Correlation of Radiographic Diagnosis and Surgical Findings of Upper Limb Fractures Among Children at Moi Teaching and Referral Hospital, Eldoret, Kenya

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***Abstract*:**

***Purpose*: The purpose of this study was to determine the level of agreement between radiology and surgery in children with upper limb fractures at Moi Teaching and Referral Hospital (MTRH).**

***Materials and Methods*: A cross-sectional study was conducted on children presenting with upper limb fractures at the paediatric and orthopaedic emergency departments of Moi Teaching and Referral Hospital,Eldoret, Kenya. A total of 148 children were recruited by consecutive sampling between July 2019 and July 2020. Radiographs conducted at Moi Teaching and Referral Hospital were reviewed and used to make diagnosis. In addition, diagnoses made by the surgery team were recorded for each child. Descriptive statistics were used to provide a summary of the data obtained. Continuous data was summarized using measures of central tendency (mean and median) and measures of dispersion (standard deviation and interquartile range). The Cohen's Kappa statistic was used to assess the level of agreement of diagnostic findings between radiology and surgery.**

***Results*: The study participants were predominantly male (68.9%), had a mean age of 7 (SD=3.2) years of which majority (54.7%) were aged 5-9 years. Falls were the major injury mechanism accounting for 90.5% of the injuries while the accidents and cuts cumulatively accounted for less than 10% of the injuries. The most common fracture types were transverse by radiography (54.1%) compared to surgery (52.7%) and oblique fractures at 29.7% by radiography and 32.4% by surgery. Segmented fractures were reported in 5.4% of the study participants by surgery and in 1.4% by radiography while green-stick, spiral and comminuted fracture types were the least observed. Fractures of the supracondylar humerus were the most common by both radiography (69.4%) and surgery (67.6%). The second most observed fractures were phalanx at 8.8% by both radiography and surgery. The level of agreement between radiography and surgery was 95.5% with the Cohen's Kappa statistic showing an almost perfect level of agreement (k=0.921, p-value<0.001).**

***Unique contribution to theory, practice and policy*: Radiography is essential in the accurate diagnosis of paediatric fractures, and its continued use is of great value in patients' management.**

***Key words*: Radiographic Findings, Surgical Findings, Upper limb Fractures, Moi Teaching and Referral Hospital (MTRH)**

I. INTRODUCTION

Published reports have indicated that fractures are a common occurrence in childhood traumatic events with considerable variations in the incidence rate from 1.2% to 5% among different studies (Elbaih et al., 2016). In this population, upper-extremity fractures account for more than half of the reported bony injuries whereby the frequency of these injuries increases with increasing mobility. The most common mechanism is a fall on an outstretched hand while playing (Arora et al., 2014).

There are certain types of fractures which can easily be missed during patient assessment in the initial radiological reports (Wei et al., 2006). In a systematic review, Wei et al., (2006) reported an overall prevalence of 3.7% of missed fractures whereby the most common locations were foot (7.6%), followed by the knee (6.3%), elbow (6.0%), hand (5.4%), wrist (4.1%), hip (3.9%), ankle (2.8%), and shoulder (1.9%). Similarly, Adams (2020) stated that fractures which are easily subject to misinterpretation are those that occur on the elbows, hands, wrists and shoulders.

Gyftopoulos et al., (2014) identified that radiographs from a number of upper extremities injuries can easily be misinterpreted of which sternoclavicular dislocation and posterior shoulder dislocation jointly accounted for 79% of the misread findings. In addition, the authors stated that scapular fractures, greater tuberosity fractures, radial head fractures, coronoid process fractures, Galeazzi and Monteggia fracture-dislocations, scaphoid fracture, scapholunate instability, peri lunate dislocation and hook of hamate fracture accounted for 21% of the fractures that were misdiagnosed. Such instances of missed fractures have been linked to long term complications for the patient (Gyftopoulos et al., 2014).

Radiographs play a major role in patient evaluation for upper extremity trauma cases alongside clinical history and physical examination. Radiographs are especially helpful for the patient who is difficult to examine, providing information crucial to identifying the underlying pathologic abnormality and help direct management (Gyftopoulos et al., 2014). Dating to as far back as 1949, missed injuries in diagnostic

radiology have been reported with Garlands pioneering articles. Subsequent studies conducted in various settings have reported missed error rates of 3.5-4% in daily practice where there is mixture of abnormal and normal cases (Donald & Barnard, 2012).

Statement of the Problem

Globally, it is estimated that fractures constitute between 10% and 25% of musculoskeletal injuries in children which occur more frequently in the upper compared to the lower extremity. Fractures on the distal radius are the most frequent and together with fracture of metacarpals and phalanges cumulatively account for up to 50% of all fractures (Arora et al., 2014). In Europe, it is estimated that fractures in the upper limbs account for 68% of fractures in children, with the forearm accounting for 27 to 45% of those and 23 to 35.8% observed in the distal region (Mark et al., 2018). In Africa, fractures due to trauma in children are less common than infections, infestations and malnutrition. However, childhood traumas are estimated to account for about 7.5% mortality rate in the continent (Andronikou et al., 2011).

Despite the reported low rates of childhood fractures, missed fractures are more common in paediatric than adult traumatic patients (George & Bixby, 2019). The proportion of missed fractures in children varies with age with younger children reporting higher incidences (George & Bixby, 2019; Mark et al., 2018; Mattijssen-Horstink et al., 2020). It is estimated that plain radiographs miss about 10-20% of childhood fractures and this proportion is higher in cross-sectional imaging (Kaewlai & Abujudeh, 2012). In addition, limited technological and human resource radiological capacity in Africa is a major contributing factor to missed fractures (Andronikou et al., 2011; Guifo et al., 2017; Kaewlai & Abujudeh, 2012). Such limitations play a critical role in the paucity of data reported from Africa and specifically Kenya on missed fractures among childhood traumatic cases observed in different hospitals.

II. METHODOLOGY

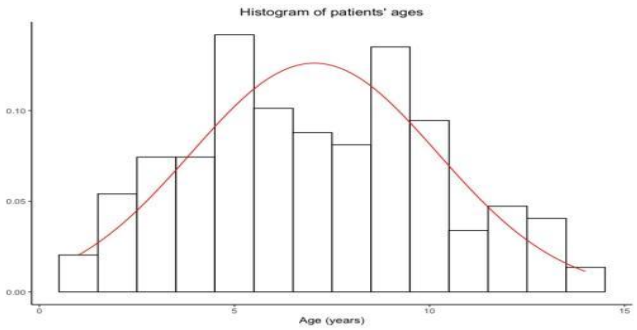
A cross-sectional descriptive study was conducted on children presenting with upper limb fractures at the paediatric and Orthopaedic emergency departments of MTRH. A total of 148 children were recruited by consecutive sampling between July 2019 and July 2020. Rdiographs conducted at Moi Teaching and Referral Hospital were reviewed and used to make diagnosis. In addition, diagnoses made by the surgery team were recorded for each child. Descriptive statistics were used to provide a summary of the data obtained. Continuous data was summarized using measures of central tendency (mean and median) and measures of dispersion (standard deviation and interquartile range). The Cohen's Kappa statistic was used to assess the level of agreement of diagnostic findings between radiology and surgery.

III. RESULTS

In this study a total of 148 children aged 1-14 years were recruited of which 101 (68.2%) were males while 46 (31.1%) were females. About 83% of the participants were of school going age while 28 (18.9%) were not enrolled in any school. A total of 107 (72.3%) of the study participants were in secondary schools, 7(4.7%) and 6 (4.1%) were at kindergarten and secondary levels respectively. The mean age of the study participants was 7.05 (SD ±3.16) years while the median age was 7 years (IQR: 5- 9). The study participants had a mean weight of 22.7 Kgs (SD: ±7.8) and a median weight of 21.4 kgs (IQR:17.0-27.0). Majority of the fractures (54.7%) occurred in the 5-9 years age group. In table 1 below, a summary of these demographic characteristics is presented while figures 1 and 2 are histograms showing the distribution of the age and weight values of the study participants.

Table I. Demographic Characteristics

		Summary Statistics
Age	Mean (SD)	7.05 (3.16)
	Median [IQR]	7.00 [5, 9]
Age category	<=1 year	33 (22.3%)
	5-9 years	81 (54.7%)
	10-14 years	34 (23.0%)
Gender	Male	102 (68.9%)
	Female	46 (31.1%)
Education Level	None	28 (18.9%)
	Kindergarten	6 (4.1%)
	Primary	107 (72.3%)
	Secondary	7 (4.7%)
Weight	Mean (SD)	22.7 (7.81)
	Median [IQR]	21.4 [17.0, 27.0]



FFigure 1: Histogram of the age distribution of study participants

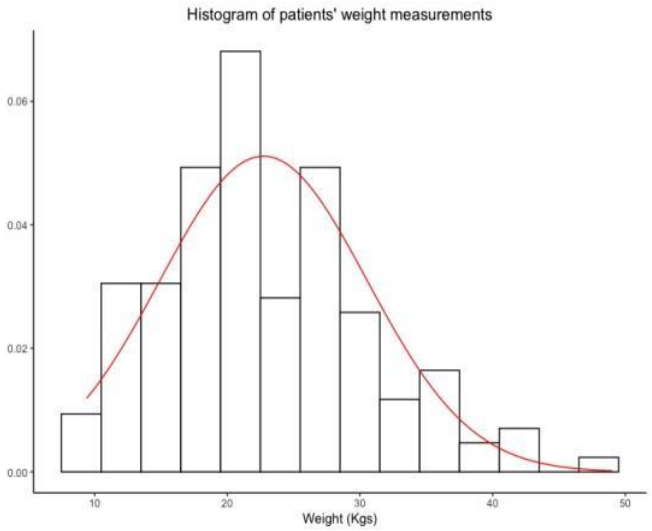


Figure 2: Histogram of the weight distribution of study participants

Clinical Findings

The mean Systolic Blood Pressure (SBP) was 123 (±17) mm/Hg and 125 (±12) mm/Hg among male and female participants respectively with an overall mean SBP of 123 (±15.8) mm/Hg. The mean Diastolic Blood Pressure (DBP) values were 70.8(13.4), 77.8 (±15.4) and 72.5 (±14.0) among males, female and overall, respectively. However, BP measures were not well captured from the participants whereby about 78% of the study participants did not have BP readings recorded. The overall mean pulse rate was 109 (±22.2) beats/minute among the study participants, 107 (±21.2) and 113 (±24.7) among male and female participants respectively. In addition, the mean respiratory rate was 22.7 (±4.7) among all participants and when stratified by age the mean values were 22.4 (±4.42) among males and 23.4 (±5.2) among females. Temperature values were collected in about 95% of the participants and an overall mean temperature of 36.8 Celsius was reported. These summary statistics are presented in the table below.

Table II. Blood Pressure Findings

		Male	**Female**	**Overall**
		(n=102)	(n=46)	(n=148)
SBP				
	Mean (SD)	123 (17.0)	125 (12.1)	123 (15.8)
	Median [Q1, Q3]	124 [109, 130]	120 [117, 133]	123 [113, 131]
	No certain diagnosis	77 (75.5%)	38 (82.6%)	115 (77.7%)
DBP				
	Mean (SD)	70.8 (13.4)	77.8 (15.4)	72.5 (14.0)
	Median [Q1, Q3]	72.0 [60.0, 82.0]	76.5 [69.5, 86.0]	72.0 [60.0, 82.0]
	No certain diagnosis	77 (75.5%)	38 (82.6%)	115 (77.7%)

Table III. Additional Clinical Findings

		Male	**Female**	**Overal**
		(n=102)	(n=46)	(n=148)
Pulse Rate				
	Mean (SD)	107 (21.2)	113 (24.7)	109 (22.2)
	Median [Q1, Q3]	110 [102, 118]	115 [106, 128]	111 [102, 120]
	No certain diagnosis	18 (17.6%)	16 (34.8%)	34 (23.0%)
Respirat ory rate				
	Mean (SD)	22.4 (4.42)	23.4 (5.19)	22.7 (4.66)
	Median [Q1, Q3]	22.0 [20.0, 24.0]	23.5 [20.0, 24.0]	22.0 [20.0, 24.0]
	No certain diagnosis	23 (22.5%)	14 (30.4%)	37 (25.0%)
Tempera ture				
	Mean (SD)	36.8 (0.511)	36.7(0.39)	36.8 (0.483)
	Median [Q1, Q3]	36.9 [36.5, 37.1]	36.6 [36.4, 37.0]	36.8 [36.5, 37.0]
	No certain diagnosis	4 (3.9%)	3 (6.5%)	7 (4.7%)

Fracture Characteristics

In table 3 below the frequencies and percentages of the fracture characteristics are presented. Among all the 148 children recruited in this study, falls accounted for the majority of the fractures at 90% of the children and when stratified by gender at 90.2% among males and 91.3% among females. Fractures due to cuts and accidents were relatively low compared to those due to falls. Across gender and overall, cuts had <7% occurrence while only about 2% of the fractures were due to accidents among the study participants.

In the study sample, a majority 121 (81.8%) of the fractures were observed on the humerus and such a high proportion was consistently seen across gender in 85(83.3%) of the male participants and 36 (78.3%) of the females. This was followed by fractures on the radius and phalanx/finger/thumb which were observed in 13 (8.8%) and 12 (8.1%) of the study participants respectively.

The distribution of open/closed fractures was fairly symmetrical at 50% in each category and this symmetry was also observed when stratified by gender. In addition, only 2 (1.4%) of all the study participants, all of whom were males, reported previous occurrence of fracture(s) other than the ones observed in this study. In general, transverse fractures were the most observed fractures which were observed in 80(54.1%) of the study participants, 51(50.0%) and 29 (63.0%) of the male and female participants respectively. Oblique fractures were the second most reported types of fractures. In total 44 (29.7%) of the study participants, 29

(28.4%) and 15 (32.6%) of male and female participants respectively had oblique fractures. Cumulatively, green-stick, spiral, comminuted and segmented fractures formed less than 7% of the fractures observed in this study.

Table IV. Fracture Characteristics

		Male	Female	Overal
		(N=102)	(N=46)	(N=148)
Injury Mechanism				
	Accident	2 (2.0%)	1 (2.2%)	3 (2.0%)
	Cut	7 (6.9%)	2 (4.3%)	9 (6.1%)
	Fall	92 (90.2%)	42 (91.3%)	134 (90.5%)
	No certain diagnosis	1 (1.0%)	1 (2.2%)	2 (1.4%)
Anatomical Site				
	Clavicle	1 (1.0%)	0 (0%)	1 (0.7%)
	Humerus	85 (83.3%)	36 (78.3%)	121 (81.8%)
	Phalanx/finger/thumb	9 (8.8%)	3 (6.5%)	12 (8.1%)
	Radius	7 (6.9%)	6 (13.0%)	13 (8.8%)
	No certain diagnosis	0 (0%)	1 (2.2%)	1 (0.7%)

Table V. Types of Fractures

		Male	Female	Overal
Open/Closed				
	Open	52 (51.0%)	23 (50.0%)	75 (50.7%)
	Closed	50 (49.0%)	23 (50.0%)	73 (49.3%)
History of Fracture	Yes	2 (2.0%)	0 (0%)	2 (1.4%)
	No	100 (98.0%)	45 (97.8%)	145 (98.0%)
	No certain diagnosis	0 (0.0%)	1 (2.2%)	1 (0.7%)
Fracture Type				
	Green-stick	2 (2.0%)	0 (0%)	2 (1.4%)
	Transverse	51 (50.0%)	29 (63.0%)	80 (54.1%)
	Spiral	4 (3.9%)	1 (2.2%)	5 (3.4%)
	Oblique	29 (28.4%)	15 (32.6%)	44 (29.7%)
	Comminuted	1 (1.0%)	1 (2.2%)	2 (1.4%)
	Segmented	1 (1.0%)	0 (0%)	1 (0.7%)
	No certain diagnosis	14 (13.7%)	0 (0%)	14 (9.5%)

Fracture type by Radiology and Surgery

Both Radiography and surgery identified transverse fractures as the most commonly observed fracture type with proportions of 54.1% and 52.7% respectively. Oblique fractures were the second most observed fractures by radiography (29.7%) and surgery (32.4%). On the other hand, green-stick, spiral, comminuted and segmented fracture types were each observed in less than 6% of the 148 cases at MTRH. These results are presented in table 4 below.

Table VI. Frequency Table of Fracture Types

	Radiography	Surgery
	N=148	N=148
Transverse	80 (54.1%)	78 (52.7%)
Oblique	44 (29.7%)	48 (32.4%)
Green-stick	3 (2.0%)	2 (1.4%)
Spiral	5 (3.4%)	5 (3.4%)
Comminuted	3 (2.0%)	2 (1.4%)
Segmented	2 (1.4%)	5 (5.4%)
No certain diagnosis	11 (7.4%)	8 (5.4%)

Table VII. Radiological Findings of Fractures

	Male	Female	Overall
	(N=102)	(N=46)	(N=148)
Clavicle fracture	1 (1.0%)	0 (0%)	1 (0.7%)
Condyle fracture	0 (0%)	1 (2.2%)	1 (0.7%)
Distal radius fracture	1 (1.0%)	2 (4.3%)	3 (2.0%)
Epicondyle fracture	4 (3.9%)	1 (2.2%)	5 (3.4%)
Humerus fracture	8 (7.8%)	3 (6.5%)	11 (7.4%)
Metacarpal fracture	0 (0%)	1 (2.2%)	1 (0.7%)
Proximal phalanx fracture	9 (8.8%)	4 (8.7%)	13 (8.8%)
Radius and Ulna fracture	6 (5.9%)	4 (8.7%)	10 (6.8%)
Supracondylar humerus fracture	72 (70.6%)	30 (65.2%)	102 (68.9%)
No certain diagnosis	1 (1.0%)	0 (0%)	1 (0.7%)

Radiological Findings

The leading radiological diagnosis among the observed children was supracondylar fracture which was observed on 102 (68.9%) of the children. This was followed by proximal phalanx fractures (8.8%), humerus fractures (7.4%) and fractures on the radius and ulna (6.8%) as shown in table 5

Surgical Findings of upper arm fractures

The Orthopaedic surgeons' reports showed that the supracondylar fractures were the most commonly observed fractures on 100 (67.6%) of the children. In descending order, proximal phalanx fractures (8.8%), radial and ulna (6.8%) and humerus fractures (6.8%) subsequently followed as shown in table 6:

Table VIII. Surgical Findings of Fractures

	Male	Female	Overall
	(N=101)	(N=46)	(N=148)
Clavicle fracture	1 (1.0%)	0 (0%)	1 (0.7%)
Condyle fracture	1 (1.0%)	3 (6.5%)	4 (2.7%)
Distal radius fracture	1 (1.0%)	2 (4.3%)	3 (2.0%)
Epicondyle fracture	4 (4.0%)	1 (2.2%)	5 (3.4%)
Humerus fracture	7 (6.9%)	3 (6.5%)	10 (6.8%)
Metacarpal fracture	0 (0%)	1 (2.2%)	1 (0.7%)
Proximal phalanx fracture	9 (8.9%)	4 (8.7%)	13 (8.8%)
Radius and Ulna fracture	6 (5.9%)	4 (8.7%)	10 (6.8%)
Supracondylar humerus fracture	71 (70.3%)	28 (60.9%)	100 (67.6%)
No certain diagnosis	1 (1.0%)	0 (0%)	1 (0.7%)

There was a high sense of agreement on the diagnosis made by radiography and surgery. Specifically, radiography and surgery made the same diagnostic conclusion by radiography and surgery on 142 (95.9%) of the children yet only 6 (4.1%) had different diagnosis. Further analysis using Cohen's Kappa showed an almost perfect level of agreement between radiographic and surgical findings (k=0.921, p-value<0.001).

Sample radiological findings

In this section, a sample of radiological findings is presented.

Figure 3: This is a left Lateral elbow radiography of a 10 years old, a boy with olecranon line of fracture.

Avulsion fracture of medial Condyle of the humerus was found during surgery.

Figure 4: Left AP elbow radiography

(continuation figure 4.8.1).

Figure 5: This is antero-posterior and lateral radiography of the left elbow of a boy of 12 years old showing supracondylar fracture with dislocation.

Figure 6: This AP and lateral views radiography of the left elbow of a boy 12 years old, post reduction and surgery for supracondylar fracture right humerus.

Figure 7: This an AP and lateral radiography of the left index finger of a boy of 10 years old, with fracture of middle phalanx of index finger.

Figure 8: This is an AP and lateral radiography of the left elbow of the female of 13 years old, with supracondylar fracture of left humerus.

Figure 9: Colle's fracture

Figure 10: This is a left lateral radiography of ring finger of a 12 years old male postero-anterior and lateral ring and little finger of the left hand: noted proximal phalanx fracture of the ring finger with dislocation.

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Majority of upper limb paediatric fractures, identified by radiology and surgery, were observed on the supracondylar followed by proximal phalanx
2. The major fracture type was transverse followed by oblique type.
3. There was a high level of agreement between radiological and orthopaedic surgical findings in the diagnosis of upper limb fractures in children.

Recommendations

Radiography is essential in the accurate diagnosis of paediatric fractures, and its continued use is of great value in patient management.

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REFERENCES

[1] Adams, H. (2020, October 21). Commonly Missed Orthopedic Injuries Missed Orthopedic Injuries. https://www.xpowerpoint.com/Commonly-Missed-Orthopedic-Injuries-Holly--PPT.html

[2] Alogayyel, N. S., Aldawodi, M. D., Ahmed, B., & Jawadi, A. H. (2018). Posterior shoulder dislocation in a 10-year-old child: Case report. Annals of Medicine and Surgery, 33(August), 32–35. https://doi.org/10.1016/j.amsu.2018.08.005

[3] Andronikou, S., Mchugh, K., Abdurahman, N., Khoury, B., Mngomezulu, V., Brant, W. E., Cowan, I., & Mcculloch, M. (2011). Paediatric radiology seen from Africa. Part I : providing diagnostic imaging to a young population. https://doi.org/10.1007/s00247-011-2081-8

[4] Apostolides, J. G., Lifchez, S. D., & Christy, M. R. (2011). Complex and rare fracture patterns in perilunate dislocations. Hand, 6(3), 287–294. https://doi.org/10.1007/s11552-011-9330-z

[5] Arora, R., Fichadia, U., Hartwig, E., & Kannikeswaran, N. (2014). Pediatric Upper-Extremity Fractures. Pediatric Annals, 43(5), 196–204. https://doi.org/10.3928/00904481-20140417-12

[6] Barbee, M. G. A., Berry-cabán, C. S., & Jacobs, B. R. (2013). Acute perilunate dislocation in a pediatric patient. 27–29. https://doi.org/10.1097/01.JAA.0000430340.10272.a5

[7] Berlin, L. (2001). Defending the "Missed" Radiographic Diagnosis. American Journal of Roentgenology, 176(2), 317–322. https://doi.org/10.2214/ajr.176.2.1760317

[8] Bochang, C., Katz, K., Weigl, D., Jie, Y., Zhigang, W., & Bar-On, E. (2008). Are frequent radiographs necessary in the management of closed forearm fractures in children? Journal of Children's Orthopaedics, 2(3), 217–220. https://doi.org/10.1007/s11832-008-0101-5

[9] Brady, A. P. (2017). Error and discrepancy in radiology: Inevitable or avoidable? Insights into Imaging, 8(1), 171–182. https://doi.org/10.1007/s13244-016-0534-1

[10] Caruso, G., Caldari, E., Sturla, F. D., Caldaria, A., Re, D. L., Pagetti, P., Palummieri, F., & Massari, L. (2021). Management of pediatric forearm fractures: What is the best therapeutic choice? A

narrative review of the literature. MUSCULOSKELETAL SURGERY, 105(3), 225–234. https://doi.org/10.1007/s12306-020-00684-6

[11] Chew, E. M., & Chong, A. K. S. (2012). Hand fractures in children: Epidemiology and misdiagnosis in a tertiary referral hospital. The Journal of Hand Surgery, 37(8), 1684–1688. https://doi.org/10.1016/j.jhsa.2012.05.010

[12] Donald, J. J., & Barnard, S. A. (2012). Common patterns in 558 diagnostic radiology errors. Journal of Medical Imaging and Radiation Oncology, 56(2), 173–178. https://doi.org/10.1111/j.1754-9485.2012.02348.x

[13] Eberl, R., Singer, G., Schalamon, J., Petnehazy, T., & Hoellwarth, M. E. (2008). Galeazzi lesions in children and adolescents: Treatment and outcome. Clinical Orthopaedics and Related Research, 466(7), 1705–1709. https://doi.org/10.1007/s11999-008-0268-6

[14] Elbaih, A., Taha, M., Saker, A., Aziz, S., & Shahate, A. (2016). Patterns of extremities trauma in children and their management in emergency department in Suez Canal University Hospital, Ismailia, Egypt. International Surgery Journal, 3(2), 887–892. https://doi.org/10.18203/2349-2902.isj20161163

[15] Fassier, A., Gaucherand, P., & Kohler, R. (2013). Fractures in children younger than 18months. Orthopaedics & Traumatology: Surgery & Research, 99(1, Supplement), S160–S170. https://doi.org/10.1016/j.otsr.2012.11.004

[16] Flynn, J. M., Sarwark, J. F., Waters, P. M., Bae, D. S., & Lemke, L. P. (2002). The operative management of pediatric fractures of the upper extremity. The Journal of Bone and Joint Surgery. American Volume, 84(11), 2078–2089. https://doi.org/10.2106/00004623-200211000-00025

[17] Gadgil, A., Roach, R., Neal, N., & Maffulli, N. (2002). CASE REPORT ISOLATED AVULSION FRACTURE OF THE CORONOID PROCESS REQUIRING OPEN REDUCTION IN A PAEDIATRIC PATIENT : A CASE REPORT. 4–6.

[18] George, M. P., & Bixby, S. (2019). Frequently Missed Fractures in Pediatric Trauma: A Pictorial Review of Plain Film Radiography. Radiologic Clinics of North America, 57(4), 843–855. https://doi.org/10.1016/j.rcl.2019.02.009

[19] Giannoulis, F. S., & Sotereanos, D. G. (2007). Galeazzi Fractures and Dislocations. 23, 153–163. https://doi.org/10.1016/j.hcl.2007.03.004

[20] Gil-albarova, J., Jorge, H. S., Universitario, H., Servet, M., & Herrera, A. (2013). Management of sternoclavicular dislocation in young children: Considerations about diagnosis and treatment of four cases Management of sternoclavicular dislocation in young children: Considerations about diagnosis and treatment of four cases. May 2014. https://doi.org/10.1007/s12306-012-0240-1

[21] Goulding, A. (2007). Risk factors for fractures in normally active children and adolescents. Medicine and Sport Science, 51, 102–120. https://doi.org/10.1159/000103007

[22] Guifo, M. L., Tochie, J. N., Oumarou, B. N., Tapouh, J. R. M., bang, A. G., Ndoumbe, A., Jemea, B., & Sosso, M. A. (2017). Paediatric fractures in a sub-saharan tertiary care center: A cohort analysis of demographic characteristics, clinical presentation, therapeutic patterns and outcomes. The Pan African Medical Journal, 27, 46. https://doi.org/10.11604/pamj.2017.27.46.11485

[23] Guly, H. R. (2001). Diagnostic errors in an accident and emergency department. Emergency Medicine Journal, 18(4), 263–269. https://doi.org/10.1136/emj.18.4.263

[24] Gupta, R., Kumar, A., Ansari, T., & Ratan, R. (2012). Coronoid Fracture. In Mastering Orthopedic Techniques: Intra-Articular Fractures (pp. 105–114). Jay Pee.

[25] Gyftopoulos, S., Chitkara, M., & Bencardino, J. T. (2014). Misses and errors in upper extremity trauma radiographs. American Journal of Roentgenology, 203(3), 477–491. https://doi.org/10.2214/AJR.14.12589

[26] Hannonen, J., Hyvönen, H., Korhonen, L., Serlo, W., & Sinikumpu, J.-J. (2019). The incidence and treatment trends of pediatric proximal humerus fractures. BMC Musculoskeletal Disorders, 20(1), 571. https://doi.org/10.1186/s12891-019-2948-7

[27] Hannonen, J., Sassi, E., Hyvönen, H., & Sinikumpu, J.-J. (2020). A Shift From Non-operative Care to Surgical Fixation of Pediatric Humeral Shaft Fractures Even Though Their Severity Has Not Changed. Frontiers in Pediatrics, 8, 728. https://doi.org/10.3389/fped.2020.580272

[28] Hedström, E. M., Svensson, O., Bergström, U., & Michno, P. (2010). Epidemiology of fractures in children and adolescents. Acta Orthopaedica, 81(1), 148–153. https://doi.org/10.3109/17453671003628780

[29] Jordan, R. W., & Jones, A. DR. (2017). Radial Head Fractures. The Open Orthopaedics Journal, 11(Suppl-8, M8), 1405–1416. https://doi.org/10.2174/1874325001711011405

[30] Kaewlai, R., & Abujudeh, H. (2012). Peer review in clinical radiology practice. American Journal of Roentgenology, 199(2), 1–5. https://doi.org/10.2214/AJR.11.8143

[31] Kaisidis, A., Pantos, P. G., Bochlos, D., & Lindner, H. (2018). Biomechanical Analysis of the Fixation Strength of a Novel Plate for Greater Tuberosity Fractures. The Open Orthopaedics Journal, 12(1), 218–228. https://doi.org/10.2174/1874325001812010218

[32] Khambalia, A., Joshi, P., Brussoni, M., Raina, P., Morrongiello, B., & Macarthur, C. (2006). Risk factors for unintentional injuries due to falls in children aged 0–6 years: A systematic review. Injury Prevention, 12(6), 378–381. https://doi.org/10.1136/ip.2006.012161

[33] Kim, H., Kwon, B., Kim, J., & Nam, K. (2018). Isolated hook of hamate fracture in sports that require a strong grip comprehensive literature review. 97(46).

[34] Kitay, A., & Wolfe, S. W. (2012). Scapholunate instability: Current concepts in diagnosis and management. Journal of Hand Surgery, 37(10), 2175–2196. https://doi.org/10.1016/j.jhsa.2012.07.035

[35] Lazzaro, A. Di, & Guzzanti, V. (2014). Radial Neck Fractures in Children: Results When Open Reduction Is Indicated. January 2015. https://doi.org/10.1097/BPO.0000000000000299

[36] Luigi, G., Gennaro, D., Spina, M., Lampasi, M., Libri, R., & Donzelli, O. (2008). Fractures of the proximal humerus in children. December 2014. https://doi.org/10.1007/s12306-008-0050-7

[37] Lyons, R. A., Delahunty, A. M., Kraus, D., Heaven, M., McCabe, M., Allen, H., & Nash, P. (1999). Children's fractures: A population based study. Injury Prevention, 5(2), 129–132. https://doi.org/10.1136/ip.5.2.129

[38] Mark, J., Nimphius S., Hart N.H., Chivers P., Rantalainen T., Rueter K., Borland M.L., McIntyre F., Stannage K., & Siafarikas A. (2018). Appendicular fracture epidemiology of children and adolescents: A 10-year case review in Western Australia (2005 to 2015). Archives of Osteoporosis, 13(1).

[39] Marzi, I., & Reimers, A. K. (2018). Children's Independent Mobility: Current Knowledge, Future Directions, and Public Health Implications. International Journal of Environmental Research and Public Health, 15(11), 2441. https://doi.org/10.3390/ijerph15112441

[40] Mattijssen-Horstink, L., Langeraar, J. J., Mauritz, G. J., van der Stappen, W., Baggelaar, M., & Tan, E. C. T. H. (2020). Radiologic discrepancies in diagnosis of fractures in a Dutch teaching emergency department: A retrospective analysis. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 28(1), 38. https://doi.org/10.1186/s13049-020-00727-8

[41] MTRH. (2021). Moi Teaching and Referral HospitalAbout Us. Moi Teaching and Referral Hospital. http://www.mtrh.go.ke/about-us

[42] Murphy, A., Ekpo, E., Steffens, T., & Neep, M. J. (2019). Radiographic image interpretation by Australian radiographers: A systematic review. Journal of Medical Radiation Sciences, 66(4), 269–283. https://doi.org/10.1002/jmrs.356

[43] Pahlavan, S., Baldwin, K. D., Pandya, N. K., Namdari, S., & Hosalkar, H. (2011). Proximal humerus fractures in the pediatric population: A systematic review. Journal of Children's Orthopaedics, 5(3), 187–194. https://doi.org/10.1007/s11832-011-0328-4

[44] Pinto, A. (2010). Spectrum of diagnostic errors in radiology. World Journal of Radiology, 2(10), 377. https://doi.org/10.4329/wjr.v2.i10.377
[45] Popkin, C., Levine, W., & Ahmad, C. (2015). Evaluation and Management of Pediatric Proximal Humerus Fractures. The Journal of the American Academy of Orthopaedic Surgeons, 23, 77–86. https://doi.org/10.5435/JAAOS-D-14-00033
[46] Rennie, L., Court-Brown, C. M., Mok, J. Y. Q., & Beattie, T. F. (2007). The epidemiology of fractures in children. Injury, 38(8), 913–922. https://doi.org/10.1016/j.injury.2007.01.036
[47] Rowland, D. (2011). Common upper limb injuries in childhood. Surgery (Oxford), 29(4), 153–161. https://doi.org/10.1016/j.mpsur.2011.01.008
[48] Shannon, S., Larson, A. N., & Milbrandt, T. A. (2017). High-energy Pediatric Scapula Fractures and Their Associated Injuries. February 2018. https://doi.org/10.1097/BPO.0000000000000969
[49] Supakul, N., Hicks, R. A., Caltoum, C. B., & Karmazyn, B. (2015). Distal humeral epiphyseal separation in young children: An often-missed fracture-radiographic signs and ultrasound confirmatory diagnosis. AJR. American Journal of Roentgenology, 204(2), W192-198. https://doi.org/10.2214/AJR.14.12788
[50] Ting, B., Sesko Bauer, A., Abzug, J. M., Cornwall, R., Wyrick, T. O., & Bae, D. S. (2017). Pediatric Scaphoid Fractures. Instructional Course Lectures, 66, 429–436.
[51] Urch, E. Y., & Lee, S. K. (2015). Carpal fractures other than scaphoid. Clinics in Sports Medicine, 34(1), 51–67. https://doi.org/10.1016/j.csm.2014.09.006
[52] Wang, H., Feng, C., Liu, H., Liu, J., Ou, L., Yu, H., & Xiang, L. (2019). Epidemiologic Features of Traumatic Fractures in Children and Adolescents: A 9-Year Retrospective Study. BioMed Research International, 2019, e8019063. https://doi.org/10.1155/2019/8019063
[53] Wang, H., Yu, H., Zhou, Y., Li, C., Liu, J., Ou, L., Zhao, Y., Song, G., Han, J., Chen, Y., & Xiang, L. (2017). Traumatic fractures as a result of falls in children and adolescents: A retrospective observational study. Medicine, 96(37), e7879. https://doi.org/10.1097/MD.0000000000007879
[54] Wei, C.-J., Tsai, W.-C., Tiu, C.-M., Wu, H.-T., Chiou, H.-J., & Chang, C.-Y. (2006). Systematic analysis of missed extremity fractures in emergency radiology. Acta Radiologica (Stockholm, Sweden: 1987), 47(7), 710–717. https://doi.org/10.1080/02841850600806340
[55] Whitley, Stewart. A., Sloane, C., Hoadley, G., Moore, A., & Alsop, C. (2017). Clark's Positioning in Radiography. In Journal of Medical Radiation Sciences (12th ed., Vol. 64, pp. 38–77). Oxford University Press Inc.,.
[56] Yin, Z.-G., Zhang, J.-B., Kan, S.-L., & Wang, X.-G. (2012). Diagnostic accuracy of imaging modalities for suspected scaphoid fractures. The Journal of Bone