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Original Article

Evaluation and management of clavicle fractures in the juvenile population: a retrospective analysis of 456 patients

Mustafa İştahlı [1*]

[1]Department of Orthopedics and Traumatology, University of Health Sciences Kayseri City Training and Research Hospital, 38080, Kayseri, Turkey

[*]**Corresponding author:** Mustafa İştahlı, MD, Department of Orthopedics and Traumatology, University of Health Sciences Kayseri City Training and Research Hospital, 38080, Kayseri, Turkey; mustafaistahli@gmail.com

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Abstract

Background: Pediatric clavicle fractures in the juvenile population are common injuries that typically heal successfully with nonoperative treatment. Despite this favorable natural history, many centers continue to schedule routine outpatient follow-up visits and obtain repeated radiographs after the initial orthopedic consultation, although the true clinical value of these practices remains uncertain. **Methods:** We retrospectively reviewed 456 children aged 3–10 years who presented with clavicle fractures. Fracture location, displacement pattern, periosteal integrity, treatment modality, union status, and radiographic remodeling were recorded, along with demographic variables. The primary outcome measure was any change in clinical management following the initial orthopedic consultation. Patients with polytrauma, pathologic fractures, or those lost to follow-up were excluded; the analysis focused on isolated clavicle fractures in this age group. **Results:** The majority of fractures were located at the midshaft (93.0%). Nonoperative management predominated: Velpeau bandages were used in 63.2% of patients and figure-of-eight bandages in 36.4%. Surgical treatment was required in only two patients (0.4%), both due to an increased risk of skin compromise. Complete fracture union was observed in 453 of 456 patients (99.3%); two refractures subsequently achieved union, and one case demonstrated radiographic findings consistent with clavicular pseudoarthrosis. In asymptomatic patients, follow-up visits and repeat radiographs did not lead to any change in management, and no neurovascular complications were identified. **Conclusions:** In juvenile patients with isolated and uncomplicated clavicle fractures—including completely displaced patterns—routine clinical follow-up and serial radiographic evaluations after the initial assessment may be unnecessary. A selective follow-up strategy based on clinical findings could reduce radiation exposure and healthcare utilization without compromising patient outcomes.

Keywords: Clavicle fractures, conservative treatment, juvenile, preschool child, pseudoarthrosis, malunion

Introduction

Clavicle fractures are among the most common bone injuries in the pediatric population, accounting for approximately 15% of all pediatric fractures [1,2]. Approximately 95% of these injuries involve the middle third of the clavicle [2,3]. Conservative treatment using a sling or figure-of-eight bandage typically yields excellent outcomes [2,3]. This study investigates the necessity of routine outpatient follow-up and repeated radiographs following the initial orthopedic evaluation of isolated clavicle fractures in the juvenile age group. Previous research involving children aged 14 and under reported no instances of nonunion or refracture [3]. This suggests that complication rates in pediatric clavicle fractures are exceptionally low, implying that serial follow-up may not be necessary until clinical healing is achieved [3].

In uncomplicated pediatric fractures that do not require long-term monitoring, less experienced physicians often opt for frequent clinical and radiographic follow-ups [2]. This management

preference increases hospital visits, leading to unnecessary time loss and costs for both the healthcare system and parents, while subjecting pediatric patients to extra ionizing radiation [4]. It has been suggested that skeletally immature patients with uncomplicated clavicle fractures may be discharged from follow-up after the initial orthopedic evaluation [2]. These injuries occur through various mechanisms: simple falls on the shoulder (30%), traffic accidents (25%), sports injuries (25%), and other causes (20%) [5]. In males, fractures are most prevalent during the first two decades of life, whereas in later life, the distribution is nearly equal between genders [6]. Fractures of the middle third of the shaft account for 75%, the lateral third for 20%, and the medial third for less than 5% [7]. Various classification systems exist for clavicle fractures, including Allman, Neer, Craig, Nordqvist and Petersson, Robinson (Edinburgh), and AO/OTA; the Allman system specifically categorizes them into lateral, middle, and medial segments [8].

We aimed to evaluate the necessity of surgery, conservative treatment modalities, and outpatient follow-up requirements in juvenile clavicle fractures. Our goal is to propose a strategy to prevent unnecessary radiation exposure and socioeconomic burdens if no surgical indications—such as skin compromise, open fracture, neurovascular injury, or medial physeal injury—are present during the initial assessment. The hypothesis of this study is that routine outpatient check-ups and serial radiographs following the initial orthopedic evaluation are unnecessary in most juvenile clavicle fractures lacking signs of complications.

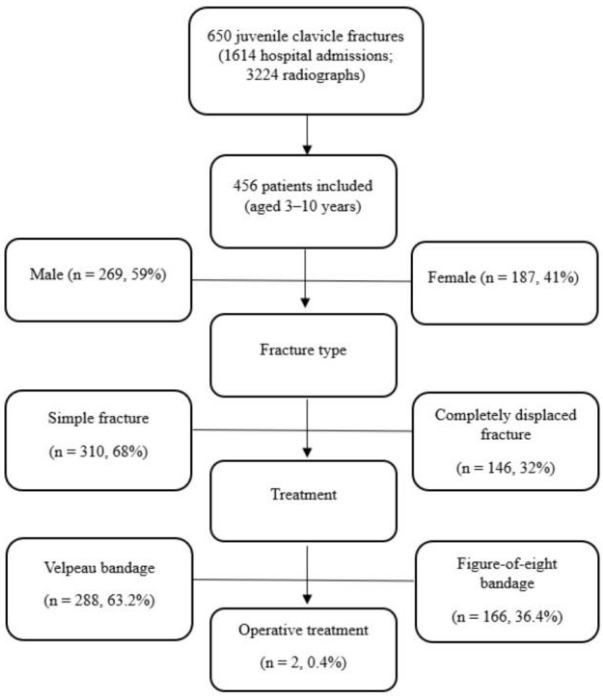

Figure 1. Flowchart illustrating patient inclusion, fracture type distribution, and treatment modalities in juvenile clavicle fractures (ages 3–10 years).

Materials and methods

Study Design and Population

Clinical records and radiographs of pediatric patients aged 3–10 years who presented to the Orthopedics and Traumatology and Emergency Departments with clavicle fractures between January 2017 and December 2024 were retrospectively reviewed. The age range of 3–10 years was specifically selected to represent the juvenile subgroup, characterized by high skeletal immaturity and significant remodeling potential, prior to the biological and biomechanical changes of early adolescence. Children younger than 3 years were excluded due to inconsistent radiographic follow-up and challenges in clinical assessment, while those older than 10 years were excluded to avoid the transitional adolescent period, where fracture behavior and treatment protocols differ.

The study included juvenile patients with isolated clavicle fractures and documented follow-up until remodeling was observed. Exclusion criteria were polytrauma, pathologic fractures, and patients lost to follow-up. Complicated fractures were defined as those associated with neurovascular injury, open fractures, or those presenting a risk of skin tenting or perforation. While complicated cases were identified, the primary analysis focused on isolated fractures.

Data Collection and Radiographic Assessment

Patient data, including age, gender, affected side, treatment modality, and the number of hospital visits, were recorded. Radiographic parameters—fracture localization (medial, middle, lateral), displacement pattern (greenstick or complete), angulation, and periosteal integrity—were evaluated. Fracture localization followed the principles of the Allman classification. Angulation was measured on anteroposterior (AP) radiographs using the intersection angle of cortical lines, performed by a single physician to ensure consistency. Temporal variables, such as healing time, follow-up duration, and time to remodeling, were also documented via the hospital information system.

Statistical analysis

Out of 1614 hospital admissions and 3224 radiographs involving 650 juvenile patients, 456 patients met the inclusion criteria (Figure 1). This study is a descriptive retrospective analysis. Data are presented as means for temporal variables and as frequencies/percentages for categorical variables. Due to the minimal number of patients in the surgical subgroup, comparative statistical tests were not performed.

Results

The mean age of the 456 patients (juvenile group) was 5.85 years. The highest incidence was observed in the 3-year-old (n = 89, 19.5%) and 4-year-old (n = 71, 15.6%) cohorts, with a gradual decline in frequency as age increased. Males accounted for 269 patients (59.0%) and females for 187 (41.0%). The 3–4 year-old group represented the most frequent age bracket for fractures (35.1%) (Table 1). Regarding fracture laterality, 231 patients (50.7%) had right-sided, 222 (48.7%) had left-sided, and 3 (0.7%) had bilateral fractures; the distribution was consistent across genders.

The vast majority of fractures involved the middle diaphysis (93.0%), while lateral (5.5%) and medial (1.3%) locations were significantly less common.

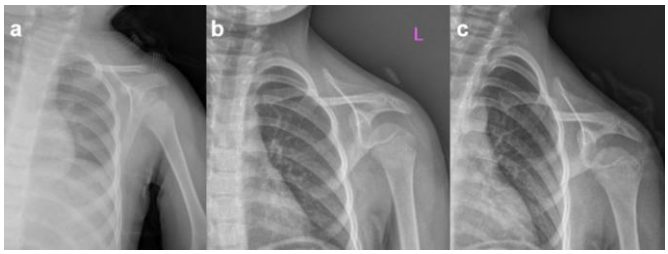

Figure 2. Serial AP radiographs of the left clavicle in a pediatric patient with pseudoarthrosis. **(a)** AP radiograph at age 3 shows a displaced fracture of the left clavicle. **(b)** Follow-up AP radiograph at age 5. **(c)** Follow-up radiograph at age 7 shows an absence of callus formation, sclerotic bone ends, and permanent separation between fragments, consistent with clavicular pseudoarthrosis. No clinical or radiographic data from the neonatal period were available.

Fractures were classified as simple in 310 cases (68.0%) and completely displaced in 146 cases (32.0%). Conservative management was the primary approach: 63.2% of patients were treated with a Velpeau bandage and 36.4% with a figure-of-eight bandage. Surgical intervention was performed in only two patients (0.4%)—one via plate fixation and the other with a K-wire.

Among the 453 patients (99.3%) available for union assessment, complete union was achieved in nearly all cases. Two patients experienced union following a refracture, and one patient (0.2%) developed radiographic pseudoarthrosis. In the case of pseudoarthrosis—initially diagnosed at age 3 with a displaced left clavicle fracture—radiographic follow-ups at ages 5 and 7 confirmed persistent fragment separation and sclerosis without callus formation. No clinical or radiographic history from the neonatal period was available for this patient (Figure 2).

Treatment selection appeared independent of fracture type. In simple fractures, Velpeau (65.5%) and figure-of-eight bandages (34.2%) were used exclusively, with no requirement for surgery. A similar distribution was noted in completely displaced fractures, where Velpeau (57.5%) and figure-of-eight (41.1%) methods predominated. These findings suggest that displacement does not significantly influence treatment choice in this age group.

The mean remodeling time was comparable between conservative methods: 18.26 months for Velpeau bandages and 18.67 months for figure-of-eight bandages. No distinct differences were observed regarding complications or radiographic remodeling outcomes between the two immobilization techniques. Although the two surgical cases showed a remodeling time of 6 months, this was not statistically analyzed due to the small sample size. No consistent trend was found between age and remodeling time: 3–4 years (18.6 months), 5–6 years (18.7 months), 7–8 years (16.0 months), and 9–10 years (20.1 months). Simple fractures had a mean remodeling time of 17.98 months, compared to 19.21 months for displaced fractures (Figures 3 and 4). Notably, remodeling time reflects radiographic documentation in hospital records rather than the time to clinical recovery or primary union.

For the most common location—middle diaphyseal fractures (n = 424) —conservative treatment was nearly universal: 262 Velpeau, 161 figure-of-eight, and 1 plate fixation. Lateral fractures (n = 25) were mostly managed conservatively (19 Velpeau, 5 figure-of-eight), with one K-wire stabilization. All medial (n = 6) and segmental (n = 1)

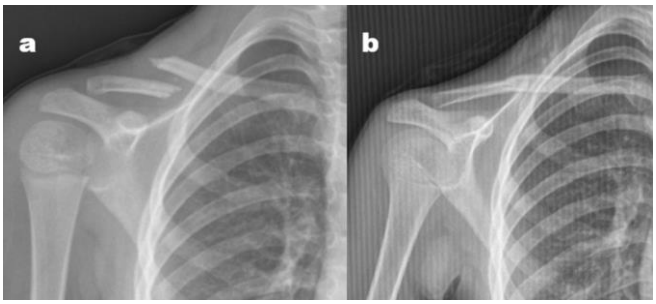

Figure 3. Radiographic appearance demonstrating complete remodeling of a pediatric midshaft clavicle fracture approximately 18 months after injury. **(a)** AP radiograph of a 7-year-old male patient showing a displaced diaphyseal fracture. **(b)** AP radiograph of the same patient demonstrating a fully remodeled clavicle.

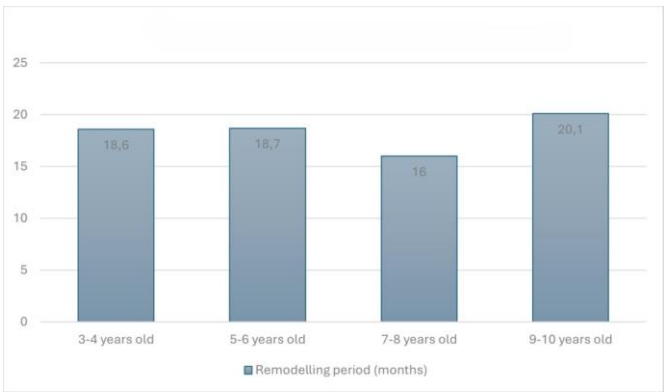

Figure 4. Mean remodeling period by age group (months). Values represent the mean remodeling time; no comparative statistical analysis was performed.

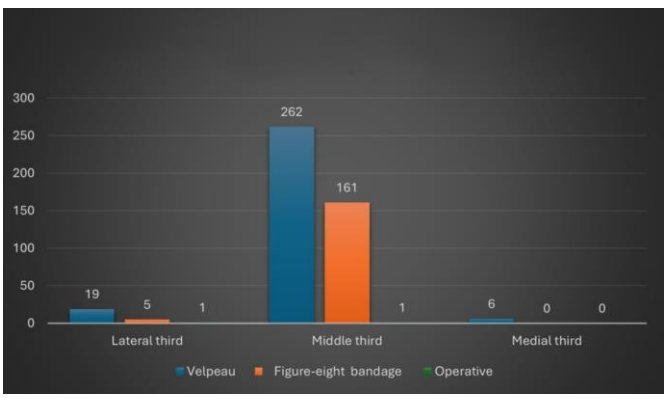

Figure 5. Distribution of treatment modalities according to fracture location in juvenile clavicle fractures (ages 3–10 years).

fractures were treated conservatively (Figure 5). Surgical choices were based on the risk of secondary skin perforation as assessed by the attending physician.

The mean fracture angulation was higher in simple fractures (23.1°) than in completely displaced fractures (15.4°). Despite these differences, angulation did not dictate the choice of immobilization or impact clinical outcomes.

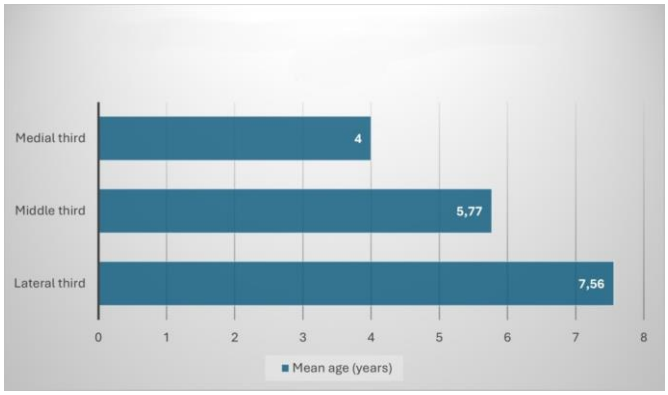

Figure 6. Mean patient age according to fracture location.

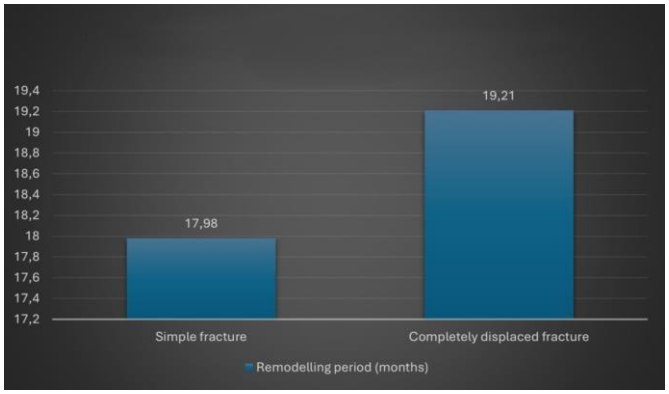

Figure 7. Mean remodeling period according to fracture type. Values represent mean time in months; no comparative statistical analysis was performed. Remodeling time indicates the time to radiographic documentation of complete remodeling.

Discussion

Clavicle fractures are common in pediatric emergency departments, and while the vast majority heal with conservative treatment, complications can lead to long-term disability [9]. Standard recommendations often include 2–3 weeks of immobilization with a sling, 4–6 weeks of radiographic follow-up, and 8–10 weeks of activity restriction [9]. In our cohort, a conservative approach was adopted, consistent with the literature; Velpeau and figure-of-eight bandages were the predominant immobilization methods. We observed no significant clinical differences between these two methods. Given that the type of immobilization does not fundamentally alter the biomechanical stability of clavicle fractures, it appears that the choice of bandage does not significantly influence the remodeling process.

Surgical intervention in pediatric clavicle fractures is typically reserved for complicated cases, such as widespread comminution, skin tenting, neurovascular injury, or open fractures [3]. Our findings support this selective approach. In our series of 456 patients, surgical intervention was required in only two cases, both due to an elevated risk of complications. The high union rates achieved through conservative management—even in completely displaced fractures—suggest that surgery should be limited to highly specific cases. This indicates that the surgical indications defined in the literature pertain to a very limited patient population in clinical practice.

The robust periosteal sleeve of the pediatric clavicle limits excessive displacement and, through its strong remodeling potential, ensures uncomplicated healing even in completely displaced or lateral-end fractures [10]. While approximately 70% of adult clavicle fractures involve the diaphysis, this rate approaches 95% in the pediatric population [11]. In our study, 93.0% of fractures were located in the middle diaphysis, confirming this high diaphyseal tendency. Furthermore, we observed that lateral-end fractures were more frequent in older children, whereas medial-end fractures were seen in younger age groups, aligning with established age-related anatomical patterns (Figure 6).

Complete displacement of fracture ends is often cited as the strongest predictor of complications such as nonunion or malunion [11]. Literature suggests a 3.2 times higher risk of complications in displaced fractures compared to those with contacting bone ends [11]. However, in our juvenile cohort, complete displacement did not significantly impact the development of complications. Healing rates remained high, and remodeling time was only minimally prolonged (19.21 months vs. 17.98 months), with no adverse functional outcomes (Figure 7). We attribute the relatively long remodeling times in our data to the timing of radiographic documentation in the hospital system; clinical recovery typically preceded radiological evidence of remodeling.

The observation that simple fractures exhibited higher angulation than displaced ones may be related to the preservation of periosteal integrity, which allows for axial angulation; in contrast, displaced fractures involve fragment translation due to loss of periosteal support, yet angulation remains limited [12-15]. The fact that these deformities do not lead to functional loss highlights the extraordinary remodeling capacity of juvenile bone [13-16].

While studies in adolescents have suggested that symptomatic malunion rates may be higher than expected, there is limited research focusing exclusively on the juvenile age group and the necessity of follow-up [12-16]. In our isolated juvenile series, no cases of traumatic nonunion were detected. Primary union occurred in 99.3% of cases. The single recorded case of pseudoarthrosis showed persistent radiographic separation and sclerosis. However, due to the lack of neonatal history and imaging, its etiology remains unclear. Since radiographic features of congenital clavicular pseudoarthrosis can overlap with post-traumatic nonunion, this case is best interpreted as a descriptive radiographic finding rather than a definitive complication of an acute fracture.

In asymptomatic patients, repeat outpatient visits and radiographs did not result in any changes to clinical management. Although some suggest that discharge should be contingent upon radiographic union, several studies argue that repeated imaging is unnecessary in asymptomatic children [13-16]. Our findings corroborate this; in patients who were painless with restored shoulder function, radiographic follow-up seldom altered the treatment plan. No asymptomatic patient required a transition to surgery.

The retrospective design of this study may involve individual variations in clinical decision-making and potential recording gaps. Furthermore, the focus on radiographic union and remodeling limits the systematic evaluation of long-term functional scores and parent satisfaction. However, given our aim to evaluate the safety and follow-up requirements of conservative treatment, the minimal number of surgical cases does not detract from the study's primary conclusions.

Conclusions

The findings of this study support the conclusion that in isolated juvenile clavicle fractures—including completely displaced patterns—routine orthopedic follow-up and serial radiographic evaluations may be unnecessary after the initial assessment, provided no complications are present at the time of injury. Clinical follow-up can be safely managed when parents are adequately informed about pain control, home-based immobilization, and activity restrictions. This approach could reduce the socioeconomic burden on the healthcare system and significantly minimize ionizing radiation exposure for pediatric patients. Regarding immobilization, no significant superiority was found between the figure-of-eight bandage and the Velpeau bandage. Consequently, treatment choice for juvenile clavicle fractures can be based on physician preference and clinical habit, as conservative methods remain safe and effective across this age range.

Author contributions

The author confirms sole responsibility for the following: study conception and design, material preparation, data collection, analysis, and manuscript preparation.

Statements and declarations

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Conflict of Interest

The authors declare that they have no conflict of interest.

Ethical statement

The University of Health Sciences Kayseri City Training and Research Hospital Clinical Research Ethics Committee approved the study protocol (Approval No:8.7.2025/485), informed consent was obtained from each patient, and the study was conducted in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki and its later amendments.

ORCID iD

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