كلية الطب
جامعة النهرين
تأسست عام ١٩٨٧

Distal forearm fractures in children

A THESIS

Submitted to the department of surgery in Al-Nahrain University - College of Medicine as partial Fulfillment of the requirements for graduation

2018 – 2019

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Acknowledgement

I take this opportunity to express my gratitude to my supervisor **Prof. Dr. Abd Ali Muhsen** for his scientific guidance, great help and advices. I would like to thank every member of my family, for their endless support. Special thanks go for my patients who willingly accept to be part of this, also I thank staff members who supported me through this venture.

Dedication

To my beloved parents, who were there for me
With their support and encouragement,
I dedicate this work to all their loving tears and beautiful smiles.

To all my respectable teachers,
Who enlightened me with their knowledge and understanding

To all my fellow students, friends, and colleagues
For their unconditional Support and love.

To all patients out there, hoping this little work will do something to help them more in their sufferings.

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Abstract

Background: Childhood forearm fractures are very common and typically occur after a fall on an outstretched hand, This fracture can be classified according to site or displacement. the child with a distal forearm fracture typically has a history of a fall on an outstretched hand with swelling, bony pain, and/or deformity of the distal forearm.

Aim of the study: to review the patterns and epidemiology of distal forearm fracture in population of children

Patients and methods: descriptive cross-sectional study was performed on 22 patients visiting the orthopedic outpatient clinic in Al-Imamain Al-Kadhimain medical city, Baghdad, Iraq, from November 2018 to March 2019. Data was collected through a direct interview with the participants. A verbal consent was taken. Patients of both sexes of pediatric age groups were included in the study on the basis of diagnosis of distal forearm fractures confirmed clinically and by x-ray.

Results: 22 patients within pediatric age groups, had distal forearm fractures, with male predominant (57.7%), the commonest age group with distal forearm fracture was the primary school age (5-12) years with 16 (72.7%) patients, and fall from height was the most common mechanism of injury with 18 (82%) patients, followed by blunt trauma of direct hit in 3 (13.5%) patients, and for the types of fractures, the meta-physeal fractures was the commonest and found in 14 (64%) patients, and displacements and angulation of the distal forearm fractures in was found in 10 (46%) patients.

Conclusion: Childhood distal forearm fractures are very common mostly at metaphysis due to fall from height being the most common mechanism of such injuries. Displacements and angulation are common in this type of fractures at this age group.

Key words: Orthopedics, surgery, distal forearm fracture.

Chapter One

Introduction

Introduction

Childhood forearm fractures are very common and typically occur after a fall on an outstretched hand. Early assessment should focus on identifying an open fracture, neurovascular compromise, and/or associated injuries. Nondisplaced distal forearm fractures other than complete fractures of the distal radius and ulna can then be referred for scheduled evaluation and further management by an orthopedist with pediatric expertise.

Epidemiology — Forearm fractures are among the most common fractures in children [1,2]. The distal third of the forearm, involving the radius and/or ulna, is the most common location [3,4]. This high incidence can be explained by increased body mass in relation to an overall decreased bone mineral content during growth and development [2]. Most of these fractures will occur in children older than five years (peak age 10 to 14).

Pertinent anatomy — The bones, muscles, ligaments, and tendons all work together in stabilizing the forearm. An interosseous membrane connects the radius and ulna, and the radius rotates around the ulna during supination and pronation of the forearm [1,3,5-7].

The articular surface of both the radius and ulna is initially formed by the epiphysis, which is separated from the metaphysis by the physis or the cartilaginous growth plate [8]. The physeal area, where longitudinal growth occurs, is firmly connected to the metaphysis by periosteum, and is difficult to separate by injury [5]. The distal radial and ulnar physes account for 75 to 80 percent of forearm growth and almost half of upper extremity growth [9].

The porous nature of bones in children makes them more flexible than in adults, and thus, they are able to tolerate more bending and deformation before a fracture occurs. The periosteum around the bones in children is thick and strong and provides some mechanical stability after fracture. It is less readily torn than periosteum in adults, but when it is torn, a fracture becomes displaced. Rapid growth in children and abundant blood supply to the distal radius and ulna permits excellent healing and remodeling of forearm fractures [5,6,10].

Mechanism OF INJURY — A fall onto an outstretched hand (FOOSH) accounts for most forearm fractures in children [2,5,6,11,12]. When falling, a child usually braces against the fall with the arm while extending the wrist. This arm position puts maximum axial force onto the forearm.

Common high-risk activities include snowboarding, skateboarding, skim-boarding, soccer goalkeeping, and horseback riding, although any activity that results in a fall with sufficient force can cause a distal forearm fracture [12-16]. Wrist guards have been shown to reduce the risk of fracture associated with snowboarding by 71 percent (95% CI: 13-90 percent) and are also recommended for inline skating [17].

Most forearm fractures result from falls on an outstretched arm and are not associated with multiple trauma. However, children who fall from a height greater than three times their standing height or sustain a distal forearm fracture as a result of another major trauma mechanism are at risk for multiple trauma and warrant a complete physical examination and appropriate ancillary studies.

Clinical features — The child with a distal forearm fracture typically has a history of a fall on an outstretched hand with swelling, bony pain, and/or deformity of the distal forearm.

Diagnosis — With the exception of nondisplaced Salter I physeal (growth plate) fractures, plain radiographs of the forearm provide the diagnosis and should be obtained in children with bony tenderness or deformity. If radiographs are not readily available, then ultrasonography by a trained examiner can detect distal forearm fractures in children with high sensitivity and specificity.

Nondisplaced Salter I fracture — Patients with a nondisplaced Salter I physeal fracture of the distal radius or ulna usually have normal plain radiographs at initial presentation. However, bony tenderness is present over the physis in these patients and helps to differentiate this injury from a bruise or ligamentous strain or sprain [18]. Other radiographic findings that may be present soon after injury include a volar fat pad on the lateral view and epiphyseal widening on stress views. However, stress views are painful for the patient and usually unnecessary.

Imaging

Plain radiographs — When obtaining radiographs in the child with a suspected distal forearm fracture, the necessary films should be taken with minimal movement of the extremity. In patients with an obvious deformity or where high suspicion for a displaced fracture exists, and splinting is advisable prior to obtaining radiographs. Otherwise, a sling typically provides adequate support of nondisplaced fractures and allows for radiographs to be obtained more easily.

- **Radiographic views –** All patients with suspected forearm fractures need a true anteroposterior (AP) and lateral view of the injured forearm that includes the wrist and distal humerus. A good AP view of the forearm should have minimal superimposition of the radial tuberosity (located at the proximal radius) over the proximal ulna, and similar radiographic density for the proximal and distal forearm [19]. A true lateral view of the forearm has superimposition of the radial head upon the ulnar coronoid process at the proximal end, superimposition of the radius and ulna at the distal end, a view of the soft tissues around both bones, and an elbow position that is 90 degrees of flexion [19]. If there is concern about a wrist and/or elbow fracture or dislocation based upon physical findings and/or initial forearm radiographs, the clinician should order separate wrist and/or elbow radiographs [5,6].
- **Classification** – Additional radiographic findings and examples of each type of distal forearm fracture are described below by fracture type.

  When describing and documenting a distal forearm fracture, the key elements include whether the fracture is open or closed; the presence of physeal involvement, angulation, displacement; and the presence of bony rotation [6].
  - A closed fracture has no connection between the fracture site and any adjacent skin wounds whereas an open (compound) fracture has obvious bony protrusion through the skin or a contiguous open wound.
  - Physeal fractures are described by using the Salter-Harris classification system and indicate whether the radius, ulna, or both are injured.
  - Distal metaphyseal fractures of the radius and/or ulna are described as torus (or buckle), greenstick, or complete fractures based upon the radiographic findings.

- Fracture displacement is defined on the lateral view by the displacement of the distal fragment (dorsal or volar).
- The angulation is described by the direction of the apex of the deformity (dorsal or volar) and the degree of angulation.
- Most displacements are also rotated. Rotation of the fracture is judged by a break in the smooth curve of the bone or change in the diameter of the bone or width of the cortex of the two fragments [5,6].
- If there is displacement or angulation on the AP view, descriptions are similar, but in the radial or ulnar direction.

Specific fractures — Several different types of fractures may be seen in children with distal forearm injuries.

Physeal fractures — Physeal separations or fractures occur across the growth plate of the bone. Until fused, the physes (growth plates) are a site of relative weakness and are therefore prone to fracture. When there is a fracture at the physis, it usually occurs between the calcified and uncalcified layers of cartilage corresponding to the hypertrophic zone.

Physeal injuries of the distal radius are the most common sites of growth plate injury [20]. Ulnar physeal injuries are much less common and typically occur in conjunction with radial fractures. When there is injury to the radial or ulnar physis, circulation typically remains unaffected, and growth is usually not disturbed [5].

The Salter-Harris system is the most commonly used classification scheme for describing these fractures. The Salter-Harris levels progress from type I to type V. Salter-Harris types I and II comprise the majority of distal physeal forearm injuries. The higher levels (type III or higher) correspond to an increased need for surgical intervention and a greater risk for growth arrest after fracture healing.

In infants and very young children, who have minimal or no ossification of the epiphysis, the fracture may be difficult to appreciate on plain radiographs. In this situation, it may be necessary to get multiple radiographic views, comparison views of the other side, or rarely, other imaging. Discussion with a pediatric radiologist and/or an orthopedic surgeon is advisable to guide the diagnostic approach in these patients.

Bone bruise — A subset of children with presumed nondisplaced Salter-Harris distal forearm fractures may have normal acute and follow-up radiographs, and if obtained, normal computed tomography of the forearm, but exhibit persistent bony pain despite immobilization for four to five weeks [21]. Magnetic resonance imaging with fat suppression may detect microfractures, termed "bone bruises" in such patients.

Torus (buckle) fractures — A buckle fracture occurs at the distal metaphysis, where the bone is most porous, usually in younger children. This injury is caused by buckling of the cortex due to compression failure. On clinical presentation there is tenderness over the bone, but other symptoms (e.g., swelling, decreased range of motion) may be minimal and not highly suggestive of a fracture.

The most common buckle fracture involves the dorsal surface of the distal radius but may involve both bones. It is important to look at all views for a disruption of the smooth contour of the metaphysis, since the buckle may be very subtle.

Greenstick fractures — A greenstick fracture is a complete fracture of the tension side of the cortex of the radius or ulna and a plastic deformation, or buckling, of the compression side. On radiograph, the fracture will be seen as a complete disruption on one side of the bone with a buckle on the opposite side. Commonly a complete or buckle fracture of one bone accompanies a greenstick fracture of the other.

Complete fractures — A fracture is considered complete when it passes through both cortices of the distal metaphysis (distal third) of the radius and/or ulna, often with displacement. They are usually caused by a high energy fall onto the hand with the wrist in a pronated and extended position [1,22]. These fractures do not affect the growth plate. If the fracture extends completely through the distal radius and ulna, the extension of the hand during these falls gives a characteristic deformity to these fractures sometimes referred to as the dinner fork deformity. A fall on a flexed hand results in the opposite deformity. Slight variations in mechanism can produce different injuries.

Because children's bones are more flexible than those of adults, these pediatric fractures are rarely comminuted. The bony segments assume the position that is dictated by the muscle forces exerted on the bone [1,6]. In particular, the brachioradialis muscle exerts a volar deforming force with the hand in pronation and with total bony displacement, shortening of the forearm with overlapping fracture fragments [7].

Ulnar styloid fractures — This fracture a distal avulsion fracture at the site of the triangular fibrocartilage complex (TFCC) or the ulnocarpal ligament attachment. It typically occurs in conjunction with a radial fracture. In most instances, fracture care is determined by the type of radial fracture with one exception; a displaced fracture that occurs at the base of the ulnar styloid may indicate a disruption of the TFCC and may warrant surgical intervention [23,24].

Associated fractures — Forearm fractures are associated with supracondylar fractures in up to 5 percent of cases [25]. The combination of supracondylar and forearm fractures is termed the "floating elbow" and increases the possibility of compartment syndrome [26]. For this reason, anteroposterior and lateral radiographs of the forearm should include the distal humerus in all patients with forearm fractures.

Proximal humerus, clavicle, wrist, and hand fractures may also occur with a distal forearm fracture. Deformity and/or bony tenderness during physical examination dictate appropriate radiographic assessment of these areas in selected patients.

Ultrasound — Detection and management of distal forearm fractures is a developing use of bedside ultrasound. However, most centers still use plain radiographs for diagnosis of forearm fractures and bedside fluoroscopy to check adequacy of fracture reduction. Further evidence is needed to determine if ultrasound can be performed instead of plain radiography. However, given the high specificity of bedside ultrasonography when performed by an experienced physician, limitation of plain radiographs to patients who are ultrasound negative appears to be a reasonable strategy.

Based upon a meta-analysis of 12 studies with a total enrollment of 951 children (18 years of age and younger), ultrasound detects distal forearm fractures with a

pooled sensitivity of 98 percent and a specificity of 96 percent using plain radiographs as the gold standard [27]. These findings correspond to an estimated 3 out of 100 distal forearm fractures missed by ultrasound. In most studies, the ultrasound was performed at bedside by the managing physician rather than by a radiologist. Thus, ultrasound by a trained and experienced physician is a viable alternative to plain radiographs for the diagnosis of distal forearm fractures when plain radiographs are not readily available. The six-view ultrasound technique is associated with the best sensitivity and specificity.

In two studies not included in the aforementioned meta-analysis, ultrasound was less painful than plain radiographs [28,29]. In one of these studies, the median time to perform the ultrasound examination was 1.5 minutes [29]. Furthermore, some emergency physicians have used ultrasound successfully to guide distal forearm fracture reductions and determine when the fracture has been adequately reduced [30-32].

Aim

To review the patterns and epidemiology of distal forearm fracture in population of children

Chapter Two

Patients and method

Patients and methods

This descriptive cross-sectional study was performed on 22 patients visiting the orthopedic outpatient clinic in Al-Imamain Al-Kadhimain medical city, Baghdad, Iraq, from November 2018 to March 2019.

Selection criteria

Patients of both sexes of pediatric age groups were included in the study on the basis of diagnosis of distal forearm fractures confirmed clinically and by x-ray.

Base line assessment

Data was collected through a direct interview with the participants. A verbal consent was taken. Thorough information concerning the patient's condition was obtained, via the questionnaire, from the history, physical examination and investigations.

Exclusion criteria

Patients with multiple injuries, open fractures, metabolic bone disease, or history of previous injury to the affected forearm were excluded from this study

Data collection

Involved Age, gender, which forearm was involved, mechanism of injury, and displacement and all pre-reduction radiographs were reviewed by orthopedic physician. Caution had been considered to avoid repetition of the interview with the same patient by looking only for newly registered patients and marking their files during the time of the study.

Statistical analysis

Data were encoded and filled using Microsoft excel for windows then analysis was performed using SPSS Inc. version 24.

Chapter Three

Results

Results

During the study period, 22 patients within pediatric age groups, had distal forearm fractures, they were 13 males (57.7%) and 9 females (42.3%) with male:female ratio of 1.4:1 as shown in fig.1. Their ages range from 6-16 years with mean age of 11 years.

Table (1) Gender distribution

Gender	N	%
Male	13	57.7%
Female	9	42.3%
Total	22	100%

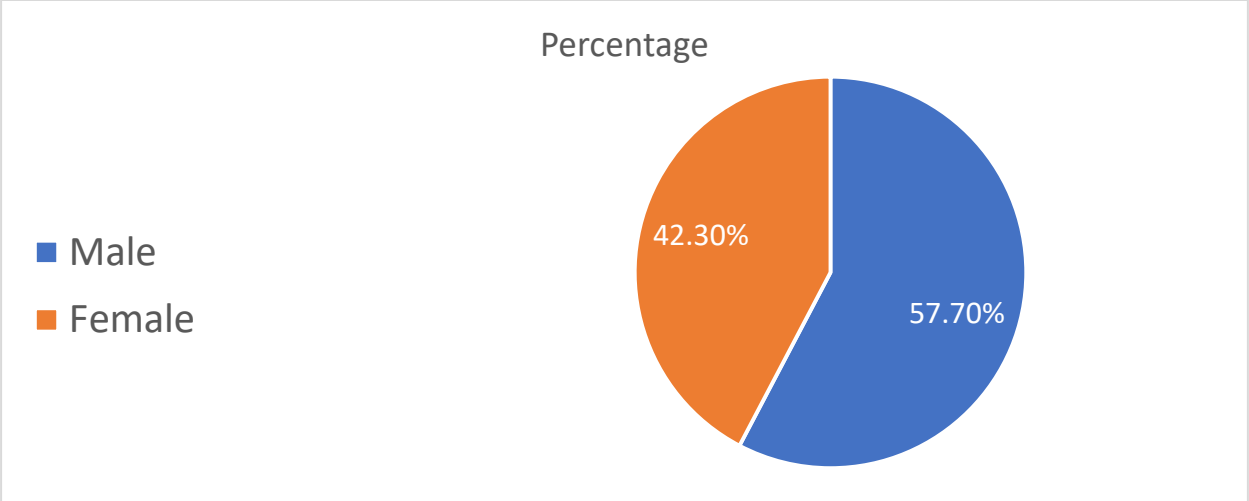

Figure (1) Gender distribution

In this study, the commonest age group with distal forearm fracture was the primary school age (5-12) years with 16 (72.7%) patients.

Table (2) Age groups distribution

Age Group	N	%
Primary School (5-12) yrs	16	72.7%
Secondary School (12- 16) yrs	6	27.3%
Total	22	100.0

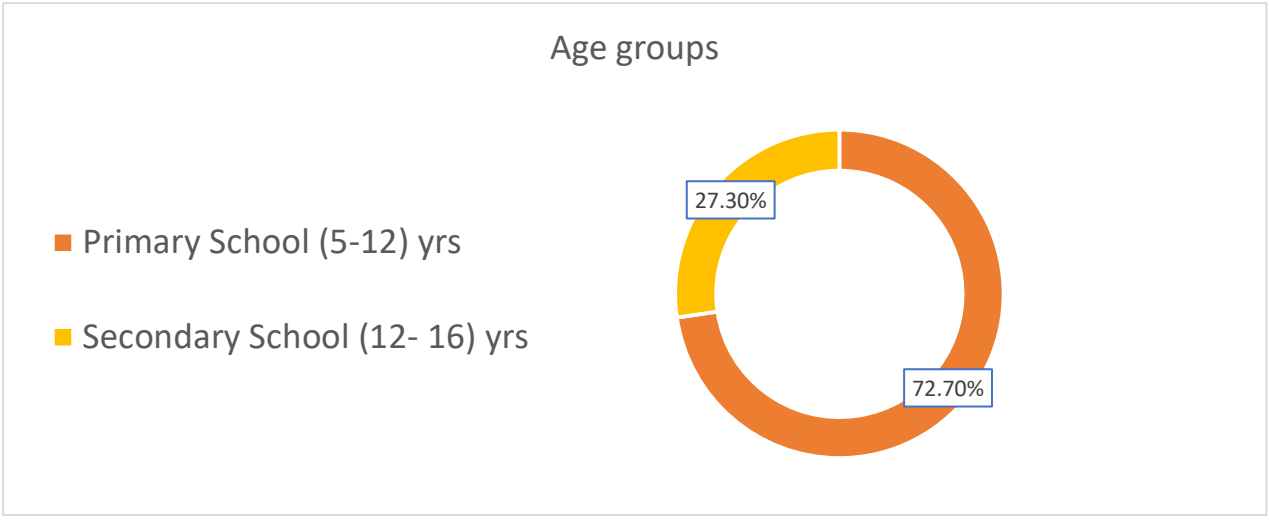

Figure (2) Age groups distribution

Regarding mechanisms of injury, fall from height, was the most common one in 18 (82%), patients followed by blunt trauma of direct hit in 3 (13.5%) patients, as shown in fig. 3

Table (3) Mechanisms of injury of distal forearm fractures

Mechanism of injury	**N**	**%**
Fall from Height	18	82%
Sport	1	4.5%
Direct Hit	3	13.5%
Total	22	100%

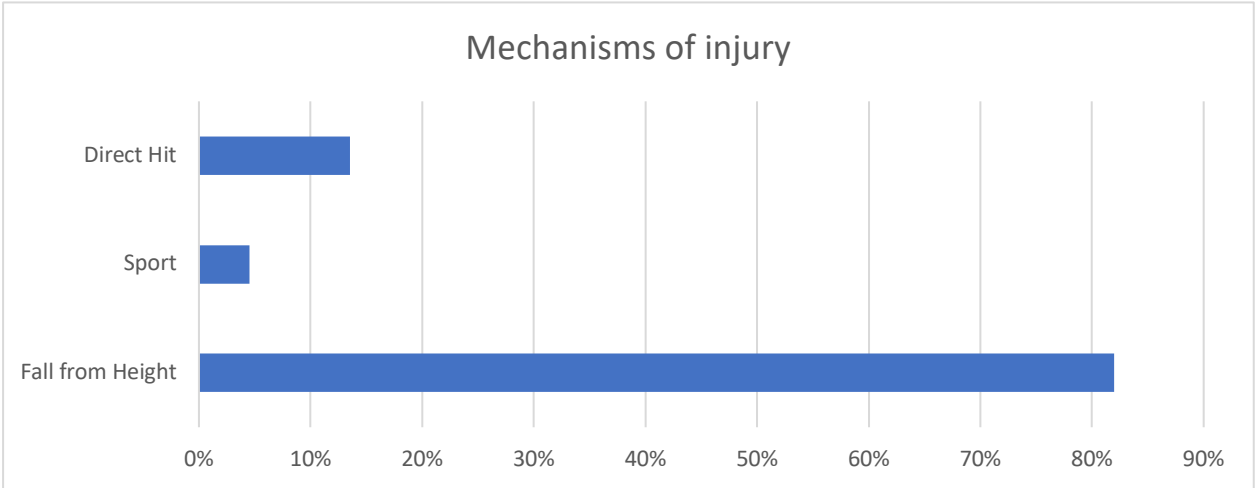

Figure (3) Mechanisms of injury of distal forearm fractures

In this study, we compared between the right and left forearm fractures, where home left forearm fractures were found in 16 patients (72.8%), and right forearm fractures were found in 6 (27.2%) patients

Table (4) A injury frequency between left and right forearm

Forearm	**N**	**%**
Right	6	27.2%
Left	16	72.8%
Total	22	100.0

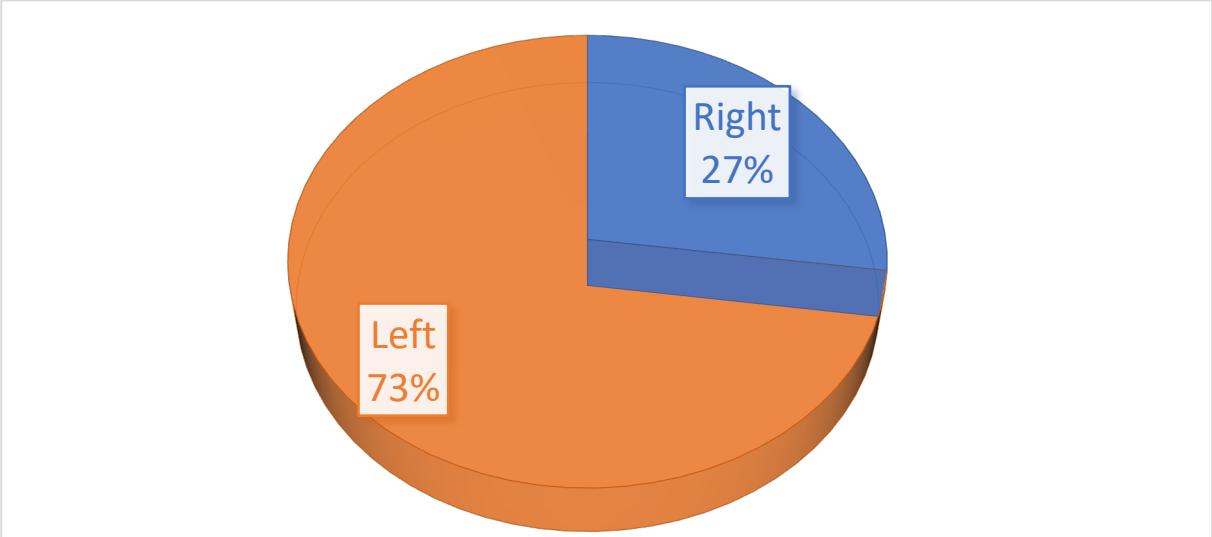

Figure (4) injury frequency between left and right forearm

Regarding fractures types, the metaphyseal fractures found in 14 (64%) patients, was the most common type, followed by distal diaphyseal fractures with 5 (23%) patients, and epiphyseal fractures was found in 3 (13%) patients as shown in figure (5).

Table (5) Type of Fractures in distal forearm

Type of Fracture	**N**	**%**
Epiphyseal	3	13 %
Metaphyseal	14	64%
Distal Diaphyseal	5	23%
Total	22	100%

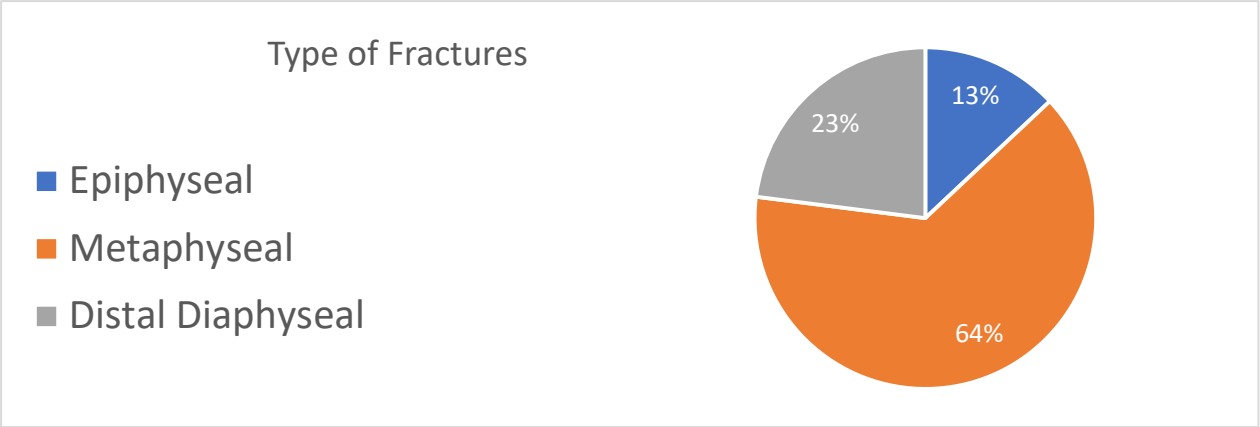

Figure (5) Type of Fractures in distal forearm

In this study, displacement of the distal forearm fractures was found in 10 (46%) patients followed by angulation of distal forearm fractures within 22 patients was found in 4 patients (18%) patients
The non-displaced fractures were found in 8 (36%) patients, as shown in fig. (6)

Table (6) Forearm fractures angulations and displacements

		N	Percentage	
Displaced	**Angulation**	4	18%	64%
	Displacement	10	46%	
No Displacement		8	36%	
Total		22	100%	

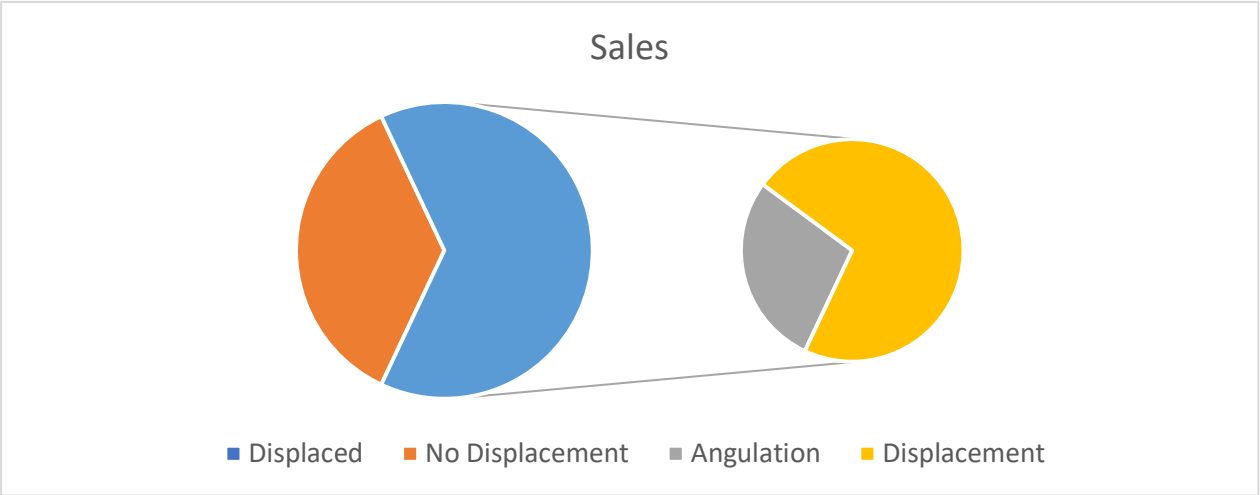

Figure (6) Forearm fractures angulations and displacements

Chapter Four

Discussion

Discussion

Childhood forearm fractures are very common and typically occur after a fall on an outstretched hand, some studies suggest that this could be the result of an overall increase in childhood participation in sports-related activities (33-36)

In this research, we found that distal forearm fractures predominantly affect pediatric age groups, within school age (6-16), with median age of 11 years in affected patients, this was approximately similar to the findings reported by Alrashedan et al (37) We could not specify the activity a child was participating in this age group because of incomplete documentation, but school-age children and teenagers may be more susceptible to injury from being pushed or by falling.

In our study population, fractures occurred more often in boys (57.7%) than in girls (42.3%), and our boy:girl ratio was 1.4:1, that is approximately similar to these reported by Alrashedan et al (37). Which stated that fractures occurred more in boys (80.82%) than in girls (19.18%) and our boy:girl ratio was 4.2:1. This might be because of the type of physical activity (mainly sports) that boys are usually engaged

In our population, fall-related injuries were the most common cause of fractures in (82%), These findings were similar to these reported by Alrashedan et al. (37) which stated that the most common mechanism of injury is a fall (83%) with others studies showing approximately 80% of injuries occurring in this manner. 2,25 as falls can occur during sports-related activities, especially while running without caution, and were more common in boys. 38

According to type of fracture in this age group, we found that metaphyseal fractures are the most common type of distal forearm fractures with (64%), this is

similar to the results obtained by Mamoowala et al (39). Which stated that metaphyseal fractures were the most common with (73%) as age is an important factor for remodeling potential with different bone mineral density from adults, 17,18

Regarding the involved forearm, left forearm was more involved than the right forearm in the distal forearm fractures, these findings were approximate the same as theses reported by Alrashedan et al (37) which stated that left forearm fractures were involved in (53.3%)

In this study, regarding fracture displacement and angulation, was found in 64% of patients, and non-displaced fractures were found for 36% of patients, these findings were similar to that reported by Pershad et al (40) which stated that (72%) was with displacement or angulations, that might be attributed to the mechanism of injury and the articular nature of these fractures.

Chapter Five

Conclusion

Conclusion

- Childhood distal forearm fractures are very common mostly at metaphysis due to fall from height being the most common mechanism of such injuries.
- Displacements and angulation are common in this type of fractures at this age group

Recommendation

Recommendation

Distal forearm fractures in children are common orthopedic presenting problem, that need a protective measure in sport activities to decrease their rates, also:

- Extending the study period to include more patients and expand the study
- Further studies regarding the preference of choice in treatment modalities

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