Research Article
Orthopaedics

EFFICACY OF ELASTIC STABLE INTRAMEDULLARY NAILING (ESIN) V/S SUBMUSCULAR PLATING IN PAEDIATRIC FEMORAL DIAPHYSEAL FRACTURES

Kamal Kumar Arora[1], Simranjit Singh[2], Rajesh Kapila[3], Priti Chaudhary[4], Dhalwinder Singh[2]

[1] - Assistant Professor, Dept. Of Orthopaedics, Govt. Medical College, Amritsar
[2] - Senior resident, Dept. Of Orthopaedics, Govt. Medical College, Amritsar
[3] - Professor, Dept. Of Orthopaedics, Govt. Medical College, Amritsar
[4] - Professor & Head, Dept. Of Anatomy, G. G. S. M.C. H. Faridkot

Corresponding Author:
Dr. Kamal Kumar Arora,
Assistant Professor, Deptt. Of orthopaedics,
Govt. Medical College, Amritsar,
163-p, bazaar no. 7, ferozepurcant 152001
Mobile no. 9855952964

Article submitted on: 09 November 2017
Article Accepted on: 17 November 2017

Abstract:
Diaphyseal femur fractures account for 1.7%[1] of all paediatric fractures. Common options for surgical stabilization include open or sub muscular plate fixation, flexible intra medullary nailing Plate fixation is stable and addresses the entire length of the femur but flexible nailing is minimally invasive and well suited to fractures of the central 2/3 of the diaphysis. Recent publications have suggested that submuscular plates achieve an earlier union than intra medullary titanium elastic nails. The present study consisted of 50 cases with diaphyseal femoral fracture of either sex within age group 5-16 years, treated with elastic stable intramedullary nail (ESIN) & submuscular plating (25 cases in each group). Average time of union was 10.2 weeks for submuscular plating &10.9 weeks for titanium nailing. The final outcome was excellent in 76% (40% cases in plating, 36% in ESIN), satisfactory in 20% cases and had 4% poor outcome. The main complication with nailing was mal union and pain with irritation at the site of nail insertion.

Key words: *femur, fracture, titanium, submuscular, plating.*

Introduction

During the past decade, surgical stabilization has gained favour in the management of femoral shaft fractures in skeletally immature paediatric patients. Diaphyseal femur fractures account for 1.7%[1] of all paediatric fractures. Patients in this intermediate age group have high risk of shortening and malunion when conservative measures are used.[2,3,4]

Common options for surgical stabilization include open or submuscular plate fixation, flexible intramedullary nailing. Each method has advantages and disadvantages, with the ideal technique largely debated. In comminuted fractures, ESIN may require supplemental external support. Plate fixation is stable and addresses the entire length of the femur but flexible nailing is minimally invasive and well suited to fractures of the central 2/3 of the diaphysis.

Metaizeau and the team from Nancy, France, developed the technique of Operative flexible stable intra-medullary pinning (FSIMP) using titanium pins[5,6]

Both titanium elastic nails & submuscular plate osteosynthesis are gaining popularity as the treatment for femoral shaft fractures in 5-15 years of age. They preserve the fracture hematoma as well. Recent publications have suggested that submuscular plates achieve an earlier union than intra medullary titanium elastic nails This study aimed to compare the results of treatment of femur fracture in children treated with retrograde intramedullary Titanium Elastic Nail and AO plate osteosynthesis.

Aims And Objectives Of Study

To compare the efficacy of elastic stable intramedullary nailing (ESIN) v/s sub-muscular plating in diaphyseal fracture of femur in children.

Material And Methods

The present study consisted of 50 cases with diaphyseal femoral fracture of either sex within age group 5-16 years, admitted in Orthopaedics Department, of a tertiary Hospital, Punjab treated with elastic stable intramedullary nail (ESIN) & submuscular plating (25 cases in each group). An informed consent & approval from the ethical committee was of the institution taken.

Inclusion criteria for surgery

- Children and adolescent patients from 5 to 16 years of both sexes.
- Children with only closed diaphyseal femoral fractures, otherwise fit for surgery were included fractures.

Exclusion criteria for surgery

- Patients less than 5 years of age and more than 16 years of age.
- Patients unfit for surgery or not willing for surgery due to any reason – medical or otherwise / with compound fractures.

Pre-operatively detailed history was taken related to the mode of injury, any past and associated medical illness & were assessed clinically for general condition and skeletal and soft tissue injuries. Hemodynamic stability was ensured. The fractured limb was immobilized with skin traction.

- Radiological assessment: Plain radiographs of AP and lateral views of thigh including hip and knee joints.
- Patients who were posted for surgery &underwent scrubing of the entire limb on the day before surgery and in operation theatre prior to the surgery along with intravenous antibiotics.

Plate length- was determined from the type of fracture. A minimum of 10 hole plate was used. Emphasis was on keeping the adequate working length at the fracture site.

Nail width – The diameter of the nail is selected as per:-

(a) Flynn et al's formula.
Diameter of nail= width of the narrowest point of the medullary canal onAP and lateral view × 0.4mm

(b) Intra operative assessment: Diameter of the nail is chosen so that each nail occupies at least 1/3rd -40% of the medullary cavity.

Nail length- should extend from the level of the distal femoral physis to a point just 2 cm distal to the capital femoral physis and 1 cm distal to the greater trochanteric physis.

General/spinal anaesthesia of was administered. Patient appropriately was placed supine on spica table with traction to the affected limb and table adjusted as per requirement of image intensifier.

The operative extremity cleaned, painted and draped. Physics identified by fluoroscopy; 2.5 cm longitudinal skin incision was made over the medial and lateral surface of the distal femur starting 2 cm proximal to the distal femoral epiphyseal plate, soft tissue was split down to the bone. Bone entry was made with the help of Awl/ 3.2 mm drill bit.

The drill/awl was then inclined 10^{o} to the distal femoral cortex. A prebent nail was introduced with T-handle by rotation movements of the wrist.

Under image intensifier control, the nail was driven with twisting movements up to the fracture site which was aligned to near anatomical

position with particular attention to limb rotation.Thereafter nail was pushed to the proximal fragment aligning the fragments in the process. Same was done on medial side and both nails were pushed further proximally till their tips became fixed into the cancellous bone of the proximal femoral metaphysis short of reaching the epiphyseal plate. The tips of the nail that entered the lateral femoral cortex should come to rest just distal to the trochanteric physis. The opposite nail should be at the same level towards the calcar region. Correct position of the nails was confirmed through image intensifier.

The two-nail construct should be in the symmetrical alignment face to face with the maximum curvature of the nails at the level of fracture.

Distally the nails were cut leaving only 0.5-1 cm outside the cortex. The extra-osseous portion of the nail was slightly bent away from the bone to facilitate removal later on.Wounds were irrigated with normal saline and then stitched in layers. Aseptic dressing was done.

In other group, under general/spinal anesthesia, on a standard table the patient is supine. After preparation, a postero-lateral approach with minimal soft tissue dissection and periosteal elevation to avoid devitalization or excessive callus formation is performed. Manipulation to achieve reduction, correction of angulation and length restoration is tried and then applications of 4.5 narrow dynamic compression plate applied. Closure in layers is used over a suction drain.

Post-operatively I/V antibiotics for Ist 3 days, switched over to oral antibiotics on the 4th day were given. Sutures were removed on the 12th postoperative day and patients were discharged with an advice not to bear weight till instructed.

Post operatively static quadriceps exercises begun within 48 hours & active knee and hip movements started after 3-4 days. Segmental or long spiral fractures were applied lacer postoperatively. Partial weight bearing allowed after 6 weeks but delayed in segmental fractures & full weight bearing by 8-12 weeks. Assessment was done at 6, 12 and 24 weeks.

Clinical assessment

1. Any associated pain& its severity
2. Range of movements

Joints movements	Hip		Knee	
	Flexion	Extension	Flexion	Extension
Full range	0-160	0-10	0-140	-
Mild restriction	0-140	0-10	0-120	-
Moderate restriction	0-100	0-10	0-100	-
Severe restriction	<100	-	<100	-

3. Measurement of limb length for limb length discrepancy.
4. Time of partial & full weight bearing (in weeks).

Radiological Assessment

X-ray thigh full length with hip and knee joints – AP and LATERAL views

- Alignment sagittal/coronal angulation (in degrees - <10 or >10)
- Rotational mal alignment (in degrees - <10 or >10)
- Circumferential callus formation – good / adequate / poor.
- Visibility of fracture line – seen clearly / masked / obliterated

Complications

Minor complications included:-

1. Pain at the site of nail insertion/ application of plate
2. Minor angulation (< 10 degree – saggital/coronal)
3. <10 degree rotational mal allignment at final follow-up (24 weeks)
4. Minor leg length discrepancy(< 2cm – shortening/lengthening) at final follow-up (24 weeks)
5. Superficial infection at site of nail insertion/application of plate

Major complications included

1. Angulation exceeding the guidelines (>10 degree – saggital/coronal; or > 10 degree rotational mal alignment) at final follow-up
2. Leg length discrepancy exceeding the guidelines (>2cm – shortening/lengthening) at final follow-up
3. Deep infection
4. Loss of reduction requiring repeat surgery
5. Surgery to revise nail placement/plate removal
6. Compartment syndrome requiring surgery
7. Neurological damage after nailing
8. Delayed or nonunion with plate/ nail leading to revision

The final outcome based on the above observations is done as per Flynn's criteria (given below).[19]

TENS outcome score

Results at 24 weeks / Variables	Excellent	Satisfactory	Poor
Limb-length inequality	<1.0 cm	<2.0 cm	>2.0 cm
Mal alignment	5°	10°	>10°
Unresolved pain	Absent	Absent	Present
Other complications	None	Minor and resolved	Major and lasting morbidity

Additional Variables Included In Our Study

Variables	Excellent	Satisfactory	Poor
Range of movements	Full range	Mild restriction	Moderate-severe restriction
Time for union	8-12 weeks	13-18 weeks	>18 weeks

Observations And Results

Observations and results were done for the following parameters.

Age Distribution Of Patients

50 cases with fresh diaphyseal femoral fractures between the age of 05-16 years were included. The oldest patient in our study was 14.5 years of age and the youngest being 6 years. 76% of the cases were <10 years of age and 24% were above 10 years age.

Age in years	No. of patients	Percentage (%)
5-8	38	76.0
9-12	06	12.0
13-16	06	12.0
Total	50	100.0

Sex Distribution Of Patients

60% of the patients were male & 40% were females.

Sex	No. of patients	Percentage (%)
Male	30	60.0
Female	20	40.0
Total	50	100.0

Mode Of Injury Of Patients

88%of the patients suffered injuries in RTA and 12% of the patients had history of fall from height. So the overall mode of injury was road traffic accident.

Mode of injury	No. of patients	Percentage (%)
Road traffic accident (RTA)	44	88.0
Fall from height	6	12.0
Total	50	100.0

Side Affected Of Patients

52% patients suffered fractures on the right side and 44% patients on the left side and 04% patients had suffered bilateral femoral shaft fractures.

Side	No. of patients	Percentage (%)
Right	26	52.0
Left	22	44.0
Bilateral	2	4.0
Total	50	100.0

Pattern Of Fracture Of Patients

48% patients had transverse fracture, 24% had spiral and 20% patients had oblique fracture while 8% had segmental fracture.

Pattern of fracture	No. of patients	Percentage (%)
Transverse	24	48.0
Oblique	10	20.0
Spiral	12	24.0
Segmental	4	08.0
Comminuted	0	00.0
Total	50	100.0

Level Of Fracture In Patients

40 patients suffered fracture in the middle 1/3rd region, 08 patients had fracture in the proximal 1/3rd region and only 02 patient had fracture in distal 1/3rd region.

Level of fracture	No. of patients	Percentage (%)
Proximal 1/3rd	08	16.0
Middle 1/3rd	40	80.0
Distal 1/3rd	02	04.0
Total	50	100.0

Associated Fractures

A total of 96% cases had isolated femoral shaft fracture and 04% cases also had undisplaced ipsilateral tibial shaft fractures, managed by closed reduction and POP cast application.

Associated fractures	No. of patients	Percentage (%)
Isolated femur fracture	48	96.0
Femoral fracture associated with other fractures (I/L tibia)	2	04.0
Total	50	100.0

Trauma Interval Between And Surgery

Surgery was performed as soon as possible after stabilization of the patient. 80% patients operated within 2 days of injury. 12% patients operated within 3-5 days of injury, 08% patients reported to our hospital after 5 days of injury and were operated on the 7th day.

Time interval between trauma and surgery	No. of patients	Percentage (%)
<2 days	40	80.0
3-5 days	6	12.0
>5 days	4	08.0
Total	50	100.0

In Duration Of Surgery Minutes

In 08% of the patients had operative time of less than 30 minutes, 80% patients had between 30-60 minutes and 12% patients had >60 minutes. Average duration of surgery was 47.7 minutes.

Duration of surgery (min)	No. of patients			
	Plating	Percentage	Flexi-nailing	Percentage
<30	1	02.0%	3	06.0%
30-60	20	40.0%	20	40.0%
>60	4	08.0%	2	04.0%
Total	25	50.0%	25	50.0%

- The time taken for nailing was shorter than that for the plating in our study.

Duration of stay in hospital in days

86% of the patients were discharged within 5-7 days. These patients were discharged after wound inspection on the 5th day and were advised follow up on 12th day for stitch removal. 14% patients were discharged with 8-12 days.

Duration of stay (days)	No. of patients			
	Plating	Percentage	Flexi-nailing	Percentage
<7 days	21	42.0%	22	44.0%
8-12 days	04	08.0%	03	06.0%
Total	25	50.0%	25	50.0%

Partial Weight Bearing

Partial weight bearing with allowed between 6-7 weeks. 70% patients started partial weight bearing in between 6-7 weeks and 30% patients started partial weight bearing between 8-9 weeks.

Partial weight bearing	No. of patients			
	Plating	Percentage	Flexi-nailing	Percentage
6-7 weeks	20	40.0%	15	30.0%
8-9 weeks	05	10.0%	10	20.0%
Total	25	50.0%	25	50.0%

- Partial weight bearing was allowed in more no. of cases with plating (40%) in 6-7 weeks

Time Of Full Weight Bearing

Full weight bearing	No. of patients			
	Plating	Percentage	Flexi-nailing	Percentage
<12 weeks	20	40.0%	16	32.0%
>13-18 weeks	04	08.0%	05	10.0%
>18weeks	01	02.0%	04	08.0%
Total	25	50.0%	25	50.0%

- Full weight bearing was allowed in more no. of cases (40%) with plating in <12 weeks

Time For Union

80% of the patients showed radiological union in 8-12 weeks, 16% in 13-18 weeks and 4% in 19-24 weeks. No patient had delayed or non union.

Full weight bearing	No. of patients			
	Plating	Percentage	Flexi-nailing	Percentage
8-12 weeks	20	40.0%	20	40.00%
13-18 weeks	05	10.0%	03	06.00 %
19-24 weeks	00	00.0%	02	04.00%
Delayed union	-	-	-	-
Non union	-	-	-	-
Total	25	50.0%	25	50.0

- 25 patients achieved union in 18 weeks with plating as compared to 23 in ESIN

Range Of Movements At 24 Weeks

80% patients had full range of movements at knee and hip and 20% patients had mild restriction of movements in accordance with the Flynn's criteria. None of our patient

had moderate or severe restriction of movements.

No. of patients				
Range of movements (degree)	**Plating**	**Percentage**	**Flexi-nailing**	**Percentage**
Full range	22	44.0%	18	36.00 %
Mild restriction	3	6.0%	07	14.00%
Moderate restriction	-	-	00	00.00%
Severe restriction	-	-	00	00.00%
Total	25	50.0%	25	50.0

- Full range of motion was more with plating (44%) as compared to ESIN (36%) post operatively

Results

Result	No. of patients	Percentage (%)
Excellent	38	76.0
Satisfactory	10	20.0
Poor	2	04.0
Total	50	100.0

- Excellent results were obtained in 76%, satisfactory results in the 20% cases and poor in 04% cases

CASE I: case fixed with ESIN

CASE II: fixed with sub muscular plating

Discussion

The literature has compared operative outcomes in femoral shaft fractures in the skeletally immature child. However, these studies have largely focused on the adolescent population.[7,8] The current study compared 2 surgical methods of fixation in skeletally immature children 5 years and older. In our study, average age of patients was 8.16 yrs& was comparable to J. N. Ligier et al. Who studied children with a mean age of 10.2years.[17] There were 40% girls and 60% boys in the present study. The sex incidence is comparable to other studies in the literature. J. N. Ligier et al.[17] had 67.7% boys and 22.3% girls[17]. Gamal El-Adl et al,had 72.7% male and 27.3% females.[18] RTA was the most common mode of injury accounting for 88% cases and fall from height accounted for 12% of the cases comparable to J. M .Flynn et. Al[19], having 58.1% cases following RTAs, 19.6% following fall due to skidding and remaining 28.8% as a result of fall from height[18]. In our study, transverse fractures accounted for 48% cases, oblique fractures-20%, spiral fractures –24% and 8% segmental fractures in accordance with J. N. Ligier et al.[17] who encountered 38.2% transverse fractures, comminuted fractures-20.3%, oblique fractures - 23.3%, spiral fractures –15.4 and 3.2% segmentalfractures in children[7].we opted for sub muscular plating in spiral /oblique fractures as these were unstable in nature.

In our study16% had fracture in the proximal 1/3rd, 80% in the middle 1/3rd and 4% in the distal 1/3rd. In Hanumantharaya et al. et study, 25% were proximal 1/3rd, 65% were in the middle 1/3rd and 10% were in the distal 1/3rd region of femur.[20] In J. N. Ligier et al study34%fractureswere in the proximal 1/3rd, 36.5 in the middle 1/3rd and 29% were in the distal 1/3rd.[17]Average duration of surgery was a better one i.e.47.7 minutes. In Hanumantharaya et al study, average duration of surgery was 82 mins[20]. In Heybeli et al study (2004), average duration of surgery was 55 mins[21] and in Bar-On et al study (1997) it was 74 mins.[22]

In our study average time of union was 10.2 weeks for submuscular plating & 10.9 weeks for titanium nailing. Oh C.W et al reported it as 10.5 weeks.[23] Aksoy C, et al reported average time of union 16 weeks (3 to 7) months for nailing.[24] In our study, closed reduction of the fracture & preservation of fracture hematoma, improved biomechanical stability and minimal soft tissue dissection led to rapid union of the fracture & is better/

Complications

15 patients, had minor complications and none of the patient had any major complication

No. of patients				
Complications (if any)	**Plating**	**Percentage**	**Flexi-nailing**	**Percentage**
Minor	05	10.0%	10	20.00 %
Major	00	00.0%	00	10.00%
No complication	20	40.00%	15	30.00%
Total	25	50.00%	25	50.00%

- No. of complications were more (20%) with nailing when compared to plating (10%).

comparable to the previous studies in both methods but it was slightly better in plating. In the present study, the average time of full weight bearing was 10.6 weeks in plating & 11.6 weeks in ESIN, comparable Flynn et al (2002) study of (8.5) weeks[19] but slightly more due to lack of compliance on part of the patient. 80% patients had full range of hip and knee motion (44% in plating, 36% in ESIN) the present study and 14% patients had mild restriction in knee flexion at 12 weeks when nailing was done as compared to J.M.Flynn et al.[19] who reported only 0.9% cases of knee stiffness treated with titanium elastic nails mainly because of lack of comprehensive post operative rehabilitation programme. In our study, 12% patients had developed pain at site of nail insertion during initial follow up, better than J.M. Flynn et al. who reported 16.2% cases of pain at site of nail insertion treated with titanium elastic nails.[19] Previous studies showed an incidence of implant irritation after flexible nailing of as high as 52%.[14] Each of these children in his study underwent implant removal that resulted in complete symptomatic relief. In our study, in ESIN 4% patients presented with varus angulation of 5 degrees thus at par with J.M.Flynn et al who reported 4.3% cases of minor angulation.[19] Herndon et al noticed varus angulation ranging from 7 to 25° in 4% patients treated with spica casting and no varus angulation in surgical group.[25] The varus mal alignment that occurred in our study thus is within the acceptable limits. In the present study, the final outcome was excellent in 76% (40%cases in plating, 36% in ESIN), satisfactory in 20% cases and had 4% poor outcome comparable to J.M. Flynn et al. who got excellent in 65% cases, satisfactory in 25% cases and poor in 10% of the cases[19]& Heybeli et al (2004) who observed excellent in 71.4% cases, satisfactory in 25.7% cases and poor in 2.9% cases.[21] & also with Moroz et al (2006) who found excellent results in 65% cases, satisfactory in 25% cases and poor in 10% cases.[15] This confirmed that the sub muscular plating has an edge over the ESIN.

Conclusion

Operative stabilization of pediatric femur fractures with a submuscular bridge plate has also become increasingly popular as compared to ESIN. This option offers decreased risk of infection, shorter operative time, and minimal blood loss when compared with titanium elastic nailing. This technique optimizes biologic healing by providing a stable internal construct. It is found in the present study that submuscular plating provided the shortest time to full weight bearing as well as the fastest time to union. Study showed that submuscular plating is an effective alternative to ESIN for the treatment of fractures of unstable length. It is concluded that submuscular plating produced excellent healing rates, low complication rates, and early return to weight bearing. Factors associated with ESIN poor outcome and increased risk of malunion included fractures of unstable length and increased patient weight. Therefore in unstable, comminuted fractures submuscular plating is clearly a more viable option.

References

1. McCartney D, Hinton A, Heinrich SD. Opera¬tive stabilization of pediatric femur fractures. OrthopClin North Am. 1994; 25(4):635-650Scheri SA, Miller L, Lively N, Russinof S, Sullivan M,
2. Tornetta P III etal.Accidental and nonaccidental femur fractures in children. ClinOrthop and Rel Research 2000; 376:96-105.
3. Momberger N, Stevens P, Smith J, Santora S, Scott S and Anderson J.Intramedullary nailing of femoral fractures in adolescents. J PediatrOrthop 2000; 20:482-484.
4. Lee SS, Mahar AT and Nowton PO. Ender nail fixation of pediatric femurfractures. A biomechanical analysis. J PediatrOrthop 2001; 21: 442-445.
5. Metaizeau JP. Osteosynthesis in children: techniques and indications (in French)Chir Pédiatr1983; 69 : 495-511.
6. Metaizeau JP. Osteosynthèse chez l' Enfant :Embrochage Centro MédullaireElastique Stable. Sauramps Med Dif - fusion Vigot, Montpellier,1988, pp 61-102.
7. Garner MR, Bhat SB, Khujanazarov I, Fly¬nn JM, Spiegel D. Fixation of length-stable femoral shaft fractures in heavier children: flexible nails vs rigid locked nails. J PediatrOrthop. 2011; 31(1):11-16.
8. Ramseier LE, Janicki JA, Weir S, Narayanan UG. Femoral fractures in adolescents: a com¬parison of four methods of fixation. J Bone Joint Surg Am. 2010; 92(5):1122-1129.
9. Hedequist DJ, Sink E. Technical aspects of bridge plating for pediatric femur fractures. J Orthop Trauma. 2005; 19(4):276-279.
10. Ağuş H, Kalenderer O, Eryanilmaz G, Omeroğlu H. Biological internal fixation of comminuted femur shaft fractures by bridge plating in children. J PediatrOrthop. 23(2):184-189.
11. Sink EL, Hedequist D, Morgan SJ,

Hresko T. Results and technique of unstable pediatric femoral fractures treated with submuscu¬lar bridge plating. J PediatrOrthop. 2006; 26(2):177-181.

12. Samora WP, Guerriero M, Willis L, Klingele KE. Submuscular bridge plating for length-unstable, pediatric femur fractures. J PediatrOrthop. 2013; 33(8):797-802.
13. Sink EL, Faro F, Polousky J, Flynn K, Gralla J. Decreased complications of pediatric fe¬mur fractures with a change in management. J PediatrOrthop. 2010; 30(7):633-637.
14. Narayanan UG, Hyman JE, Wainwright AM, Rang M, Alman BA. Complications of elastic stable intramedullary nail fixation of pediat¬ric femoral fractures, and how to avoid them. J PediatrOrthop. 2004; 24(4):363-369
15. Moroz LA, Launay F, Kocher MS, et al. Tita¬nium elastic nailing of fractures of the femur in children: predictors of complications and poor outcome. J Bone Joint Surg Br. 2006; 88(10):1361-1366.
16. Luhmann SJ, Schootman M, Schoenecker PL, Dobbs MB, Gordon JE. Complications of titanium elastic nails for pediatric femo¬ral shaft fractures. J PediatrOrthop. 2003; 23(4):443-447.
17. Ligier JN, Metaizeau JP, Prevot J and Lascombes P. Elastic stable-intramedullary nailing of femur fracture in children. J Bone & Joint Surg (Br) 1988; 70B: 74-7.
18. Gamal El-Adl, Mohamed F. Mostafa, Mohamed A. Khalil, Ahmed Enan. Titaniumelastic nail fixation for paediatric femoral and tibial fractures.ActaOrthopBelg2009; 75: 512-520
19. Flynn JM, Hresko T, Reynolds RA, Blasier RD, Davidson R, Kasser J. Titanium elastic nails for pediatric femur fractures— a multicenter study of earlyresults with analysis of complications. J PediatrOrthop2001; 21(1):4–8
20. Hanumantharaya GH and Kamala GR. A Clinical Study of Flexible Intramedullary Nailing in Management of Diaphyseal Fractures of Femur in Children and Adolescents (6-16 years of age).ISSN 2015; 3 (9): 198-207
21. HeybeliM, MuratliHH, Celebi L. The results of intramedullary fixation with titanium elastic nails in children with femoral fractures. ActaOrthopTraumatoTurc 2004; 38(3):178-87.
22. Bar-on E, Sagiv S and Porat S. External fixation or flexible intramedullarynailing for femoral shaft fractures in children. J Bone Joint Surg (Br) 1997; 79-B:975-8.
23. Oh CW, Park BC, Kim PT, Kyung HS, Kim SJ and Inn JC. Retrogradeflexible intramedullary nailing in children's femoral fractures. IntOrthop 2002; 26 (1): 52-5.
24. Aksoy C, Caolar O, Yazyoy M and Surat A. Pediatric femoral fractures Acomparison of compression plate fixation and flexible intramedullary nail fixation. JBone& Joint Surg (Br) 2003; 85-B (3): 263
25. Herndon WA, Mahnken RF, Yngve DA and Sullivan JA. Management offemoral shaft fractures in the adolescent. J PediatrOrthop 1989, 9(1): 29-32.