Risk Factors for Upper Extremity Refractures in Children

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Background: Multiple descriptive studies have been published on refracture patterns, particularly for forearm fractures. However, few large cohorts have been analyzed quantitatively including the odds of refracture, and with a comprehensive assessment of the possible predictive factors associated with refracture. This study aimed to assess the frequency and timing of upper extremity refracture in a large pediatric orthopaedics practice, and to evaluate the strength of association of various patient-level and fracture-related factors with refracture.

Methods: Medical records were reviewed retrospectively for patients 1 to 18 years of age with at least 1 upper extremity fracture (ICD-9 codes 810 to 819) between June 1, 2010 and May 31, 2011. Characteristics of patients and fractures were assessed for the association with refracture using bivariate analysis and multivariable logistic regression.

Results: Among 2793 patients with a total of 2902 upper extremity fractures, 2% were treated for refracture within 2 years, at a median of 6 months (188 d) after the initial injury. Midshaft location, and characterization of the fracture as angulated or buckle, were associated with being more likely to refracture. Eighty percent of refractures were the result of a fall, with almost 25% involving a high-energy mechanism and about 15% from monkey bars or other playground equipment. The adjusted odds of refracture were 4 times higher if noncompliance with treatment recommendations was documented, when controlling for insurance type and number of days before orthopaedic evaluation. Forearm fractures were almost 4 times more likely to refracture compared with other bones, controlling for midshaft location, days immobilized, and buckle or torus characterization of the fracture.

Conclusions: Our practice saw a refracture occurrence in 2% of patients, with median time to refracture of ~6 months. The factors most strongly associated with refracture were midshaft fracture location, forearm fracture as opposed to clavicle or humerus, and noncompliance as defined in the study. Falls and high energy activities, such as use of wheeled devices, skis, or trampolines, were important mechanisms of refracture.

Level of Evidence: This study is a Level II prognostic study. It is a retrospective study that evaluates the effect of patient and fracture characteristics on the outcome of upper extremity refracture.

Key Words: pediatric fractures, pediatric refractures, refractures, forearm fractures, upper extremity fractures

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Upper extremity fractures are the most common fractures among children.[1,2] Studies show that between 1.5% and 5% of children with forearm fractures experience refracture of the same site.[3–6] Research is limited on the predictive factors associated with upper extremity refracture in children, and findings of some existing literature are inconsistent. Two major limitations of many studies of upper extremity refractures are small cohort size and lack of quantitative analysis of the odds of refracture, given various possible predictive factors.

In studies investigating only fractures of the forearm, diaphyseal location is the most strongly predictive factor for refracture.[3,5,7] Most refractures of the forearm occur within 9 months, and there is no difference between boys and girls.[8] Greenstick forearm fractures are frequently reported to be more prone to refracture. However, studies of this as a risk factor often lack statistical or quantitative assessment of risk and more robust studies have failed to document a significant association.[8] The shorter duration of immobilization has been associated with increased risk of forearm refracture.[3] However, this finding is also not consistently repeatable.[6,8] One study reported that forearm fractures with at least 10 degrees of angulation are more prone to refracture, with those having more than 15 degrees of angulation likely to refracture earliest after the clinical clearance.[5] A recent systematic review suggests that although falls are the most common mechanism for forearm refracture, use of wheeled vehicles and trampolines may also increase the risk.[8]

In studies investigating other upper extremity fractures, supracondylar fractures of the humerus may be more prone to refracture than other parts of the upper arm.[9] Clavicle fractures may have a relatively high refracture rate (18%), with angulation-only fractures more likely to refracture compared with displaced fractures.[10]

Considering the lingering questions about which factors most significantly affect the likelihood of refracture in the pediatric upper extremity, we set out to explore a variety of patient-level and fracture-level characteristics

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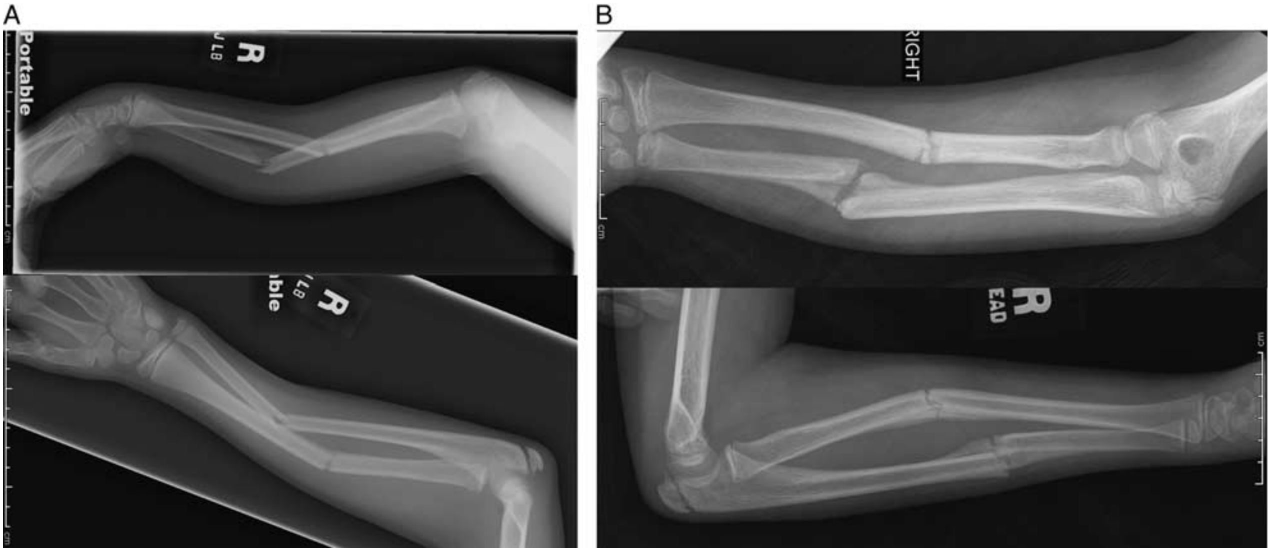

FIGURE 1. A, Forearm fracture of radius and ulna categorized as 1 fracture. Although at different locations, both are on the same arm and from the same force. B, Refracture 8 weeks after initial injury.

among a large pediatric study population. We hypothesized that between 1.5% and 5% of upper extremity fractures would refracture within the study period, and that diaphyseal location would be a significant predictor of refracture in our patient population because of the strength of existing evidence for this association. We further expected that falls would be the most common method of refracture. Finally, our review of existing literature found limited information about whether participation in specific sports may increase the risk of upper extremity refracture, so we also sought to explore involvement in organized and recreational sports to look for additional predictive factors.

METHODS

This retrospective cohort study aimed to assess the frequency and timing of refracture in children 1 to 18 years of age with an upper extremity fracture between June 1, 2010 and May 31, 2011, and to evaluate factors associated with refracture in a large pediatric orthopaedics practice. This study was approved through expedited review by our facility's Institutional Review Board.

The study utilized retrospective review of medical records from a single Pediatric Level I Trauma Center. The electronic medical record system was queried for patients with upper extremity fracture (ICD-9 codes 810 to 819) between June 1, 2010 and May 31, 2011. Children aged older than or equal to 1 and younger than 18 years of age were included. Any prior fractures of the ipsilateral extremity were noted but this was not used as a criterion for exclusion from the study. Medical records from both the hospital and the private practice providing orthopaedic service to the hospital were reviewed for each patient for 2 years after the initial presentation. Data were collected on demographics and insurance type, mechanism of injury, fracture location(s), fracture type, treatment type, dominant hand, recommended convalescence duration, actual convalescence duration, compliance with recommended care, complications, and other comorbid conditions. Fractures of the radius and ulna occurring on the same forearm, from the same force, were counted as a single fracture (Fig. 1). Otherwise, each upper extremity fracture was counted separately.

Refracture versus no-refracture was the primary outcome of interest. Refracture is generally defined as "fracture occurring at the initial fracture site" and can occur early or late relative to the time of the initial fracture.[9] Medical records were reviewed for any additional fractures, for 2 years after the date of injury, for each patient. When possible for study purposes, the treating clinician's notes were used to classify a subsequent fracture of the same bone as a refracture. If it could not be easily ascertained from the medical record whether a second fracture within the study period was considered a refracture, the radiographs and history were reviewed by the study's lead author who is a board-certified pediatric orthopaedic surgeon. As a result, the lead author reviewed 45% of refracture cases, and looked for fractures at least partly through the original fracture line on the same bone. In the case of metaphyseal fractures where the fracture might have migrated with bone growth, any remaining radiographic evidence of the location of the original fracture was used to decide whether the reinjury was likely a refracture (Fig. 2).

Fracture characteristics were documented, including displaced, angulated, buckle (torus), oblique, spiral, greenstick, longitudinal, transverse, comminuted, impacted, open, or plastic deformation. These characteristics were abstracted from the medical record by the trained study staff, utilizing radiology reports. In instances where the radiology report was unclear or contradictory regarding the fracture description, radiographs were

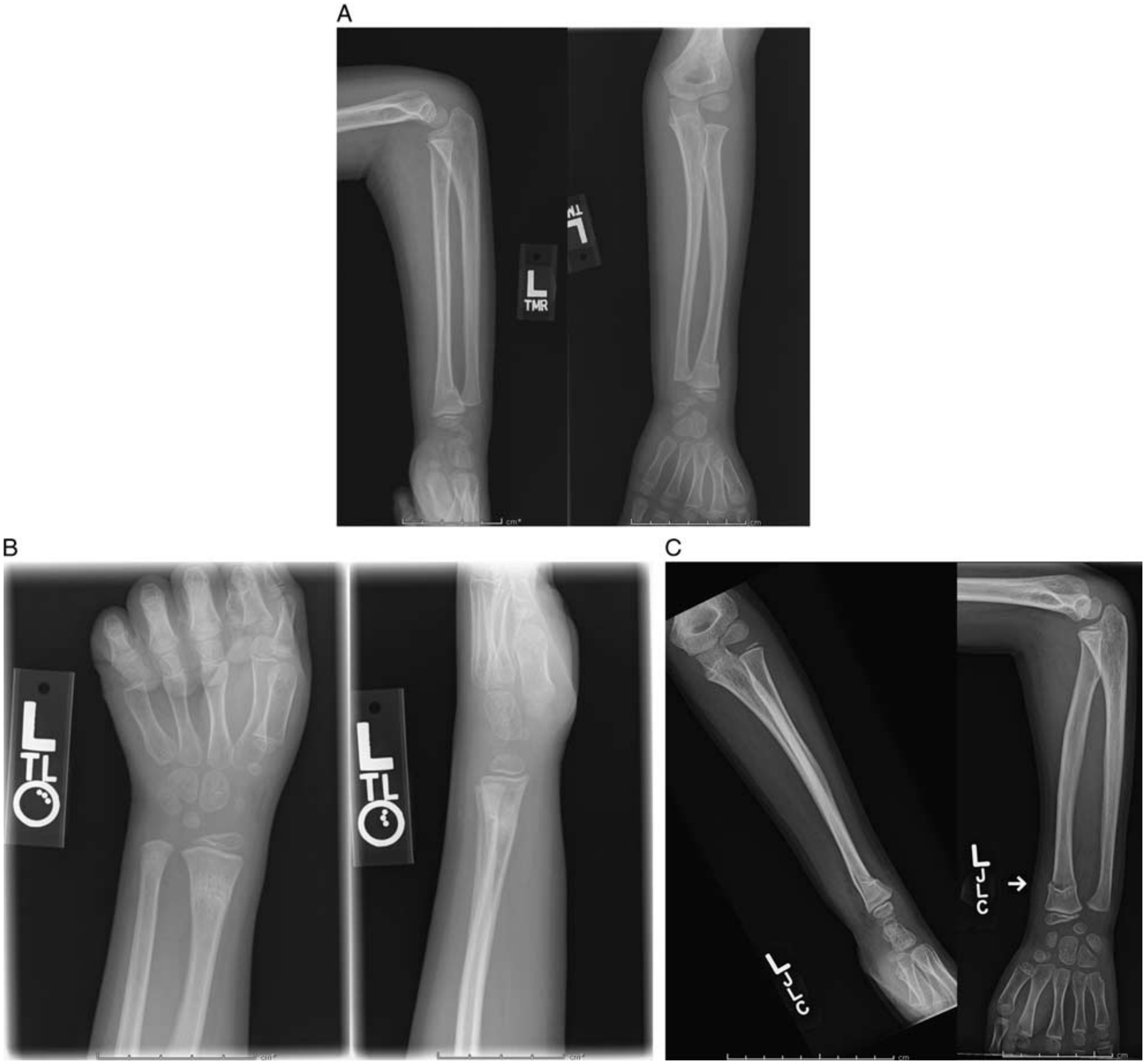

FIGURE 2. A, Buckle fracture of the distal radius in a 5-year-old patient. B, At 4.5 weeks postinjury. C, Refracture 17 months after initial injury.

reviewed by the lead orthopaedic surgeon on the study to make the final determination.

Sports-related mechanisms of injury (both for the initial fracture and any refractures) were analyzed, including football, volleyball, soccer, basketball, baseball, and lacrosse. Any medical conditions such as osteogenesis imperfecta or vitamin D deficiency that could affect bone strength or healing were noted during chart review.

Because this was a retrospective study, treatment recommendations were at the discretion of the treating physician. For each case, the medical record was reviewed in detail to determine what recommendations were made with regards to treatment, revisit frequency and timing, activity restrictions, and physical therapy or rehabilitation. During this same reading of each medical record, study staff also documented the significant deviations from those recommendations. Noncompliance with recommended care was defined as mention of noncompliant behaviors in the medical record. These included: (1) initial presentation to specialized orthopaedic care after referral delayed >2 weeks (2) a wet or damaged cast, (3) premature removal of cast at home, or discontinuation of splint or sling usage before the recommended time frame, (4) ignoring activity restrictions, or (5) not completing recommended rehabilitation or physical therapy. Physical therapy was not recommended in all cases, but when it was, noncompliance was noted when a patient either never started or never returned after the initial physical therapy visit.

For univariate comparison between the refracture and nonrefracture groups, a student t test was used for normally distributed continuous variables and a Wilcoxon rank-sum test was used for continuous variables not normally distributed. A χ^2 test was used for categorical variables, with Fisher exact test used when the expected frequency in any cell of the contingency table was <5. Results were considered statistically significant at $P<0.05$. Multivariable logistic regression was used to evaluate the odds of refracture, using a forward 10% change-in-estimate method for variable selection, and including known or suspected confounders based on existing research. Multivariable models were, by necessity, built separately for patient-level and fracture-level characteristics because some patients had multiple fractures at the index visit with differing characteristics, and we needed to isolate fracture characteristics specific to the site of refracture. Fit of the final regression models was assessed using Pearson and Hosmer-Lemeshow goodness-of-fit tests ($P>0.05$).

RESULTS

The cohort of 2793 patients had a total of 2902 upper extremity fractures. The mean age was 7.5 years, with slightly more boys than girls. Most patients (96%) presented with a single fracture. Fractures most commonly occurred to the radius alone (34.2%), both radius and ulna at the same location (28.8%), or humerus (26.8%) (Table 1).

Of the 2793 patients, 55 were seen within the same orthopaedic practice with at least 1 refracture, yielding a refracture incidence of 2.0% [95% confidence interval (CI): 1.5%-2.5%]. Of the 55 refractures, 3 were treated for another subsequent refracture within 2 years after the initial fracture. Having any documented noncompliance with recommended care was significantly associated with refracture ($P=0.007$; Table 2). There were no significant differences in demographics between patients who had a refracture and those who did not (Table 2). None of the sports evaluated as the initial mechanism of injury were significantly associated with the higher risk of refracture. In addition, patients whose initial fracture occurred on a trampoline were not significantly more likely to experience a refracture (Table 2). None of the patients with a refracture had a condition related to bone density or healing capacity documented in the medical record in the 2 years after the index fracture.

There was a statistically significant difference in the proportion refractured based on which bone was involved ($P=0.007$); fractures of the radius and ulna or the radius-only were the most likely to refracture, followed by clavicle fractures (Table 3). Forearm fractures (radius, ulna, or both) were significantly more likely to refracture if they occurred midshaft, compared with proximal or distal locations ($P<0.001$). Three of 132 clavicle fractures (1.9%, 95% CI −0.25 to 4.00) were treated for refracture. All 3 were classified as midshaft, and no clavicle fracture characteristics were significantly associated with risk of refracture. Four of 779 humeral fractures experienced refracture, and all were supracondylar (Table 3, Fig. 3). There was no apparent association between humerus refracture and documented malunion or healing with angulation; however, this analysis was limited by the low proportion of humeral refractures (0.5%, 95% CI 0.01-1.02).

Refracture was significantly more likely among fractures characterized as either angulated ($P=0.003$) or buckle/torus ($P=0.027$) (Table 3). However, refracture rate was not significantly different for greenstick fractures, compared with other types of fractures. There was no significant difference in treatment modality between fractures that refractured and those that did not (Table 3). The median time to refracture was 188 days, or ~6 months (interquartile range 103 to 405 d) (Table 4).

TABLE 1. Descriptive Statistics of Patient and Fracture Characteristics

Patient characteristics	
Total number (patients)	2793
Age, years (mean ± SD)	7.52 ± 3.74
Sex, n (%)	
Male	1586 (56.8)
Female	1207 (43.2)
Insurance status, n (%)*	
Privately insured	1660 (59.5)
Publicly insured	1001 (35.8)
Uninsured	131 (4.7)
Patient weight, kg (median, IQR)†	27.9 (19.4-42.2)
History of any previous fracture, n (%)‡	485 (17.5)
History of previous UE fracture, n (%)§	348 (12.5)
Days from injury to orthopaedic care, (median, IQR)‖	5 (3-8)
Noncompliance, n (%)¶	117 (4.2)
Number of UE fractures at presentation, n (%)	
1	2692 (96.4)
2	95 (3.4)
> 2	6 (0.2)
Fracture playing football, n (%)#	130 (4.7)
Fracture playing volleyball, n (%)#	21 (0.8)
Fracture playing soccer, n (%)#	105 (3.8)
Fracture playing basketball, n (%)#	50 (1.8)
Fracture playing baseball, n (%)#	13 (0.5)
Fracture on trampoline, n (%)#	102 (3.7)
Fracture characteristics	
Total number (fractures)	2902
Original Fracture: bone, n (%)	
Radius only	992 (34.2)
Radius and ulna	837 (28.8)
Ulna only	126 (4.3)
Clavicle	160 (5.5)
Humerus	779 (26.8)
Metacarpal	8 (0.3)

*Data for insurance status was missing for 1 observation.
†Data on patient weight was missing for 47 observations.
‡Data for previous fracture was missing for 13 observations.
§UE indicates upper extremity; Data for previous UE fracture was missing for 9 observations.
‖Data for injury date and/or first treatment date were missing for 14 observations.
¶Noncompliance with recommended care included: a damaged cast; premature removal of cast or stopped wearing splint or sling; ignoring activity restriction; not completing recommended rehabilitation or physical therapy; or delayed presentation.
#Data for the injury mechanism was missing for 23 observations.
IQR indicates interquartile range.

TABLE 2. Patient-level Predictors of Upper Extremity Refracture

Predictor Variable	No Refracture	Refracture	P
Total no. patients, n (%)	2738 (98.0)	55 (2.0)	—
Age, year (mean ± SD)*	7.51 ± 3.74	8.31 ± 3.27	0.114
Sex, n (%)†			
Male	1553 (56.7)	33 (60.0)	0.627
Female	1185 (43.3)	22 (40.00)	
Insurance status, n (%)†			
Privately insured	1623 (59.3)	37 (67.3)	0.168
Publicly insured	987 (36.1)	14 (25.5)	
Uninsured	127 (4.6)	4 (7.3)	
Patient weight, kg (median, IQR)‡	27.9 (19.3-42.2)	28.4 (22.0-42.3)	0.285
History of any previous fracture, n (%)†			
Yes	473 (17.4)	12 (21.87)	0.388
No	2,252 (82.6)	43 (78.2)	
History of previous UE fracture, n (%)†			
Yes	342 (12.5)	6 (10.9)	0.719
No	2387 (87.5)	49 (89.1)	
Days from injury to orthopaedic care, (median, IQR)‡	5 (3-8)	4 (2-7)	0.106
Noncompliance n (%)†§			
Yes	110 (4.0)	7 (12.7)	0.007‖
No	2628 (96.0)	48 (87.3)	
Number of UE fractures at presentation, n (%)†			
1	2638 (96.4)	54 (98.2)	1.000
2	94 (3.4)	1 (1.8)	
> 2	6 (0.2)	0 (0.0)	
Initial fracture playing football, n (%)†			
Yes	126 (4.6)	4 (7.4)	0.319
No	2590 (95.4)	50 (92.6)	
Initial fracture playing volleyball, n (%)†			
Yes	19 (0.7)	2 (3.7)	0.062
No	2697 (99.3)	52 (96.3)	
Initial fracture playing basketball, n (%)†			
Yes	50 (1.8)	0 (0.0)	0.625
No	2666 (98.2)	54 (100.0)	
Initial fracture on trampoline, n (%)†			
Yes	102 (3.8)	0 (0.0)	0.265
No	2614 (96.2)	54 (100.0)	

*Student *t* test.
†χ^2 test (Fisher exact if any expected frequency <5).
‡Wilcoxon rank-sum test.
§Noncompliance with recommended care included a damaged cast; premature removal of cast or stopped wearing splint or sling; ignoring activity restriction; not completing recommended rehabilitation or physical therapy; long period or delayed presentation.
‖Statistically significant ($P < 0.05$).
IQR indicates interquartile range; UE, upper extremity.

TABLE 3. Fracture-level Predictors of Upper Extremity Refracture

Predictor Variable	No Refracture	Refracture	P
Treatment modality, n (%)*			
Cast or splint only	2192 (98.3)	38 (1.7)	0.312
Closed reduction	420 (97.0)	13 (3.0)	
Closed reduction percutaneous pinning	171 (98.3)	3 (1.7)	
Open reduction	64 (98.5)	1 (1.5)	
Days immobilized, (median, IQR)†	32 (27-41)	36 (30-48)	0.005¶
Immobilized <6 wk			
Yes	2069 (98.4)	33 (1.6)	0.037¶
No	778 (97.3)	22 (2.8)	
Original Fracture: bone, n (%)*			
Radius only	966 (97.4)	26 (2.6)	0.007¶
Radius and ulna	816 (97.5)	21 (2.5)	
Ulna only	125 (99.2)	1 (0.8)	
Clavicle	157 (98.1)	3 (1.9)	
Humerus	775 (99.5)	4 (0.5)	
Metacarpal	8 (100.0)	0 (0.0)	
Original fracture: location, n (%)*			
Clavicle‡			
Midshaft	99 (97.1)	3 (2.9)	1.000
Proximal or distal	30 (100.0)	0 (0.0)	
Humerus			
Supracondylar	505 (99.2)	4 (0.8)	0.304
Not supracondylar	270 (100.0)	0 (0.0)	
Radius and ulna, radius, or ulna§			
Midshaft	154 (92.2)	13 (7.8)	< 0.001¶
Any other location	1650 (98.0)	34 (2.0)	
Original fracture: characteristics, n (%)*‖			
Displaced	608 (98.2)	11 (1.8)	0.808
Angulated	615 (96.7)	21 (3.3)	0.003¶
Buckle or torus	542 (97.0)	17 (3.0)	0.027¶
Oblique	56 (98.3)	1 (1.7)	1.000
Spiral	4 (100.0)	0 (0.0)	1.000
Greenstick	62 (96.9)	2 (3.1)	0.344
Longitudinal	4 (100.0)	0 (0.0)	1.000
Transverse	374 (99.2)	3 (0.8)	0.093
Comminuted	39 (100.0)	0 (0.0)	1.000
Impacted	47 (95.9)	2 (4.1)	0.237
Open	5 (83.3)	1 (16.7)	0.109
Plastic Deformation	8 (100.0)	0 (0.0)	1.000

*χ^2 test (Fisher exact if any expected frequency <5).
†Wilcoxon rank-sum test.
‡Clavicle fracture location was missing for 28 observations (none of those with refracture).
§Forearm fracture location was missing for 104 observations (1 of those with refracture). "Any other location" included proximal, distal, metaphyseal, or physeal.
‖A single fracture may have > 1 characteristic.
¶Statistically significant ($P < 0.05$).
IQR indicates interquartile range.

Interestingly, the median number of days of immobilization was significantly higher among those with a refracture (36 vs. 32 d), and those immobilized for < 6 weeks were significantly less likely to experience refracture ($P = 0.037$) (Table 3).

The most common mechanisms of refracture were falls (80%), with most falls occurring from ground-level activities such as walking, running, or playing (Table 4). Wheeled devices, skis, or trampolines were involved in almost one quarter of all refractures caused by a fall. About 15% of refractures involved a fall from < 1 story, including several from monkey bars or playground equipment. Roughly one quarter of refracture occurred while engaged in sports, with most being recreational or during physical education classes, although no specific sport was significantly associated with refracture (Table 4).

On the basis of the multivariable analysis for all fracture types, patients who had documented noncompliance with recommended care were 4 times more likely to refracture (odds ratio 4.2, 95% CI 1.8-9.6), when controlling for insurance type and days to initial treatment (Table 5). No single type of noncompliance with recommendations was clearly associated with refracture, although our sample size was too small to really analyze

FIGURE 3. A, Elbow fracture. B, At 6.5 weeks postinjury. C, Refracture 10 months after initial injury.

TABLE 4. Refracture Characteristics

Characteristics	
Total number	55
Days to first refracture, median (IQR)	188 (103-405)
Mechanism of first refracture injury, n (% of total)	
Fall	
Yes	44 (80.0)
Groundlevel*	23 (41.8)
From height (< 1 story)	8 (14.6)
Potentially higher energy mechanism†	13 (23.6)
No	11 (20.0)
Sports-related	
Yes	13 (23.6)
Recreational or physical education‡	8 (14.6)
Organized, competitive sports§	5 (9.1)
No	42 (76.4)

*Included walking, playing, or running.

†Included wheeled devices (skateboards (4), skates (2), scooters (2), rip sticks (2), bicycles not involving motor vehicle collision (1)), skiing (1), and trampolines (2).

‡Included PE class (2), dance class (1), recreational skiing (1), roller hockey (1), and playing ball sports with friends (1 football, 1 soccer, 1 dodgeball).

§Included volleyball (1), football (2), and soccer (2).

IQR indicates interquartile range.

this level of detail. There were a variety of noncompliance issues noted among those who had refractures and those who did not. Forearm fractures were almost 4 times more likely to refracture compared with other upper extremity bones (odds ratio 3.6, 95% CI 1.4-9.5), when controlling for midshaft location, days immobilized, and buckle or torus characterization of the fracture (Table 5).

DISCUSSION

This study examines refracture risk in detail among a large cohort that should be well representative of a major urban area. During the timeframe of the study, the cohort was drawn from the only dedicated pediatric orthopaedics practice and the only dedicated children's hospital in our metropolitan area. The findings in large part agree with previous studies of refractures in children; the incidence of 2% is on the low side of the range reported elsewhere, with midshaft fractures of the forearm and buckle/torus fractures the most prone to refracture. A very small fraction of patients with a refracture were seen for a second refracture within 2 years. One such case involved a displaced supracondylar fracture of the humerus, and the mechanism

TABLE 5. Adjusted Odds of Upper Extremity Refracture Within 2 Years From Original Fracture

Variable	Odds Ratio (95% CI)	P
Multivariable logistic regression with patient-level characteristics (n = 2778)†		
Noncompliance		
Yes	4.2 (1.8-9.6)	0.001*
No	1 (reference)	
Days to first treatment	1.0 (0.9-1.0)	0.391
Insurance type		
Publicly insured or uninsured	0.8 (0.4-1.4)	0.381
Privately insured	1 (reference)	
Multivariable logistic regression with fracture-level characteristics (n = 2616)‡		
Bone		
Forearm (radius, ulna, or both)	3.6 (1.4-9.5)	0.010*
Humerus, clavicle or metacarpal	1 (reference)	
Location		
Midshaft	4.5 (2.2-9.3)	< 0.001*
Any other location	1 (reference)	
Buckle/torus fracture		
Yes	2.2 (1.1-4.2)	0.024*
No	1 (reference)	
Days in cast	1.01 (0.99-1.03)	0.484

*Statistically significant ($P < 0.05$).

†Total number of patients = 2793. Missing covariates handled using list-wise deletion.

‡Total number of fractures = 2902. Missing covariates handled using list-wise deletion.

CI indicates confidence interval.

was a fall for both refracture incidents. Two other cases involved repeated distal radius refractures, and the mechanisms were again falls (1 on a trampoline, 2 during recreational sports, and 1 unspecified).

Although the median time from initial fracture to refracture was about 6 months, we observed a small second wave of late refractures at > 600 days (> 20 mo). Many studies of this kind have only included 18 months of follow-up, so this is an interesting finding. These "late" refractures included 1 clavicle, 1 distal humerus, and 6 forearm fractures. Each of these late refractures involved a potentially higher energy mechanism, such as a wheeled device, stairs, monkey bars, running, or sports, rather than a simple fall. It should be noted that because this was a retrospective study, cases were not actively followed for a full 2 years, rather the medical records were reviewed out to 2 years after the initial fracture. Refractures seen at another practice could have been missed.

In this cohort, shorter duration of immobilization of the original fracture was not associated with the higher risk of refracture as some studies have indicated. A recent systematic review found 1 other study of nonsurgically treated diaphyseal forearm fractures where cast time was significantly longer among refractures than nonrefractures by 1 week ($P = 0.04$).[8] The findings in our cohort are similar. Assuming immobilization was maintained for a minimum of 4 to 6 weeks, this finding is not surprising. It is possible that in our cohort, immobilization was maintained longer at the clinician's discretion when the fracture was more complex, showed evidence of slower healing, or had some other factor resulting in the clinician's decision to leave the fracture casted longer. We would expect such cases to carry a higher risk of refracture, so it is not possible to infer a causal relationship between immobilization duration and refracture. In our population, cast time was longer for displaced and angulated fractures, and shorter for buckle fractures, fitting with this idea that fracture characteristics likely contribute to the higher risk of refracture among patients with the longer cast times. In terms of the refracture risk for buckle fractures, we hypothesize that patients who experience a fall onto an outstretched hand may be more likely to do so more than once, so the risk may be more mechanistic than related to bone healing or other factors. Other studies have found a significantly higher risk of refracture for greenstick fractures. We had a relatively small number of fractures characterized as greenstick, which may have limited our statistical power to detect a difference. In contrast, our study cohort had a larger number of buckle/torus fractures. Both greenstick and buckle fractures involve the cortex and periosteum on one side of the bone (incomplete fractures), so they may share some commonalities in refracture risk. A larger study might be able to explore this question further.

Some limitations of this study include the retrospective nature and reliance on review of medical records, which may be incomplete. Misclassification bias may have occurred during medical records review, however, any questions about how to categorize a fracture were resolved through review by the study's lead orthopaedic surgeon. The retrospective nature of the study may have affected some variables more than others, for example, the location of fracture was reliably documented in every case but some of the follow-up variables like compliance with wearing a splint or brace may not have been as consistently asked or documented in the record. Although the study population should be reasonably representative of the local population, some patients may have been seen at other orthopaedic practices, especially older children who may be less likely to see a pediatric specialist. Because this was a single-center study, the results may have limited generalizability. Treatment recommendations within the practice studied may differ from those in other practices, and patient activities may also differ in other areas. Another limitation is the older timeframe of this study (2010 to 2011), although we expect the findings are still applicable to today's patient population. Several questions remain, such as the role of angulation of humeral fractures, the optimal length of time before return to sports, and the optimal length of time for immobilization, including use of functional bracing after cast removal. We did find a significant association between subjective angulation of upper extremity fractures and risk of refracture. However, we did not collect data on measured degrees of angulation, and the number of refractures of the humerus was too low to assess the effect of angulation. Therefore, conclusions about this factor are limited.

A recent retrospective study found extended bracing after cast removal (for > 8 weeks past the date of injury) did not significantly reduce the risk of refracture in diaphyseal radius and ulna fractures over a 2-year period of follow-up.[6] However, given the findings of our study related to common mechanisms for refracture, it may be worthwhile to further explore the use of a brace during the higher-risk activities, especially until the main window of refracture risk has passed.

In conclusion, our study showed a median time to refracture for upper extremity fractures of ~6 months, and our practice saw a refracture occurrence in 2% of patients. Factors most strongly associated with refracture were midshaft fracture location, forearm fracture as opposed to clavicle or humerus, and noncompliance as we defined it. We recommend cautioning patients and their parents of the possibility of refracture of upper extremities, paying specific attention to those with midshaft fractures. We also consider this an area worthy of continuing study at additional sites or with prospective methods, with the goal of informing injury prevention efforts. Future studies may be most fruitful if focused on prevention or mitigation of reinjury from falls, rather than on involvement with specific sports that did not seem to be significantly associated with refracture among our study population.

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