Long-Term Outcomes of Primary Repair of Chronic Thumb Ulnar Collateral Ligament Injuries

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Abstract

Background: The purpose of this study is to evaluate long-term outcomes of ligamentous repair rather than reconstruction for chronic thumb ulnar collateral ligament (UCL) injuries. **Methods:** Patients at least 15-years status-post repair of a chronic (greater than 6 weeks) UCL tear were contacted for clinical evaluation, radiographs, and postoperative outcome questionnaires, including the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, visual analog scale (VAS) pain scale, and study-specific questions. Twelve of 21 (57%) living patients were available for long-term, greater than 15-year follow-up (average 24.5 years, range 16.9–35.6). **Results:** Eighty-eight percent of patients had some degree of osteoarthritis. Increased age at the time of injury and higher DASH scores were correlated with increased grades of the thumb metacarpophalangeal osteoarthritis. Delay to treatment and VAS pain scores had no correlation with radiographic findings. **Conclusions:** Repair of a chronic UCL injury with available local tissue appears to be a reasonable alternative to ligament reconstruction, resulting in durable long-term outcomes despite the majority of patients progressing to osteoarthritis.

Keywords: ulnar collateral ligament of thumb, gamekeeper's thumb, skier's thumb

Introduction

The ulnar collateral ligament (UCL) of the thumb metacarpophalangeal (MCP) joint is a critical structure providing lateral and dorsal stability during activities that require grip and pinch strength.^{12,15,20,24,33,34} UCL rupture is one of the most common injuries to the thumb, which typically results in chronic joint instability, functional limitation in pinch, and persistent pain. An epidemiologic study by Moutet et al evaluated 1000 thumb MCP injuries and found that the UCL was damaged in 86% of cases.²⁷ It has also been estimated that the annual incidence of UCL injuries is approximately 50 in 100 000 individuals.⁸

The original description of the chronic attritional form of UCL instability was termed *gamekeeper's thumb* because it was a frequent occupation injury of Scottish gamekeepers who repetitively used their thumbs to snap the necks of rabbits.⁵ The more contemporary mechanism of injury is typically forceful radial deviation (abduction) of the thumb MCP joint and described as an acute injury rather than an attritional injury. These injuries are often described as athletic in nature, classically associated with skiing, but are also frequently seen in a variety of other athletes and those simply sustaining a fall onto the thumb or other forced radial deviation injury.^{20,31} Acute injuries in the absence of a Stener lesion (UCL displacement proximal

and superficial to the adductor aponeurosis) may be treated nonoperatively^{9,10,34}; chronic UCL injuries, however, often present a more challenging management dilemma for the treating surgeon.^{1,24} Operative management of chronic UCL deficiency is generally considered indicated as chronic instability is felt to result in chronic pain and the development of MCP osteoarthritis.

Although the definition of chronic varies slightly depending on the source (typically described as being at least 3–6 weeks removed from the injury),^{15,20,24,31} some chronic tears, unlike acute tears, cannot be reliably treated nonoperatively. Furthermore, there are numerous surgical techniques described ranging from direct repair to complex reconstructions with free tendon grafts. The majority of the literature focuses on acute injuries and biomechanical studies comparing various repair or reconstruction techniques. There is a paucity of long-term outcome data for treatment of chronic UCL injuries. As outlined in a recent 2013 systematic review of the literature by Samara et al, the longest

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Table 1. The Study-Specific Questionnaire Included These Questions Pertaining Specifically to the Patients' Thumb Injury and Their Subjective Perspective Regarding Their Long-Term Outcome.

1. What was the date and mechanism of your thumb injury?
2. Are you overall satisfied with your thumb (yes or no)?
3. Would you make the same decision again to have the same thumb surgery (yes or no)?
4. What percent (0-100%) of normal would you rate your thumb?
5. Do you have thumb numbness, stiffness, or instability (all yes or no)?
6. Are you able to use your thumb for normal activity?
7. Do you use pain medication for your thumb injury?
8. After surgery, were you able to return to work? If so, how long after surgery?

average length of follow-up in the literature for chronic UCL reconstructions is 75 months.³¹

There is widespread belief that primary repair rather than reconstruction is contraindicated for chronic injuries; however, this has not been supported by rigorous scientific evidence. It has been our experience that many chronic injuries can still be managed by primary repair without autograft or allograft ligament reconstruction. Our null hypothesis is that patient satisfaction will be good in the long term after primary ligament repair, even in the setting of osteoarthritis or persistent instability; patients overall do well long term regardless of the treatment method or interval between injury and surgical intervention.

Materials and Methods

After institutional review board approval was obtained, a retrospective chart review of our institution's records was queried for patients who underwent primary repair of chronic, complete UCL injuries of the thumb prior to January 1998 to provide a minimum of 15-year follow-up. As a criterion for ligament repair rather than MCP joint fusion, all patients were free of preoperative osteoarthritis of the MCP joint. Exclusion criteria were any type of tendon reconstruction rather than primary ligamentous repair or any repair done acutely prior to 6 weeks.

Patients meeting inclusion criteria were then contacted and requested to return to clinic for a clinical evaluation, study-related questionnaires, and radiographs of the affected thumb. Clinical examination consisted of thumb MCP and interphalangeal (IP) joint range of motion, grip and pinch strengths, and also stability of the MCP joint to radial stress; stability was rated on a scale of 0 to 2. A score of 0 indicates MCP stability is normal compared with the contralateral, unaffected thumb; a score of 1 indicates slight UCL laxity with a retained endpoint compared with the contralateral side; a score of 2 indicates gross UCL laxity without an endpoint compared with the contralateral side.²⁰

Patients completed the DASH questionnaire and a visual analog scale (VAS) for pain, as well as a study-specific questionnaire. The study-specific questionnaire queried patients regarding their thumb injury and subjective

Figure 1. AP (a) and lateral (b) radiographs of patient 6 who was treated 15 years after injury with ligament repair using a suture anchor and transarticular K-wire. Note. The radiographs demonstrate excellent alignment and only mild (grade I) arthritis; however, the patient reports no pain, 100% normal function, and a DASH of 2.5. AP, anteroposterior; K-wire, Kirschner wire.

perspective regarding their thumb outcome (Table 1). Static posteroanterior (PA) and lateral radiographs of the patients' affected thumbs were also obtained, which were used to measure joint subluxation and osteoarthritis. Arthritis was measured on a scale from 0 to 4, according to the Kellgren-Lawrence arthritis classification.³² Examples of several cases are shown in Figures 1 through 4.

Patients who lived too far away or were unable to return for clinical follow-up were mailed the DASH and the study-specific questionnaires. These patients were also mailed a digital goniometer with instructions on how to measure their thumb MCP and IP joint range of motions. These patients however did not receive a physical exam

Figure 2. AP (a) and lateral (b) radiographs of patient 3 treated 6 weeks after injury with primary ligament repair, which failed prompting revision with a primary ligament repair and a transarticular K-wire.

Note. The radiographs demonstrate significant radial translation and angulation, but only mild (grade 1) arthritis; despite the abnormal radiographs, the patient reports 75% normal function and denies subjective instability. AP, anteroposterior; K-wire, Kirschner wire.

Figure 3. AP (a) and lateral (b) radiographs of patient 9 who was treated 6 weeks after injury with bone tunnels and a transarticular K-wire.

Note. The radiographs demonstrate joint space narrowing and osteophytes (grade 3); however, the patient reports 90% normal function and a VAS of 0. AP, anteroposterior; K-wire, Kirschner wire; VAS, visual analog scale.

or radiographs. Statistical analysis included means, ranges, standard deviation, and Spearman correlation (r) coefficients.

Figure 4. AP (a) and lateral (b) radiographs of patient 12 who was treated 26 weeks after injury with mobilization of an osseous avulsion and K-wire fixation of the osseous fragment.

Note. The radiographs demonstrate slight radial angulation, but no arthritis (grade 0) and the patient reports 98% normal function with minimal pain. AP, anteroposterior; K-wire, Kirschner wire.

Statistical Analysis

Data are reported in terms of means, ranges, and standard deviations. The student t test was used for noncategorical data, with a P value of .05 representing statistical significance. The Spearman rank coefficient was used to assess correlations between patient factors and outcomes.

Results

Twenty-four patients were identified as having had a primary repair (without reconstruction) of a chronic UCL thumb injury (>6 weeks) from July 1977 to March, 1996. Three patients were deceased and 8 were lost to follow-up. Twelve of the 21 (57%) of the living patients (Table 2) were available for follow-up. The average postoperative period was 24.5 years (range 16.9-35.6). Nine of the 12 (75%) were available for questionnaire, clinical, and radiographic follow-up whereas 3 of 12 (25%) were available for questionnaire follow-up by mail correspondence only. There were 5 females and 7 males with an average age of 32 years (range 17-48) at the time of injury and 35 (range 17-48) at the time of surgery. The injury involved the dominant hand in 69% (9/13) cases. The average delay between injury and surgical treatment was 2.6 years (range 6 weeks to 15.2 years). All

Table 2. The Kellgren-Lawrence Classification for Osteoarthritis.

Grade	Criteria
0	Normal
1	Doubtful narrowing of joint space, possible osteophyte development
2	Definite osteophytes, absent of questionable narrowing of joint space
3	Moderate osteophytes, definite narrowing, some sclerosis, possible joint deformity
4	Large osteophytes, marked narrowing, severe sclerosis, definite joint deformity

patients were therefore at least 6 weeks after injury (or chronic) at the time of surgery. No patients had significant MCP joint arthritis, which would have prompted an MCP fusion and precluded UCL repair. Patients close to 6 weeks and those with remote injuries all demonstrated subluxation preoperatively. These 12 patients were treated by 7 different surgeons who used a variety of techniques for UCL repair, including primary ligament repair, suture anchor repair, and bone tunnel repair (sutures passed through bone drill holes), all with or without transarticular MCP K-wire fixation. The above-mentioned techniques were used and when local tissue was used, this consisted of a remnant-retracted ligament and scar tissue that was mobilized. None of the techniques however used the use of allograft or autograft ligamentous reconstruction. Data from the study-specific questionnaire and their thumb range of motion testing are shown in Tables 3 and 4, respectively.

Radiographic evaluation of the 8 patients who presented to clinic (excluding the 1 patient who went on to MCP fusion) demonstrated that only 3 patients had a PA radial deviation angle of more than 15°, with an average of 14.4° (SD 10.9). This one patient had a fusion for pain and instability in the setting of osteoarthritis. Five of 8 patients had some degree of radial translation, with an average of 3.0 mm (SD 2.6). None of the patients had volar translation or subluxation on the lateral radiographs. Seven of the 8 patients (88%) of the patients had some degree of osteoarthritis; 2 had grade 1, 3 had grade 2, and 2 had grade 3 osteoarthritis on the Kellgren-Lawrence scale.

A comparison of patients' clinical outcomes with their radiographic outcomes was also made using Spearman correlation analysis (Tables 5 and 6). Increased age at the time of injury and higher DASH scores were correlated with increased grades of the thumb MCP osteoarthritis. Coronal plane translation on radiographs had a negative correlation with total MCP joint motion and grip. Clinical instability was strongly correlated with increased radiographic coronal MCP angulation, but not MCP arthritis. Delay to treatment and VAS pain scores had no correlation with radiographic findings. Sixty-two percent of (8/13) patients were still

working part-time or full-time using the affected hand at the time of latest follow-up. All 5 patients not working were retired, which was not related to the hand injury.

Discussion

Thumb UCL injuries are common and frequently present in a delayed or chronic fashion. The anatomy and biomechanics of the MCP joint as it pertains to these injuries is very well described in the literature.^{2,3,6,7,11,12,14,16,21,23,25,29} Although there are a large variety of options for reconstruction of the UCL, there is also evidence to suggest that there is no difference in outcomes after acute ligament repair versus chronic ligament reconstruction.³¹ In July, 2013, Samora et al published their results of a systematic review of the literature analyzing all cohorts of thumb UCL injuries with at least 2-year follow-up in the English literature.³¹ Their review identified 14 articles representing 293 thumbs with at least 2-year follow-up (average 42.8 months) after non-operative, acute repair, and chronic UCL reconstruction. Those treated nonoperatively had a high failure rate of 34%; however, all were satisfied with their result at a mean follow-up of 32 years. There was no significant difference in patient-specific and injury-specific parameters between patients with successful and failed nonsurgical treatment. Both acute UCL repair and chronic autograft UCL reconstruction led to excellent clinical outcomes, without a significant difference between groups.

Currently there are no long-term outcome studies available in the English literature from which a surgeon may counsel his or her patients regarding the treatment for chronic UCL thumb injuries. The longest outcome data for both acute UCL repair and chronic UCL reconstruction are intermediate to short-term, ranging from 29 to 75 months.³¹ The series by Lane et al has the longest follow-up on acute UCL repair with 32 subjects and an average length of follow-up of just 47 months.¹⁹ This study reports 84% excellent results with 100% having restored stability and all patients able to return to previous sport. The series by Oka et al has the longest follow-up for patients treated with palmaris longus autograft for chronic UCL reconstruction with just 10 subjects and an average length of follow-up of 69 months.²⁸ This study reports 100% good to excellent outcomes, with 89% pinch strength and 90% motion.

Other studies report similar good to excellent results and short-term lengths of follow-up for both acute repairs^{4,10,17,18,30} and late reconstructions.^{13,22,26,35} There are, however, no series longer than 6.3 years for either acute or chronic injuries, nor are their series reporting the outcomes after primary repair in the chronic setting. The results herein reported are therefore consistent with short-term outcomes in that 100% of patients in this cohort were satisfied with their affected thumb. These patients, however, vary from those reported in the literature in that they were all still satisfied despite 88%

Table 3. Demographic Data for the 12 Patients Treated With Repair Rather Than Reconstruction for Chronic UCL Injuries.

	Age	Gender	Hand dominance	Hand affected	Mechanism	Stener	Repair type	Delay to surgery, weeks	Follow-up length, years	Follow-up type
1	57	Male	Right	Right	Ground-level fall	No	Bone tunnel	6	35.6	Clinical
2	57	Male	Right	Right	Skiing	No	Bone tunnel	52	26.1	Mail
3	59	Female	Right	Right	Restraining child	No	Suture anchor ^a	6	18.3	Clinical
4	69	Male	Left	Left	Unknown	Unknown	Unknown	6	23.0	Mail
5	62	Male	Right	Left	Skiing	No	Bone tunnel and MCP pinning	6	32.5	Mail
6	50	Male	Right	Left	Ground-level fall	Yes	Suture anchor and MCP pinning	790	16.9	Clinical
7	54	Male	Right	Right	Skiing	No	Unknown	47	29.1	Clinical
8	68	Female	Right	Right	Roller skating	Yes	Direct ligament repair and MCP pinning	780	21.4	Clinical
9	66	Female	Right	Left	Ground-level fall	Yes	Bone tunnel and MCP pinning	6	17.6	Clinical
10	64	Male	Right	Left	Working for UPS	No	Bone tunnel	6	29.2	Clinical
11	63	Female	Right	Right	Jammed in door	No	Unknown	6	20.0	Clinical
12	41	Female	Right	Right	Motor vehicle accident	No	Pinning of avulsion	26	24.0	Clinical

Note. UCL, ulnar collateral ligament; MCP, metacarpophalangeal; UPS, United Postal Service; K-wire, Kirschner wire.

^aFor this patient, the original surgery failed, and she was subsequently revised with a revision repair and a transarticular K-wire.

Table 4. Outcome Data From the Study-Specific, VAS, and DASH Questionnaires.

Question	Average
Overall satisfied	100%
Same decision again	92%
Normal function	92%
Pain medication	0%
Thumb numbness	31%
Thumb instability	15%
Thumb stiffness	33%
Thumb swelling	25%
VAS pain	0.6
DASH	5.9

Note. The DASH standard deviation was 8.2. VAS, visual analog scale.

having some degree of thumb MCP joint osteoarthritis and 67% had some degree of clinical instability at an average of 25 year follow-up. Of note, only 15% of patients reported instability in the questionnaires (Table 4) versus 67% on the clinical exam; this discrepancy reflects that many patients are slightly unstable (grade 1) on physical exam but do not notice it themselves. Thirty-one percent of patients noted some degree of numbness about the thumb, which was predominantly peri-incisional numbness on exam.

Table 5. Physical Exam Data for Range of Motion, Grip, and Instability.

Measurement	Average	SD
MCP flexion	57	34
MCP extension	23	20
Total MCP	79	33
IP flexion	60	31
IP extension	31	22
Total IP	91	23
Grip	97%	—
Oppositional pinch	97%	—
Appositional pinch	93%	—
Instability	67%	—

Note. Joint angles were measured using a goniometer in degrees. Grip and pinch strength are reported as a percentage of the contralateral uninjured side. Instability is reported as percentage of patients with some degree (either grade 1 or 2) of residual MCP laxity. MCP, metacarpophalangeal; IP, interphalangeal.

The advantages of this study are the long-term follow-up of at least 17 years with an average of 24-year follow-up for a cohort of patients treated with ligamentous repair rather than reconstruction for chronic UCL injury. This therefore represents the longest available outcome data in the literature for thumb UCL injuries. Another advantage of the

Table 6. Spearman Correlation Coefficient Data for Patient Clinical Outcomes Versus Radiographic Outcomes.

	X-ray film AP angle	X-ray film AP translation	X-ray film DJD
Age at injury	0.62	0.56	0.59
Delay to treatment	-0.03	0.04	-0.12
DASH	0.40	0.28	0.76
VAS	0.46	0.08	-0.24
Clinical instability	0.70	0.45	0.16
Total MCP motion	-0.31	-0.63	-0.25
Grip (% contralateral)	-0.59	-0.56	-0.25

Note. AP, anteroposterior; DJD, degenerative joint disease; VAS, visual analog scale; MCP, metacarpophalangeal.

study is that the majority (75%) of patients with follow-up data presented for a clinical examination and radiographs, which can be difficult in long-term outcome studies.

A major disadvantage of this study is the small cohort size of only 12 patients out of 21 living patients available for follow-up (57%). Another disadvantage is the large variety of surgeons and repair techniques utilized for this cohort varying from primary ligamentous repair using suture, to bone tunnels, to suture anchors. This variety however is not surprising given that the repairs were performed over a 19-year period from 1977 to 1996 by 7 different surgeons. However, all surgeons did primarily repair the ligament, thereby allowing us to study the outcomes of primary repair of the UCL in chronic situations. Future treatment of this disorder would likely benefit from a randomized prospective trial of 2 techniques by fewer surgeons with long-term follow-up. The measurement of thumb range of motion angles by patients with a goniometer sent by mail also presents another disadvantage of this study as there certainly is likely a large measurement error. However, detailed instructions regarding the use of the goniometer were sent to these patients that represents a very small portion of the cohort (3 of 12).

Thumb ulnar collateral injuries are common and may result in disability. Repair of a chronic UCL injury with available local tissue with or without joint stabilization appears to be a reasonable alternative to ligament reconstruction as it results in durable long-term outcomes in terms of overall pain relief, function, and patient satisfaction, despite a high rate of residual instability and progression to osteoarthritis.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

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 2000 and 2008.

Statement of Informed Consent

Informed consent for research purposes was obtained per institutional protocol.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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References

1. Abrahamsson S, Sollerman C, Lundborg G, Larsson J, Egund N. Diagnosis of displaced ulnar collateral ligament of the metacarpophalangeal joint of the thumb. *J Hand Surg Am.* 1990;15:457-460.
2. Barmakian J. Anatomy of the joints of the thumb. *Hand Clin.* 1992;8:683-691.
3. Bean C, Tencer A, Trumble T. The effect of thumb metacarpophalangeal ulnar collateral ligament attachment site on joint range of motion: an in vitro study. *J Hand Surg Am.* 1999;24:283-287.
4. Bostock S, Morris M. The range of motion of the MP joint of the thumb following operative repair of the ulnar collateral ligament. *J Hand Surg Br.* 1993;18:710-711.
5. Campbell C. Gamekeeper's thumb. *J Bone Joint Surg Br.* 1955;37:148-149.
6. Carlson M, Warner K, Meyers K, Harley B, Kok P. Mechanics of an anatomical reconstruction for the thumb metacarpophalangeal collateral ligaments. *J Hand Surg.* 2013;38:117-123.
7. Carlson M, Warner K, Meyers K, Hearn K, Kok P. Anatomy of the thumb metacarpophalangeal ulnar and radial collateral ligaments. *J Hand Surg.* 2012;37:2012-2026.
8. Chuter G, Muwanga C, Irwin L. Ulnar collateral ligament injuries of the thumb: 10 years of surgical experience. *Injury.* 2009;40:652-656.
9. Derkash R, Matyas J, Weaver J, et al. Acute surgical repair of the skier's thumb. *Clin Orthop Relat Res.* 1987;216:29-33.
10. Downey D, Moneim M, Omer GJ. Acute gamekeeper's thumb. Quantitative outcome of surgical repair. *Am J Sports Med.* 1995;23:222-226.

11. Firoozbakhsh K, Yi I, Moneim M, Umada Y. A study of ulnar collateral ligament of the thumb metacarpophalangeal joint. *Clin Orthop Relat Res*. 2002;403:240-247.
12. Frank W, Dobyns J. Surgical pathology of collateral ligamentous injuries of the thumb. *Clin Orthop Relat Res*. 1972;83:102-114.
13. Fusetti C, Papaloizos M, Meyer H, Borisch N, Della Santa D. The ECRL bone-tendon ligamentoplasty for chronic ulnar instability of the metacarpophalangeal joint of the thumb. *Chir Main*. 2005;24:217-221.
14. Harley B, Werner F, Green JK. A biomechanical modeling of injury, repair, and rehabilitation of ulnar collateral ligament injuries of the thumb. *J Hand Surg*. 2004;29:915-920.
15. Heyman P. Injuries to the ulnar collateral ligament of the thumb metacarpophalangeal joint. *J Am Acad Orthop Surg*. 1997;5:224-229.
16. Heyman P, Gelberman R, Duncan K, Hipp JA. Injuries of the ulnar collateral ligament of the thumb metacarpophalangeal joint. Biomechanical and prospective clinical studies on the usefulness of valgus stress testing. *Clin Orthop Relat Res*. 1993;292:165-171.
17. Jackson M, McQueen M. Gamekeeper's thumb: a quantitative evaluation of acute surgical repair. *Injury*. 1994;25:21-23.
18. Katolik L, Friedrich J, Trumble T. Repair of acute ulnar collateral ligament injuries of the thumb metacarpophalangeal joint: a retrospective comparison of pull-out sutures and bone anchor techniques. *Plast Reconstr Surg*. 2008;122:1451-1456.
19. Lane L. Acute grade III ulnar collateral ligament ruptures. A new surgical and rehabilitation protocol. *Am J Sports Med*. 1991;19:234-237.
20. Lee A, Carlson M. Thumb metacarpophalangeal joint collateral ligament injury management. *Hand Clin*. 2012;28:361-370.
21. Loebig T, Anderson DD, Baratz M, Imbriglia J. Radial instability of the metacarpophalangeal joint of the thumb. A biomechanical investigation. *J Hand Surg Br*. 1995;20:102-104.
22. Lohman M, Vasenius J, Nieminen O, Kivisaari L. MRI follow-up after free tendon graft reconstruction of the thumb ulnar collateral ligament. *Skeletal Radiol*. 2010;39:1081-1086.
23. Melone CJ, Beldner S, Basuk R. Thumb collateral ligament injuries. An anatomic basis for treatment. *Hand Clin*. 2000;16:345-357.
24. Merrell G, Slade J. *Green's Operative Hand Surgery*. 6th ed. Philadelphia, PA: Churchill Livingstone; 2011.
25. Minami A, An K, Cooney WP III, Linscheid RL, Chao EY. Ligament stability of the metacarpophalangeal joint: a biomechanical study. *J Hand Surg Am*. 1985;10:255-260.
26. Mitsionis G, Varitimidis S, Sotereanos G. Treatment of chronic injuries of the ulnar collateral ligament of the thumb using a free tendon graft and bone suture anchors. *J Hand Surg Br*. 2000;25:208-211.
27. Moutet F, Guinard D, Lebrun C, Bello-Champel P, Massart P. Metacarpo-phalangeal thumb sprains based on experience with more than 1,000 cases. *Ann Chir Main*. 1989;8:99-109.
28. Oka Y, Harayama H, Ikeda M. Reconstructive procedure to repair chronic injuries to the collateral ligament of metacarpophalangeal joints of the hand. *Hand Surg*. 2003;8:81-85.
29. Posner M, Retallaud J. Metacarpophalangeal joint injuries of the thumb. *Hand Clin*. 1992;8:713-732.
30. Ryu J, Fagan R. Arthroscopic treatment of acute complete thumb metacarpophalangeal ulnar collateral ligament tears. *J Hand Surg Am*. 1995;20:1037-1042.
31. Samara J, Harns J, Griesser M, Ruff M, Awan HM. Outcomes after injury to the thumb ulnar collateral ligament—a systematic review. *Clin J Sport Med*. 2013;23:247-254.
32. Schiphof D, Boers M, Bierma-Zeinstra SMA. Differences in descriptions of Kellgren and Lawrence grades of knee osteoarthritis. *Ann Rheum Dis*. 2007;67:1034-1036.
33. Smith R. Post-traumatic instability of the metacarpophalangeal joint of the thumb. *J Bone Joint Surg Am*. 1977;59:14-21.
34. Stener B. Displacement of the ruptured ulnar collateral ligament of the metacarpophalangeal joint of the thumb. *J Bone Joint Surg Br*. 1962;44:869-879.
35. Wong T, Ip F, Wu W. Bone-periosteum-bone graft reconstruction for chronic ulnar instability of the metacarpophalangeal joint of the thumb—minimum 5-year follow-up evaluation. *J Hand Surg Am*. 2009;34:304-308.