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Pediatric Proximal Phalanx Fractures: Outcomes and Complications after the Surgical Treatment of Displaced Fractures

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Abstract

Background—The outcomes literature on proximal phalanx fractures in children is sparse. The purpose of this study is to report the complications and outcomes of displaced proximal phalanx fractures after treatment with closed reduction and percutaneous pinning.

Methods—A retrospective chart review identified 105 patients treated with closed reduction and percutaneous pinning of displaced proximal phalanx fractures. Specific complications were recorded for all patients. Thirty-one of these patients returned more than 1 year after surgery for assessment including visual analog scales of pain level, functional ability, and aesthetics. Objective measurements included range of motion, grip and pinch strength, and finger deformity. Radiographs were taken to assess deformity.

Results—Five of the 105 patients (4.8%) had a complication including infection, pin site complication, or malunion. Thirty-six had stiffness and 31 ultimately underwent hand therapy to regain motion. Subcondylar fractures were associated with a greater likelihood of stiffness. In the 31 patients returning for assessment, the median visual analog scale score was 0 for pain (none), function (full), and aesthetics (perfect). Range of motion, grip, and pinch strength were equivalent to the contralateral side. Seven of the 31 patients (22.6%) had a measureable coronal plane deviation averaging 5° (range 3°–13°) on radiographs. Deviation was associated with subcondylar fractures and a worse aesthetic VAS. Deviation was not associated with worse outcomes overall.

Conclusions—Pediatric patients with a displaced proximal phalanx fracture treated with closed reduction and percutaneous pinning have an initial notable complication rate related to stiffness; subcondylar proximal phalanx fractures are more commonly affected. At greater than 1 year follow up, patients had full motion, no pain, and were happy with both function and appearance despite minor deformity in some. These complication data may help better inform patients and families prior to surgical intervention.

Keywords

pediatric; proximal phalanx; pinning; outcomes; complications

INTRODUCTION

Proximal phalanx fractures are the most common hand fracture in children. Most commonly, these fractures occur at the base of the proximal phalanx as a physeal or periphyseal fracture or distally as a subcondylar fracture. Phalanx shaft fractures are less common. (1, 2)

Minimally or non-displaced fractures are treated with immobilization with expected good outcomes. Displaced injuries, however, can lead to deformity that compromises hand function^(3, 4), and surgery may be utilized to correct a problematic deformity.^(5, 6) Therefore, displaced proximal phalanx fractures are usually treated with closed reduction and casting or, failing a stable reduction, closed or open reduction and fixation. Various fixation methods have been reported for these injuries.⁽⁷⁻¹¹⁾ One common treatment for unstable proximal phalanx fractures is closed reduction and percutaneous pinning (CRPP). This technique minimizes soft tissue damage, provides secure fixation, and is the preferred treatment at our institution for those children that fail closed reduction alone.

Despite the prevalence of proximal phalanx fractures in children, there is sparse literature on the outcomes of any treatment option. The purpose of this investigation was to assess the complications and outcomes of displaced proximal phalanx fractures in children treated with closed reduction and percutaneous pinning.

MATERIALS & METHODS

The institutional review board approved this retrospective call-back study. We performed a chart review for children treated with closed reduction and percutaneous pinning for proximal phalanx fractures (Current Procedural Terminology code 26727) from 2003-2011. Inclusion criteria were patients with open physes with displaced proximal phalanx fractures treated with closed reduction and pinning. We excluded patients with fractures that were open, multiple, or intra articular. We excluded patients treated with closed reduction alone or open reduction. One hundred and five patients with proximal phalanx fractures treated during this time period met our criteria.

All charts were reviewed for patient age, sex, fracture type, mechanism of injury, pin duration, number of follow-up visits, date of last follow-up visit, time to healing, time from surgery to need for therapy, range of motion, qualitative assessments of motion, and complications. Complications were defined to include infection, pin site issues such as drainage or migration, malunion, avascular necrosis, and need for any secondary procedures. Patient stiffness and a need for therapy (at second postoperative visit) were also documented, but not considered a complication. Study data were collected and managed using REDCap electronic data capture tools hosted at our institution.⁽¹²⁾

The average patient age was 11 years (range 5-16) at the time of surgery. There were 70 males and 35 females. There were 49 fractures of the small finger, 19 of the thumb, 14 of the long finger, 13 of the ring finger, and 10 of the index finger. Phalangeal base fractures, including physeal and periphyseal, were most common (80), followed by subcondylar (15), and shaft (10).

Sports related activities were the most common cause of injury, noted in 56 of the fractures. Falls accounted for 29 fractures while 18 were from undefined mechanisms, and 1 occurred when the finger was shut in a door.

Patients failing closed treatment underwent surgery at a median of 6 days after injury (range: 0-18 days). After surgery, patients were casted and pins remained in place for an average of 31 days (range 19-45 days). While highly variable, patients returned for an average of 3 follow up visits (median, range 1-13) with the last follow-up visit occurring 25 days after pin removal for those who returned (median, range 7- 357). All fractures healed (median 40 days, range 22-99) as determined by radiographic assessment and the absence of pain on clinical examination. One patient required revision surgery for loss of reduction 3 weeks after initial surgery.

Treatment Protocol

Children with displaced proximal phalanx base fractures are usually treated with closed reduction and immobilization. If closed reduction fails to restore proper alignment or if there is a loss of alignment after reduction, then surgery is recommended. We treat displaced subcondylar fractures with CRPP without an attempted closed reduction alone. The decision for surgical treatment is based on patient age and on sagittal and coronal alignment, dorsal displacement and tilt of the distal fragment, and prominence of the volar “spike” which impedes flexion at the proximal interphalangeal joint.

In the operating room, proximal phalanx base fractures are closed reduced and stability is assessed. If there is a question to the stability of the fracture, we typically stabilized the fracture with 2 antegrade crossed, 0.9mm Kirschner wires starting at the radial and ulnar base of the proximal phalanx. The pins are left out of the skin to allow removal in clinic (Fig 1a and 1b). Subcondylar fractures are closed reduced and stabilized with 2 retrograde, crossed Kirschner wires, without crossing the proximal interphalangeal joint (PIP) (Fig 2a and 2b). Specific pin configuration is at the discretion of the treating surgeon. Patients are casted in the operating room and most commonly seen at 4 weeks in the office for cast and pin removal. Patients are instructed on self-directed range of motion activities with instructions for another return visit 2-4 weeks later. If motion is not full at that visit, patients are sent to hand therapy at the discretion of the treating surgeon.

Patient Assessment

For the call back portion of the study, we attempted to contact the parent or legal guardian of each patient by telephone and mail. Despite extensive efforts to contact the families of the patients, only 31 of the 105 total patients (30%) returned for either an evaluation in the office (27) or at the patient's home (4). The average age at follow up was 15 years old (range 9-20), and each patient was at least 1-year after treatment (median: 2.3 years after treatment, range: 1-9).

An examiner who was not the treating surgeon evaluated each patient. Subjective data included three 10 cm visual analogue scales (VAS) to document the patient's assessment of finger pain, finger function, and appearance (0=no pain, perfect function, and perfect aesthetics; 10=extreme pain, no function, severely deformed). Patients completed the form

in the same room as their parent if they were under 18 years of age. We measured finger flexion and extension at the metacarpophalangeal (MCP), proximal interphalangeal (PIP), and distal interphalangeal (DIP) joints of the affected and contralateral finger using a standard goniometer (Baseline small joint goniometer, Fabrication Enterprises Inc, White Plains, NY). We measured grip and pinch strength with a standard hand dynamometer (Jamar hydraulic dynamometer, Sammons Preston Inc, Bolingbrook, IL). Measurement of the distance of the fingertip to the distal palmar crease (DPC) was recorded along with degree of deviation or rotation of the affected finger and the contralateral finger. Static anteroposterior and lateral fluoroscopic images of the injured and the contralateral fingers were taken to allow measurement of any angulation or deformity.^(13, 14)

Statistics

Normality of data was assessed by the Shapiro-Wilk test and appropriate descriptive statistics were performed. Chi-square analyses were performed to determine associations between demographic data and injury history/treatment with the development of complications. For the patients that returned for additional follow-up, Fisher's exact tests were used to determine associations between post-operative complications and patients' fingers being deviated or rotated. Mann Whitney-U tests were used to determine if patients' total arc of motion and VAS values differed between patients who experienced post-operative complications and those who did not. Significance for all tests was defined as $P < 0.05$.

RESULTS

Retrospective Chart Review

Five patients (4.8%) had a complication related to surgery, all in the physeal fracture group (6.3%). There were no complications in the subcondylar fracture or shaft fracture groups. These 5 complications included 2 patients with pin migration, 1 patient with a pin site infection, 1 patient with a pin site infection and pin migration, and 1 patient with a pin migration and loss of reduction requiring revision surgery. There were no cases of avascular necrosis or malunion but we did not include any patients with an open reduction

Fifty- six patients recovered full motion by the time of the last office visit without the need for additional therapy or intervention. However, 36 patients had motion limitation including 6 with a flexion contracture at the PIP joint and 30 with limited flexion demonstrated by either an increased DPC measurement or a decrease in flexion at the MCP and/ or PIP joints. The availability of these data was variable and we lacked quantitative data for 14 patients.

Due to stiffness at the second postoperative appointment, these 36 patients were determined to need formal therapy. There were 23 physeal fractures, 9 subcondylar fractures, and 4 shaft fractures. Ultimately, 31 of these 36 patients with stiffness underwent hand therapy, beginning at an average of 35 +/- 15 days after surgery. .

We were not able to identify any association between age at injury, sex, mechanism of injury, or fracture type with the development of any of the above complications or stiffness

as a whole. Subcondylar fractures were significantly more likely than phalangeal base fractures (33% versus 6%) to develop stiffness requiring therapy ($p=0.003$).

Call- back patients

Subjectively, all 31 patients were doing well with a median VAS score of 0 for pain (range 0-2), appearance (range 0-9), and function (range 0-5). Eleven of the 31 patients had stiffness in the immediate post-operative period that resolved by final follow- up. There was no association between patient pain or function and the development of stiffness. However, the group that experienced postoperative stiffness did rate their finger aesthetically worse than the non-stiffnessgroup (stiffness median=1.9, no stiffness median=0.0; $P=0.003$).

Final range of motion and grip strength data are listed in Table 1. Total arc of motion ($p=0.35$), DPC measurement ($p=0.17$), and grip strength ($p=0.15$) were not different for patients that had experienced postoperative stiffness and those who had not. There were 7 patients with finger deviation averaging $12^{\circ} \pm 9^{\circ}$. Asymmetric rotational deformity was present in 3 patients, averaging $6^{\circ} \pm 1^{\circ}$. These deformities were not associated with post-operative stiffness ($P=0.53$).

We obtained comparison radiographs in all 27 of the patients that returned for in- office examination. The median deviation of the proximal phalanx in the coronal plane compared to the contralateral finger was 0° , but 7 of the patients had an average of 5° (range 3° - 13°) of measurable deviation. These were the same patients that had measured deviation on clinical exam. There was no deformity in the sagittal plane. Five of the 7 subcondylar fractures had some deviation and were more likely than other fracture types to have deviation of the finger ($P=0.02$). Radiographic deviation of the finger was not associated with pain, altered function, or other complications. However, there was a statistically significant difference in the VAS for appearance in patients with a deviated finger. The median aesthetic VAS was 0 for those without deviation and 1.4 for those that had deviation ($P=0.03$).

DISCUSSION

Our patients with a displaced proximal phalanx fracture and open growth plates treated with closed reduction and percutaneous pinning did well after surgery. While temporary stiffness requiring therapy was common, major complications were avoided. At a median of two years after surgery, patients did not complain of pain, abnormal appearance, or functional limitations. Subcondylar fractures were more likely to be associated with early postoperative stiffness and also more likely to develop a malunion or deviation of the finger. However, at final follow-up, overall outcomes were excellent for all patients without differences in subjective pain, function, or objective measures.

Early mobilization of phalanx fractures in the adult is recommended to minimize the risk of stiffness. It has been shown that finger immobilization for longer than 3 weeks can lead to stiffness, so patients with these fractures are usually started on an early therapy program.⁽⁸⁾ Despite early motion, many adult patients experience stiffness after surgery and in this previous report, the difficulties in treating the adult with a displaced proximal phalanx fracture are highlighted by the 52% complication rate.

We view children differently from adults for two reasons. First, children are more likely to avoid stiffness and adhesions after all surgeries.⁽¹⁵⁾ Second, children are less compliant, and casting is deemed more appropriate in the child. In our study, pins were left in place for a median time of approximately 4 weeks, and then most children began independent range of motion exercises. Those patients that did not regain motion on their own were enrolled in formal therapy. By final follow-up, the children had motion equal to the contralateral finger and did not have pain or functional deficit despite having initial post-operative stiffness.

The literature is limited in the assessment of proximal phalanx fractures in children, especially when considering surgical intervention and duration of follow-up. The few studies to evaluate outcomes include a population somewhat different than our own. Al-Qattan treated juxta-epiphyseal fractures in 34 patients with reduction and immobilization.⁽¹⁶⁾ Only 6 patients were treated with surgery for severely displaced fractures. All patients in the study except 2 regained full motion; these 2 had significant displacement and the loss of motion was attributed to malunion. Fischer and McElfresh treated 451 proximal phalanx fractures including 28 subcondylar fractures; 21 of these 28 were treated with closed reduction and Kirschner wire fixation while the other fractures were typically treated with closed reduction and immobilization alone.⁽¹⁷⁾ The authors reported good outcomes with only 6 complications for the entire group including pain, decreased range of motion, mild deformity, internal rotation, extensor lag, and premature closure of physis.

In 1984, Hastings and Simmons reported on 354 pediatric hand fractures with at least 2 year follow up; 43% were proximal phalanx fractures. Extra-articular fractures had 88% good results if non-displaced and 74% good results if displaced.⁽⁴⁾ The authors concluded that remodeling in the plane of motion of the finger could be expected and that displaced subcondylar fractures were among the most problematic fractures. Recently, Karl et al described a closed reduction and percutaneous fixation technique on 4 patients with subcondylar fractures. All 4 patients had full or nearly full range of motion without pain at an average of 18-months follow-up.⁽⁷⁾

We agree that subcondylar fractures can be challenging and we use a similar technique in the treatment of subcondylar fractures as described by Karl et al.⁽⁷⁾ Overall, our outcomes were similar between subcondylar and phalangeal base fractures. However, we did find that patients with subcondylar fractures were more likely to have stiffness early on as well as deviation of the finger at final follow-up. Anatomical correction of the sagittal plane deformity- typically ulnar deviation- is crucial at the time of surgery and, in our opinion, deserves as much attention as the coronal plane correction. In our population, early stiffness did require additional treatment with hand therapy, but with good ultimate outcomes.

Our study has inherent limitations. First, as with all other previous studies on this topic, we are limited by the retrospective nature of the study design. For example, not all of the patient records have complete range of motion data, nor was it recorded in a uniform manner across providers, so we were not able to perform a quantitative analysis of early post-operative motion. We compensated for this creating a call- back arm to this study for a detailed evaluation. Despite only 30% of patients returning for evaluation, they were a representative

sample population of our study group as a whole with a similar complication rate. The groups had a similar fracture type distribution and similar outcomes (at the time of the last visit of the group that did not return for final check). We also chose to examine a heterogeneous group of proximal phalanx fractures. However, when we analyzed the fractures by type, overall there was no association with complications and outcomes.

Closed reduction and percutaneous fixation of displaced, unstable proximal phalanx fractures in children is safe with few major complications but a common finding of early stiffness. These data have helped to inform our preoperative discussions with families regarding postoperative expectations. In the longer term, most patients and families can expect excellent function and appearance without pain.

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Figure 1. Anteroposterior (1a) and lateral (1b) radiographs of a typical fixation pattern for a proximal phalanx Salter Harris 2 fracture. Antegrade pins are left outside of the skin for removal in clinic at 4 weeks.

Figure 2. Anteroposterior (1a) and lateral (1b) radiographs of a typical fixation pattern for a subcondylar fracture of the proximal phalanx. Retrograde pins are left outside of the skin for removal in clinic at 4 weeks.

Table 1

Objective Outcome Data for 31 patients evaluated at final follow- up

	Injured finger	Contralateral finger/ hand
MCP extension/ flexion (°)	5/ 86	5/ 85
PIP extension/ flexion (°)	3/ 90	0/ 90
DIP extension/ flexion (°)	0/ 77	0/ 75
Total arc of motion (°)	270	265
Distal palmar crease (cm)	0	0
Grip strength (lbs)	58 +/- 22	58 +/- 20

MCP = metacarpophalangeal joint; PIP = proximal interphalangeal joint; DIP = distal interphalangeal joint; DPC = distal palmar crease