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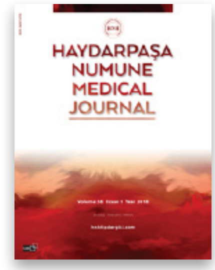

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ORIGINAL ARTICLE

Comparison of Angulation Deformity After Remodelling of Pediatric Femoral Fractures

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Abstract

Introduction: Although, there is a consensus on treatment of femoral shaft fractures in children under 4 years old and adolescents, the treatment method is still contraversial for children between 4 and 10 years old. Therefore different kinds of treatment methods are described. The aim of the study is to investigate the healing capacity of femoral shaft fractures in 4-10 years old patients who treated nonsurgically and compare the clinical and radiological results with the surgically treated patients in the same age group.

Methods: Fifty-nine patients between 4 and 10 years old were included in the study.The study included 18 (31%) females and 41 (69%) males. The mean age of the patients was 6.9 years (range; 4-10). The mean follow-up period was 84 (range; 38-107) months. The mean age of non-surgical group (n=32) and surgical group (n=27) were 5.9 and 7.1 years, respectively. The causes of fractures were falls from height (n=29), motor vehicle accidents (n=20), child abuse (n=1) and other causes (n=9).

Results: The improvement values at the angulation grades were significantly higher in AP and LAT radiographs in both groups (p<0.01). There was no significant difference between the groups in foot thigh angle, foot progression angle and leg length discrepancy. Fracture localization was not effective on leg length discrepancy and clinical outcome success, and there was no significant difference between the two groups in terms of clinical outcomes.

Discussion and Conclusion: The immediate postoperative radiological reduction quality was significantly higher in surgically treated group than the early post-reduction in non surgically treated goup. But, the differences of thigh foot angles and foot progression angles between the groups were not statistically significant. Also no difference was observed in terms of leg length discrepancies between the groups.

Keywords: Cast; femur diaphysis; plate; screw; trauma.

Femoral shaft fractures represent %1.6 of all bony injuries in pediatric population. The most common causes of these fractures are high energy traumas, accidents and falls from height[1-4]. Pediatric fractures have high potential of physiological healing and remodeling capacity. This remodeling capacity is higher with the tractional effect of physeal growth of long bones such as femur, radius and ulna. Femur shaft fractures, which have high remodeling properties, do not always heal without problems[5-7]. Leg length discrepancies (LLD), coronal plane, sagittal plane

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and rotational deformities can occur inspite of the appropriate treatment. Although angulation deformities can heal via remodelling, rotational deformities and limb length discrepancies can not entirely recover. These can cause several problems in the later period of life[8]. The aim of the study is to investigate the healing capacity of femoral shaft fractures in 4-10 years old patients who treated nonsurgically and compare the clinical and radiological results with the surgically treated patients in the same age group.

Materials and Methods

After approval of ethical committee [HNHEAH-KAEK 2016/KK/83], we retrospectively reviewed 92 patients with femoral shaft fractures treated between January 2006 and December 2014. The patients with multiple injuries, accompanying lower limb fractures, brain and spinal cord traumas, severe soft tissue injuries were excluded. The study included 59 patients 18 (31%) females and 41 (69%) males. The mean age of the patients was 6.9 years (range; 4-10). The mean follow-up period was 84 (range; 38-107) months. The mean age of non-surgical group (n=32) and surgical group (n=27) were 5.9 and 7.1 years, respectively. The causes of fractures were falls from height (n=29), motor vehicle accidents (n=20), child abuse (n=1) and other causes (n=9). There were 30 right and 29 left femoral fractures. Localization and types of fractures was as shown on Table 1 and Table 2.

All fractures were classified according to their localizations and fracture type. The patients were divided in two groups according to the treatment method, the non-surgical group was treated with skeletal traction and spica cast and surgical group was treated with plate fixation method. Final

Table 1. Distribution of the fractures according to the localizations

Fracture Localizations	n	%
Distal	10	16.9
Middle	39	66.1
Proksimal	10	16.9
Total	59	100.0

Table 2. Distribution of the fractures according to the classfication

Fracture Type	n	%
Oblique	10	16.9
Comminuted	6	10.2
Spiral	20	33.9
Transvers	23	39.0
Total	59	100.0

clinical and radiological evaluation of the patients done in the outpatient clinic. All of the femur anteroposterior (AP) and lateral (LAT) radiographies of the injuried and uninjured sides were obtained from outpatient clinic follow-ups. Clinical evaluation was made by measuring thigh foot angle and foot progression angle[9].

Clinical Evaluation Procedure: Thigh foot angle was measured on prone position keeping the knees at 90º flexion and foot at neutral position. The angle on the bisecting point of the line passing mid-thigh and the line between heel and 2nd toe was measured by using goniometer. Foot progression angle was estimated by selecting ten of the footprints, after the child with the colored feet walked on the straight line. The median value of these ten footprints was obtained as foot progression angle. The foot progression angle of non-injured limb was considered as normal and deviation of the injuried side from the normal values was measured. The positive values considered as greater from the normal. The negative values considered as the smaller from the normal. The clinical and radiological outcomes evaluated as very good, good and poor. Very good: No clinical limb deformity, no limping, <5 mm clinical leg length discrepancy, radiologically <5º angulation in per plane; Good: <15 mm clinical leg length dicrepancy, no limping, radiologically <15º angulation in per plane; Poor: >15 mm leg length dicrepancy, limping presentation, radiologically >15º angulation in per plane and rotational deformity[10].

Skeletal traction and spica cast procedure: Proximal tibial skeletal traction was applied under local anesthesia at the level of tuberositas tibia and the pins were inserted from lateral side to medial to avoid peroneal nerve injury. Appropriate traction weight was applied depending on patients weight and age. The AP and LAT radiographs of the femur were obtained weekly and the traction weight was modified according to the alignment. The spica cast was applied when the callus formation was observed on the radiographs. Spica cast was applied with 30º hip flexion and abduction, 20º knee flexion including the ankle on the injuried side and ended above the knee on the contralateral side. The patients were followed 3 to 6 weeks after applying spica cast and the cast was removed when the fracture healing was observed (Fig. 1).

Surgically treated patients procedure: Open reduction and internal fixation was made by using titanium or steel dynamic compression plate. Lateral longitudinal incision was used in all cases. Routine follow-ups were made on the 14th day, 30th day and 90th day postoperatively.

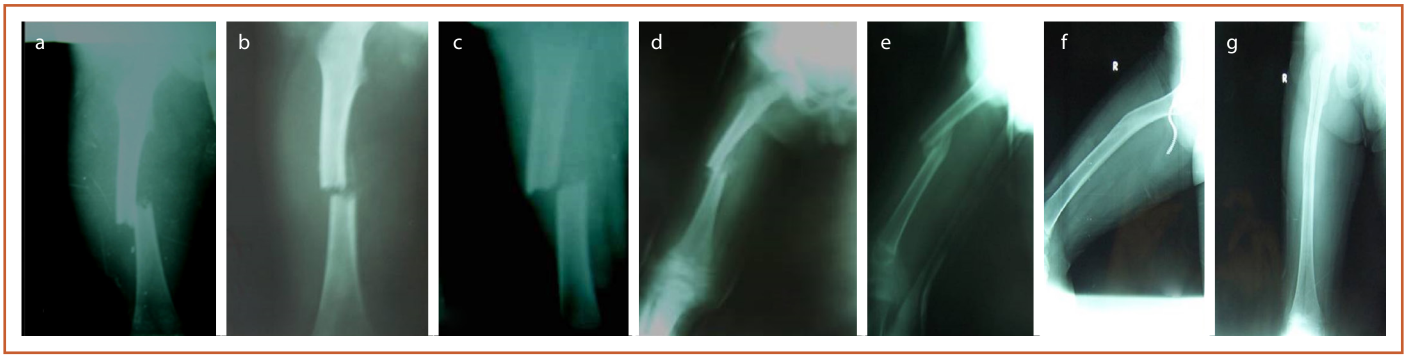

Figure 1. Five-year-old boy fall from high, (a) first AP x-ray, (b,c) 12. day in skeletal traction AP, Lat, (d,e) 26. day in spica cast AP angulation 167 degree, Lat 163 degree x-ray graph. (f,g) Four year later AP angulation 175 degree, Lat angulation 168 degree.

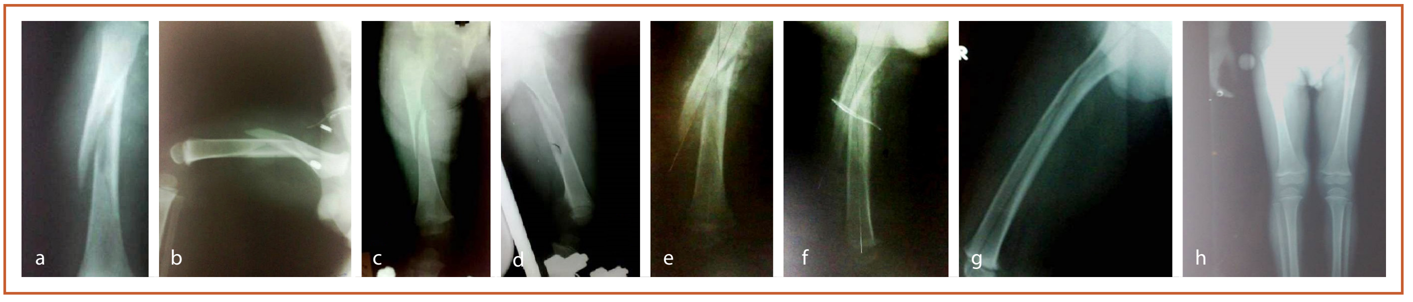

Figure 2. Four-year-old boy, traffic accident, (a,b) first AP, Lat x-ray, (c,d) 8. day skeletal traction finished by pin tract enfection AP, Lat. (e,f) 20. day in spica cast AP angulation 159 degree, Lat 156 degree x-ray graph. (g,h) Three year later AP angulation 178 degree, Lat angulation 175 degree.

Statistical Analysis

Statistical analysis was performed using MedCalc Statistical Software version 12.7.7 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2013)

To describe contiuous variations, descriptive statistics were used (medium, standart deviation, minimum, median, maximum). Differencial categorical datas were compared using the chi-square test and Fisher–Freeman–Halton test. To compare independent normal distributed two samples student t test was used. To compare independent non parametric two samples Mann Whitney u test was used. Paired sample t test was used to compare dependent two samples and Wilcoxon Signed Rank test was used to compare dependenet non-parametric two samples. Statistical significance was set as $p<0.05$.

Results

The correction of angulation degrees of AP and LAT radiographs in the latest follow-up was significantly higher in both groups ($p<0.01$). The correction of angulation degrees between two groups was significantly higher in surgically treated group ($p<0.01$) (Table 3).

The differences of thigh foot angles and foot progression angles between the groups were not statistically significant. However, length of hospitalization was significantly longer

Table 3. Radiographic outcomes of the groups

Groups	AP Plane Mean±SD Med (Min-Max)		Lateral Plane Mean±SD Med (Min-Max)	
	Before	After	Before	After
Non surgical (n=32)	14.5±7.44 15 (3-30)	6.7±5.2 (0-18)	14.8±7.6 15 (3-34)	9.8±7.5 10 (0-25.2)
Surgical (n=27)	18.9±6.9 20 (10-40)	0	18.9±5.6 20 (10-30)	0
p		<0.01*		<0.01*

*Wilcoxon.

Table 4. Clinical outcomes of the groups

Groups	Thigh foot angle Mean±SD Med (Min-Max)	Foot progression angle Mean±SD Med (Min-Max)	Length of hospitalization (day) Mean±SD Med (Min-Max)
Non surgical (n=32)	1.5±6.8	(-) 0.12±3.2	17.8±4.6
	0 (-10-16)	0 (-10-7)	18 (9-33)
Surgical (n=27)	(-) 3.3±10.4	(-) 0.67±2.5	11.9±5.7
	0 (-20-10)	0 (-6-6)	12 (4-27)
p	0.121*	0.243*	<0.01**

*Mann Whitney U testi; ** Student t.

Table 5. The measurements of leg length discrepancies of the groups

	Non-Surgical n (%)	Surgical n (%)	Total n (%)
Non- Equal	17 (53.1)	18 (66.7)	35 (59.3)
Equal	15 (46.9)	9 (33.3)	24 (40.7)
Total	32 (100)	27 (100)	59 (100)

Shortening Grups	n	Mean*	Med.*	SD	Min.*	Maks.*
Non-Surgical	9	7.8	5	4.4	5	15
Surgical	6	12.7	15	4.3	5	16
Lengthening Grups	**n**	**Mean***	**Med.***	**SD**	**Min.***	**Maks.***
Non-Surgical	8	15.25	10	14.9	5	50
Surgical	12	14.2	14.5	5.8	5	25

*: milimeter value.

Tablo 6. Distribution of the outcomes

Clinical outcomes	Non surgical n (%)	Surgical n (%)	p
Poor	2 (50.0)	2 (50.0)	0.425
Good	24 (60.0)	16 (40.0)	
Very good	6 (40.0)	9 (60.0)	

Fisher's Exact.

in non surgically treated group (Table 4). The differences of leg length discrepancies between the groups were not statistically significant (p=0.291) (Table 5). The differences in clinical outcomes between the groups were not statistically significant (p=0.425) (Table 6). It was also demonstrated that the leg length discrepancy and the clinical outcomes were not related with the fracture localization.

In the non-surgical group, 4 patients had pin tract infections and 3 case were treated with local antiseptics and antibiotics. In one patient, scelatal traction was terminated early, followed by minimal wound debridement and splint, and union was achieved (Fig. 2). In one patient in the surgical group, an infection developed after removal of the implant. The patient was re-admitted and treated twice with debridement and parenteral antibiotherapy.

Discussion

Successful results were reported after non-surgical treatment of femoral shaft fractures in pediatric population[11-13] Surgical procedures were preferred in comminuted fractures and when accompanied multiple injuries are present. The most common surgical procedures performed between 4 and 10 years old are (titanium) elastic nailing and plate fixation[14, 15]. Both surgical and non-surgical methods have advantages and disadvantages. However, recently, the indications of surgical methods are seen to be increasing due to complications of non surgical methods, such as malunion, shortness, radiation exposure, length of hospitalization and high cost[16-20]. Although, there is a consensus in treatment of femoral shaft fractures in childeren under 5 years old and in adolescents, the treatment method is still contraversial for children between 4 and 10 years old. In adolescents, the results of surgical methods are better than the non surgical methods[13, 15].

After healing of femoral shaft fractures 1.5-2 cm leg length discrepancy can be well tolerated between 4 and 10 years old[16, 19, 21]. Hammad et al.[22] reported that LLD were observed in 6 of 15 patients which were treated by dynamic compression plate. Eren et al. reported that mean

1.2 cm LLD was observed in 10 of 35 patients which were treated by plate fixation[23]. In our study, LLD was observed in %53 of the non surgical group and %66 of the surgical group. However, in both groups less than %5 of patients had LLD more than 2 cm. LLD was affected by quality of reduction in both groups. It was reported that after anatomical reduction, increase in bone vascularity during fracture healing, resulted with overgrowth of femur in surgical procedures[24-26]. In current study overgrowth of femur was observed twice as much as shortened femur. In non surgical group overgrowth and shortening rates were similar. It was reported that the angulation after reduction of femoral shaft fractures was healed by remodallization via Wolf's law, particularly in proximal shaft fractures[5, 27-29]. In this study, anatomical reduction was obtained in surgical group. Although, the residual angulation deformities which were less than 10 degrees in both planes were seen in early radiographs in non surgical group, the correction of angulations were significant in last follow-up. Stephens et al. demostrated in their study that angulations under 10 years old were completely corrected via remodalization, in which the patients treated with non surgical methods[16]. Our thought is, although the anatomical reduction can not be obtained in non surgical methods, low degrees of angulation can be tolerated because of intensive muscle and fat tissue of thigh.

Other complications of pediatric femoral shaft fractures are rotational deformities which can be seen in both surgical and non-surgical methods[30, 31]. This situtation clinically represents as lower extremity malalignments, limited hip range of motion and gait problems. In the literature, rotational deformities were measured by using computerized tomography (CT). In our study, CT was not preferred to avoid from high radiation exposure. Özel et al. described a method whereby rotational deformities can be measured by using direct radiography[32]. However, the accuracy of this method decreases in healed fractures. Therefore, we preferred to measure the rotational deformities by clinically. We found the correction of rotational deformities was closer to anatomical alignment in surgical group, the differecences of both groups were not found to be statistically significant. Bulut et al. demonstrated 17 external rotation deformities and 9 internal rotation deformities in CT examination of 28 femur shaft fractures which were treated by non surgical method and also reported more than 10 degrees of rotational deformity in 4 patients[33]. In pediatric population less than 25 degrees of rotational demormties of femur can be well tolerated. Davids et al. also reported that the rotational deformities after femoral fractures were not completely corrected. However, symmetric thigh-foot angles were regained with remodallization of soft tissues and joints[34]. In our study, rotational deformities which caused clinical problems were not seen in both groups.

The major limitation of this study is the number of the patients. Patients was statistically enough to compare two methods, but more patients were needed for comparation of subgroups in terms of fracture type. We believe that the study would be more powerful and spesific if subgroup anlysis could be studied. However, the surgical group which only consisted of patients with plate fixation, makes the study more spesific. Intramedullary nailed patients were excluded because of the controversy of the nails in correction of rotational deformities. The patients who were performed external fixator were also excluded. While the majority of these patients subjected to multitrauma, the results could be misleading in terms of LLD.

Many treatment options are present for pediatric femoral fractures. Fortunately, outcomes are almost always great[7, 11, 15, 19]. However, leg length discrepancies, rotational and angulation deformities can be observed in all treatment types. In addition to these, surgical treatments have some disadvantages as secondary surgery for implant removal, need of a postoperative surgical site care, cosmetic issues after wound healing (scarring).

This study supports the hypothesis that there were no any difference between outcomes and clinical results of femur shaft fractures that treated in two methods in 4-10 years old. Although, the early postoperative radiological reduction quality was significantly higher in surgically treated group, the differences of clinical outcomes were not found to be statistically significant.

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Conflict of Interest: None declared.

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References

1. Hinton RY, Lincoln A, Crockett MM, Sponseller P, Smith G. Fractures of the femoral shaft in children; incidence, mechanisms and sociodemographic risk factors. J Bone Joint Surg Am 1999, 81:500-9.
2. Bombacı H, Ülkü K, Adıyeke L, Kara S, Görgeç M. Childhood injuries, their etiologies, and preventive measures. Acta Orthop Traumatol Turc. 2008;42:166–73.
3. Daly KE, Calvert PT. Accidental femoral fractures in infants. Injury 1991, 22:337-8.
4. Moraes FB, Silva LL, Ferreira FV, Ferro AM, da Rocha VL, Teixei-

ra KI. Epidemiologıcal And Radiological Evaluatıon Of Femoral Shaft Fractures: Study Of 200 Cases. Rev Bras Ortop. 2015 Nov 16;44(3):199-203.

5. Wallace ME, Hoffman EB: Remodelling of angular deformity after femoral shaft fractures in children. J Bone Joint Surg Br 1992, 74(5):765.9.
6. Irani RN, Nicholson JT, Chung MK. Long-term results in the treatment of femoral shaft fractures in young children by immediate spica immobilization. J Bone Joint Surg Am 1976, 58:945-51.
7. Aronson DD, Singer RM, Higgins RF: Skeletal traction for fractures of the femoral shaft in children. A long-term study. J Bone Joint Surg Am 1987,69 (9):1435-9.
8. Sauli A.P, Martina L, Reijo T.P, Jari I.P, Yrjana N. Chilhood femoral fracture can lead to premature knee joint arthritis. Acta Orthop. 2013 Feb;84(1):71-5
9. Keskin D, Ezirmik N, Tatlı L. Rotational Deformities as the complication of the conservative treatment in children's femoral shaft fractures. Ulus Travma Derg. 2001 Apr;7(2):122-5.
10. Akıncı O, Şekerlisoy A, Kuyurtaş F, Işık T. Results of conservative treatment of femur diaphysis fractures in children. Acta Orthop Traumatol Turc. 1996;30,125-7.
11. Lee YHD, Lim KBL, Gao GX, Mahadev A, Lam KS, Tan SB, et. al. Traction and spica casting for closed femoral shaft fractures in children. J Orthop Surg (Hong Kong). 2007 Apr;15(1):37-40.
12. Claudıo S, Mıguel A, Gılberto W, Tabata A, Tatyana A , Sandro L. B, et. al. Bloodless treatment of femoral diaphyseal Ffactures in children. Acta Ortop Bras 2005; 13(5):249-252
13. Stans AA, Morrissy RT, Renwick SE. Femoral shaft fracture treatment in patients age 6 to 16 years. J Pediatr Orthop. 1999 Mar-Apr; 19(2):222-8.
14. Jain A, Aggarwal A, Gulati D, Singh MP. Controversies in Orthopaedic Trauma- Management of fractures of shaft of femur in children between 6 and 12 years of age. Kathmandu Univ Med J 2014;45(1):77-84.
15. Rapp M, Kaiser M. M, Grauel F, Gielok C, Illing P. Femoral shaft fractures in young children (<5 years of age): operative and non-operative treatments in clinical practice. European Journal of Trauma and Emergency Surgery (2015): 1-6.
16. Stephens MM, Hsu LC, Leong JC. Leg length discrepancy after femoral shaft fractures in children. Review after skeletal maturity. J Bone Joint Surg Br. 1989 Aug;71(4):615-8.
17. Martinez AG, Carroll NC, Sarwark JF, Dias LS, Kelikian AS, Sisson GA Jr. Femoral shaft fractures in children treated with early spica cast. J Pediatr Orthop. 1991 Nov-Dec;11(6):712-6.
18. Curtis JF, Killian JT, Alonso JE. Improved treatment of femoral shaft fractures in children utilizing the pontoon spica cast: a long-term follow-up. J Pediatr Orthop. 1995 Jan-Feb;15(1):36-40.
19. Ward WT, Levy J, Kaye A. Compression plating for child and adolescent femur fractures. J Pediatr Orthop. 1992 Sep-Oct;12(5):626-32.
20. Stanitski CL, Monroe MT, Stanitski DF, Minster G, Goldstein A. Radiation exposure during skeletal traction treatment of pediatric femoral fractures. J Pediatr Orthop. 1998 MarApr;18(2):271-2.
21. Griffin P.P, Anderson M, Green W. T. Fractures of the shaft of the femur in children treatment and results. Orthop Clin North Am. 1972 Mar;3(1):213-24.
22. Hammad A. Locking plate construct for femoral shaft fractures in skeletally immature patients. Acta Orthop Belg. 2008 Oct;74(5):630-5.
23. Eren O.T, Küçükkkaya M, Kabukçuoğlu Y, Balcı V, Kuzgun Ü. Plate fixation of closed femoral shaft fractures in adolescents. Acta Orthop Traumatol Turc 2002;36:124-128.
24. Reynolds DA. Growth changes in fractured long-bones: a study of 126 children. J Bone Joint Surg[Br] 1981 ;63-B:83-8.
25. Ziv 1, Rang M. Treatment of femoral fractures in the child with head injury. J Bone Joint Surg[Br] 1983:65-B:276-8.
26. Barfod B, Christensen J. Fractures of the femoral shaft in children with special reference to subsequent overgrowth. Acta Chir Scand 1958- 9:1 16:235-250.
27. Kamegaya M, Saisu T, Segawa Y, Kakizaki J, Sakamoto Y, Hagiwara S. Remodeling of angulation deformities in diaphyseal femoral fracture in children. J Orthop Sci. 2012 Nov;17(6):763-9.
28. Murray DW, Wilson-MacDonald J, Morscher E. Bone growth and remodeling after fracture. J Bone Joint Surg Br. 1996;78:42–50.
29. Jeng C, Sponseller PD, Yates A, Paletta G. Subtrochanteric femoral fractures in children. Alignment after 90 degrees-90 degrees traction and cast application. Clin Orthop Relat Res. 1997 Aug;(341):170-4
30. Norbeck DE, Asselmeier M, Pinzor MS. Torsional malunion of a femur fracture: diagnosis and treatment. Orthop Rev. 1990;19:625
31. Benum P, Ertresvag K, Hoiseth K. Torsion deformities after traction treatment of femoral fractures in children. Acta Orthop Scand. 1979 Feb;50(1):87-91.
32. Ozel MS, Ketenci IE, Kaya E, Tuna S, Saygi B. Calculation of pediatric femoral fracture rotation from direct roentgenograms. J Orthop Traumatol. 2013 Dec;14(4):269-75.
33. Bulut S, Bulut O,Tas F, Egilmez H. The measurement of the rotational deformities with computed tomography in femoral shaft fractures of the children treated with early spica cast. Eur J Radiol. 2003 Jul;47(1):38-42.
34. Davids J. R.: Rotational Deformity and Remodelling after Fractures of Femur in Children. Clin Orthop Relat Res. 1994 May;(302):27-35.