日小整会誌 (J Jpn Ped Orthop Ass) 17(2) : 406-410. 2008.
第 18 回日本小児整形外科学会学術集会 2007 JPOA Asian Fellows

Bone Overgrowth after Fracture in the Femoral Shaft in Children

Su-Mei Yong MS(Ortho)
Department of Orthopaedics and Traumatology, Hospital Selayang, Selangor
A Saw FRCS, S Sengupta FRCS
Department of Orthopaedic Surgery, University Malaya Medical Centre, Kuala Lumpur
A M Bulgiba PhD
Department of Social and Preventive Medicine, University Malaya Medical Centre, Kuala Lumpur

Abstract : Forty children have been treated non-operatively for a fracture in the femoral shaft and are reviewed with regard to differences in limb length after treatment. The follow up duration ranged from two to seven years. The average femoral overgrowth was 0.85 cm (range 0-2.5 cm), and this was influenced by age at the time of the fracture. We found no association between the quantity of overgrowth and race, gender, level or configuration of the fracture.

Introduction

There are many published studies regarding overgrowth of the femur after a fracture in a growing child. In 1921, Truesdell[1] was the first to report on post-traumatic increase in growth. This phenomenon of overgrowth had been attributed by Speed[2] to a compensatory mechanism. Others regarded the increase to be due to hyperaemia associated with the healing process[3].

It is important to recognise the factors that influence overgrowth, so that overriding of bone fragments can be adjusted in such a way as to minimize the final leg length discrepancy. Various authors have recommended differing amounts of overlap ranging from 1.5 cm to 3.0 cm[4)~7)]. Most studies published to date are based on Western populations. In 1989 Stephens, Hsu and Leung[8] reviewed a series of 30 skeletally mature patients in Hong Kong after an isolated femoral fracture in childhood (age range at time of fracture 7～13y). However, children below the age of seven years were not included in that study. We therefore conducted a retrospective study on children with a femoral shaft fracture treated at our institution to investigate the degree of overgrowth and have attempted to correlate clinical factors that may influence the outcome with such overgrowth.

Material and Methods

We retrospectively reviewed the clinical records of all children between the ages of 0 to 12 years who presented at our hospital with a unilateral femoral shaft fracture, from January 1992 to October 1997. Patients with less than 2

Key words : children, femoral shaft fracture, overgrowth
Corresponding Author : S M Yong. Department of Orthopaedic Surgery, University Malaya Medical Centre, 50603 Kuala Lumpur, Malaysia
E-mail : sumei_y@yahoo.com Fax : 603-79535642

years of follow up, pathological fractures, bilateral fractures, and fractures treated with internal fixation were excluded.

Treatment of the patients was age dependent. Bryant's traction was used for children under the age of two or less than 6.8 kg. The traction would be applied on both lower limbs for about 3 weeks, with the child's buttocks lifted just off the surface of the mattress. Hip spica was applied for an additional 3 weeks. For older children, skin traction would be applied for 3 weeks using a Thomas splint. Weights were adjusted based on radiographs, so that the fragments overlapped by about 1.0 cm. Hip spica would then be applied for an additional 3 to 5 weeks.

Radiographs taken at the time of admission till callus formation were reviewed. We assumed that limb lengths were equal prior to the fracture ; therefore the amount of any overlap would represent the initial limb length discrepancy. Magnification factor was taken into consideration. Final limb length discrepancy was evaluated clinically, with the patient in a supine position and the pelvis squared. One researcher conducted all clinical evaluations to prevent discrepancy due to different evaluators. The distance between the distal point of the anterior superior iliac spine (ASIS) to the tip of the medial malleolus was measured. The average of three measurements was used as the recorded discrepancy. Overgrowth was determined by subtracting the final limb length discrepancy from the initial limb length discrepancy.

The ranges of motion in the hips and knees were also assessed. Patients were asked about any limitations in sports or daily activities. Complications such as postural scoliosis due to limb length discrepancy and abnormal gait were also investigated.

Results were analysed using the SPSS (Statistical Package for the Social Sciences) Version 11 for Windows. Data cleaning and pre-processing were performed before analysis. Distributions were examined, and variances were tested for homogeneity before statistical testing. The *t*-test and one-way ANOVA (with Scheffe's post-hoc test) were used to compare means between groups. Prior to utilizing the *t*-test or ANOVA, normality assumptions were assessed using the Kolmogorov-Smirnov test and homogeneity of variances were tested using Levene's test. All statistical tests were carried out using a significant level of 0.05, and 95% confidence intervals were calculated for all factors in this study.

Results

A total of 58 patients were admitted for a femoral fracture during the period of this study. Twelve patients had their subsequent follow-up in other hospitals. There were two pathological fractures, and another two were treated with fixation. We were not able to trace the records and initial radiographs for 2 other patients. The families of the remaining 40 patients were willing to return for clinical evaluation. The mean follow-up period was 54.9 months (range from 27 to 81 months). All patients included in this study had at least 24 months of follow-up. The mean overgrowth for the study sample was 0.85 cm (range from 0 to -2.5 cm)

Gender and Overgrowth

There were 29 males and 11 females included in the current study. The mean overgrowth in the femur in the male patients was 0.90 cm, whereas that in the female patients was 0.71 cm. The mean difference between the males and females was 0.18 cm, but there was no statistical-

Table 1. Mean Overgrowth and Factors Investigated

Factor	Number	Mean difference in cm (95% CI)
Gender		
Male	29	0.90 (0.64, 1.15)
Female	11	0.71 (0.33, 1.08)
Race		
Malay	22	0.75 (0.45, 1.04)
Chinese	10	0.85 (0.47, 1.23)
Indian	8	1.11 (0.57, 1.65)
Age		
0-<2	12	0.36 (0.08, 0.64)
2-<7	17	0.95 (0.68, 1.21)
7-<12	11	1.22 (0.76, 1.68)
Level		
Upper	13	0.94 (0.49, 1.39)
Middle	23	0.77 (0.53, 1.00)
Lower	4	1.00 (0, 2.30)
Pattern		
Spiral	9	0.78 (0.45, 1.10)
Oblique	9	0.87 (0.49, 1.24)
Transvers	22	0.86 (0.52, 1.20)

ly significant difference between the two groups (Table 1).

Race and Overgrowth

Twenty-two (55%) of the children were Malay, ten (25%) were Chinese, and eight (20%) were Indian. The mean overgrowth in the Malays was 0.75 cm ; Chinese 0.85 cm, and in the Indians 1.1 cm. There were no statistically significant differences in the mean overgrowth among the three groups (Table 1).

Age groups and Overgrowth

The children were divided into three different age groups ; twelve (30%) were<2 years ; seventeen (42.5%) were between 2 to 7 years, and eleven (27.5%) were between 7 to 12 years of age. The mean age of all children was 4 years and 6 months. The mean overgrowth in 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 of age group was statistically significant ($p<0.026$). The difference between the less than 2 years and the 7 to 12 years of 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-third, and four (10%) were in the lower-third. The mean overgrowth at the fracture in the upper-third group was 0.94 cm ; in the middle-third the mean was 0.77 cm, and in the lower-third the mean was 1.00 cm. There were no statistically significant differences among the three groups (Table 1).

Pattern of fracture and Overgrowth

The mean overgrowth for a transverse fracture (22 cases) was 0.86 cm ; for an oblique fracture (9 cases) 0.87 cm, and for a spiral fracture (9 cases) it was 0.78 cm. There was no statistically significant difference among the three groups (Table 1).

Correlation between initial shortening and Overgrowth

Based on the Pearson correlation test, there was a positive correlation between initial shortening and subsequent overgrowth in the fractured limb. The correlation coefficient was 0.74 ($p<0.01$). However, it was not a perfect correlation as some cases showed no overgrowth.

Final limb length

In this study, all but 5 patients 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. 22 of the 40 patients achieved equal limb length, 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 0.5 cm of lengthening.

Complications

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

Discussion

In 1923, Burdick and Siris[9] reported a large study on fractures in the shaft of the femur in children. Of these, 118 had a shortening of 0.5-3 cm at discharge. Within 3 years, 53 of those children had bone length equality while others had reduced discrepancy. The authors drew a practical conclusion that slight shortening in fractures of this nature need not be corrected. In the same year, Speed[2] published an article in which he discussed overgrowth in relation to osteomyelitis, but in the introduction, he mentioned in passing that he had observed about 20 cases of so-called compensatory overgrowth as a result of a fracture in the femur. According to Blount[10], open reduction of a diaphyseal fracture was practically never indicated as this was associated with a risk of significant increase in growth. He recommended that a diaphyseal femur fracture in a child be allowed to heal with a shortening of 1-2 cm, which would likely be eliminated during the course of further growth. He found no correlation between the distance of the fracture from the growth plates and the degree of the overgrowth.

In this study, we found that the age of the patient at the time of the fracture influenced the final amount of femoral overgrowth. There was significantly more overgrowth in the 2 to 7 and in the 7 to 12 years age groups compared to the 0-2 years age group. A literature search regarding the influence of age on overgrowth was hampered by different age distributions from study to study. Several authors found that overgrowth was related to age[5),11)~13)]. Most expressed the opinion that overgrowth was greatest when the fracture occurred in children aged between 4 and 8. Other authors found no statistically significant difference in overgrowth between 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. However, Clement and Colton[3] found that the most important factor influencing overgrowth was gender. There was no statistical difference in the amount of femoral overgrowth based on the race of the patient.

We also found that overgrowth did not appear to be influenced by level of the femoral fracture, similar to findings reported by several other studies.[1),15),16)], whereas Staheli[12] (1967) reported more overgrowth in cases of a proximal fracture. From our data, we did not find any difference in the amount of overgrowth among oblique, transverse and spiral fractures, unlike findings reported by Barford and Christensen[5] (1958). In their follow-up study of 114 femurs, oblique and comminuted fractures were shown to produce

more overgrowth.

Conclusion

Overgrowth after a fracture in 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, race, 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 in 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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