Femoral overgrowth following plate fixation of the fractured femur in children

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ABSTRACT

Introduction: The purpose of this study is to determine the overgrowth phenomenon of the affected femur following plate fixation of femoral fractures in children.

Methods: 15 patients (aged between eight and 14 years old), who underwent open reduction and plate fixation for fractures of the femur, were assessed at two years postoperation for limb length discrepancy. Measurements were made using a computed tomography (CT) scanogram. Its association with age, limb dominancy and site of fracture were analysed.

Results: There were 12 boys and three girls. All children had femoral overgrowth of the injured femur, ranging from 0.1 cm to 2.0 cm with a mean of 1.15 cm. There was a significant correlation between age and bone overgrowth. Limb dominancy and site of fracture had no significant influence on femoral overgrowth.

Conclusion: The amount of femoral overgrowth following fracture stabilisation with plate in children was minimal. It could still occur even without fracture overlapping during the healing process. The overgrowth was less in older subjects.

Keywords: computed tomography, femoral fracture, limb overgrowth, plate stabilisation

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INTRODUCTION

Femoral overgrowth following fracture of the femur in children is well known[1-3]. This is due to stimulation of the growth plate[4]. Opinions differ as to whether this phenomenon is a compensatory mechanism to adjust for discrepancy of length or an inevitable physiological response to trauma with no such compensatory role[5-7]. Most of the previous studies were performed on conservatively-treated patients using either clinical examination or radiography to measure the limb length[3,6]. Some authors suggested that conservative treatment of femoral fractures in patients between the ages of seven and ten years old should be aimed at 1 cm overlap at union[8]. Hedin et al found that the mean overgrowth at two years after anatomical reduction with external fixator was 0.5 cm, and hence did not recommend shortening[9].

Knowledge about the amount of affected femoral overgrowth will be useful in deciding whether or not the femur should be shortened during open reduction and plate fixation. It may also help surgeons to explain to parents regarding the possible overgrowth following operative anatomical reduction of femoral fracture in children. This study was designed to review the overgrowth phenomenon of the femur using computed tomography (CT) scanogram in children who had undergone anatomical reduction and plate fixation for femoral fracture.

METHODS

This cross-sectional study was conducted in Kota Bharu General Hospital and Hospital Universiti Sains Malaysia. The ethical board committees of both hospitals approved the study. The study group consisted of children with closed unilateral femoral shaft fracture treated with open anatomical reduction and plate fixation without creating shortening. Their ages during the trauma were between eight and 14 years. Those patients with comminuted or open fractures were excluded. All patients in the study had their plates removed between six months and one year after initial surgery.

The case records and radiographs of the children were reviewed, with particular reference to age, sex, site of fracture, and limb dominancy. The patients were then called for assessment two years after operative fixation of the femur. The patients and their parents were asked whether they were

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Table I. List and data of patients.

Patient	Age (years)	Sex	Side of injury	Site of fracture	Length of affected femur (cm)	Length of unaffected femur (cm)	Overgrowth of affected femur (cm)
1	12	M	D	M	44.1	43.0	1.1
2	9	M	ND	M	34.8	33.0	1.8
3	14	M	D	M	41.8	41.3	0.5
4	11	M	D	P	38.5	37.0	1.5
5	13	M	D	D	45.1	44.2	0.9
6	13	M	D	M	44.7	43.7	1.0
7	10	M	D	M	34.3	32.6	1.7
8	12	F	ND	D	39.0	37.9	1.1
9	8	M	ND	M	35.0	33.0	2.0
10	9	M	D	M	37.8	35.9	1.9
11	14	M	D	M	40.8	39.6	0.4
12	14	M	ND	D	38.3	38.1	0.2
13	10	F	ND	M	45.6	44.3	1.3
14	11	M	ND	P	39.7	38.8	0.9
15	13	F	D	D	37.9	37.0	0.9
Mean	**11.5**						**1.15**

M: male, F: female, D: dominant side, ND: non-dominant side, P: proximal third, M: middle third, D: distal third.

aware of any limping. Limb length discrepancy was assessed while patient was in supine position using CT scanogram (Siemens Somatom four-Plus, Medical Engineering Group, Berlin and Munich, Germany). The femoral length was measured from the most proximal portion of the femoral head to the mid-point of the line connecting the distal ends of the femoral condyles.

A single radiologist carried out all the measurements in order to minimise bias. The femoral length was considered to be equal before the fracture. The overgrowth in the injured femur was taken as the excess of the length compared to non-injured side. The association of femoral overgrowth with the age was analysed using Spearman correlation test. Its association with limb dominancy was tested using Mann-Whitney test, while its association with site of fracture was analysed using Kruskal-Wallis test.

RESULTS

There were 12 boys and three girls. All injured femurs had overgrowth ranging from 0.1 cm to 2.0 cm, with a mean of 1.15 cm (Table I). There was a strong correlation ($R=-0.94$, $p<0.05$) between age and femoral overgrowth (Fig. 1). Mean overgrowth of patients who had fractures on the dominant side was 1.10 cm, while those who had fractures on the non-dominant side was 1.22 cm. However, the difference was not statistically significant ($p=0.63$). Mean overgrowth according to location of fracture at proximal, middle or distal third of femur was 1.20 cm, 1.30 cm and 0.78 cm, respectively. However, the difference was not statistically significant ($p=0.24$). Neither the patients nor their parents were aware of the limb length discrepancy.

DISCUSSION

The treatment recommendations for paediatric femoral fractures are mainly non-operative[10]. Operative treatment is recommended in the multiple-injured patients. Fixation devices used to anatomically stabilise paediatric femoral fractures include compression plates, external fixation and flexible intramedullary nails. Flexible intramedullary nail is the popular method of fixation; however, it is expensive, requires radiological exposure during insertion, is not suitable for comminuted fracture and may cause irritation of soft tissue near the joint leading to infection[11]. External fixation is reported to have high rates of re-fracture, pin tract infection, and loss of reduction[12]. Plate fixation is still useful in certain situations, when a quick and easy fracture reduction and stabilisation are needed without

fluoroscopic imaging, like in multiple-injured patients[13]. Therefore, the number of cases treated with this method in our institutions is small.

Assessment at two years postoperation was chosen, because longitudinal overgrowth occurs mainly in the first 24 months[3,14,15]. It was also aimed to address the possibility of overgrowth following removal of implants that were performed between six months and one year after the first surgery. CT scanogram was chosen as the method for assessment, because it has better accuracy, consumes less time and utilises less radiation compared to orthoroentgenography[16]. Clinical measurement had an accuracy only to the nearest 5 to 10 mm while radiographical measurement was inaccurate by 2 to 3 mm due to distortion by magnification[17,18]. Limb length measurement using CT scanogram has an accuracy of 0.2 mm[19].

Unlike our results, other studies found that not all patients had femoral overgrowth following plate fixation. This difference could be due to different methods of assessment. Ward et al[20] used block test measurement and found the occurrence of overgrowth in 41.2% of cases. Kregor et al[21] used radiographical measurements and found that 70% of cases had overgrowth with mean of 0.9 cm. The mean overgrowth in our study as well as in two other previous studies on plate fixation were greater, compared to results from non-operative treatment (0.7 to 0.8 cm) and external fixation treatment (0.5 cm)[1,3,9,22]. This difference could be due to secondary periosteal trauma during removal of plate[23].

Hougaard[2] and Reynolds[3] concluded that there was a relationship between overgrowth and age of the patient between one and 14 years. Other studies found a greater overgrowth in children between four and seven years old compared to those who were outside this age range[17,22,24]. Excluding patients who were younger than eight years old, we found that the overgrowth decreases as the age increases. Shapiro[14] found that overgrowth was not influenced by whether the fracture was in the proximal, middle, or distal thirds of the femur. This is consistent with our findings. However, other studies showed higher mean overgrowth in proximal third femoral fractures[25,26]. This study, like that of Meals[6], showed that the fractured femur on a non-dominant side had greater mean overgrowth than that on a dominant side. However, the difference was not significant.

Gait analysis and biomechanic studies in children showed that a discrepancy of 2 cm (3.7%) or less resulted in an acceptable gait. It did not produce changes in joint kinematics likely to lead to joint abnormalities[27-29]. This was the reason why all the patients and their parents in this study were not aware of the limb length discrepancy. Since the overgrowth was less than 2 cm (mean of 1.15 cm) and there was no reliable predictor to this phenomenon, we do not recommend primary shortening during the operative procedure of anatomical reduction and plate fixation in managing femoral fracture in children between eight and 14 years of age. This recommendation was drawn with the consideration that the ipsilateral tibial overgrowth of an average of 0.2 to 0.3 cm was minimal, and that this amount of difference can also be found in normal legs[14,17,25].

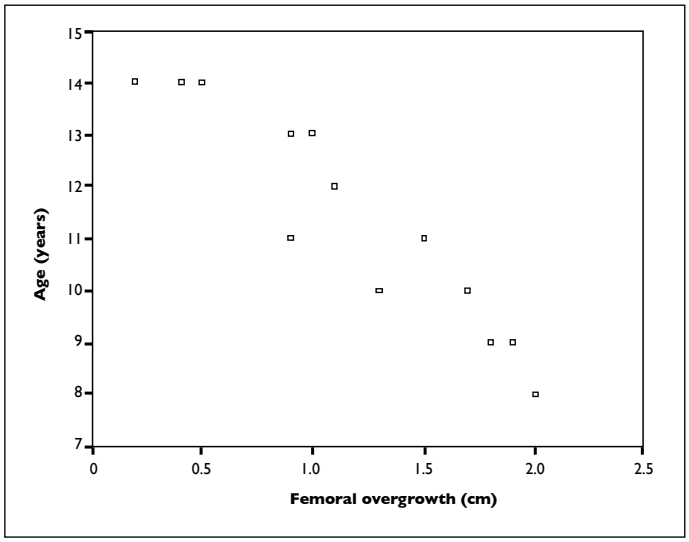

Fig. 1 Scatter graph shows a strong correlation (R=-0.94, p<0.05) between age at time of fracture and the femoral overgrowth.

Anatomical reduction obtained with open reduction and plate fixation eliminated the factor of overlapping at fracture site; hence the only remaining cause of over lengthening was a physiological response to trauma. This study supports the opinion that the overgrowth phenomenon can still occur even without length discrepancy caused by the trauma. A small sample size was the weakness of this study. The sample size was small because plate fixation of femoral fracture in children was only performed in selected situations. We plan to continue the observation on similar cases to strengthen the findings in future.

We conclude that the amount of femoral overgrowth following its fracture in children between eight and 14 years of age was 0.1 cm to 2.0 cm, with a mean of 1.15 cm. It could still occur even without fracture overlapping during the

healing process. There was a negative correlation between femoral overgrowth and the age at time of fracture in children within this age group.

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