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ORIGINAL ARTICLE

Elastic Intramedullary Nail versus K. Wires in Management of Pediatric Both-Bone Forearm Fractures

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Abstract

Background: ***Diaphyseal fractures of both bones in the forearms are amongst the most prevalent fractures in children, making up anywhere from 13 to 40 percent of all pediatric fractures.***

Aim and objectives: ***To evaluate pediatric diaphyseal fracture fixation outcomes using k-wires compared with elastic intramedullary nails.***

Patients and methods: This was a prospective randomized control trial carried out on twenty children with diaphyseal both bone forearm fractures at Bab Al-Sharia (Sayed Galal) university hospital & Abo Khalifa Hospital: 10 fractures were fixed by K-wires, and elastic nails fixed other ten fractures.

Results: ***There was no statically significant variance among k-wires & Elastic intramedullary nails concerning delayed union & time of union with (p-value=0.305 & 0.415) correspondingly. There was no significant difference between k-wires and Elastic intramedullary nails concerning complications & complications Type. Considerable variations among the K-wires group and intramedullary elastic nails regarding operative time were higher in the intramedullary elastic nails than in the K-wires group.***

Conclusion: ***Intramedullary fixation is a sound method of surgery for the stabilization of diaphyseal forearm fractures in children who require surgery. Utilizing either K-wires or Nancy nailing can yield excellent findings. Theoretically, k-wires offer advantages, but in our study, they weren't found to enhance outcomes significantly.***

Keywords: Elastic Intramedullary Nail; K. Wires; Fracture; Both-Bone Forearm

1. Introduction

Diaphyseal fractures affecting both bones in the forearms are a prevalent type of fracture observed in children, making up anywhere from 13 to 40 percent of all pediatric fractures.[1] There is a range of severity in fractures, from plastic deformation to significant displacement. The usual treatment for these fractures is closed reduction & immobilization with an above-elbow cast for 4-6 weeks.[2] However, a number of problems can happen if the fracture doesn't heal properly because it is likely to re-displace if it is unstable.[3] After the remodeling and healing, a forearm fracture will be considered successful if the case can return to normal function with the restored length, alignment & rotation. [4]

Intramedullary fixation has attained widespread popularity in treating pediatric forearm fractures, which mainly involve utilizing flexible nails, rods, or wires. Thus, it relies on an interference fit and a strategically placed bow for stability. Rod dimensions, contour, and placement techniques are crucial. Motion is generally present at the fracture site after fixation, and these fractures typically demonstrate secondary fracture healing with callus formation. The fixation technique is practically unstable to rotational displacement, although an appropriately placed rod diameter and bow lessen this. Most surgeons initially supplement rod fixation with cast immobilization postoperatively. [5]

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K-wire fixation offers many benefits in the simplicity of placement, affordability, ease of removal, availability in most hospitals, and limited risk of physical injury regarding not endangering bone growth. On the other hand, Elastic intramedullary nails aid in speedy bone healing by keeping the fracture site appropriately reduced, providing less invasive, relatively easy application, protecting bone alignment through three-point contact, and speeding up the formation of a bridging callus through micro-movements at the fracture site. [6]

This research aimed to assess outcomes of pediatric diaphyseal fracture fixation using k-wires compared with elastic intramedullary nails.

2. Patients and methods

This prospective comparative trial was performed on twenty patients with fractures of both bones in the forearm. Those cases were allocated into two equal groups:

Group A: 10 individuals were fixed intramedullary by k-wires, and Group B: 10 were fixed intramedullary elastic nails.

Inclusion criteria: Diaphyseal both bone forearm fractures, Age: 4-14 years, Both genders and non-comminuted fractures.

Exclusion criteria: Open fractures, NV injury, Old fractures, Comminuted or pathological fractures, & Child below four or above 14 years.

Sample Size (n):

This study is based on a survey carried out by NAGESO et al.. The sample size was measured by Epi Info STATCALC, considering the following assumptions: The study utilized a 95 % two-sided confidence level and a power of 80%, with a margin of error of 5 percent. The ultimate maximum sample size extracted from the Epi-Info output was 18. Therefore, the sample size was augmented to include 20 cases to account for any dropout throughout the follow-up period.[7]

$$\left(\frac{Z_{a/2} + Z_B}{P_1 - P_2}\right)^2 (p_1q_1 + p_2q_2)$$

Takazawa& Morita. [8]

n = sample size

Z a/2 (The crucial number that demarcates the center 95 percent of the Z distribution)

ZB (The crucial number that demarcates the center 20 percent of the Z distribution)

p1 = prevalence in case group

p2 = prevalence in the control group.

q = 1-p

Methods

Every patient admitted underwent a thorough workup that included a complete medical history, a physical examination, a radiological evaluation, and laboratory tests.

Methods of Examination: History, Clinical examination, and Radiological evaluation (The X-ray film must include the elbow and wrist joints to exclude associated dislocations or epiphyseal injuries).

Methods of treatment: First aid treatment, Routine laboratory tests, and Timing of surgery.

Surgical technique

For k-wires (group 1): All participants were supine on the operating table while under general anesthesia. The wounded upper limb was then placed on a radiolucent arm table. The shoulder was abducted by 90 degrees, and the forearm was extended and supinated. In conjunction with the induction of anesthesia, antibiotic prophylaxis was administered to prevent infection. The image intensifier was parallel to the patient's body; the arm was prepared and disinfected with betadine. Fluoroscopy was first used to test closed reduction. The ulnar fracture was treated first after closed, or open reduction since fixing it was easier because the medullary canal was straight. The k-wires group proceeded by inserting the wire through the olecranon tip, then using the image intensifier to drill under vision across the fracture site to the distal metaphysis, careful not to break its growth plate. Finally, a radius wire was inserted by surgically drilling through Lister's tubercle.

At the end of the procedure, the K-wires were bent and cut outside the skin, leaving the ends of the K-wires exposed, avoiding skin breakdown. Group B: Elastic Nail Surgical Technique: The skin was cut 1.5 to 2 centimeters in a longitudinal direction, approximately three centimeters from the apophysis, and antegrade from the lateral cortex in the elastic nail group. To achieve an incision, the awl was positioned distally, three centimeters from the apophysis and just before the back border, or about four millimeters laterally to the back of the olecranon's crest. The intended outcome necessitated these actions. The nail was further advanced distally to the fracture site using mild oscillating movements after being inserted by a T-handle. The distal lateral radius was then incised using a longitudinal incision that was between one and two centimeters in length. Following the removal of soft tissue, an awl is inserted near the physical line under the supervision of a fluoroscopic examination to protect the dorsal branch of the superficial radial nerve. After that, an intramedullary nail that is flexible and of the appropriate size is implanted. Under the skin's surface, the nail's distal end was

severed. Titanium nails were utilized in every instance. Each bone received one nail. Following the rule of thumb for nail diameter choice: nail diameter = 40% of intramedullary canal diameter.[9] Compression dressing was applied for all cases. The limb was then put in an above-elbow slab, with the elbow in ninety-degree flexion and the forearm in mid-pronation. Implant removal was done in the K-wires group after 6-7 weeks in the outpatient clinic and after 3-5 months in the elastic nails group with the second removal operation.

3. Results

Table1. Comparison among k-wires & Elastic intramedullery nails concerning demographic data

		K-WIRES GROUP	ELASTIC INTRAMEDULLERY NAILS	TEST VALUE	P-VALUE	SIG.
		No. = 10	No. = 10			
AGE	Mean ± SD	8.70 ± 2.06	9.60 ± 2.37	-0.908•	0.376	NS
	Range	6 – 12	6 – 14			
SEX	Female	4 (40.0%)	5 (50.0%)	0.202*	0.653	NS
	Male	6 (60.0%)	5 (50.0%)			

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS) *:Chi-square test; •: Independent t-test

This table demonstrated that there was no significant variance observed among k-wires & Elastic intramedullery nails concerning age and sex .Table 1

Table 2. Comparison among k-wires & Elastic intramedullery nails concerning dominate hand, mechanism of injury, fracture pattern and location.

		K-WIRES GROUP		ELASTIC INTRAMEDULLERY NAILS		TEST VALUE*	P-VALUE	SIG.
		No.	%	No.	%			
DOMINANT HAND	Right	8	80.0%	7	70.0%	0.267	0.606	NS
	Left	2	20.0%	3	30.0%			
MECHANISM OF INJURY	Fall	7	70.0%	6	60.0%	0.220	0.639	NS
	Accident	3	30.0%	4	40.0%			
FRACTURE PATTERN	Short oblique	3	30.0%	2	20.0%	0.267	0.606	NS
	Transverse	7	70.0%	8	80.0%			
FRACTURE SIDE	Right	6	60.0%	7	70.0%	0.000	1.000	NS
	Left	4	40.0%	3	30.0%			
LOCATION	Midshaft	7	70.0%	6	60.0%	0.277	0.871	NS
	Distal	2	20.0%	3	30.0%			
	Proximal	1	10.0%	1	10.0%			

There was no statically significant variance among k-wires and Elastic intramedullery nails concerning dominate hand, mechanism of injury, fracture pattern and location. Table 2

Table 3. Comparison among k-wires and Elastic intramedullery nails concerning delayed union and time of union

		K-WIRES GROUP	ELASTIC INTRAMEDULLERY NAILS	TEST VALUE	P-VALUE	SIG.
		No. = 10	No. = 10			
SLAB DURATION (WEEKS)	Mean ± SD	6.60 ± 1.26	4.00 + 0.00	6.500•	0.000	HS
	Range	6 – 10	4 – 4			
DELAYED UNION	No	10 (100.0%)	9 (90.0%)	1.053*	0.305	NS
	Yes	0 (0.0%)	1 (10.0%)			
TIME OF UNION (WEEKS)	Mean ± SD	6.60 ± 1.26	7.90 ± 3.14	-1.214•	0.241	NS
	Range	6 – 10	6 – 16			

There was no statically significant variance among k-wires & Elastic intramedullery nails concerning delayed union & time of union with (p-value=0.305 & 0.415) respectively. Table 3

Table 4. Comparison between k-wires and Elastic intramedullery nails concerning complications and removal of implant

		K-WIRES GROUP	ELASTIC INTRAMEDULLERY NAILS	TEST VALUE*	P-VALUE	SIG.
		No. = 10	No. = 10			
COMPLICATIONS	Non-Complicated	9 (90.0%)	7 (70.0%)	1.250	0.264	NS
	Complicated	1 (10.0%)	3 (30.0%)			
NON-COMPLICATED		9 (90.0%)	7 (70.0%)	4.250	0.236	NS
SUPERFICIAL RADIAL NERVE		0 (0.0%)	1 (10.0%)			
PIN TRACT INF.		1 (10.0%)	0 (0.0%)			
SKIN IRRITATION		0 (0.0%)	2 (20.0%)			

There was no statistically significant among k-wires and Elastic intramedullery nails concerning complications & complications Type with (p-value>0.05). Table 4

Table 5: Comparison between k-wires and Elastic intramedullery nails regarding Implant removal manoeuver and Removal of implant (months)

		K-WIRES GROUP	ELASTIC INTRAMEDULLERY NAILS	TEST VALUE	P-VALUE	SIG.
		No. = 10	No. = 10			
IMPLANT REMOVAL MANOEUVER	Removal in outpatient	10 (100.0%)	0 (0.0%)	20.000*	0.000	HS
	Removal in operating room under general anesthesia	0 (0.0%)	10 (100.0%)			
REMOVAL OF IMPLANT (MONTHS)	Mean ± SD	1.55 ± 0.11	3.20 ± 0.63	-8.138•	0.000	HS
	Range	1.5 – 1.75	3 – 5			

There was statically significant difference found between k-wires and Elastic intramedullery nails regarding removal of implant and implant removal surgery. Table 5

Table 6. Comparison among k-wires and Elastic intramedullery nails concerning range of motion.

RANGE OF MOTION		K-WIRES GROUP	ELASTIC INTRAMEDULLERY NAILS	TEST VALUE•	P-VALUE	SIG.
		No. = 10	No. = 10			
FLEXION WRIST	Mean ± SD	64.50 ± 5.99	68.00 ± 8.23	-1.087	0.291	NS
	Range	55 – 75	55 – 80			
EXTENSION WRIST	Mean ± SD	62.00 ± 4.22	61.00 ± 6.15	0.424	0.676	NS
	Range	55 – 70	55 – 70			
FLEXION ELBOW	Mean ± SD	126.00 ± 4.40	125.80 ± 6.21	0.083	0.935	NS
	Range	120 – 135	120 – 135			
EXTENSION ELBOW	Mean ± SD	126.00 ± 4.40	125.80 ± 6.21	0.083	0.935	NS
	Range	120 – 135	120 – 135			
RADIAL DEVIATION	Mean ± SD	16.60 ± 2.46	15.70 ± 2.31	0.843	0.410	NS
	Range	13 – 20	12 – 19			
ULNER DEVIATION	Mean ± SD	27.00 ± 2.83	27.70 ± 2.11	-0.627	0.538	NS
	Range	21 – 30	24 – 30			
SUPINATION	Mean ± SD	78.70 ± 4.92	78.50 ± 5.13	0.089•	0.930	NS
	Range	70 –85	70 – 85			
PRONATION	Mean ± SD	67.60 ± 2.12	67.30 ± 2.00	0.325•	0.749	NS
	Range	65 – 70	65 – 70			

There was no significant variance among k-wires and Elastic intramedullery nails concerning range of motion (P-value >0.05). Table 6

Table 7: Comparison among k-wires and Elastic intramedullery nails concerning outcome according to Clavien Dindo classification.

CLAVIEN DINDO CLASSIFICATION	K-WIRES	ELASTIC INTRAMEDULLERY NAILS	TEST VALUE	P-VALUE	SIG.
	No. = 10	No. = 10			
NO COMPLICATIONS	9 (90.0%)	9 (90.0%)	2.000*	0.849	NS
1	0 (0.0%)	1 (10.0%)			
2	1 (10.0%)	0 (0.0%)			
3	0 (0.0%)	0 (0.0%)			
4	0 (0.0%)	0 (0.0%)			
5	0 (0.0%)	0 (0.0%)			

There was no statically significant variance among k-wires and Elastic intramedullery nails concerning Clavien Dindo classification (P-value >0.05). Table 7

Table 8: Comparison between k-wires and Elastic intramedullery nails regarding operative time

OPERATIVE TIME (MIN.)	K-WIRES GROUP	INTRAMEDULLERY ELASTIC NAILS	TEST VALUE	P-VALUE	SIG.
	No. = 10	No. = 10			
MEAN ± SD	27.10 ± 4.86	39.40 ± 4.58	-5.825•	<0.001	HS
RANGE	20 – 35	34 – 45			

There was significant distinction among K-wires group and intramedullery elastic nails regarding operative time was found higher in intramedullery elastic nails than K-wires group. Table 8

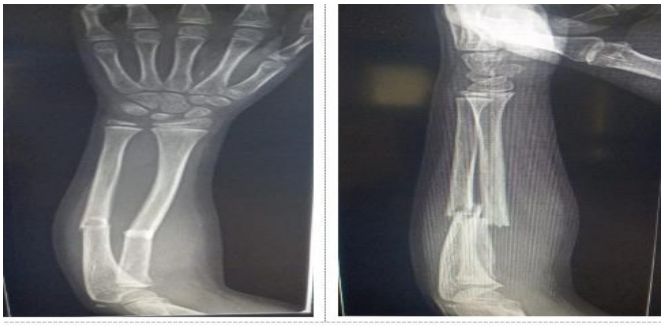
3.1.CASE PRESENTATION

Case 1:

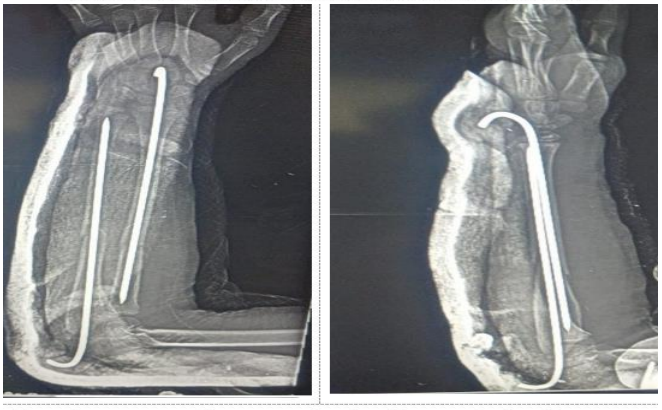
Male child 8 year's old came to E.R. complaining of pain and swelling of the left forearm after falling on the ground.

By examination localized tenderness over the forearm and diffuse swelling on the dorsum of the forearm was found, clinically angular deformity of the forearm was noticed and patient was neurovascular intact.

X-ray showed short oblique diaphyseal fracture of left both bone forearm.



Short oblique fracture left both bone forearm A/P & lat views.



Immediate postoperative x-ray showing fracture fixed with two intramedullary K-wires.

Post removal k wires x- rays (P.A and lateral views) showing stable united fracture

Full supination and pronation three months post-operative

Figure 1. case 1 (group).

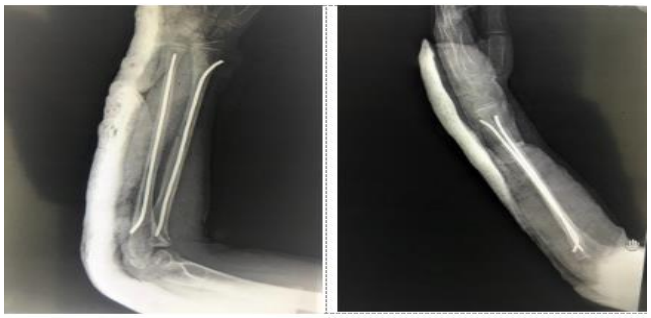
Case 2:

Male child 10 year's old came to E.R. of hospital complaining of pain and swelling of the left forearm after falling on the ground.

By examination localized tenderness over the forearm and diffuse swelling on the dorsum of the forearm was found, clinically angular deformity of the forearm was noticed and patient was neurovascular intact.

X-ray showed transverse diaphyseal fracture of left both bone forearm.

Transverse fracture left both bone forearm A/P &lat views.



Immediate postoperative x ray showing fracture fixed with two intramedullary elastic nails.

Post removal elastic intramedullary nails x- rays (P.A and lateral views) showing stable united fracture.

Full supination and pronation three months post-operative

Figure 2. case 2 (group B).

4. Discussion

Regarding the participants' demographic data, the current research discovered that in group A, males represent 60%, females 40%, and in group B, males represent 50%, and females represent 50%. There was no statistically significant variance among the two groups concerning sex; the mean± SD of sex and mean± SD. of age in group A is 8.70 ± 2.06 years old and ranges from 6 - 12 years, while in group B, the Mean ± SD. of age is 9.60 ± 2.37 years old and range from 6 to 14 years. There was no statistically significant variance among groups concerning age.

Compared to the study of Calder et al., there were 21 boys and 15, with a mean age of 10.6 years (which varies from 2.2 to 15.5 years). In group 2, there were 22 boys and two girls, with a mean age of 9.4 years (which ranged from 1.4 to 15.2 years, with a p-value of 0.11), and there was no statistical variation among them in terms of gender. [10]

In this research, we found that the majority of participants, 80% in group A, were right-handed, and 20% were left-handed. In comparison, the majority of participants, 70% in group B, were right-handed, and 30% were left-handed. The two groups had no statistically significant disparity concerning the dominant hand. Regarding the side incidence in the present study, the majority of participants, 60% in group A, had a right-side incidence, and 40% had a left-side incidence. Most participants, 70% in group B, had a right-side incidence, and 30% had a left-side incidence. There was no significant distinction between the two groups concerning side incidence.

In harmony with our findings, Hassan's study aimed to investigate the influence of dominant hand and gender on forearm fractures in children and adolescents. The findings of this research revealed that all children who suffered from unilateral forearm fractures were treated and evaluated by the parameters indicated earlier: There were a total of 70.2 percent boys and 29.8 percent girls. Boys were injured at an average age of 8.97 years (range 2-15 years), while girls were hurt at an average age of 5.98 years (range 2-12 years). A total of 69.6 percent of all cases involved youngsters who were of school age. There 59.17 percent of the children who had forearm fractures in the hand that was not their dominant hand (58.89 percent for right-handed children and 66.66 percent for left-handed children). The children were 90.05 percent right-handed and 9.95 percent left-handed for the most part.[11]

Concerning the mechanism of injury, the current research revealed that in group A, the % of cases were due to falls, 70%, and 30% were accidents. In comparison, in group B, 60% was due to falls, 40 was accidents, and there was no significant variance between the two groups concerning the mechanism of injury, while regarding the Level of fracture, showing that in group A, the majority of cases are at mid-shaft fracture 70%, 10% was proximal and 20% was distal, while in group B 60% was in mid-shaft, 30% in distal fracture and 10% in proximal. The two groups had no statistically significant variation concerning the fracture level.

Contrary to our findings, the research of Alrashedan et al.that This study aimed to assess the frequency of forearm fractures in children up to the age of 18 at a level I trauma center. It also sought to distinguish between children aged ≥4 & <12 years old in terms of sex, fracture site, fracture side, and injury mechanism. The results showed that 82.1 percent of the participants had injuries caused by falls. The distal forearm was the most commonly fractured site (48.11%), with fractures in the distal third of the forearm shaft following at 34.28%. 16.04% of the forearm shaft fractures were in the middle third, whereas 1.57% were in the proximal third. The radius and ulna diaphyseal fractures were classified into three distinct thirds: proximal, medial, and distal. Most commonly, this research identified shaft fractures in the distal third of the radial and ulnar shafts as the most common type of shaft fracture.

Grabal reviewed 126 cases (7.55%) that were

found to be radial shaft fractures out of 1668 cases of forearm fractures when the fractures were classified in accordance to their site.[10, 12]

This research found no significant distinction among the two groups regarding associated fractures or conditions. Regarding different postoperative functional parameters, we found no statistically significant difference between the two groups relating to the degree of loss of flexion and extension of the elbow and wrist, the Percentage of loss of supination and pronation, Infection, or Complications.

The study of Vander Reis et al. found no distinction between intramedullary nailing and plate fixation regarding functional outcomes, union rate, or complication rate. The advantages of the intramedullary approach were highlighted.[13]

The present study revealed that the Mean ±SD of slab duration in group A is 6.60 ± 1.26 weeks and 4.00 + 0.00 weeks in group B, and there was a significant variation between the two groups. Regarding implant removal, our study revealed that the Mean ±SD of implant removal in group A is 1.55 ± 0.11 months and 3.20 ± 0.63 months in group B, and there was a significant distinction between the two groups.

In line with our outcomes, the research of Kruppa et al. reported that after an average of 3.8 months (range 0.4-16.3 months), 166 fractures (82.2%) were surgically removed from our department. No follow-up consultation for problems was conducted in 137 out of 166 (82.5%) participants following implant removal.[14]

On the other hand, our findings demonstrated that the majority in both groups, 80%, was of 6 weeks in Time of union. The mean ±SD of Time of union in group A is 6.60 ± 1.26 weeks and 7.90 ± 3.14 weeks in group B, and there is no significant distinction between the two groups regarding Time of union.

In line with our results, the study of Lascombes et al. reported Union time usually varies from 6-12 weeks, with an average of 8.1 weeks. Every single individual had a fracture that was united.[15]

5. *Conclusion*

Intramedullary fixation is a sound method of surgery for the stabilization of diaphyseal forearm fractures in children who require surgery. Utilizing either K-wires or Nancy nailing can yield excellent findings. Theoretically, k-wires offer advantages, but in our study, they weren't found to enhance outcomes significantly.

5.1 Limitations

This study needed a more extended period for the patient to follow up; it was done at early ages only, included small sample size, and was not made in the multicenter location.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

References

1. Nguyen A, Hart R. Imaging of non-accidental injury; what is clinical best practice?. J Med Radiat Sci. 2018;65(2):123-130.
2. Pace JL. Pediatric and Adolescent Forearm Fractures: Current Controversies and Treatment Recommendations. J Am Acad Orthop Surg. 2016;24(11):780-788
3. Franklin CC, Robinson J, Noonan K, Flynn JM. Evidence-based medicine: management of pediatric forearm fractures. J Pediatr Orthop. 2012;32 Suppl 2:S131-S134.
4. Antabak A, Luetic T, Ivo S, et al. Treatment outcomes of both-bone diaphyseal paediatric forearm fractures. Injury. 2013;44 Suppl 3:S11-S15.
5. Vopat ML, Kane PM, Christino MA, et al. Treatment of diaphyseal forearm fractures in children. Orthop Rev (Pavia). 2014;6(2):5325.
6. Passiatore M, De Vitis R, Perna A, D'Orio M, Cilli V, Taccardo G. Extraphyseal distal radius fracture in children: is the cast always needed? A retrospective analysis comparing Epibloc system and K-wire pinning. Eur J Orthop Surg Traumatol. 2020;30(7):1243-1250.
7. Nageso D, Tefera K, Gutema K. Enrollment in community based health insurance program and the associated factors among households in Boricha district, Sidama Zone, Southern Ethiopia; a cross-sectional study. PLoS One. 2020;15(6):e0234028.
8. Takazawa A, Morita S. Optimal Decision Criteria for the Study Design and Sample Size of a Biomarker-Driven Phase III Trial [published correction appears in Ther Innov Regul Sci. 2020 Sep;54(5):1035-1036.
9. Alrashedan BS, Jawadi AH, Alsayegh SO, et al. Patterns of paediatric forearm fractures at a level I trauma centre in KSA. J Taibah Univ Med Sci. 2018;13(4):327-331.
10. Calder PR, Achan P, Barry M. Diaphyseal forearm fractures in children treated with intramedullary fixation: outcome of K-wire versus elastic stable intramedullary nail. Injury. 2003;34(4):278-282.
11. Hassan FO. Hand dominance and gender in forearm fractures in children. Strategies Trauma Limb Reconstr. 2008;3(3):101-103.
12. GRABALA, Pawel. Epidemiology of forearm fractures in the population of children and adolescents: Current data from the typical polish city. Orthop Muscular Syst, 2015, 4.203: 2161-0533.
13. Van der Reis WL, Otsuka NY, Moroz P, Mah J. Intramedullary nailing versus plate fixation for unstable forearm fractures in children. J Pediatr Orthop. 1998;18(1):9-13.
14. Korup LR, Larsen P, Nanthan KR, et al. Children's distal forearm fractures: a population-based epidemiology study of 4,316 fractures. Bone Jt Open. 2022;3(6):448-454.
15. Lascombes P, Haumont T, Journeau P. Use and abuse of flexible intramedullary nailing in children and adolescents. J Pediatr Orthop. 2006;26(6):827-834.