—	—	—
16	Long	RCL	—	—	—	—	—	—	0
17	Long	RCL	32	—	—	—	—	—	1.7
18	Long	RCL	57	10	89	79	—	—	1.7
19	Long	RCL	39	0	90	90	0	42	10
	Ring	RCL	—	0	90	90	0	—	—
20	Long	UCL	—	—	—	—	—	—	—
21	Long	UCL	37	20	70	50	0.5	—	20
22	Ring	RCL	78	0	85	85	0.5	—	10
23	Ring	RCL	—	0	80	80	0.5	50	1.7

RCL radial collateral ligament, UCL ulnar collateral ligament, MPJ metacarpophalangeal joint, DPC distal palmar crease distance, DASH disabilities of arm, shoulder, and hand

were closed in standard fashion and the patient was placed in a splint with the MPJ immobilized in 80–90° of flexion and the interphalangeal joints in extension.

The affected joint was immobilized for a total period of 4 weeks. Range of motion exercises were initiated 4 weeks after surgery under the supervision of the hand therapist.

Fig. 1 **a** Static metacarpophalangeal joint instability on radiographs. AP radiograph of right hand in patient 14 who sustained injury to the ring and small finger. Joint incongruity and ulnar deviation of ring and small finger at metacarpophalangeal joint are present, compared to uninjured long finger. **b** Postoperative radiograph after suture anchor repair of RCL of ring and small finger. MPJ joint congruity is restored

Fig. 2 **a** Axial and **b** coronal images of T2-weighted MRI demonstrating increased signal intensity in the ring finger RCL at its insertion on the proximal phalanx, consistent with disruption of the RCL. Arrows depicting regions of increased signal intensity

Results

Preoperative MRI indicated a complete collateral ligament tear of the involved MPJ in 14 of 22 digits (63.6 %). In seven cases (31.8 %), MRI suggested high grade, partial collateral ligament disruption. In one case (4.5 %), the MRI study was negative for collateral ligament disruption. Intraoperative findings revealed complete avulsion tears in 100 % of fingers. Collateral ligament disruption occurred at the insertion on the base of the proximal phalanx in 20 of 25 (80 %) fingers, from the origin of the metacarpal in 4 of 25 (16 %) fingers, and from both sites in 1 of 25 (4 %) fingers. We found no cases of mid-substance tears. In all cases, the collateral ligament remnant was determined to be suitable for primary repair.

The average follow-up was 21 months (range 12–34). At final clinical follow-up, MPJ stability was maintained in all cases and no clinical evidence of residual instability was identified. There was no statistically significant difference in DASH scores in the six patients (eight digits) with both preoperative and postoperative data (preop DASH 39.1 vs. postop DASH 23.8, $p=0.17$). There was no statistically significant difference in patient demographics or postoperative DASH scores between this subgroup and the remainder of the study group (age 44.3 vs. 49.9 years, $p=0.37$; gender distribution 66 vs. 23 % male, $p=0.13$; injury distribution 50 vs. 38.5 % at-risk CL, $p=0.67$; time to surgery 9.3 vs. 17.2 weeks, $p=0.16$; and DASH 23.8 vs. 16.8, $p=0.53$), suggesting homogeneity in the study group. The overall average postoperative DASH score was 19 (range 0–65) in the 19 patients (21 digits) where this was available (Table 2).

In 14 patients (16 fingers), the average postoperative grip strength was available and found to be 68 % (range 32–100 %) of the contralateral hand. In the 18 patients (20 fingers) where postoperative metacarpophalangeal joint range of motion was available, the average extension lag was 5° (range 0–20) and the average flexion was 80° (range 65–90°). Postoperative metacarpophalangeal joint arc of motion averaged 75° (range 50–90°). In 14 patients (16 fingers), the average distance from fingertip to distal palmar crease was 1 cm (range 0–2 cm).

The average postoperative DASH scores in index finger RCL, small finger RCL, and other finger CL repairs were 21.7 (range 1.7–45), 35.3 (range 10–65), and 6.5 (range 0–20), respectively. Post hoc analysis with unpaired t test showed that the difference in postoperative DASH scores between small RCL and other finger CL repairs was statistically significant ($p=0.007$). The difference in postoperative DASH scores between index finger RCL and other finger CL repairs was not statistically significant ($p=0.08$).

Discussion

Injury to the collateral ligaments of the MPJ in the fingers is less common than similar injuries to the thumb. It may be, in part, that these injuries are underreported. In fact, Delaere et al. reported that 1 in 1,000 injuries to the hand included MPJ collateral ligament injuries, and 39 % of these involved the fingers [6]. Treatment of collateral ligament disruptions is based upon injury severity and acuity. Grades I and II ligament injuries, indicated by no joint laxity or laxity with a firm endpoint, respectively, may be treated nonoperatively with joint immobilization in 30–50° of flexion for a period of 3–6 weeks [10, 15, 18]. The treatment algorithm for grade III (complete) collateral ligament tears, where there is no endpoint, is not as well defined in the fingers as in the thumb. Most authors recommend surgical intervention, especially for the RCL of the index finger or in the setting of significant joint instability [8–10, 16, 23]. If there is significant arthrosis, repair or reconstruction is not indicated and joint fusion is appropriate [10].

The outcomes after repair of finger collateral ligament injuries in the acute setting have been good [6, 8, 10, 16]. However, the results of primary repair of chronic injuries are mixed. Some authors have reported good function despite a delay in treatment [8, 16, 23] while others have noted that repair or reconstruction in the chronic setting can fail, necessitating salvage with MCP arthrodesis [10].

In a series of 14 index finger RCL tears with varying severity of injury and delay in presentation, Gaston et al. reported that patients with delayed presentation had fair to

poor results, with half of the surgically treated patients requiring revision to MPJ fusion [10]. These authors advocated early repair of grade III injuries but were unable to recommend repair or reconstruction for chronic injuries. Nonoperative treatment was sufficient in four low-demand patients, although these patients were noted to bypass their injured finger. In contrast, Kang et al. reported on 12 patients with repair of acute or chronic injuries of the RCL of the index finger and found all of their patients reported resolution of pain and had a stable joint [16]. These authors concluded that repair of index finger RCL injuries is possible, even in patients with a delayed presentation. Riederer et al. reported long-term results in the largest series of collateral ligament reconstructions for chronic tears in the fingers [21]. An anatomic reconstruction was performed with use of palmaris longus or other tendon autograft. At an average 8-year follow-up, 14 of 20 (70 %) fingers were “absolutely stable,” and overall function in 80 % of fingers were graded as good or excellent, highlighting that ligament reconstruction may be a viable alternative in the setting of chronic irreparable collateral ligament injuries.

While the distribution of collateral ligament injuries among the fingers is not well known, the index finger and small finger RCL have received the greatest attention, perhaps because they are more symptomatic than other collateral ligament injuries [8, 10, 16, 21, 27]. Complete injury to the RCL of the index finger can be persistently symptomatic because of its crucial role in providing stability for key pinch [8, 10]. The small finger can remain symptomatic because of its location as a border digit, it is subject to extrinsic ulnar-directed forces, and lacks an adjacent digit to serve as a buttress. In addition, the combined pull of the abductor digiti quinti and flexor digiti minimi are thought to contribute to the persistence of symptoms after RCL injury in the small finger [27]. We found higher statistically significant postoperative disability in small finger RCL repairs compared with central digit CL repairs.

In our series, primary repair of the collateral ligament was possible in all cases. The torn ligament was of sufficient quality to restore joint stability after repair with a mini suture anchor, even in patients as far out as 1 year from injury. Although our patients demonstrated improvement in terms of DASH score, this difference was not statistically significant. Many patients had residual disability as measured by postoperative DASH score, and decreased grip strength compared to the contralateral hand.

Surgical treatment of complete collateral ligament tears of the thumb MPJ is recommended in the acute setting because results are uniformly favorable [3, 7, 11, 24, 25]. In the chronic setting, however, treatment results are less consistent [2, 12]. While still not entirely predictable, in the chronic setting, static ligamentous reconstruction or dynamic tendon transfer seem to have greater success than primary repair [4, 5,

12, 19, 22, 24]. Similarly, we found that the outcomes after repair of chronic finger MPJ collateral ligament tears were poor. While repair did restore stability to the joint intraoperatively and postoperatively, this did not translate to favorable results. If the clinical scenario is analogous to that of the thumb, then perhaps ligament reconstruction may have led to improved outcomes. On the other hand, since the postoperative problems related primarily to pain and decreased ROM rather than instability, it is also possible that results of reconstruction would be similarly disappointing.

In contrast to the thumb, where MRI has been shown to be accurate in diagnosing collateral ligament injuries [13, 14, 20], we found that MRI was poor in assessing the extent of injury to the collateral ligaments of the finger MPJs. In the eight cases where MRI was negative for a complete tear, persistent patient symptoms, functional disability, and clinical findings of ligamentous laxity consistent with complete collateral ligament disruption led to surgical intervention. These patients were confirmed intraoperatively to have complete ligament tears. This finding suggests that physical examination may play a greater role in diagnosing these injuries than imaging studies. Although not utilized in our patients, MRI arthrogram has been shown to be more sensitive than non-contrast MRI for detection of finger collateral ligament injuries in a cadaveric study and this may have increased the diagnostic accuracy [26].

Limitations of our study include the retrospective nature of our review and that we did not compare our outcomes with a similar cohort of patients treated nonoperatively or with ligament reconstruction. Another significant limitation is that preoperative and postoperative data such as DASH score, MPJ range of motion, and grip strength were not available on all patients. We may have had a selection bias, in that for the purposes of the study we identified patients who were treated surgically but did not evaluate patients who were successfully treated nonoperatively. This may have selected for a cohort of patients with more severe injuries.

Based upon our experience, we conclude that complete disruptions of finger MPJ collateral ligaments can lead to persistent symptoms and disability. Surgeons should remain vigilant about this injury and surgical repair of complete tears in the acute setting, much like in the thumb, may be appropriate to optimize results. However, further studies are required to better define the role of acute surgical intervention in these injuries. Patients who present in the chronic setting can be offered a trial of nonoperative management, but symptoms often persist. Results after repair of these injuries are variable and may be dependent upon which finger is injured. Further studies are necessary to determine if alternative surgical options such as ligament reconstruction can improve outcomes in subacute and chronic finger MPJ collateral ligament injuries.

Conflicts of interest Drs. Beredjiklian, Lutsky and Wong have not received anything of value from or own stock in a commercial company or institution directly or indirectly related to the subject of this research. Dr. Beredjiklian or a member of his immediate family has received research support from the Department of Defense and holds stock in Tornier.

Statement of human rights Institutional review board approval was obtained prior to performing the study. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of informed consent Informed consent was obtained from all patients for being included in the study.

Disclosures The authors did not receive an outside grant or other financial assistance for conducting this research. Additionally, the authors have no financial disclosures related to the research presented.

References

1. Aguila MB, Carné JS, Lluch AH. Rupture of the ulnar collateral ligament of the metacarpophalangeal joint of the index finger. *J Hand Surg (Br)*. 2000;25(5):108–9.
2. Arnold DM, Cooney WP, Wood MB. Surgical management of chronic ulnar collateral ligament insufficiency of the thumb metacarpophalangeal joint. *Orthop Rev*. 1992;21(5):583–8.
3. Baskies MA, Lee SK. Evaluation and treatment of injuries of the ulnar collateral ligament of the thumb metacarpophalangeal joint. *Bull NYU Hosp Jt Dis*. 2009;67(1):68–74.
4. Breck JC, Tan AM, van Thiel TP, Daantje CR. Free tendon grafting to repair the metacarpophalangeal joint of the thumb. Surgical techniques and a review of 70 patients. *J Bone Joint Surg Br*. 1989;71(3):383–7.
5. Catalano LW, Cardon L, Patenaude N, Barron OA, Glickel SZ. Results of surgical treatment of acute and chronic grade III tears of the radial collateral ligament of the thumb metacarpophalangeal joint. *J Hand Surg [Am]*. 2006;31(1):68–75.
6. Delaere OP, Suttor PM, Degolla R, Leach R, Pieret PJ. Early surgical treatment for collateral ligament rupture of metacarpophalangeal joint of the fingers. *J Hand Surg [Am]*. 2003;28(2):309–15.
7. Derkash RS, Matyas JR, Weaver JK, et al. Acute surgical repair of the skier's thumb. *Clin Orthop Relat Res*. 1987;216:29–33.
8. 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;14B:248–50.
9. Dray G, Millender LH, Nalebuff EA. Rupture of the radial collateral ligament of a metacarpophalangeal joint to one of the ulnar three fingers. *J Hand Surg [Am]*. 1979;4(4):346–50.
10. Gaston RG, Lourie GM. Radial collateral ligament injury of the index metacarpophalangeal joint: an underreported but important injury. *J Hand Surg [Am]*. 2006;31(8):1355–61.
11. Gerber C, Senn E, Matter P. Skier's thumb. Surgical treatment of recent injuries to the ulnar collateral ligament of the thumb's metacarpophalangeal joint. *Am J Sports Med*. 1981;9(3):171–7.
12. Glickel SZ, Malerich M, Pearce SM, Littler JW. Ligament replacement for chronic instability of the ulnar collateral ligament of the metacarpophalangeal joint of the thumb. *J Hand Surg [Am]*. 1993;18(5):930–41.
13. Hergan K, Mittler C, Oser W. Ulnar collateral ligament: differentiation of displaced and nondisplaced tears with US and MR imaging. *Radiology*. 1995;194(1):65–71.
14. 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(6):1431–4.
15. Ishizuki M. Injury to collateral ligament of the metacarpophalangeal joint of a finger. *J Hand Surg [Am]*. 1988;13A:444–8.
16. Kang L, Rosen A, Potter HG, Weiland AJ. Rupture of the radial collateral ligament of the index metacarpophalangeal joint: diagnosis and surgical treatment. *J Hand Surg [Am]*. 2007;32(6):789–94.
17. Lourie GM, Gaston RG, Freeland AE. Collateral ligament injuries of the metacarpophalangeal joints of the fingers. *Hand Clin*. 2006;22(3):357–64.
18. Merrell G, Slade JF. Dislocations and ligament injuries in the digits. In: Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, editors. *Green's Operative Hand Surgery*. Vol 1. 6th ed. Philadelphia, PA: Elsevier; 2011. p. 291–332.
19. Neviaser RJ, Wilson JN, Lievano A. Rupture of the ulnar collateral ligament of the thumb (gamekeeper's thumb). Correction by dynamic repair. *J Bone Joint Surg Am*. 1971;53(7):1357–64.
20. Plancher KD, Ho CP, Cofield SS, et al. Role of MR imaging in the management of “skier's thumb” injuries. *Magn Reson Imaging Clin N Am*. 1999;7(1):73–84.
21. Riederer S, Nagy L, Buchler U. Chronic post-traumatic radial instability of the metacarpophalangeal joint of the finger. Long-term results of ligament reconstruction. *J Hand Surg (Br)*. 1998;23(4):503–6.
22. Sakellarides HT, DeWeese JW. Instability of the metacarpophalangeal joint of the thumb. Reconstruction of the collateral ligaments using the extensor pollicis brevis tendon. *J Bone Joint Surg Am*. 1976;58(1):106–12.
23. Schubiner JM, Mass DP. Operation for collateral ligament ruptures of the metacarpophalangeal joint of the fingers. *J Bone J Surg Br*. 1989;71(3):388–9.
24. Smith RJ. Post-traumatic instability of the metacarpophalangeal joint of the thumb. *J Bone Joint Surg Am*. 1977;59(1):14–21.
25. Tang P. Collateral ligament injuries of the thumb metacarpophalangeal joint. *J Am Acad Orthop Surg*. 2011;19(5):287–96.
26. Theumann NH, Pfirrmann CW, Drapé JL, Trudell DJ, Resnick D. MR imaging of the metacarpophalangeal joints of the fingers: part I. Conventional MR imaging and MR arthrographic findings in cadavers. *Radiology*. 2002;222(2):437–45.
27. Wolf BA, Cervino AL. Rupture of the radial collateral ligament of the fifth metacarpophalangeal joint. *Ann Plast Surg*. 1988;21(4):382–7.