



International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2021; 7(4): 764-769
© 2021 IJOS
www.orthopaper.com
Received: 19-06-2021
Accepted: 22-07-2021

Govind Pratap Singh
Department of Orthopedic
Surgery, Maharishi
Markandeshwar Medical College
& Hospital, Solan, Himachal
Pradesh, India

Arshad Ashraf
Department of Orthopedic
Surgery, Maharishi
Markandeshwar Medical College
& Hospital, Solan, Himachal
Pradesh, India

Harsh Mander
Department of Orthopedic
Surgery, Maharishi
Markandeshwar Medical College
& Hospital, Solan, Himachal
Pradesh, India

Nikunj Gupta
Department of Orthopedic
Surgery, Maharishi
Markandeshwar Medical College
& Hospital, Solan, Himachal
Pradesh, India

Bhandari Vaibhav
Department of Orthopedic
Surgery, Maharishi
Markandeshwar Medical College
& Hospital, Solan, Himachal
Pradesh, India

Corresponding Author:
Harsh Mander
Department of Orthopedic
Surgery, Maharishi
Markandeshwar Medical College
& Hospital, Solan, Himachal
Pradesh, India

Titanium elastic nails versus plating in paediatric femoral fractures: A prospective randomized study

Govind Pratap Singh, Arshad Ashraf, Harsh Mander, Nikunj Gupta and Bhandari Vaibhav

DOI: <https://doi.org/10.22271/ortho.2021.v7.i4k.2966>

Abstract

Background: Femoral shaft fractures are a common paediatric injury that can be treated in a variety of ways. We conduct a randomised trial to compare two operational strategies.

Material and methods: From 2019 to 2021, we treat 26 patients with fracture shaft femur.

The patients ranged in age from 4 to 12 years old, with 15 boys and 11 girls. 12 patients had left-sided injuries, whereas 14 had right-sided injuries. The first group of 13 patients (8 males and 5 females) were treated with titanium elastic nails (TENS), while the second group of 13 patients (7 males and 6 females) were treated with open reduction and internal fixation utilising thin plates. The clinical and radiological findings were evaluated using the Flynn et al (2001) scoring system at regular intervals (2 weeks, 6 weeks, 3 months, 6 months, and 1 year).

Results: Eight patients in the TENS group had outstanding results, while five others had good results with minor problems. With an average of 8.4 weeks, the union was completed (rang 6 - 12 weeks). Seven patients in the plating group had great results, four had acceptable results with mild problems, and two patients had poor results, including re-fracture after metal removal, severe infection that healed after later metal removal and debridement, and severe infection reaching the bone. Union took an average of 9.6 weeks, ranging from 6 to 14 weeks.

Conclusion: Pediatric femoral fractures can be treated using TENS, which is a simple, dependable, successful, and less invasive approach.

Keywords: TENS, Elastic nails, femoral fractures, plating in children

Introduction

Diaphyseal femoral shaft fractures are a common occurrence in children ^[1]. For this decapitating damage, various therapeutic procedures have been used. Many factors influence these procedures, the most important of which being the patient's age. The treatment of femoral fractures in children under the age of four years is generally agreed upon ^[2]. Locked intramedullary nailing is currently available to those over the age of 16. Treatment for children aged 4 to 16 years is a contentious subject ^[3], with doctors debating whether to use traction followed by Spica, open reduction internal fixation with plates and screws, or the less invasive elastic intramedullary nails. Every method has its own set of advantages and disadvantages. To compare the outcomes of open reductions internal fixation and the use of titanium elastic nails to treat similar fractures, we conducted a prospective randomised experiment.

Materials and Methods

A total of 26 patients with fracture shaft femur were admitted to our hospital between 2019 and 2021. This study included patients who were over the age of four and under the age of twelve. There are 15 boys and 11 girls in the research. In 12 patients, the left side was afflicted. In this series, 14 patients had right-sided femur fractures, but no one had a bilateral femur fracture.

13 patients (8 males and 5 females) were treated with titanium elastic nails (TENS) out of a total of 26 patients. The remaining 13 patients (7 males and 6 females) were treated with open reduction and internal fixation utilising narrow dynamic compression plates. Road traffic accidents were the cause of trauma in 11 patients, falls in 13 patients, and heavy object trauma

in two patients. Two cases with associated injuries were discovered, one with a brain injury and the other with an abdominal injury.

Study design

We created a prospective randomised experiment to assess the outcomes of two operational procedures for treating paediatric femoral fractures in children aged 4 to 12 years old, using either TENS or narrow plates and screws.

Patient Sample

This study enlisted the participation of 26 patients. Patients who had a recent traumatic closed femoral shaft fracture were included in our study if they were over the age of 4 and under the age of 12. Patients with proximal or distal femoral fractures close to the epiphyseal plate, open femoral fractures, and old or late-presented malunited fractures were excluded from this investigation.

Documentation and follow up

Every child's full record was saved, including his or her name, age, sex method of injury, and any accompanying injuries. Also, the type, degree, and nature of the fracture. In addition to the time it takes to fix the nail, the length of the operation, the size of the nail, and any intra-operative difficulties or

blood loss. Finally, any residual issues and post-operative data (duration of hospital stay, kind of post-operative immobilization, time to union, time to metal removal, any post-implant removal complications, and length of follow-up period). All patients were evaluated clinically and radiographically at regular intervals (2 weeks, 6 weeks, 3 months, 6 months, and 1 year) for hip and knee motion, postoperative infection, and any problems until full bone healing, remodeling, and metal removal. Every clinic visits comprised antero-posterior and lateral radiographs to verify alignment, any loss of reduction, bone healing duration and quality, and implant-related problems. After clinical and radiographic union, the metals were removed. Patients were tracked for an average of 10.51 months (range 6- 17 months).

Assessment

After full clinical and radiographic bone healing, all patients were evaluated clinically for residual pain, limping, hip and knee joint range of motion, functional daily activities, limb-length disparity, and any rotational malalignment of the injured extremity at the conclusion of the follow-up period. The alignment, degree of bone healing, and limb-length discrepancy were all assessed by radiography.

The Flynn *et al.* (2001) grading system was used to evaluate the final clinical and radiological data (Table 1).

Table 1: Flynn scoring system:

	Excellent results	Satisfactory results	Poor results
Limb-length inequality	< 1.0 cm	< 2.0 cm	> 2.0 cm
Malalignment	5 degrees	10 degrees	> 10 degrees
Pain	Non	Non	Present
Complication	Non	Minor and resolved	Major and lasting morbidity

Surgical technique and post operative care

Surgical technique of TENS

After a single prophylactic dose of antibiotic, the patient is supine on a conventional translucent orthopedic table under general anaesthesia. A 1-2 cm longitudinal incision on the lateral and medial supracondylar ridges is made 2 cm proximal to the distal femoral physis. To reach the bone, only a small amount of soft tissue is dissected. A suction drain trocar is used as a curved awl to saintly expose the femoral cortex, eliminating the risk of soft tissue injury and slippage that comes with using a drill bit with strong handle control. The slightly hand curved nail with a suitable size is introduced in a retrograde manner using a T-handle by rotation movements of the wrist and pushed to the fracture site under fluoroscopic control, paying utmost care to avoid penetration of the contra lateral cortex, especially with the use of hammering. The nail is carried to the proximal femur,

where the lateral one should terminate just distal to the greater trochanter physis and the medial one should aim and fix the femur neck. The biggest diameter possible should be employed; typically, preoperative planning uses the isthmus diameter as a guide to determine the nail size, which should be roughly 40% of the isthmus diameter. Finally, the two nail constructs should be aligned and faced, with the nail's maximal curvature as close to the fracture location as practicable. Special attention should be paid to the rotation of the limb, Calcar direction, and avoidance of the epiphyseal plate while assessing the alignment and radiographic reduction. Both nails' distal ends are cut short outside the bone, curved away to make removal easier, and then lodged in the soft tissue. Closure of the wounds and administration of a hip spica for three weeks to relieve pain, edema, and guarantee the youngster does not have to bear weight is completed.



Fig 1: Showing Pre and post x-ray of femur shaft fracture after TENS

Surgical technique of plating

The patient is supine on a typical table while under general anaesthesia. To avoid devitalization or excessive callus formation, a postero-lateral approach using a muscle splitting method with limited soft tissue dissection and periosteal elevation is used after preparation. Manipulation to achieve reduction, angulation correction, and length restoration are attempted, followed by the use of a 4.5 AO narrow dynamic compression plate using the same AO fixation principles. Over a suction drain, layers of closure are utilised. There was no need for an intraoperative X-ray. Postoperatively, active hip and knee exercises were permitted right away



Fig 2: Showing x ray of post-operative plating in a 9 years old patient.

Results

The TENS group's average operative time was 35 minutes, whereas the plating group's average operative time was 55 minutes. In terms of hospital stay, patients in the TENS group were discharged on the second postoperative day unless they had other concomitant injuries, whereas patients in the plating group were discharged on the third postoperative day. The TENS group had an average union time of 8.4 weeks, whereas the plating group had an average union time of 9.6 weeks. In the TENS group, there was anterior angulation in 2 cases (15.3%) (Less than 10 degrees), whereas no case of anterior angulation was recorded in the plating group. In the TENS

group, rotational malalignment was recorded in 3 cases (23.07%), with less than 15° in half of them, while no rotational malalignment was reported in any of the plating cases.

Limb length disparity was discovered in 18 cases (64.2%) in the TENS group, which was less than 1 cm in final follow-up, while 15 patients (53.6%) in the plating group had a 1.7 cm average limb length discrepancy.

In the TENS group, there were 4 cases (14.2%) of irritation bursa around the nail insertion but no reported cases of infection, whereas in the plating group, there were 2 cases (7.1%) of infection. The first case had severe infection that started after 6 weeks when union had occurred and we continued with the plate until complete union was achieved, after which metal removal and debridement was performed, and the infection resolved. The second instance presented with a serious infection that had progressed to the bone and was unresponsive to medical treatment, so we chose to remove the metal and debride the area before applying external fixation for 6 weeks.

In our study, there were no incidences of nail bending or bone refracture following plate removal in the TENS group, but one case (3.5%) refractured after plate removal and required replating. In the TENS group, no blood transfusion was required, however in the plating group, blood transfusion was required in 8 cases (28.6%), and a unit of blood was available in all cases.

In the TENS group, there was a small limitation of knee motion in four cases (14.2%) due to close nail insertion, whereas in the plating group, there were three cases (10.7%) of hip or knee limitation of motion. Weight bearing was allowed once a callus had formed across the fracture site, which usually occurred after 6 weeks. In this series, full weight bearing was obtained progressively based on radiographic advancement to union, with an average period of 6 to 12 weeks. Another finding of this study is that the rate of union is higher in children under the age of ten.

Table 2: Flynn scoring system of currnt Results

Results	Elastic rods	Plating
Excellent	9	7
Good	4	4
Poor	Zero	2

Table 3: Comparative results of using elastic rod or plating

Item	Elastic rod	Plate
Mean operative time	35 min	55 min
Blood transfusion	No	4 Cases (30.76%)
Painful bursa	2cases (15.3%)	No
Intraoperative X-ray	Yes	No
Mean union time	8.4 weeks	9.6 weeks
Anterior angulation	2 cases (15.3%) but less than 10 degrees	No
Rotational malalignment	3 cases (23.07%), less than 15°	No
Limb length discrepancy	8 cases (61.5%) < 1 cm	7 patients (53.8%) Average 1.7 cm
Knee joint motion	2 cases (15.3%) but was slight limitation	1 cases (7.6%)
Infection	No	2 cases (15.2%)
Refracture after	No	1 case (7.6%)
Flynn score	100%	84.6%

Table 4: Master sheet of cases of fracture femur fixed by elastic nails

Number	Age	Sex	Side	Mechanism of Injury	Associated injuries	Time to fixation (days)	Nail Technique closed semi-Open-Open	Operation Time (minutes)	Post operative immobilization	Time to union (Weeks)	F.U. Period (months)	Time to metal removal (month)	Complications	Score
1	6Y	F	Rt	FOG	No	1	Closed	35	H.S.	8	6	5	No	Ex.
2	4Y	F	Lt	MCA	Splenectomy	4	Semi open	45	H.S.	6	7	4	No	Ex.
3	4Y	F	Rt	MCA	No	4	Closed	40	H.S.	6	6	4	No	Ex.
4	8Y	M	Rt	FOG	No	1	Closed	35	H.S.	10	8	5	No	Ex.
5	9Y	F	Rt	MCA	No	1	Closed	30	H.S.	8	9	5	No	Ex.
6	5Y	M	Rt	FOG	No	1	Closed	35	H.S.	8	7	4.5	Minor	G
7	5Y	F	Lt	HOT	No	1	Closed	25	H.S.	6	8	5	No	Ex.
8	9Y	M	Rt	FOG	No	1	Closed	35	H.S.	10	9	5	Minor	G
9	8Y	M	Rt	FOG	No	1	Closed	40	H.S.	10	10	5	Minor	G
10	8Y	M	Rt	MCA	No	1	Closed	35	H.S.	10	9	4	No	Ex.
11	8Y	M	Lt	FOG	No	1	Closed	35	H.S.	10	11	6	No	Ex.
12	9Y	M	Rt	FOG	No	1	Closed	25	H.S.	10	9	4	Minor	G
13	6Y	M	Lt	FFH	Head Trama	4	Closed	40	H.S.	8	7	4	No	Ex.

Table 5: Master sheet of cases of fracture femur fixed by plating.

Number	Age	Sex	Side	Mechanism of Injury	Associated Injuries	Time to fixation (days)	Operation time (minutes)	Post-OP Immobilization	Time to union (Weeks)	F.U. Period (month)	Time to metal removal	Complications	Score
1	10 Y	M	Rt	MCA	No	1	50	No	12	14	12m	No	Ex.
2	10 Y	F	Lt	MCA	No	1	60	No	12	9	6m	No	Poor
3	8 Y	F	Lt	MCA	Head trauma	5	60	H.S.	8	15	12m	No	Ex.
4	10 Y	F	Lt	FFH	No	1	55	No	12	13	12m	No	Ex.
5	9 Y	M	Rt	MCA	No	1	60	No	10	14	12m	No	Ex.
6	9 Y	F	Lt	FFH	No	1	65	No	10	15	12m	No	Ex.
7	10 Y	F	Rt	MCA	No	1	60	No	12	14	12m	No	Ex.
8	9 Y	M	Lt	FFH	No	1	55	No	8	12	10m	No	Ex.
9	8 Y	F	Rt	MCA	No	1	60	H.S.	10	12	10m	Minor (resolved)	Good
10	10 Y	M	Rt	FOG	No	3	55	H.S.	10	10	3m	Deep infection	Poor
11	9 Y	M	Lt	FOG	No	3	65	No	12	15	12m	Minor (resolved)	Good
12	9 Y	M	Lt	MCA	No	1	60	No	10	14	12m	Minor	Good
13	8 Y	F	Lt	MCA	No	1	55	No	10	11	8m	superficial infection	Good

Discussion

Fracture of the femoral shaft is a common injury in youngsters, and determining the best treatment option has proven difficult. Staheli [5] defines the optimal therapy for that injury as one that maintains alignment and length, does not severely compress or elevate the extremities, is comfortable for the child and convenient for the family, and has the least negative psychological impact conceivable.

Treatment is dependent on the child's age and size, as well as any accompanying injuries and local practice [6]. Many consequences have been reported as a result of early initial spica cast treatment or subsequent traction, including limb-length disparity, angulations, rotational deformity, psychological, and economic issues [7-9].

In 50 percent of closed, high-energy femoral shaft fractures in children younger than 10 years of age, Pollak *et al.* [10] found shortening and angulation that required repeat reduction or further therapy. External fixation has long been the preferred treatment for polytrauma patients, as well as for closed and isolated open fractures. Pin-track infections, delayed union, nonunion, loss of knee range of motion, and refracture are all hazards [11, 12].

In a comparison of external fixator and elastic rod treatment, Baron *et al.* [11] found that elastic rods had superior results than external fixators in terms of return to school, complete range of neighbouring joints, and early union. External fixators were only used for open or badly comminuted fractures. Almost identical results were reported by Buechsenschuetz [13]. Avascular necrosis of the femoral head,

trochanteric epiphysiodesis, and coxa valga have all been reported after solid antegrade intramedullary nailing [14-16].

Many publications have described the use of AO compression plates to treat femoral shaft fractures in children and adolescents. Ward *et al.* [17] reported good fracture healing without leg length difference in children aged 6 to 16 years after compression plating of femoral fractures, with an average healing period of 11 weeks and limb length discrepancy in 25% of patients. Patients with severe head injuries or multiple traumas should be treated with compression plates, according to the researchers. Hanson *et al.* [18]. Reported complete healing of all fractures treated with plating in a series of 11-year-old patients with no angulation or rotation, a mean overgrowth of 7 mm, and no restricted hip or knee motion. All patients treated with plating in our series attained union in an average of 9.6 weeks, with no cases of anterior angulation or rotational malalignment (figure 1 a,b,c). Plating has its own drawbacks, such as the requirement for a second operation to remove the plate and the poor visual appearance of the incision scar, as well as the observed greater levels of overgrowth as compared to intramedullary fixation [1]. Because femoral shaft fractures heal so quickly in childhood, plate breakage is significantly less of a concern in children than it is in adults. Stress fractures via the screw holes are possible within the first few months after plate removal, albeit they are uncommon. After plate removal, one case (3.5%) refractured, and replating was performed. Our patients were infected in 7% of the time. In 53.6 percent of patients, significant overgrowth of up to 1.7 cm was recorded.

Our patients required blood transfusions in 28.6% of cases. The optimum device for treating femoral fractures in children is a simple, load-sharing internal splint that allows for early mobilisation while maintaining length and alignment for many weeks until a bridging callus forms without compromising the epiphyseal blood supply [8, 13, 19, 20]. In addition to their biocompatibility and lack of metal sensitivity reactions, TENs have been reported to aid healing by decreasing stress shielding [8, 21, 22].

Several writers have reported positive outcomes while using elastic intramedullary fixation. With the application of elastic stable intramedullary nails, Ligier *et al* [22], reported outstanding outcomes.

In a prospective analysis of 78 diaphyseal femur fractures, Heinrich *et al.* [21], found modest varus or valgus angulation (11%), as well as mild anterior or posterior malalignment (8 percent). In 10.2 percent of the cases, there was a minor rotational misalignment of 8 degrees. At the follow-up, however, 89 percent of the youngsters had identical leg lengths. In our TENS series, we found anterior angulation in 17.8% of cases, but it was less than 10 degrees, and rotational malalignment in 21.4 percent of patients, but it was less than 15 degrees in half of them. In the final follow-up, 64.2 percent of the patients had a limb length disparity of less than 1 cm.

Oh *et al.* [23] employed retrograde flexible intramedullary nailing on 31 femoral shaft fractures and found that the average duration for union was 10.5 weeks. One nail was fractured, but there was no infection or refracture. There was no malunion or limb-length inequality greater than 1 cm. They believe that femoral fractures in children aged 5–10 years can be treated successfully using retrograde flexible intramedullary nailing with little surgical risks. Figure 2 a,b,c shows the mean union time in our series, which was 8.4 weeks.

In a study of 50 prospectively examined cases, Flynn *et al.* [24] discovered that the most common complication was discomfort at the nail insertion site, which occurred in 18% of cases. 14.2 percent of our patients developed irritation bursa surrounding the nail insertion in our study.

Titanium elastic nails can be applied retrogradely without opening the fracture site or removing the periosteum, therefore they don't cause overgrowth unless a transverse fracture is present. In our investigation, the only documented overgrowth was 0.5 cm. They have the drawback of poor rotational stability control, thus we take extra precautions during intraoperative limb positioning and use a post-operative hip spica in all instances.

Conclusion

Despite the strong rotational control, lack of radiation exposure, and early start of postoperative rehabilitation, the use of plating is nevertheless hampered by the requirement for blood transfusion, increased muscle stress, and increased infection risk. To assist nursing and early rehabilitation, it must be kept for instances involving head trauma and individuals who are polytraumatized. Titanium elastic nails have the advantages of being simple, biological, easy to apply, less invasive, and require no blood transfusion during surgery. It also has a faster time to union and causes less bone development disruption. The only flaw is the lack of rotational control and the need for intraoperative irradiation.

References

1. Levy J, Ward WT: Pediatric femur fractures: an overview of treatment. *Orthopedics* 1993, 16(2):183-190.

2. Guttman GG, Simon R: Three-point fixation walking spica cast: an alternative to early or immediate casting of femoral shaft fractures in children. *Journal of pediatric orthopedics* 1988, 8(6):699-703.
3. Flynn JM, Luedtke LM, Ganley TJ, Dawson J, Davidson RS, Dormans JP, Ecker ML, Gregg JR, Horn BD, Drummond DS: Comparison of titanium elastic nails with traction and a spica cast to treat femoral fractures in children. *The Journal of bone and joint surgery American volume* 2004, 86-A(4):770-777.
4. Flynn JM, Hresko T, Reynolds RA, Blasler RD, Davidson R, Kasser J: Titanium elastic nails for pediatric femur fractures: a multicenter study of early results with analysis of complications. *Journal of pediatric orthopedics* 2001, 21(1):4-8.
5. Staheli LT: Femoral and tibial growth following femoral shaft fracture in childhood. *Clinical orthopaedics and related research* 1967, 55:159-163.
6. Hunter J: Femoral shaft fractures in children. *Injury* 2005 36(1):A86-93.
7. Martinez AG, Carroll NC, Sarwark JF, Dias LS, Kelikian AS, Sisson GA, Jr.: Femoral shaft fractures in children treated with early spica cast. *Journal of pediatric orthopedics* 1991;11(6):712-716.
8. Sanders JO, Browne RH, Mooney JF, Raney EM, Horn BD, Anderson DJ, *et al.* Treatment of femoral fractures in children by pediatric orthopedists: results of a 1998 survey. *Journal of pediatric Orthopedics* 2001;21(4):436-441.
9. Tolo VT. External skeletal fixation in children's fractures. *Journal of pediatric Orthopedics* 1983;3(4):435-442.
10. Pollak AN, Cooperman DR, Thompson GH: Spica cast treatment of femoral shaft fractures in children--the prognostic value of the mechanism of injury. *The Journal of trauma* 1994;37(2):223-229.
11. Bar-On E, Sagiv S, Porat S. External fixation or flexible intramedullary nailing for femoral shaft fractures in children. A prospective, randomised study. *The Journal of bone and joint surgery British* 1997;79(6):975-978.
12. Siegmeth A, Wruhs O, Vecsei V. External fixation of lower limb fractures in children. *European journal of pediatric surgery: official journal of Austrian Association of Pediatric Surgery [et al.] = Zeitschrift fur Kinderchirurgie* 1998;8(1):35-41.
13. Buechsenschuetz KE, Mehlman CT, Shaw KJ, Crawford AH, Immerman EB. Femoral shaft fractures in children: traction and casting versus elastic stable intramedullary nailing. *The Journal of trauma* 2002;53(5):914-921.
14. Beaty JH, Austin SM, Warner WC, Canale ST, Nichols L. Interlocking intramedullary nailing of femoral-shaft fractures in adolescents: preliminary results and complications. *Journal of pediatric Orthopedics* 1994;14(2):178-183.
15. Gonzalez-Herranz P, Burgos-Flores J, Rapariz JM, Lopez-Mondejar JA, Ocete JG, Amaya S. Intramedullary nailing of the femur in children. Effects on its proximal end. *The Journal of bone and joint surgery British volume* 1995;77(2):262-266.
16. Stans AA, Morrissy RT, Renwick SE. Femoral shaft fracture treatment in patients age 6 to 16 years. *Journal of pediatric Orthopedics* 1999;19(2):222-228.
17. Ward WT, Levy J, Kaye A. Compression plating for child and adolescent femur fractures. *Journal of pediatric Orthopedics* 1992;12(5):626-632.
18. Hansen TB. Fractures of the femoral shaft in children

- treated with an AO-compression plate. Report of 12 cases followed until adulthood. *Acta Orthopaedica Scandinavica* 1992;63(1):50-52.
19. Gregory P, Sullivan JA, Herndon WA: Adolescent femoral shaft fractures: rigid versus flexible nails. *Orthopedics* 1995;18(7):645-649.
 20. Vrsansky P, Bourdelat D, Al Faour A. Flexible stable intramedullary pinning technique in the treatment of pediatric fractures. *Journal of pediatric Orthopedics* 2000;20(1):23-27.
 21. Heinrich SD, Drvaric DM, Darr K, MacEwen GD. The operative stabilization of pediatric diaphyseal femur fractures with flexible intramedullary nails: a prospective analysis. *Journal of pediatric Orthopedics* 1994;14(4):501-507.
 22. Ligier JN, Metaizeau JP, Prevot J, Lascombes P: Elastic stable intramedullary nailing of femoral shaft fractures in children. *The Journal of bone and joint surgery British* 1988;70(1):74-77.
 23. Oh CW, Park BC, Kim PT, Kyung HS, Kim SJ, Ihn JC. Retrograde flexible intramedullary nailing in children's femoral fractures. *International orthopaedics* 2002;26(1):52-55.
 24. Flynn JM, Luedtke L, Ganley TJ, Pill SG. Titanium elastic nails for pediatric femur fractures: lessons from the learning curve. *Am J Orthop (Belle Mead NJ)* 2002;31(2):71-74.