A Comparison of Conservative and Operative Management of Thumb Ulnar Collateral Ligament Avulsion Fractures in Children

Minh N. Q. Huynh¹ , Ken Tang², and Kevin Cheung³

Abstract

Background: The optimal management of pediatric thumb ulnar collateral ligament (UCL) avulsion fractures remains poorly defined. The purpose of this study was to elucidate patient outcomes based on initial management and fracture characteristics. **Methods:** A retrospective study of all patients younger than 18 years of age presenting with a thumb UCL avulsion fracture was performed. Patients were grouped by their initial management. The primary outcome of the study was time to return to full activity. Fractures were characterized by articular surface involvement, displacement, and rotation. **Results:** Forty-seven patients with thumb UCL avulsion fractures were identified. Ten patients underwent surgery as initial treatment; all healed without complication, with a mean recovery time of 6.2 ± 1.8 weeks. Thirty-seven patients were treated conservatively; although most healed, the recovery time was longer (9.2 ± 8.3 weeks, adjusted hazard ratio = 2.3, 95% confidence interval = 1.0–5.5). Four cases (11%) required conversion to surgery that all healed without complications. Fractures treated with immobilization alone were significantly smaller, less displaced, and less rotated than those initially treated with surgery; however, 19 fractures that would have met criteria for surgery were treated with immobilization and successfully healed within 7.1 ± 2.9 weeks. Fracture characteristics did not predict which patients would fail conservative treatment or have prolonged recovery times. **Conclusions:** While surgery provided definitive treatment without delay in recovery, immobilization may not be an unreasonable treatment choice even for patients with large or displaced fractures. In cases where patients failed immobilization, surgery as a second-line treatment had good results.

Keywords: fracture, hand, pediatric, patient outcome, ulnar collateral ligament

Introduction

The ulnar collateral ligament (UCL) is the most commonly injured structure associated with thumb trauma.^{1–3} Excessive valgus forces can result in either a direct injury to the ligament or an avulsion fracture of the ligament from its insertion at the base of the proximal phalanx. Acute injuries are known colloquially as skier's thumb due to the high association with falls while holding a ski pole. Chronic injuries may be referred to as a gamekeeper's thumb. With substantial displacement, a Stener lesion may result when the UCL is displaced superficial to the aponeurosis of the adductor pollicis muscle. In cases of a Stener lesion, proper healing cannot occur.^{1–5}

The thumb UCL is critical to function as it provides lateral stability of the thumb during pinch.^{2,6,7} Persistent thumb pain or instability may lead to long-term morbidity and reduced grip strength and function. Prompt and appropriate treatment is essential. Patients who present with a history of

thumb abduction or hyperextension and clinical signs of UCL injury should undergo radiography to rule out fractures. If the diagnosis of a UCL injury cannot be made clinically, an ultrasonography or magnetic resonance imaging may be considered.^{1–3}

The UCL avulsion fractures can be managed either conservatively or surgically. In adults, minimally displaced avulsion fractures may be treated conservatively with immobilization using a thumb spica splint.^{1–3} Surgical repair may be indicated

¹Faculty of Medicine, University of Ottawa, ON, Canada

²Children's Hospital of Eastern Ontario Research Institute, Ottawa, Canada

³Children's Hospital of Eastern Ontario, Ottawa, Canada

Supplemental material is available in the online version of the article.

Corresponding Author:

Kevin Cheung, Division of Plastic Surgery, Children's Hospital of Eastern Ontario, 401 Smyth Road, Ottawa, ON, Canada K1H 8L1.
Email: kcheung@cheo.on.ca

Figure 1. Method of measuring fracture displacement, surface involvement, and rotation.

with $>30^\circ$ of valgus laxity or evidence of a Stener lesion.^{2,3,5-13} Surgery may also be indicated due to the intra-articular nature of the fracture: if the fragment involves $>25\%$ to 30% of the articular surface, if the articular gap is displaced >2 mm, or if there is an articular step of >1 mm.^{6,14-20}

In children, there is a paucity of evidence to guide the management of thumb UCL avulsion fractures. The aim of this study was to evaluate the management practices and outcomes of children presenting with this injury.

Materials and Methods

A retrospective study of all patients over the past 9 years (September 2007-July 2016) who presented acutely to a tertiary pediatric hand surgery clinic with a radiography-confirmed thumb UCL avulsion fracture was conducted. Patients were identified using the *International Classification of Diseases, Tenth Revision, Canada (ICD-10-CA)* codes (see appendix). We tried to be as inclusive as possible as there is no specific *ICD-10-CA* code for thumb UCL avulsion fracture, and the accuracy of coding at our institution has not been validated. Patients were excluded if they presented >1 month after injury, were older than 18 years of age, and had comminuted, open, or multiple hand fractures. Demographic variables including age, sex, history of previous fractures, and comorbidity were collected. Clinical data including mecha-

nism of injury, examination findings, growth plate status (open or closed), management, and clinical outcome were also collected. Fracture characteristics (absolute fragment size and as percentage of articular surface involvement, displacement, and rotation) were measured from radiographs using picture archiving and communication system (PACS) imaging software as demonstrated in Figure 1. The PACS has the capacity to measure the distance and angle between 2 points, allowing users to accurately calculate the displacement and rotation of fractures. Displacement was calculated as the largest distance on any view between the phalanx and the fragment. The percentage of articular surface involvement was calculated as the proportion of the articular surface size of the fragment and the total articular surface. Fragment rotation was calculated as the angle between the original axis of the fracture and the angulated fragment.

The decision of initial management (immobilization vs surgery) was made on an individual patient basis by one of the 3 treating staff surgeons. Patients treated with immobilization were provided with a removable, custom-made thermoplastic hand-based thumb spica splint. Patients treated with surgery underwent repair of the avulsed fracture fragment with internal fixation, bone anchor, or pull-out suture as previously described.²¹ Postoperatively, patients were treated with a forearm-based thumb spica splint followed by transition to a hand-based thermoplastic splint until clinical union.

Figure 2. Evaluation of UCL avulsion fracture management.

Note. UCL = ulnar collateral ligament.

^aNineteen patients met surgical criteria.

The primary outcome was healing time, defined as the time from initial presentation to the clinic to asymptomatic return to full activity. This was assessed by patient report and clinical examination. In some cases, patients who were almost healed were instructed to wean the use of their splint and gradually resume normal activity. If they were asymptomatic and had returned to full activity, they could cancel their future scheduled follow-up. Healing for these patients was assumed to have occurred at least by the time of their canceled follow-up, 4 to 6 weeks following their last visit.

The study received ethics approval from our institutional research ethics board.

Statistical Analysis

Descriptive statistics were used to describe patient characteristics. To compare the characteristics of patients receiving immobilization with those receiving surgery as the initial management, Wilcoxon rank sum and Pearson χ^2 tests were used to assess continuous and categorical variables, respectively. Wilcoxon rank sum tests were also performed to assess whether fracture characteristics differed between those successfully treated with immobilization alone and those who failed initial immobilization and later required surgery.

Cumulative incidence plots and multivariable Cox regressions applying the time to healing were performed to address 3 specific questions: (1) Are fracture characteristics associated with recovery among patients initially receiving conservative management? (2) Is initial management strategy (conservative vs surgery) associated with recovery among patients with fractures retrospectively meeting surgical criteria at initial presentation? (3) Is initial management strategy (conservative vs surgery) associated with recovery

among all patients. Surgical criteria were defined based on the literature values for articular surface involvement ($>25\%$ - 30%), articular displacement (>2 mm), and fragment rotation ($>35^\circ$).^{6,14-20}

For all Cox regressions, a unique data consideration was required for any patients who were initially managed conservatively but subsequently required surgery due to persistent symptoms ($n = 4$). Although the patients were classified in the “conservative management” group in the analysis, we believe their observed recovery times may be biased low (ie, underestimated) due to the benefits of subsequent surgery and, therefore, may not be indicative of the outcomes associated with conservative management only. To reconcile this potential bias in our analyses, we made an assumption that these 4 patients would have remained symptomatic for at least as long as any other patient in the conservative management group.

For all multivariable Cox regressions, the proportional hazard assumption was verified by assessing smoothed Schoenfeld residual plots and then formally checking for the lack of significant correlation between residuals and time. Adjusted hazard ratios with 95% confidence intervals (CIs) were reported for key model predictors of interest. All statistical analyses were performed using R statistical software (R Core Team 2016).²²

Results

We identified 4343 patients with the diagnostic codes of interest. All the radiographs of these patients were reviewed; 47 patients had confirmed thumb UCL avulsion fractures (Figure 2). The remainder did not meet inclusion criteria. The mean time of presentation from initial injury was 5.4 ± 6.1 days. Patients ranged in age from 7 to 17 years (mean = 14.3 ± 2.0 years), with a higher prevalence of males (Table 1). All patients were nonsmokers. No patients had documented evidence of a Stener lesion, but valgus stress was not uniformly documented at the initial consultation. Five patients received advanced imaging 14 ± 11 weeks from their initial consultation: 2 healed with conservative management alone, and 3 failed conservative management and required surgery. No patients received advanced imaging if they were initially treated with surgery.

Ten patients underwent surgery as initial treatment; all healed without complication, with an average healing time of 6.2 weeks (± 1.8 weeks, maximum = 11 weeks) (Table 1).

Thirty-seven patients were initially treated with immobilization; mean healing time for all patients who received conservative management was 9.2 ± 8.3 weeks. Four cases (11%) required conversion to surgical treatment due to persistent symptoms. For the patients failing immobilization, the average time to surgery from date of presentation was 18 ± 14 weeks, with an average recovery time of 7.3 ± 0.96 weeks following surgery. The remainder of the patients

Table 1. Patient Demographics, Initial Treatment, Fracture Characteristics, and Outcomes of Patients With Ulnar Collateral Ligament Avulsion Fractures.

Characteristics	Initial treatment		P value
	Immobilization Mean (SD)	Surgery Mean (SD)	
Patient demographics			
N	37	10	
Age, y	14 (2.1)	15 (1.2)	NS
Male, %	64	90	NS
Skeletally immature, %	72	80	NS
Fracture properties			
Displacement, mm	1.8 (1.4)	3.8 (2.1)	.001
Articular surface, %	14 (15)	32 (1.7)	.001
Rotation, deg	18 (24)	37 (27)	.05
Mean recovery time, wk	9.2 (8.3)	6.2 (1.8)	.05

Note. NS = not significant.

Table 2. Fracture Characteristics and Outcomes of Patients Who Initially Received Conservative Management.

Characteristics	Initial treatment		P value
	Immobilization Mean (SD)		
Outcome	Healed	Failed	
N	33	4	
Fracture properties			
Displacement, mm	1.7 (1.4)	2.0 (1.2)	NS
Articular surface, %	13 (15)	19 (15)	NS
Rotation, deg	17 (24)	21 (24)	NS
Mean recovery time, wk	7.3 (4.8)	7.3 (0.96) ^a	NS

Note. NS = not significant.

^aAverage time before receiving surgery was 18 weeks.

treated with immobilization alone healed in 7.3 weeks (± 4.8 weeks, maximum = 30 weeks) (Table 2).

In total, 19 patients who were treated with conservative management retrospectively would have met the surgical criteria based on fracture properties. The average recovery time for these patients was 7.1 ± 2.9 weeks with immobilization alone. Two patients in this group failed immobilization and required subsequent surgery.

Fracture characteristics differed significantly between patients who initially received conservative management and those who received surgical management. Fractures that were treated with immobilization alone ($n = 33$) were significantly smaller ($13\% \pm 15\%$ of the articular surface vs $32\% \pm 1.7\%$, $P < .001$), less displaced (1.7 ± 1.4 mm displacement vs 3.8 ± 2.1 mm, $P < .001$), and less rotated ($17^\circ \pm 24^\circ$ rotation vs $37^\circ \pm 27^\circ$, $P < .05$) than those initially treated with surgery ($n = 10$). There were no significant differences between the fracture properties of patients

Figure 3. Cumulative incidence plot for patients who received conservative management as initial treatment.

Note. Each uptick demonstrates a patient recovery. Patients who failed immobilization and required surgery were censored and assumed to take at least as long as the last patient who healed from immobilization to recovery. The shaded area represents 95% confidence intervals.

who healed with immobilization alone and those who failed immobilization and required subsequent surgery ($19\% \pm 15\%$, 2.0 ± 1.2 mm, $21^\circ \pm 24^\circ$, $n = 4$, $P > .05$) (Figure 3).

Cumulative incidence plots demonstrate time to healing for those who initially received immobilization (Figure 3), those who would have retrospectively met surgical criteria (Figure 4), and for all patients (Figure 5). Each uptick represents a patient who made a full recovery. Multivariate Cox regression models suggested that surgery was associated with a greater probability of a faster recovery compared with immobilization among surgical candidates (median recovery time = 6.0 weeks, 95% CI = 4.0-6.0 weeks vs 7.0 weeks, 95% CI = 6.0-8.0; adjusted hazard ratio = 2.9, 95% CI = 1.2-7.3) and among all patients (adjusted hazard ratio = 2.3, 95% CI = 1.0-5.5). Fracture characteristics were not associated with patient outcomes nor time to recovery for any group. For all Cox regression models, the proportional hazard assumption was supported based on no significant correlations between Schoenfeld residuals and time.

Discussion

Currently, there is a paucity of evidence to guide the management of pediatric thumb UCL avulsion fractures. Current management is loosely based on the adult criteria, but often the decision between immobilization and surgery relies on clinical judgment and patient/family preference,

Figure 4. Cumulative incidence plot for surgical candidates who received conservative versus surgery as initial treatment. Note. Each uptick demonstrates a patient recovery. Patients who failed immobilization and required surgery were censored and assumed to take at least as long as the last patient who healed from immobilization to recovery. The shaded area represents the 95% confidence intervals.

Figure 5. Cumulative incidence plot for patients who received conservative management versus surgery as initial treatment among all patients. Note. Each uptick demonstrates a patient recovery. Patients who failed immobilization and required surgery were censored and assumed to take at least as long as the last patient who healed from immobilization to recovery. The shaded area represents the 95% confidence intervals.

rather than on evidence-based medicine. We performed a retrospective review of pediatric patients with a thumb UCL

avulsion fracture to elucidate their outcomes based on initial management and fracture characteristics to provide better evidence for management.

Both immobilization and surgery demonstrated good results regardless of the fracture characteristics. Most fractures treated with immobilization alone healed (89%, $n = 33/37$), including 89% ($n = 17/19$) of fractures that would have met traditional criteria for surgery based on fracture characteristics. Fractures treated initially with surgery healed slightly faster than those treated with immobilization (mean recovery time = 6 vs 9 weeks), although it is unknown whether this difference is clinically significant, due to limitations in outcome assessment, or driven by a few outliers. All patients who failed immobilization had good results with surgery, despite an average 18-week delay before receiving the surgery. A caveat to the reported delay in surgery is that some surgeons placed patients on an elective surgical list, artificially inflating the wait time for surgery.

Fracture properties could not predict which patients would fail conservative management or require prolonged periods of immobilization (Figure 3). There may be other factors beyond fracture properties that might predict which patients may benefit from early surgical intervention; however, these were not identified due to sample size limitations. With the retrospective nature of the study, furthermore, there may be biases in patient selection and limitations in outcome assessment and reporting. Other outcomes such as functional strength were not routinely documented, and the lack of long-term follow-up fails to capture potential sequela such as growth deformity or post-traumatic arthritis.

The adult literature aligns with our findings. Nonoperative management of UCL injuries has been documented to have reasonable results. Landsman et al²³ performed a retrospective review of 40 adult patients who sustained acute UCL injuries (30% were avulsion fractures) who were treated with thumb spica splints. Thirty-four patients healed nonoperatively without complications (85%). The remaining 5 patients required surgery due to persistent symptoms and healed uneventfully. Pichora et al²⁴ and Kuz et al²⁵ independently demonstrated similar findings. Pichora et al prospectively followed a cohort of 42 patients with a mixture of ligamentous and avulsion fractures. They reported 91% of their patients had normal or satisfactory outcomes, and only 2 patients required subsequent surgery. Their cohort also contained 5 patients who had Stener lesions that all healed uneventfully with conservative management. Kuz et al reviewed 30 patients with avulsion fractures. All of their patients were satisfied with their treatment; however, 5 patients showed radiographic evidence of malunion at their 1-year follow-up. Less promising results with conservative management have been reported by Dinowitz et al.²⁶ Their study consisted of a series of 9 adult patients with small, minimally displaced avulsion fractures that all failed conservative management, but had full recovery with

surgery. Regardless, all the studies demonstrated excellent outcomes with subsequent surgery.

Ultimately, the choice between immobilization and surgical intervention has both advantages and disadvantages. The options and the evidence supporting each should be weighed in the context of each individual patient and discussed with patients and their families. All patients undergoing surgery healed in 11 weeks with no reported complications and slightly faster than those treated with immobilization. Immobilization, however, may not be an unreasonable treatment choice even for patients with large or displaced fractures. In cases where patients failed immobilization, surgery as a second line had good results.

Further work needs to examine the factors that might predict which patients may benefit from early surgical intervention. Long-term follow-up is required to ensure that patients do not develop growth deformity or post-traumatic arthritis.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

This article does not contain any studies with human or animal subjects.

Statement of Informed Consent

No informed consent was required for the study.

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.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Minh N. Q. Huynh <https://orcid.org/0000-0003-3931-1351>

References

1. Moutet F, Guinard D, Lebrun C, et al. Metacarpophalangeal thumb sprains based on experience with more than 1,000 cases. *Ann Chir Main.* 1989;8(2):99-109.
2. 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.
3. Rhee PC, Jones DB, Kakar S. Management of thumb metacarpophalangeal ulnar collateral ligament injuries. *J Bone Joint Surg Am.* 2012;94(21):2005-2012. doi:10.2106/jbjs.k.01024.
4. Deibert MC, Aronsson DD, Johnson RJ, et al. Skiing injuries in children, adolescents, and adults. *J Bone Joint Surg Am.* 1998;80(1):25-32.
5. Blitzer CM, Johnson RJ, Ettlinger CF, et al. Downhill skiing injuries in children. *Am J Sports Med.* 1984;12(2):142-147.
6. Madan SS, Pai DR, Kaur A, et al. Injury to ulnar collateral ligament of thumb. *Orthop Surg.* 2014;6(1):1-7. doi:10.1111/os.12084.
7. Avery DM III, Caggiano NM, Matullo KS. Ulnar collateral ligament injuries of the thumb: a comprehensive review. *Orthop Clin North Am.* 2015;46(2):281-292. doi:10.1016/j.ocl.2014.11.007.
8. Anderson D. Skier's thumb. *Aust Fam Physician.* 2010;39(8):575-577.
9. Tang P. Collateral ligament injuries of the thumb metacarpophalangeal joint. *J Am Acad Orthop Surg.* 2011;19(5):287-296.
10. Stener B. Displacement of the ruptured ulnar collateral ligament of the metacarpophalangeal joint of the thumb. *Bone Joint J.* 1962;44-B(4):869-879.
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):171-177.
12. Lee AT, Carlson MG. Thumb metacarpophalangeal joint collateral ligament injury management. *Hand Clin.* 2012;28(3):361-370. doi:10.1016/j.hcl.2012.05.024.
13. Berger C, Holzach P, Matter P. [Skier's thumb injury in the child]. *Helv Chir Acta* 1994;60(4):615-621.
14. Kjaer-Petersen K, Langhoff O, Andersen K. Bennett's fracture. *J Hand Surg Br* 1990;15(1):58-61.
15. Soyer AD. Fractures of the base of the first metacarpal: current treatment options. *J Am Acad Orthop Surg.* 1999;7(6):403-412.
16. Kozin SH. Fractures and dislocations along the pediatric thumb ray. *Hand Clin.* 2006;22(1):19-29. doi:10.1016/j.hcl.2005.09.001.
17. Osterman AL, Hayken GD, Bora FW Jr. A quantitative evaluation of thumb function after ulnar collateral repair and reconstruction. *J Trauma.* 1981;21(10):854-861.
18. Arranz Lopez J, Alzaga F, Molina J. Acute ulnar collateral ligament injuries of the thumb metacarpophalangeal joint: an anatomical and clinical study. *Acta Orthop Belg.* 1998;64(4):378-384.
19. Malik AK, Morris T, Chou D, et al. Clinical testing of ulnar collateral ligament injuries of the thumb. *J Hand Surg Eur Vol.* 2009;34(3):363-366. doi:10.1177/1753193408100957.
20. Goth D, Haussmann P. [Surgical treatment of the ruptured ulnar collateral ligament of the metacarpophalangeal joint of the thumb]. *Handchirurgie.* 1979;11(1):61-64.
21. Wolfe S PW, Hotchkiss R, Kozin S. *Green's Operative Hand Surgery.* Philadelphia, PA: Elsevier; 2010.
22. R Core Team. *R: A Language and Environment for Statistical Computing.* Vienna, Austria: R Foundation for Statistical Computing; 2016. <https://www.R-project.org/>. Accessed February 9, 2019.
23. Landsman JC, Seitz WH, Froimson AI, et al. Splint immobilization of gamekeeper's thumb. *Orthopedics.* 1995;18(12):1161-1165.
24. Pichora DR, McMurtry RY, Bell MJ. Gamekeepers thumb: a prospective study of functional bracing. *J Hand Surg Am.* 1989;14(3):567-573.
25. Kuz JE, Husband JB, Tokar N, et al. Outcome of avulsion fractures of the ulnar base of the proximal phalanx of the thumb treated nonsurgically. *J Hand Surg Am.* 1999;24(2):275-282. doi:10.1053/jhsu.1999.0275.
26. Dinowitz M, Trumble T, Hanel D, et al. Failure of cast immobilization for thumb ulnar collateral ligament avulsion fractures. *J Hand Surg Am.* 1997;22(6):1057-1063. doi:10.1016/S0363-5023(97)80049-4.