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Evaluation of Outcome of Percutaneous K-wires Fixation of Pediatric Both Bone Forearm Fractures

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ABSTRACT
Background: Forearm fractures are the most common fractures in children, representing 40 to 50 percent of all childhood fractures. **Objective:** To improving outcome of pediatric both bone forearm fractures using K-wires. **Patients and Methods:** This study included 24 patients aged between 3 and 12 years with closed displaced fractures of shaft of both bones forearm presented to Zagazig General Hospital. On admission all patients were assessed by history taking, clinical examination and radiological evaluation. The K-wires were passed under control of image intensifier across the fracture site as far as the proximal physis in the radius and the distal metaphysis in the ulna taking care not to reach the growth plate. Postoperatively the limb was placed in above elbow plaster cast with the elbow at 90 degrees of flexion and the forearm at mid pronation. After the follow up period (6 - 12) month the results of patients were assessed clinically and radiologically and were classified according to the Price criteria. **Results:** 9 patients (37.5%) were classified as excellent results while 15 patients (62.5%) were classified as good results and no patients were classified as fair or poor results. **Conclusion:** Closed reduction percutaneous intramedullary fixation of pediatric displaced diaphyseal forearm fractures by K-wires is a safe, reliable, minimally invasive procedure and effective method of treatment. Based upon this study, it is concluded that displaced fractures of both forearm bones in children are preferred to be intramedullary fixed with K-wires when surgery is indicated with excellent and good results.
Keywords: Bone Forearm Fractures, Outcome, Pediatric, Percutaneous K-wires Fixation.

INTRODUCTION
Forearm fractures are the most common fractures in children, representing 40 to 50 percent of all childhood fractures. In one large series, forearm shaft fractures of the radius ranked as the third most common fracture after distal radial fractures and supracondylar humeral fractures. In addition, midshaft forearm fractures are the most common sites for refracture in children and among the most common sites of pediatric open fractures [(1)].

The rate of forearm shaft fractures in school-age children (more than 5 years old) is more than double that in toddlers (1.5 to 5 years old). Age also may have an effect on injury severity. In boys there is a bimodality peak, the first at approximately age 9 years and the second at approximately 13 or 14 years of age. Girls show a single peak at approximately 5 or 6 years [(2)].

Approximately 75 % to 84 % of forearm fractures occur in the distal third with another 15 % to 18 % in the middle third, while 1 % to 7 % of cases occur in the proximal third. A small percentage are bilateral, and as many as 13 % have an associated supracondylar fracture. Just over 50% of these fractures are greenstick fractures [(3)]. Initial preoperative translation of more than 100% (no cortical contact) has been correlated with a greater chance of tissue interposition that requires a mini-open reduction [(4)].

Because of numerous differences in both treatment and prognosis, shaft fractures are considered to be clinically distinct from fractures of the distal (metaphyseal fractures and physeal fractures) and proximal (radial neck fractures and physeal fractures) ends of the same bones. Many experienced clinicians have pointed out the increasing level of treatment difficulty as the level of forearm fracture moves proximally and more proximal fractures tend to occur in older patients [(5)]. The goal of treatment of forearm and distal radius injuries is to facilitate union of the fracture in a position that restores functional range of motion to the elbow and forearm. Most shaft injuries present no unusual challenges and require nothing more than skillful closed reduction and cast immobilization due to the unique property of the growth potential of the immature skeleton [(6)].

There is a subset of patients in whom surgical intervention is indicated. The most common indications for surgery are failure of closed reduction, open fractures, and fracture instability. When operative intervention is indicated different techniques can be employed such as intramedullary nailing, osteosynthesis with plate and screw fixation and external fixators. Intramedullary nailing has been shown to produce excellent clinical results and in contrast to plate fixation is considered as a minimal invasive procedure [(7)].

The aim of this study was to improving outcome of pediatric both bone forearm fractures using K-wires.

PATIENTS AND METHODS
This a clinical trial study included 24 patients with fractures of forearm bones in children aged between 3 and 12 years with closed displaced fractures of shaft of both bones forearm presented to Zagazig General Hospital.

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Inclusion criteria: The type of trauma: fractures of forearm bones in children. Both genders were included, and age from 3 years up to 12 years.
Exclusion criteria: Pathological fractures. Chronic diseases as renal, hepatic, cardiac patients. Malnutrition. Malignancy, and open fractures.

All patients included in the study were subjected to the following:
Patients' information's had been collected from the hospital data and connection with them had been through phone calling and hospital follow up visits. Patients had been subjected to clinical and radiological examination including:
Detailed history taking including:

- Patients' age and gender.
- Time of trauma.
- Mood of trauma.
- Medical comorbidities as (diabetes mellitus (DM), etc.)

Careful clinical examination:
General:

- Blood pressure, pulse, cardiovascular, neurological and respiration assessment.

Local:

- Inspection: for deformity, edema, skin condition, wounds.
- Palpation: for tenderness.
- Range of motion.
- Neuro-vascular examination with examination of dorsalis pedis artery, posterior tibial artery, common peroneal nerve and posterior tibial nerve.

Previous studies investigating the use of K-wires have used one or more wires through the radial styloid or Lister's tubercle. It is unknown whether the number of K-wires is associated with fracture redisplacement. Reported complications of K-wire fixation include pin-track infections, pin migration, and hypertrophic scars at a rate of 0–38 % [8].

Radiographic evaluation:
The patients had the following radiological examinations:

- Plain X-ray: an anteroposterior (AP) and lateral views of the forearm.
- Computed tomography (CT) may be taken for more findings that are not apparent on plain radiographs (as in comminuted fractures, radio-ulnar joints, and articular involvement).

Laboratory investigations:

- The patients had the following preoperative routine lab investigations:
- Complete blood count (CBC).

(Red blood cell indices, Hemoglobin (Hb), Hematocrit (HCT, packed cell volume, PCV), Red blood cell (RBC) count.)

- Bleeding and coagulation profile.

Bleeding profiles are screening tests (Activated Partial Thromboplastin Time, Prothrombin Time, Thrombin Time, Fibrinogen) designed to detect abnormal blood clotting.
when interpreted together are used to identify deficiencies and defects in coagulation factors, the presence of inhibitors to coagulation factors, the effectiveness of blood-thinning medications, hereditary conditions, severe infections and liver problems.

- Random blood glucose level. HBA1C for diabetic patients.
- Urine analysis.
- Thyroid function tests.
- Lipid profile.
- ECG.

Preparation for surgery:

- Date of admission in hospital
- Time of operation: after subsidence of edema.
- Blood: one unit of packed RBCs was reserved for the case before the operation.
- Medications: analgesics, antiedematous and anticoagulant drugs.
- Past history of previous interventions.
- Laboratory investigations: To evaluate patient fitness for operative intervention: Complete blood count, random blood sugar, liver function tests, kidney function tests, bleeding and coagulation profile

Technique

The insertion sites were on the dorsal aspect and on the lateral edge of the distal radial metaphysis. A 10 mm incision was performed at each insertion site, followed by dissection to avoid tendon and neurovascular lesions. We used K-wires with 2 mm and 2.5 mm diameter in smaller and larger children, respectively. A dorsal K-wire was used to reduce the dorsal or volar tilt.

The K-wire was manually inserted in the fracture site, without crossing the physis, to lever out and reduce the distal fragment of the radius in the sagittal plane. Then, it was drilled forward, to penetrate the volar cortex to stabilize the fracture. After wiring, the stability test was performed with maximal flexion and extension of the wrist under radiographic control, to assess the stability and the necessity of an additional wire. If necessary, to achieve the reduction in the coronal plane, the same procedure was performed with a second K-wire intra-focally and extra-physeally inserted from the lateral incision. When radiographs and the stability test revealed good reduction and fixation, the K-wires were bent and cut, leaving the extremity exposed.

In case of open fractures or when regular pin tract care could not be assured by parents, K-wires were cut shorter and buried. In case of diaphyseal ulnar fracture, an elastic stable intramedullary nail was anterogradely inserted. At the end of the operation, the arm was immobilized with an above-elbow cast

Ethical consent:

An approval of the study was obtained from Zagazig University Academic and Ethical Committee. All patients and their guardians were informed about their fracture, the chosen treatment modalities, the operative technique, the expected outcomes and possible complications. Informed written consent was obtained from parents for participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical Analysis:

The collected data were computerized and statistically analyzed using SPSS program (Statistical Package for the Social Sciences) version 20.0. Qualitative data were represented as frequencies and relative percentages. Quantitative data were expressed as mean ± SD (Standard deviation) and range. Chi square test or McNemar test was used to calculate difference between qualitative variables in different groups. Independent and paired t-test were used to calculate differences between quantitative data. P value < 0.05 was considered significant.

RESULTS

The demographic data and the associated morbidity are shown in table 1.

Table (1): Age, sex, residence and associated medical conditions of the studied cases

Variable	(n=24)	
Age: (year)		
• Mean ± SD	8.17±2.84	
• Range	3-12	
	No	**%**
Age group:		
• 3 – 7 years	10	41.7
• 8 – 12 years	14	58.3
Sex:		
• Female	11	45.8
• Male	13	54.2
Residence:		
• Rural	11	45.8
• Urban	13	54.2
Associated medical conditions:		
• No	21	87.5
• Yes (Type 1 diabetes mellitus)	3	12.5

SD: Standared deviation

The mechanism of trauma in 54.2% of the cases were fall onto an outstretched hand (FOOSH) and in 16.7% of cases were road traffic accident (RTA) while 29.2% of cases were injured by direct trauma. Side of the lesion, dominant hand and affected bone and associated fractures among the studied cases are shown in table 2.

Table (2): Mechanism of trauma, side of the lesion, dominant hand and affected bone and associated fractures among the studied cases

Variable	(n=24)	
	No	**%**
Mechanism:		
• FOOSH	13	54.2
• RTA	4	16.7
• Direct	7	29.2
Dominant hand:		
• Right	19	79.2
• Left	5	20.8
Side:		
• Right	12	50
• Left	12	50
Lesion in dominant hand:		
• No	7	29.2
• Yes	17	70.8
Level:		
• **Middle 1/3**	17	70.8
• **Distal 1/3**	7	29.2
Affected bone:		
• Radius only	2	8.3
• Ulna only	3	12.5
• Both	19	79.2

In all cases the operation were succeeded. The time of the operation and its outcome according to Price scoring system, and its complications are shown in table 3.

Table (3): Operation time and outcome according to the criteria of Price and complications of the studied cases

Variable	(n=24)	
Intraoperative time: (min)		
• Mean ± SD	48.71±6.17	
• Range	40-60	
Union time: (weeks)		
• Mean ± SD	7.58±1.72	
• Range	5-10	
	(n=24)	
	No	**%**
Operation outcome:		
• Failed	0	0
• Succeed:	24	100
○ Excellent	9	37.5
○ Good	15	62.5
Complications:		
• No	19	79.2
• Yes (pin tract infection)	5	20.8

SD:Standared deviation

As regard limitation in forearm, there was statistical significant difference when comparing pre- with postoperative frequency. Also there was a statistical significant increase in mean range of rotation, a statistical significant decrease in mean difference in range of supination and a statistical significant decrease in mean difference in range of pronation on comparing pre- and postoperative values **(Table 4).**

Table (4): Range of rotation among the studied group pre- and postoperative

Variable	Pre (n=24)		Post (n=24)		Test	P
	No	%	No	%		
Limitation in forearm:						
No	4	16.7	4	16.7	**Mc**	
Yes in supination	3	12.5	6	25	**10.4**	**0.04***
Yes in pronation	2	8.3	3	12.5		
Yes in both	15	62.5	11	45.8		
Range of rotation:					**t**	
Mean ± SD	165.21±8.78		169.17±7.02		**4.16**	**<0.001**
Range	150-180		160-180			**
Limitation in Supination:					**t**	
Mean ± SD	9.72 ± 1.18		9.12±3.18		**1.99**	**0.04***
Range	5 - 10		5-15			
Limitation in pronation:					**t**	
Mean ± SD	10.59 ± 4.64		6.43±2.34		**5.51**	**<0.001**
Range	5 - 20		5-10			**

SD: Standared deviation, Mc:McNemar test, t:paired t test
***: Significant (P<0.05), **: highly significant (P<0.001)**

There was no statistical significance relation between outcome and age, sex or residence among the studied cases **(Table 5).**

Table (5): Relation between outcome and age, sex and residence among the studied cases

Variable	Good (n=15)		Excellent (n=9)		t	P
Age : (year)						
• Mean ± SD	7.60±2.97		9.11±2.47		1.28	0.21
• Range	3-12		6-12			
Variable	**No**	**%**	**No**	**%**	**χ^2**	**P**
Age group:						
• 3 – 7 years	6	60	4	40	0.05	0.83
• 8 – 12 years	9	64.3	5	35.7		
Sex:						
• Male	7	53.8	6	46.2	0.91	0.34
• Female	8	72.7	3	27.3		
Residence:						
• Rural	8	72.7	3	27.3	0.91	0.34
• Urban	7	53.8	6	46.2		

SD:Standared deviation t:Independent t test χ^2: Chi square test

There was no statistical significant relation between outcome and associated medical conditions but there was a statistical significant increase in frequency of injury by FOOSH in excellent cases compared to good cases. There was no statistical significant relation between outcome and side, site or affected bone among the studied cases. There was a statistical significant decrease in operation time among excellent cases compared to good cases but no difference was found between them in union time **(Table 6).**

Table (6): Relation between associated medical conditions and mechanism of trauma, side, level and site and operation time and time of fracture union outcome among the studied cases

Variable	Good (n=15)		Excellent (n=9)		χ^2/t	P
	No	%	No	%		
Associated medical conditions:						
• No	13	61.9	8	38.1	0.03	0.87
• Yes (Type 1 DM)	2	66.7	1	33.3		
Mechanism:						
• FOOSH	5	38.5	8	61.5	**7.22**	**0.03***
• RTA	4	100	0	0		
• Direct	6	85.7	1	14.3		
Side:						
• Rt	7	58.3	5	41.7	**0.18**	**0.67**
• Lt	8	66.7	4	33.3		
Lesion in dominant hand:						
• No	5	71.4	2	28.6	**0.34**	**0.56**
• Yes	10	58.8	7	41.2		
Level						
• Middle 1/3	11	64.7	6	35.3	**0.12**	**0.73**
• Distal 1/3	4	57.1	3	42.9		
Affected bone:						
• Radius only	2	100	0	0		
• Ulna only	2	66.7	1	33.3	**1.39**	**0.50**
• Both	11	57.9	8	42.1		
Intraoperative time: (min)						
• Mean ± SD	50.53±6.70		45.67±3.78		**2.28**	**0.03***
• Range	40-60		41-51			
Union time: (weeks)						
• Mean ± SD	7.6 ± 1.88		7.56 ± 1.51		0.06	0.95
• Range	5 - 10		5 - 10			

χ^2: Chi square test, t: Independent t-test, *: Significant (P<0.05)

There was a statistical significance increase in frequency of limitation in both pronation and supination in good cases compared to excellent cases. There was no statistical significant relation between outcome and complication among the studied cases **(Table 7).**

Table (7): Relation between limitation in supination or pronation and complication and outcome among the studied cases

Variable	Good (n=15)		Excellent (n=9)		χ^2	P
	No	%	No	%		
Limitation in forearm:						
• No	0	0	4	100		
• Yes in supination	0	0	3	100	**17.88**	**<0.001****
• Yes in pronation	1	50	1	50		
• Yes in both	14	93.3	1	6.7		
Associated medical condition:						
• No	13	68.4	6	31.6	**1.36**	**0.24**
• Yes: (Pin tract infection)	2	40	3	60		

χ^2: Chi square test, **: Highly Significant (P<0.001)

DISCUSSION

In our study, we reported excellent (8 patients) and good (4 patients) results in children with unstable forearm fractures treated by intramedullary fixation with K-wires. **Sahin *et al.*** [10] study showed that intramedullary fixation of forearm fractures in children with titanium nail or K-wire does not affect radiological and clinical results. Both elastic stable intramedullary nail and K-wire fixation were effective in stabilizing pediatric diaphyseal forearm fractures. Percutaneous IM K-wiring with immobilization in a cast is an easy, minimally invasive, and safe method with a good functional outcome. They stated that only 5 of 57 patients had angulation from 10° to 15° and none had nonunion, premature epiphyseal closure, or deep infection. They assessed the outcome of K-wires or ESIN as the method for fracture stabilization in such diaphyseal forearm fractures and demonstrated no difference in outcome between K-wires and ESIN as our study, although the nails do offer some theoretical advantages.

Various studies have shown that intramedullary nailing can provide precise fracture reduction, maintains stabilization for fracture healing, results in minimal cosmetic deformity and facilitates easy removal of implants after treatment [11]. However, documented complications of this technique include nail site infections, skin irritation at nail insertion sites, implant migration or failure (bent or broken pins), loss of reduction, refracture, nerve and tendon injury, decreased range of motion, delayed union, nonunion and compartment syndrome. Because of the low complication rate, these authors recommended intramedullary nailing for most children older than 10 years and children younger than 10 years for whom conservative treatment failed [12].

In our study the age of the studied cases ranged from 3 to 12 years with mean 8.17 years. Also 50% of the cases were from 3 to 7 years and 50% were from 8 to 12 years. **Alrashedan *et al.*** [12] reported that the incidence of pediatrics forearm fractures was more common in males than in females. This observation can be explained by the fact that males are more involved in sports and traffics than females, so they are more prone to injuries. While other reported almost equal incidences. In our study there were 6 males (50%) and 6 females (50%).

Open reduction and use of plate fixation make stabilization and anatomic reduction of forearm fractures, as well as more complete correction of malrotation and restoration radial bow to allow early range of motion [13]. Others advised that after reduction, the forearm should be immobilized in the same position that reduced the fracture. Even if these types of fractures rarely require intervention after initial closed reduction, it is prudent to avoid high-risk activities Supplemental plaster cast immobilization after intramedullary fixation is still recommended, as the rotational stability of pediatric forearm fractures treated by intramedullary pinning is still under investigations [14].

The mean time to union in our study was 7.58 $\pm$ 1.72 weeks (the earliest was 5 weeks and the latest was 10 weeks). This was like the results obtained by **Dwivedi *et al.*** [15], the most common functional deficit after malunited forearm fractures is particularly reduced motion of pronation and supination.

Studies consistently demonstrate that clinically significant limitations of forearm rotation occur after 15–20° of radio-ulnar or dorso-volar angular deformity **Jayakumar and Jupiter** [16] demonstrated that diaphyseal angulations of 10° or less in the dorso-volar direction or toward the IOM did not alter forearm motion. However, angulations of 20° in the radius or ulna in either direction caused 30 % loss of pronation–supination and functionally important restrictions to rotation. Most activities of daily living could be accomplished with 100 degree of forearm rotation equally divided between pronation and supination. **Kataoka** [17] reported that only 2 of 17 patients with persistent malunion (defined as angulation of 20^{o}) noted a functional or cosmetic problem.

Given the potential failure of nonoperative management (1.5% to 31%), the importance of minimizing angular deformity to preserve normal forearm rotation and operative management of pediatric forearm fractures has become increasingly popular [16]. In our study there were 7/12 patients had a difference between the two sides in forearm rotation.

In the current study, complications were detected in 3 patients (25%). **Kelly *et al.*** [18] reported 24%, complication rate.

The study of **Zupancic *et al.*** [19] included 88 (42 boys) children. The average age of children at day injury was 10.5 ± 2.59 years (range 4-16), and at the review clinic was 13.4 ± 1.85 years (range 7-18). Forty-six (52.3 %) had right forearm and 42 (47.7%) had left fracture respectively. Open reduction was required in 20 (22.7%) children. Primarily surgically treated were 62 (70.5%) children and 26 (29.5%) were operated upon as a second procedure after failed conservative management. There was one delayed union. Rotational forearm restriction with values between 11 and 20 degrees was present in nine children. Six children developed radial nerve hypoesthesia which eventually resolved with time. After removal of the implant one child sustained a refracture. The overall complication rate was 25%. Complete recovery to the original condition was noted in 76 (86.4%) children, eleven children (12.5%) had good and only one (1.1%) had poor outcome. In our study no cases of refracture. Refracture is another rare complication that can happen up to 6 months after the initial injury. A 20% refracture rate was noted in patients who had unicortical delayed union, and the authors emphasized the importance of 6 week follow up radiographs before return to activity [20].

Other studies have advocated the insertion of the wire from the metaphysis of the distal radius and

proximal ulna to spare the growth plate and epiphysis, but the technique requires a larger bending angle to pass the pins through the medullary canal [21].

Wang *et al.* [22] in the comparative study with the inconsistent definition of the complications across all included studies, the meta-analysis of overall complications was inappropriate. Thus, only the major adverse events including incidence of fixation failure, infection, nonunion, symptomatic hardware, hypertrophic scar, and refracture after implant removal were incorporated into the meta-analysis to summarize the evaluation. Six studies reported the incidence of fixation failure, with a low frequency in both groups.

CONCLUSION

Closed reduction percutaneous intramedullary fixation of pediatric displaced diaphyseal forearm fractures by K-wires is a safe, reliable, minimally invasive procedure and effective method of treatment. Based upon this study, it is concluded that displaced fractures of both forearm bones in children are preferred to be intramedullary fixed with K-wires when surgery is indicated with excellent and good results.

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REFERENCES

1. **Iyer R, Thapa M, Khanna P *et al.* (2012):** Pediatric bone imaging: imaging elbow trauma in children- a review of acute and chronic injuries. AJR Am J Roentgenol., 198(5):1053-68.
2. **Corsino C, Reeves R, Sieg R (2021):** Distal Radius Fractures. In: StatPearls . Treasure Island (FL): StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK536916/
3. **Denisiuk M, Afsari A (2021):** Femoral Shaft Fractures. In: StatPearls . Treasure Island (FL): StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK556057/
4. **McCoy J, Nelson R (2021):** Avulsion Fractures. In: StatPearls . Treasure Island (FL): StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK559168/
5. **Pencle F, Varacallo M (2021):** Proximal Humerus Fracture. In: StatPearls . Treasure Island (FL): StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK470346/
6. **Johnson N, Smolensky A (2021):** Galeazzi Fractures. In: StatPearls . Treasure Island (FL): StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK470188/
7. **Paluvadi S, Lal H, Mittal D, Vidyarthi K (2014):** Management of fractures of the distal third tibia by minimally invasive plate osteosynthesis - A prospective series of 50 patients. J Clin Orthop Trauma, 5(3):129-136.
8. **Ramoutar D, Silk R, Rodrigues J *et al.* (2014):** Quality of plaster molding for distal radius fractures is improved through focused tuition of junior surgeons. J Orthop Trauma, 28(8): 180-5.
9. **Valisena S, Hamitaga F, Gonzalez J *et al.* (2019):** Osteochondral flap fracture of the coronoid in pediatric elbow dislocation: a case report and literature review. Eur J Orthop Surg Traumatol., 29(1):213-220.
10. **Sahin N, Akalın Y, Türker O *et al.* (2017):** ESIN and K-wire fixation have similar results in pediatric both-bone diaphyseal forearm fractures. Turkish Journal of Trauma & Emergency Surgery, 23(5):415-420.
11. **Jubel A, Andermahr J, Isenberg J *et al.* (2005):** Outcomes and complications of elastic stable intramedullary nailing for forearm fractures in children. Journal of Pediatric Orthopedics. Part B., 14: 375-80.
12. **Alrashedan B, Jawadi A, Alsayegh S *et al.* (2018):** Patterns of paediatric forearm fractures at a level I trauma centre in KSA. J Taibah Univ Med Sci., 13(4):327-331.
13. **Zheng W, Tao Z, Chen C *et al.* (2018):** Comparison of three surgical fixation methods for dual-bone forearm fractures in older children: a retrospective cohort study. Int J Surg Lond Engl., 51:10–16
14. **Naranje S, Erali R, Warner W *et al.* (2016):** Epidemiology of pediatric fractures presenting to emergency departments in the United States. Journal of Pediatric Orthopaedics, 36(4): 45-48.
15. **Dwivedi R, Joshi R, Panthi S *et al.* (2015):** Outcome of both bone forearm fracture fixation in children by rush nails. JNMA J Nepal Med Assoc., 53: 244-9.
16. **Jayakumar P, Jupiter J (2014):** Reconstruction of malunited diaphyseal fractures of the forearm. Hand (N Y), 9(3):265-273.
17. **Kataoka H (2015):** SPME techniques for biomedical analysis. Bioanalysis, 7(17):2135-44.
18. **Kelly B, Shore B, Bae D *et al.* (2016):** Pediatric forearm fractures with in situ intramedullary implants. Journal of Children's Orthopaedics, 10(4): 321-327.
19. **Zupancic B, Antabak A, Popovic L *et al.* (2002):** Successful early pyeloplasty in infants. Arch Med Res., 33(2):158-61.
20. **Truntzer J, Vopat M, Kane P *et al.* (2015):** Forearm diaphyseal fractures in the adolescent population: treatment and management. European Journal of Orthopaedic Surgery & Traumatology, 25(2): 201-209.
21. **Gogna P, Gaba S, Mukhopadhyay R *et al.* (2017):** Neglected epiphyseal injuries of the distal end of the radius with ulnar impaction: analysis of distal osteotomy of both bones using a dorsal midline approach. J Orthopaed Traumatol., 18: 31–36.
22. **Wang Q, Du M, Pei X *et al.* (2019):** External fixator-assisted ulnar osteotomy: A novel technique to treat missed Monteggia fracture in children. Orthopaedic Surgery, 11(1): 102-108.