Fracture of the femoral shaft in children associated with bone overgrowth

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Abstract
Forty children were treated with conservative non-operative management for femoral shaft fractures. These children were reviewed with regard to the differences that were observed in the limb length after treatment. The average femoral overgrowth was 0.85 cm (0- 2.5cm). This was influenced by the age at the time of the fracture. We were not able to find any association between the quantity of overgrowth and race, gender, level or configuration of the fracture.

Keywords: Femoral shaft fractures, Overgrowth, Children, Conservative management.

Introduction
Femoral shaft fractures represent 1.6% of all fractures in the paediatric population. There is abnormal distribution of incidence with the first peak being from two to four years of age and the second in mid adolescence. During childhood, remodelling in the femur causes a change from primary weaker bone to stronger lamellar bone. Upto age sixteen years, there is geometric increase in the femoral shaft diameter and relative cortical thickness of the femur resulting in a markedly increased area movement of inertia and strength. This partially explains the bimodal distribution of injury pattern, in which younger patients experience fracture under local conditions like normal play or minor trauma.

There are many studies that have been published related to the overgrowth of femur after fracture in a growing child. In 1921, Truesdell[1] was the first to report on post traumatic increase in growth. This overgrowth phenomenon was studied by K Speed,[2] who concluded that this was due to a compensatory mechanism. Others regarded this increase to be associated with hyperaemia which would occur with the healing process[3] in the fracture of these children.

Recognizing the factors that influence overgrowth is important in this study so as to adjust the overriding of bones, in a way that would minimize the final length discrepancy. Various authors have recommended differing amounts of overlap ranging from 1.5cm to 3cm.[4-7]

In 1989, Stephens, Hsu, and Leung[8] renewed a series of 30 skeletally mature patients after isolated femoral fractures in childhood (age ranging between 7-13 years), however children below 7 years of age were not included in this study. We therefore conducted a study on children with femoral shaft fractures treated in the Department of Orthopaedics, Dr D.Y. Patil Hospital, Pimpri, Pune to investigate the degree of overgrowth and have attempted to correlate clinical factors that may influence the outcome with such overgrowth.

Materials and Methods
This is a retrospective study. Children between the age of 0 to 12 years were included in this study. We reviewed charts of these children who presented in, the Department of Orthopaedics, Dr D.Y. Patil Hospital, Pimpri, Pune with unilateral femoral shaft fractures from January 2011 to October 2016. Patients with less than 3 years of follow up, pathological fractures, bilateral fractures and fractures treated with internal fixation were excluded from this study.

The treatment received by the patients was age dependant. Bryants traction was used for children under the age of two years or less than 6.8kg. The treatment protocol followed in the conservative management of these fractures was the application of traction for about 3 weeks. This was followed by Hip spica for an additional 3 weeks for older children, skin traction would be applied for 3 weeks using a Thomas splint in which the adjustment of weight was based on radiographs so that the fragments overlapped by around 1 cm. This would be followed by application of Hip spica for an additional 3 to 5 weeks.

Radiographs taken at the time of admission till callus formation were reviewed. Assuming that prior to fracture the limb length were equal, therefore the amount of overlap would represent the initial limb length discrepancy. We took into consideration the magnification factor. Final limb length discrepancy was evaluated after squaring of the pelvis and the patient lying in a supine position. The measurement between the tip of the medial malleolus and the anterior superior iliac spine was taken. The average of three measurements was used as the recorded discrepancy. Substraction of the final limb length from the initial limb length was done to determine the overgrowth. Range of movements of the knee and the hip was assessed along with equity into the limitation in sports or daily activities of the patients. Investigation was also done to assess complications such as postural scoliosis which could occur as a result of limb length

discrepancy and abnormal gait. Results were analysed using SPSS (Statistical Package for Social Sciences).

Results

A Total of 58 patients were admitted for femoral fracture during this period of study. Out of the total number of patients 12 patients preferred to have their subsequent follow up in other hospitals. There were two pathological fractures and another two were treated with fixation. The documents of two other patients couldn't be traced by us. The rest 40 patients were willing to return for clinical evaluation. The mean follow up period was 54.9 months (range: 27 to 81 months). All patients included in this study had at least 24 months of follow up. 0.85 was the mean over growth for this study sample with the mean ranging from 0-2.5 cm.

Gender and Overgrowth: A total number of 29 males and 11 female were included in the current study. The observation found was that the mean overgrowth of the femur in male patients was 0.90cm and that of females was 0.71cm. The mean difference between the male and female was 0.18cm but there was no statistically significant difference between the two group. (Table 1)

Age Groups and Overgrowth: There was division of the children into three different age groups; twelve (30%) were < 2 years; seventeen (42.5%) were between 2 to 7 years and eleven (27.5%) were 7 to 12 years of age. Mean age of all the children was 4 years and 6 months. Mean overgrowth of the femur in children below the age of two was 0.36 cm. Older children between the ages of 2 to 7 had a mean overgrowth of 0.95 cm and those between the ages of 7 to 12 had a mean overgrowth of 1.22 cm. The mean difference in overgrowth between < 2 years and the 2 to 7 years age group was statistically significant ($p < 0.026$). The difference between the less than 2 years and the 7 to 12 age group was also found to be statistically significant ($p < 0.003$). However, there was no statistically significant difference between the 2 to 7 and the 7 to 12 age groups (Table 1).

Level of Fracture and Overgrowth: Thirteen (33%) of the fractures were in the upper third of the femur; twenty-three (57%) were in the middle and four (10%) were in the lower third. Mean overgrowth of fractures in the upper third group was 0.94 cm; for the middle third the mean was 0.77 cm and lower third mean was 1.00 cm. There were no statistically significant differences found between the three groups (Table 1).

Pattern of Fracture and Overgrowth: The mean overgrowth for transverse fractures (22 cases) was 0.86 cm; oblique fracture (9 cases) 0.87 cm and spiral fracture (9 cases) 0.78 cm. There were no statistically significant differences found between the three groups (Table 1).

Correlation between Initial Shortening and Subsequent Overgrowth: There was a positive correlation between initial shortening and subsequent overgrowth of the fractured limb, based on the Pearson correlation test. The correlation coefficient was 0.74 ($p<0.01$). However we cannot conclude that it was a perfect correlation as some cases included in the study did not show any overgrowth.

Final Limb Length: In this study, all but 5 cases had overgrowth. However, not all of those patients with overgrowth had equal limb length at follow-up, although, all showed reduction of the initial discrepancy. Equal limb length was achieved in 22 of the 40 patients, 16 had shortening and 2 showed increased length on the fractured side. Ten patients had shortening of 0.5 to 1.0 cm; five had 1.0 to 1.5 cm shortening and one had shortening of 2.0 cm. The two patients who showed increased length had lenghthening of 0.5cm.

Complications: There was one case of postural scoliosis which was correctable with a raised shoe in a child with 2.0cm shortening. All other patients were able to participate in sports and normal activities. Clinically, all patients had full range of hip and knee movements.

Table 1:

Factor	Number	Mean in CM
Gender		
Male	29	0.90
Female	11	0.71
Age Group		
0 - < 2	12	0.36
2 - < 7	17	0.95
7 - < 12	11	1.22
Level of Fracture		
Upper third	13	0.94
Middle third	23	0.77
Lower third	4	1.00
Pattern of Fracture		
Spiral	9	0.78
Oblique	9	0.87
Transverse	22	0.86

Discussion

In 1923, Burdick and Siris[9] reported on a large study of fractures of the shaft of femur in children. Of these, 118 had a shortening of 0.5-3cm at discharge. Within 3 years, 53 of those children had bone length equality while others had less discrepancy. The authors based on their study concluded that slight shortening in the fractures of this nature need not be corrected. According to Blount,[10] open reductions of diaphyseal fractures were practically never indicated as they were associated with a risk of significant increase in growth.

He was of the opinion that the diaphyseal femur fractures in children be allowed to heal with a shortening of 1-2cm, which would likely be eliminated

during the course of further growth. During his study, he did not find any relationship between the distance of fracture from the growth plates and the degree of overgrowth. In this study, we found that there was influence of the age of the patient at the time of fracture on the final quantity of femoral overgrowth. There was more overgrowth in the 2 to 7 and the 7 to 12 years age groups as compared to the 0 to 2 years age group. Literature searches regarding the influence of age on overgrowth were hampered by the different age distributions from study to study. Overgrowth being related to age was concluded by many authors.[5,11-13]

Most were of the opinion that overgrowth was greatest when the fracture occurred in children aged between 4 to 8 years. Some authors did not find any significance statistically between the difference in overgrowth in different age groups.[14-16] Similar to the findings of Shapiro,[15] we found that the gender of the child did not influence the amount of overgrowth. Clement and Colton[3] were of the opinion that the most important factor that was influencing overgrowth was gender. We found that the level of the femoral fracture did not influence overgrowth, which was similar to findings in various other studies.[1,15,16] From our findings we could conclude that we did not find any difference in the amount of overgrowth between oblique, transverse and spiral fractures, unlike findings reported by Barford and Christensen.[5]

Conclusion

Overgrowth after fracture of the femur in children is a universal phenomenon. A mean increase in length of 0.85 cm can be expected in the affected femur, although those below 2 years old have less potential for such overgrowth.

Gender, level and pattern of fracture do not affect the quantity of overgrowth. Although a majority of patients end up with equal limb length, we expect all patients to achieve a reduction of the initial discrepancy in length; of those patients who do not show equal leg length at the last follow up, most have slight shortening, while a smaller number will have slight lengthening.

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