Medical Journal of Bakırköy

Med J Bakirkoy 2025;21:14-18
DOI: 10.4274/BMJ.galenos.2024.2024.8-6

Research

Frequencies and Lines of Pediatric Distal Humerus Fractures: Where and How are the Fractures?

Pediatrik Distal Humerus Kırıklarının Sıklığı ve Çizgileri: Kırıklar Nerede ve Nasıldır?

Malik Çelik[1], Ahmet Çanlıoğlu[2], Murat Tıngır[3], Vedat Öztürk[1], Cemal Kural[1]

[1]University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital, Clinic of Orthopaedics and Traumatology, İstanbul, Türkiye

[2]University of Health Sciences Türkiye, Kartal Dr. Lütfi Kırdar Training and Research Hospital, Clinic of Orthopaedics and Traumatology, İstanbul, Türkiye

[3]State Hospital, Clinic of Orthopedics and Traumatology, Trabzon, Türkiye

ABSTRACT

Objective: The type, lines, and location of the fracture play an important role in the complications and clinical course of distal humerus fractures in children. This study aims to demonstrate the fracture lines of pediatric distal humerus fractures on a 2D model, determine where the fractures are concentrated, and investigate the relationship between these findings and age range.

Methods: A total of 194 pediatric distal humerus fractures were retrospectively reviewed and analyzed. For each fracture, a map of the fracture lines was drawn and graphically overlaid on the 2D model (anterior, lateral) with this method, fracture lines were determined according to age ranges. Fracture models and density maps were created.

Results: Our analysis was based on 194 X-ray images of pediatric distal humerus fractures, including 131 male and 63 female patients. It included 14 epiphyses, 83 physes and 97 metaphyses fractures. In the mapping, it was seen that the fracture lines between the ages of 2-6 were mostly concentrated on the physis. In addition, it was mostly seen in the metaphysis in patients aged 6-12 years.

Conclusion: Pediatric distal humeral fracture lines follow characteristic patterns that are closely related to bone structure and age. Understanding the characteristics of these fractures can assist surgeons during diagnosis, preoperative planning, and implementation of surgical strategies.

Keywords: Pediatric, elbow, distal humerus, fracture frequency, fracture lines

ÖZ

Amaç: Çocuklarda distal humerus kırıklarının komplikasyonları ve klinik seyrinde kırığın tipi, hatları ve yeri önemli rol oynar. Bu çalışmanın amacı, pediatrik distal humerus kırıklarının kırık hatlarını 2 boyutlu bir modelde göstermek, kırıkların nerede yoğunlaştığını belirlemek ve bu bulgular ile yaş aralığı arasındaki ilişkiyi araştırmaktır.

Gereç ve Yöntem: Toplam 194 pediatrik distal humerus kırığı retrospektif olarak incelendi ve analiz edildi. Her kırık için, kırık hatlarının haritası 2 boyutlu modele (ön, yan) çizildi ve grafiksel olarak üst üste bindirildi. Bu yöntemle, kırık hatları yaş aralıklarına göre belirlendi. Kırık modelleri ve yoğunluk haritaları oluşturuldu.

Bulgular: Analizimiz, 131 erkek ve 63 kadın hastayı içeren 194 pediatrik distal humerus kırığı röntgen görüntüsüne dayanmaktadır. On dört epifiz, 83 fiziz ve 97 metafiz kırığı içeriyordu. Haritalamada, 2-6 yaş arasındaki kırık hatlarının çoğunlukla fizizde yoğunlaştığı görüldü. Ayrıca, 6-12 yaş aralığındaki hastalarda çoğunlukla metafizde görüldü.

Sonuç: Pediatrik distal humerus kırık hatları, kemik yapısı ve yaşla yakından ilişkili karakteristik desenleri takip eder. Bu kırıkların özelliklerini anlamak, cerrahlara tanı, ameliyat öncesi planlama ve cerrahi stratejilerin uygulanması sırasında yardımcı olabilir.

Anahtar Kelimeler: Pediatrik, dirsek, distal humerus, kırık sıklığı, kırık hatları

Address for Correspondence: Malik Çelik, University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital, Clinic of Orthopaedics and Traumatology, İstanbul, Türkiye
E-mail: drmalikcelik@hotmail.com **ORCID ID:** orcid.org/0000-0002-3696-9644

Cite as: Çelik M, Çanlıoğlu A, Tıngır M, Öztürk V, Kural C. Frequencies and lines of pediatric distal humerus fractures: where and how are the fractures? Med J Bakirkoy. 2025;21:14-18

Received: 22.08.2024
Accepted: 04.10.2024
Publication Date: 25.03.2025

INTRODUCTION

Distal humerus fractures are a significant concern among pediatric orthopaedic injuries, accounting for approximately 60% of all elbow fractures. These fractures occur at the distal end of the humerus, just above the elbow joint, and are often encountered in children due to their active lifestyles and vulnerability to traumatic incidents (1). It is essential for healthcare providers to comprehend the epidemiology, clinical presentation, classification, and management of distal humerus fractures, as these fractures can significantly impact a child's functional recovery and limb development (2-4).

Distal humerus fractures in children can vary in severity from mild to moderate to severe and can be managed through a range of treatment options, including non-surgical methods such as casting and surgical procedures such as closed reduction or open reduction (5). The choice of treatment depends on various factors, including the fracture type, degree of displacement, age of the patients, and associated neurovascular compromise. These fractures demand specialized care, as complications such as neurovascular injury and malunion can have lasting effects on a child's quality of life (6,7).

The advancement of medical imaging software has led to the popularization of "fracture mapping", a novel technique used to describe the distribution of fracture lines. Fracture mapping can record the size, shape, number, and orientation of fracture fragments, and help surgeons determine the most appropriate treatment (8). In the literature, many different anatomical regions in adult patients, such as patella fracture (9), tibia plateau fracture (10), femur intertrochanteric fracture (11), and distal humerus fracture (12), have been investigated based on Tri-dimensional (3D) images, and the results have been published. These studies have shown that fracture mapping can provide valuable information for preoperative planning and postoperative evaluation, ultimately improving patient outcomes. Additionally, the use of 3D imaging in fracture mapping has the potential to revolutionize the field of orthopaedic surgery by allowing for more precise and personalized treatment strategies (10). However, concerns about created using tomography (CT) imaging in pediatric patients have led to a paucity of similar studies for the pediatric population.

The study aimed to map the most common fracture lines and locations using X-ray (2D) imaging. We hypothesized that we would find differences in fracture pattern and location as the physis closes and bone maturity occurs in different age ranges.

METHODS

Study design

After approval from the local ethics committee, the study was conducted retrospectively. Patients admitted to our tertiary hospital with elbow fractures between October 1, 2019, and October 1, 2023, were evaluated. The inclusion criteria were as follows: (1) distal humeral fractures; (2) under 18 years of age; (3) patients who were followed up in our hospital for at least 6 months. The exclusion criteria were as follows: • >18 years; • complex fracture (with radius, ulna, dislocation); • insufficient medical record (Figure 1). The patients were divided into four groups according to age: Ages 0-2, ages 2-6, ages 6-12, and ages 12-18 (13). The etiology of the patients' injuries, whether surgery was performed, and the presence of post-fracture complications were noted. The distal humerus was anatomically noted as having three regions: Metaphysis, physis, and epiphysis.

Distal Humerus Templates

2D images were imported into Adobe Illustrator (Adobe Inc., Mountain View, CA, USA) and used as the fracture mapping templates.

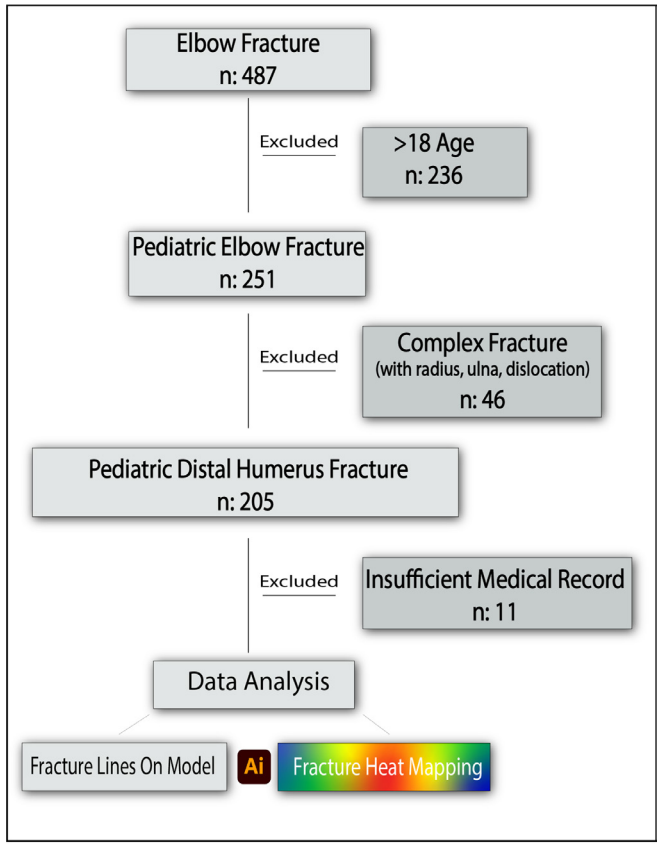

Figure 1. Study flowchart

Fracture Lines Heat Map

The original Digital Imaging and Communications in Medicine files were collected and analyzed with Synapse Vincente (Fujifilm Co., Ltd., Tokyo, Japan). The fracture lines were clearly observed. These reductive fracture models were then modified to generate 2D images that were presented in the same anatomical plane as the templates. In Adobe Illustrator, the fracture lines were manually drawn onto the template layer and then graphically overlapped to compile a fracture map. The superimposition of all layers resulted in maps showing density variations in correlation with the frequency and location of fractures.

Statistical Analysis

The IBM SPSS 26 (Chicago, IL, USA) program was used for statistical analysis. Descriptive statistical methods (minimum, maximum, median) were used when evaluating the study data. The chi-square test was used in the analysis of qualitative independent data. Statistical significance was accepted as $p<0.05$.

RESULTS

The patients' demographic features are presented in Table 1. Among the 194 X-ray images, there are 131 male and 63 female patients, including 32 (16.5%) aged 0-2; 100 (51.5%) aged 2-6; 53 (27.3%) aged 6-12; and 9 (4.6%) aged 12-18 (Figure 2). According to the fracture area, the epiphysis 14 (7.2%), the physis 83 (42.8%), and the metaphysis 97 (50%) (Figure 3).

Table 1. Demographic features of the patients

		Frequency (n)	Percent (%)
Age range	0-2 year	32	16.5
	2-6 year	100	51.5
	6-12 year	53	27.3
	12-18 year	9	4.6
Gender	Male	131	67.5
	Female	63	32.5
Etiology	Low energy	177	91.2
	High energy	17	8.8
Surgery	(+)	168	86.6
	(-)	26	13.4
Complication	(+)	180	92.8
	(-)	14	7.2
Fracture location	Epiphysis	14	7.2
	Physis	83	42.8
	Metaphysis	97	50.0

The descriptive features of pediatric distal humerus fracture patients in age groups are presented in Table 2. The etiology of fracture and complication rates did not differ significantly between groups ($p>0.05$). However, low-energy falls and fractures without complications were more common in both groups. A statistical difference was detected between age groups and fracture regions. Fracture lines were seen more frequently in the physis in the "0-2 age" group and in the metaphysis in the "6-12 age" group ($p<0.05$).

DISCUSSION

The histological structure of the bone, which changes with age, the anatomy of the distal humerus, and the activity levels of children at different ages make these fractures

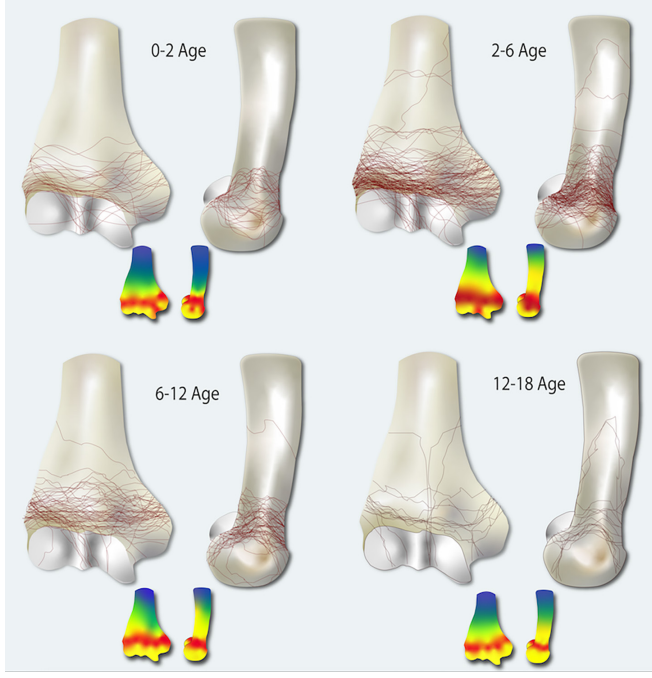

Figure 2. Fracture lines and heat map of pediatric supracondylar fracture by age range

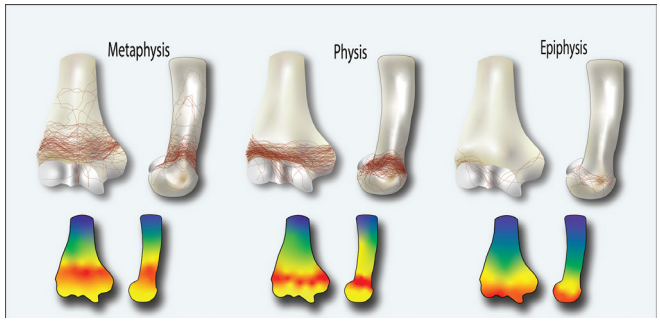

Figure 3. Fracture lines and heat map of pediatric supracondylar fracture by fracture region

Table 2. Relationship between age range and demographic features

		Age (year)				p[c]
		0-2	2-6	6-12	12-18	
Gender	Male	13	68	41	9	0.001
	Female	19	32	12	0	
Surgery	(+)	20	90	50	8	0.001
	(-)	12	10	3	1	
Etiology	Low energy	32	91	47	7	0.233
	High energy	0	9	6	2	
Complication	(-)	32	90	49	9	0.226
	(+)	0	10	4	0	
Fracture region	Epiphysis	7	5	2	0	0.001
	Physis	24	49	7	3	
	Metaphysis	1	46	44	6	

[c]Chi-square test

inevitable. I continues to be a challenge for families and healthcare professionals. This study is valuable because it investigates the fracture lines, their localization, and their relationship with age in pediatric patients presenting with a diagnosis of distal humerus fracture. The most important finding of our study was that physeal fractures were more common in younger age groups, and metaphyseal fractures were more common in older age groups.

Omid et al. (14) and Cheng et al. (2) found that pediatric distal humerus fractures are commonly observed in school-age children. This age group had a higher fracture rate in our study, which is consistent with previously published studies. An elevated risk of fracture is a well-known result of high activity levels, less parental control, and an active role in public play events. All of this can increase as children reach school age (15). Distractions that occur during play, along with the experimentation accompanying the learning of new informational skills, may also contribute to an increased risk of fractures. So, we believe that the pattern of increased injury frequency and severity that we observed between ages 2-6 and 6-12 could be related to social development at school age. On the other hand, although some current publications in the literature (16,17) suggest that the number of patients is the same for both genders, in our study we observed that distal humerus fractures are more common in males, in line with traditional knowledge.

The distal humerus includes several ossification processes that develop at various ages. The fracture structure changes when the ossification centres transition from cartilage to bone. Knowing the general ossification sequence gives the surgeon important information that helps characterize the anatomy on radiographs and guide treatment (18). At one year of age, the capitellum initially appears. Around ages 4-5, the medial epicondyle starts to ossify; this is followed by the trochlea's epiphysis around ages 8 or 9. Around age 10, the lateral condyle often develops last (19,20). The varying ages at which ossification occurs also explain the frequency of distal humerus fractures at different ages.

With the development of artificial intelligence, technological innovations, and medical imaging software, intelligent medicine has become popular as a research topic in orthopaedic literature (21,22). Large amounts of data can be collected from models CT, X-ray, and magnetic resonance images of patients, and more objective data can be obtained about the anatomical region. Due to the increasing interest in big data analysis to serve orthopaedic diagnosis, implant design, preoperative preparation, patient/medical education and treatment using CT images, Armitage et al. (8) examined scapula fractures and Cole et al. (23) examined pilon fractures. Over the years, many anatomical regions, such as the proximal femur (11), tibial plateau (10), distal radius (24), and calcaneus (25), have been examined with this hypothesis, and the results have been published. In their study investigating adult distal humerus fractures, Wang et al. (12) published the fracture lines and density map. However, they did not provide data regarding pediatric patients. High radiation is one of the biggest obstacles to performing tomography on pediatric patients. Therefore, we only have X-ray images as data. Using two-dimensional mapping technology, we characterized the fracture lines and location characteristics of pediatric distal humerus fractures in our study.

Study Limitations

It should be noted that there are certain limitations to this study. First, this study's sample size is small. Secondly, since patients referred to our tertiary hospital were included in the study, we found that there was a discrepancy between the surgical rate and the literature. Thirdly, since only AP and lateral X-ray imaging were evaluated in the study, the three-dimensional fracture line could not be evaluated. In addition, drawing the fracture line manually may have caused subjective results. Finally, there hasn't been any analysis done on the injury mechanism of pediatric distal humeral fractures and how it relates to fracture maps. Further studies could increase the sample size and investigate the difference. However, our study also had important aspects. To our knowledge, our study is the first to examine the fracture mapping method in pediatric distal humerus fractures.

CONCLUSION

In conclusion, pediatric distal humerus fractures are common and cause serious disabilities when inadequately treated. This continues to be a challenge for treatment practitioners. Fracture mapping offers numerous advantages, including precision in assessment, optimized treatment planning, improved surgical guidance, complication prediction, long-term monitoring, research potential, and enhanced patient education.

ETHICS

Ethics Committee Approval: This study was approved by the Clinical Research Ethics Committee of the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital, (decision no: 2022-20-04, date: 17.10.2022).

Informed Consent: Since this study was retrospective, patient consent was not required.

FOOTNOTES

Authorship Contributions

Surgical and Medical Practices: M.Ç., V.Ö., C.K., Concept: M.Ç., Design: M.Ç., V.Ö., C.K., Data Collection or Processing: M.Ç., A.Ç., M.T., Analysis or Interpretation: M.Ç., A.Ç., M.T., C.K., Literature Search: M.Ç., A.Ç., M.T., V.Ö., Writing: M.Ç., V.Ö.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Otsuka NY, Kasser JR. Supracondylar fractures of the humerus in children. J Am Acad Orthop Surg. 1997;5:19-26.
2. Cheng JC, Lam TP, Maffulli N. Epidemiological features of supracondylar fractures of the humerus in Chinese children. J Pediatr Orthop B. 2001;10:63-7.
3. Schuller A, Hahn S, Pichler L, Hohensteiner A, Sator T, Jaindl M, et al. Correlation of fall height, fracture severity and clinical outcome in pediatric supracondylar fractures-a retrospective analysis with an observation period of 20 years. Children. 2023;10:510.
4. Çelik M, Kantarci M, Sapmaz İ.E, Baca E, Duramaz A. Characterization and mapping of upper extremity fractures in children by a tertiary hospital quarantine and post-quarantine period. Jt Dis Relat Surg. 2024;35:692-8.
5. Vaquero-Picado A, Gonzalez-Moran G, Moraleda L. Management of supracondylar fractures of the humerus in children. EFORT Open Rev. 2018;3:526-40.
6. White L, Mehlman CT, Crawford AH. Perfused, pulseless, and puzzling: a systematic review of vascular injuries in pediatric supracondylar humerus fractures and results of a POSNA questionnaire. J Pediatr Orthop. 2010;30:328-35.
7. Wu J, Perron AD, Miller MD, Powell SM, Brady WJ. Orthopedic pitfalls in the ED: pediatric supracondylar humerus fractures. Am J Emerg Med. 2002;20:544-50.
8. Armitage BM, Wijdicks CA, Tarkin IS, Schroder LK, Marek DJ, Zlowodzki M, et al. Mapping of scapular fractures with three-dimensional computed tomography. J Bone Joint Surg Am. 2009;91:2222-8.
9. Cho JW, Yang Z, Lim EJ, Sakong S, Choi W, Son WS, et al. Multifragmentary patellar fracture has a distinct fracture pattern which makes coronal split, inferior pole, or satellite fragments. Sci Rep. 2021;11:22836.
10. Molenaars RJ, Mellema JJ, Doornberg JN, Kloen P. Tibial plateau fracture characteristics: computed tomography mapping of lateral, medial, and bicondylar fractures. J Bone Joint Surg Am. 2015;97:1512-20.
11. Li M, Li ZR, Li JT, Lei MX, Su XY, Wang GQ, et al. Three-dimensional mapping of intertrochanteric fracture lines. Chin Med J (Engl). 2019;132:2524-33.
12. Wang C, Zhu Y, Long H, Lin Z, Zhao R, Sun B, et al. Three-dimensional mapping of distal humerus fracture. J Orthop Surg Res. 2021;16:545.
13. Williams K, Thomson D, Seto I, Contopoulos-Ioannidis DG, Ioannidis JP, Curtis S, et al. Standard 6: age groups for pediatric trials. Pediatrics. 2012;129(Suppl 3):153-60.
14. Omid R, Choi PD, Skaggs DL. Supracondylar humeral fractures in children. J Bone Joint Surg Am. 2008;90:1121-32.
15. Petridou E, Sibert J, Dedoukou X, Skalkidis I, Trichopoulos D. Injuries in public and private playgrounds: the relative contribution of structural, equipment and human factors. Acta Paediatr. 2002;91:691-7.
16. Farnsworth CL, Silva PD, Mubarak SJ. Etiology of supracondylar humerus fractures. J Pediatr Orthop. 1998;18:38-42.
17. Mitchelson AJ, Illingworth KD, Robinson BS, Elnimeiry KA, Wilson CJ, Markwell SJ, et al. Patient demographics and risk factors in pediatric distal humeral supracondylar fractures. Orthopedics. 2013;36:700-6.
18. Yigitbay A, Celik M. A rare case: transphyseal distal humerus fracture in a newborn. Acta Chir Orthop Traumatol Cech. 2024;9:120-2.
19. Gartland JJ. Management of supracondylar fractures of the humerus in children. Surg Gynecol Obstet. 1959;109:145-54.
20. Skaggs DL. Elbow fractures in children: diagnosis and management. J Am Acad Orthop Surg. 1997;5:303-12.
21. Bini SA. Artificial intelligence, machine learning, deep learning, and cognitive computing: what do these terms mean and how will they impact health care? J Arthroplasty. 2018;33:2358-61.
22. Langerhuizen DWG, Janssen SJ, Mallee WH, van den Bekerom MPJ, Ring D, Kerkhoffs G, et al. What are the applications and limitations of artificial intelligence for fracture detection and classification in orthopaedic trauma imaging? A systematic review. Clin Orthop Relat Res. 2019;477:2482-91.
23. Cole PA, Mehrle RK, Bhandari M, Zlowodzki M. The pilon map: fracture lines and comminution zones in OTA/AO type 43C3 pilon fractures. J Orthop Trauma. 2013;27:152-6.
24. Li S, Zhang YQ, Wang GH, Li K, Wang J, Ni M. Melone's concept revisited in comminuted distal radius fractures: the three-dimensional CT mapping. J Orthop Surg Res. 2020;15:222.
25. Zhang B, Lu H, Quan Y, Wang Y, Xu H. Fracture mapping of intra-articular calcaneal fractures. Int Orthop. 2023;47:241-9.