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# BONE OVERGROWTH FOLLOWING DIAPHYSEAL FEMORAL FRACTURE IN CHILDREN

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## Abstract

Limb length discrepancy is the most common complication reported after femoral shaft fractures in children, usually resulting from overgrowth of the injured femur. The exact cause of this overgrowth is still not known but it has been attributed to age, gender, fracture type, fracture level, handedness and amount of overriding of the fracture fragments.

This study aimed to evaluate femoral length discrepancy and rate of femoral overgrowth after one year of union following diaphyseal fracture of femur in children and find possible factors that accelerates this phenomenon.

A 34 femora with femoral shaft fractures were included in study, age ranged (1.5-15yrs.), 26 were males and 8 were females, 19 were treated by hip spica, 15 were treated by open reduction and internal fixation.

Normal and fractured femoral length were assessed both clinically and radiologically at time of union and one year later. Clinically from anterior-superior iliac spine to medial knee joint line and radiologically by measuring distance between most proximal bony point of femur and distal mid intercondylar line.

Radiologically, 97% of femora were shortened at time of union, 26% of them remained shortened one year later, Clinically, overgrowth occurred in 76.5% of cases (average 0.4cm./yr.), while radiologically occurred in all (100%) cases (average of 0.8 cm./yr.).

In conclusion, x-ray of both femora in one film is relatively safe technique for femoral length assessment compared to other patterns of radiological assessment, and more accurate than clinical assessment. Proximal-third and spiral fractures in children younger than 8 years had greater tendency to correct shortening. The greatest and significant overgrowth occurred within first year after injury. The overgrowth phenomenon is physiological response to trauma rather than compensatory to the discrepancy. Sex and side of fracture did not seem to have any significant influence on femoral overgrowth.

## Introduction

Femoral shaft fractures are common in children[1], the age distributions is bimodal, with peaks at 2 and 17 years, Boys have higher rate than girls at all ages.

Most femoral fractures in children are closed injuries and traditionally have been treated by closed methods (tractions and spica)[2], the choice of closed method depends largely on the age and weight of the child, if satisfactory reduction cannot be achieved by traction, internal or external fixation is justified, especially in older children and those with multiple injuries[2].

Limb length discrepancy is the most common complication reported after femoral shaft fractures in children[3], usually resulting from overgrowth of the injured femur. The exact cause of this overgrowth is still not known but it has been attributed to age, gender, fracture type, fracture level, handedness and amount of overriding of the fracture fragments[4]. The overgrowth is due to stimulation of the growth plate[5]; it is believed to be due to physiological process associated with posttraumatic hyperemia of the growth plate[6].

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], most authors agree that significant overgrowth occurs in the first two years after injury and will not be further corrected[3].

The aim of this study is to evaluate femoral length discrepancy and rate of femoral overgrowth after one year of union following diaphyseal fracture of femur in children and find possible factors that accelerate this phenomenon.

## Patients and methods

Thirty-four femoral shaft fractures in children were included, the mean of their age was 6.2 years (ranged 1.5-15 years), and the duration of follow-up was one year (12 months).

Fracture side distribution; of 34 cases, 22(64.7%) cases were with dominant fracture side and 12(35.3%) cases were with nondominant fracture side.

Fracture site Distribution; of 34 cases, 16(47%) cases were proximal third, 12(35%) cases were middle third and six (18%) cases were distal third.

Types of fracture; of 34 fractures, 12(35.3%) fractures were spiral, 9 (26.5%) fractures were oblique, 9(26.5%) fractures were comminuted, and 4(11.8%) fractures were transverse pattern.

Type of holding; of 34 cases, 19(55.9%) cases had been treated by hip spica and 15 (44.1%) cases by plate and screws.

Inclusion criteria: Diaphyseal closed fracture, Age up to 15 years, Traumatic fracture, Unilateral isolated fracture, No limb length discrepancy before exclusion criteria; Metaphyseal and epiphysis injuries, Open fractures, Pathological fractures, Bilateral fracture femur, Coxa vara, poliomyelitis and Developmental Dysplasia of the Hip are excluded, External fixation and intramedullary nail, Age above 15 years, delay-union and non-union fractures.

Specific treatment done for the patient under general anesthesia either spica or plate and screws; hip spica (when applied) either early or delayed reduction after two weeks of traction. Follow up was done-twice for each patient- at time of union both clinically and radiologically and one year after union. The time of union ranged between 6-9 weeks (average was 7 weeks).

Clinical assessment; it can be assessed by direct measurement of both femora and X-Ray assessment Single exposure technique of both femora, including hip and knee joints, and patient in correct position as well as application of gonad protector.

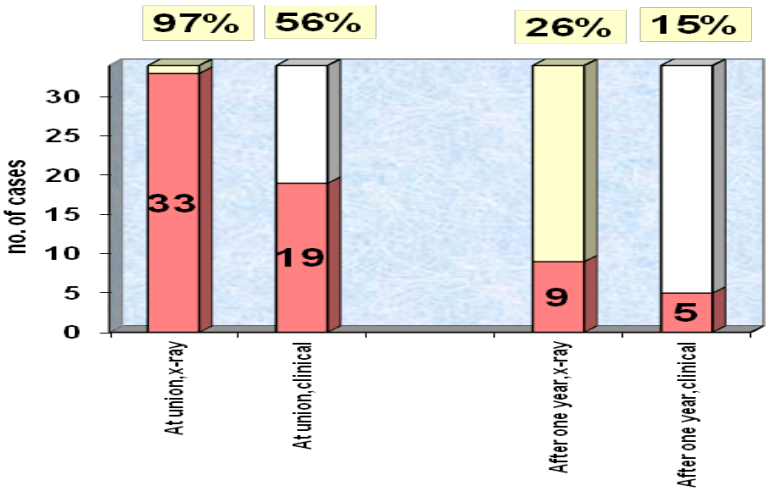
After one year of union; Second assessment performed, by repeating same manner of the first assessment- clinically and radiologically, all data been recorded in the formulae again.

## Results

Shortening of fractured femur:

At time of union; By x-ray measurement; of 34 fractures, 33 (97%) fractures united with range of shortening 0.2-2cm (average 0.7cm), only one (3%) case was with (0.1cm) lengthening (Plus discrepancy). While By clinical assessment; 19 (56%) fractures united with range of shortening, ranging 0.1-1.5 cm (average 0.6 cm), and 15(44%) cases united without discrepancy.

After one year of union By x-ray measurement; shortening remained just in 9(26%) cases, ranged 0.2-0.9cm (average 0.5cm), 2(6%) femurs were with equal length, lengthening occurred in 23 (68%) femurs, while by clinical assessment; shortening remained just in 5(15%)cases, ranged between 0.2-0.6 cm (average 0.4 cm) of shortening histogram (I).



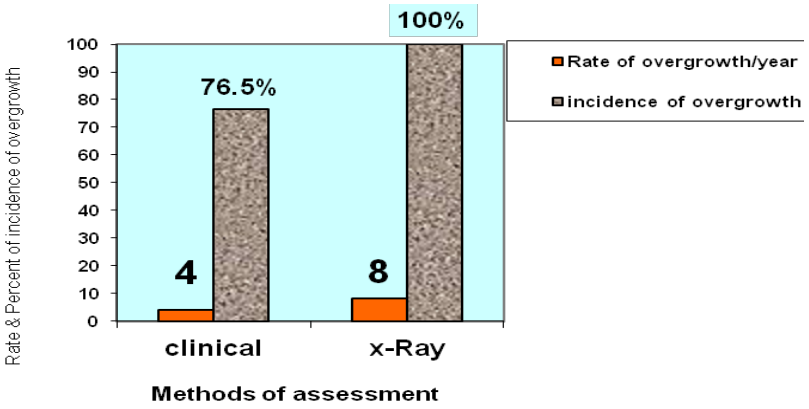

**Histogram (I): incidence of shortening at time of union and after one year**

The incidence and rate of overgrowth per one year.

By x-ray measurement, of 34 cases, in 34(100%) cases overgrowth occurred within the range of 4-16 mm (average 8 mm).

By clinical measurement; of 34 cases, 26(76.5%) cases were with overgrowth within the range of 0-12 mm (average 4 mm), while in 8 (23.53%) cases, the discrepancy remained unchanged (undetected between first and second measurement the overgrowth not happened (clinically).

The Difference (between x-ray and clinical measurement) ranged between 0-7 mm (Average 4 mm) see histogram (II).




**Histogram (II): accuracy of x-ray versus clinical assessment**

Relationship between Age and rate of overgrowth by x-ray measurement.

younger than 8 years; of 27 cases, the rate of overgrowth of 25 (92.6%)cases were between 6-12 mm, and overall Range of overgrowth was 4-16 mm(average 8.7 mm).

older than 8 years; of 7 cases, 3 (42.9%) cases were between 6-12 mm, and overall Range of overgrowth was 4-7 mm (average 5.2 mm).

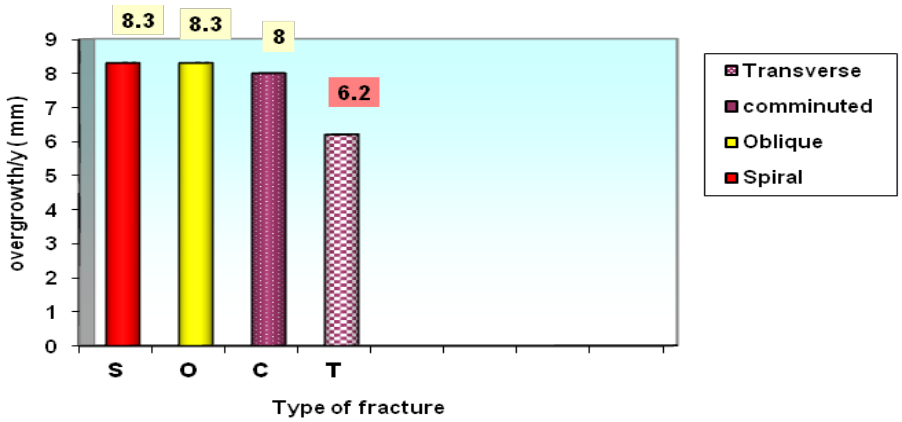
Relationship between type of fracture and rate of overgrowth by x-ray measurement

Spiral fractures; of 21 cases, 10 (83.3%) cases were with overgrowth between 6-12mm,and overall Range of overgrowth was 6-10 mm (average 8.3 mm).

oblique fractures; of 9 cases, 9(100%) cases were with overgrowth between 6-12 mm, and overall Range of overgrowth was 6-10 mm(average 8.3 mm).

comminuted fractures; of 9 cases,5 (55.6%) cases were with overgrowth between 6-12 mm, and overall Range of overgrowth was 4-16 mm( average 8.0 mm).

transverse fractures of 4 cases, 3 (75%) cases were with overgrowth between 6-12 mm, and overall Range of overgrowth was 4-7 mm(average 6.2 mm).(histogram III).




**histogram (III): relationship between type of fracture and Overgrowth**

Type of fixation and rate of overgrowth per one year by x-ray measurement

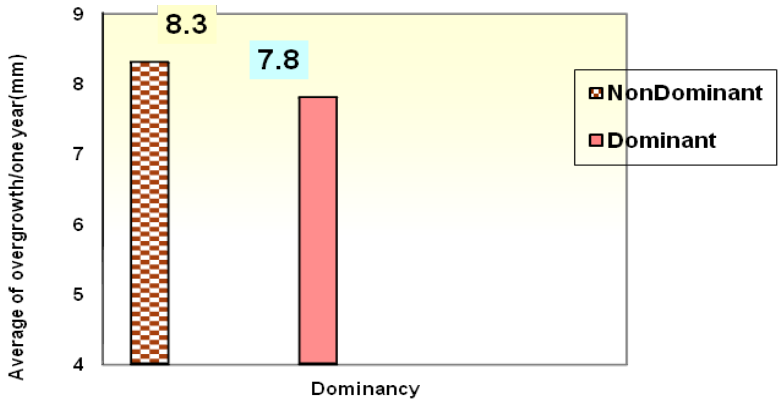
Hip spica; of 19 cases, 17(89.5%) cases were with overgrowth between 6-12 mm ,and overall Range of overgrowth was 4-16 mm (average 9.2 mm).

Plate and screws; of 15 cases, 10(66.7%) cases were with overgrowth between 6-12 mm, and overall Range of overgrowth was (4-10) mm (average 6.4mm.

Side of fracture and rate of overgrowth per one year by x-ray measurement

Non dominant cases; of 12 Cases, 11(91.7%) Cases were with overgrowth between 6-12mm, and Overall Range of overgrowth was 5-12 mm (average 8.3 mm).

Dominant cases; of 22 cases, 16 (72.7%) Cases were with overgrowth between 6-12mm, and Overall Range of overgrowth was 4-16 mm (average 7.8mm). (histogram IV).




Histogram (IV): overgrowth and Dominancy

Site of fracture and rate of overgrowth per one year by x-ray measurement:

proximal third fractures; of 16 cases, 13(81.3%) cases were with overgrowth between 6-12mm, and overall Range of overgrowth was 5-16 mm ( average 8.8mm). Middle third fractures; of 12 cases, 10 (83.3%) cases were with overgrowth between 6-12mm,and overall Range of overgrowth was 4-11 mm ( average 7.4 mm). distal third fractures; of 6 cases, 4(66.7%) cases were with overgrowth between 6-12mm, and overall Range of overgrowth was 4-7 mm (average 6.2mm).

Sex and rate of overgrowth by x-ray measurement per one year.

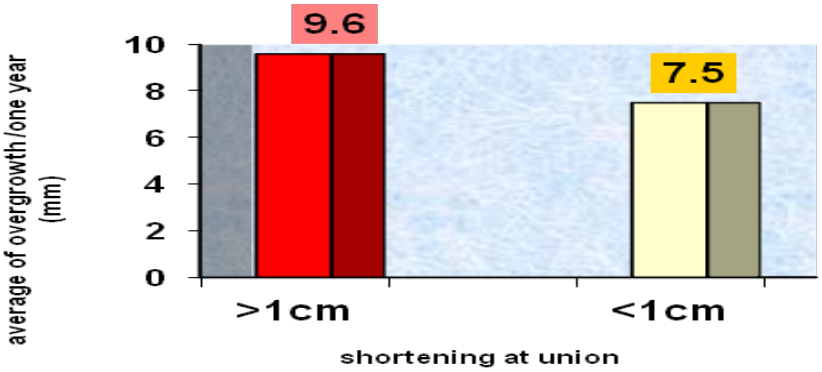
Male: of 26 cases, 20(76.9%) cases were with overgrowth between 6-12mm, and overall Range of overgrowth was 4-16mm (average7.9 mm).

Female: of 8 cases, 7 (87.5%) cases were with overgrowth between 6-12mm, and

overall Range of overgrowth was 5-11 mm (average 8.2 mm).

Shortening at time of union and rate of overgrowth by x-ray per one year: shortening more than 1cm; of 9 cases, 7(77.8%) cases were with overgrowth within 6-12 mm, one (11.1%) case was with overgrowth above 12 mm, and overall Range of overgrowth was 4-16 mm (average 9.6 mm).

Shortening less than 1cm; of 25 cases, 20 (80%) cases were with overgrowth between 6-12 mm, no case (0%) with overgrowth above 12mm, and overall Range of overgrowth was 4-11 mm (average 7.5 mm. (See histogram V)




Histogram (V): shortening at time of union and Average of overgrowth

## Discussion

Sex distribution: the ratio of male to female in this study was 3.2:1. This was almost identical to that of Hinton, Shapiro and Hougaard in their study; Boys were involved more often than girls with a ratio of 2.6:1[7].

Age incidence; (53%) of cases were their ages between 4-7.5 years .This is in contrast to the report by Hedlund and Lindgren, which noted the maximum incidence in children to be between two and five years of age[6]. The difference is probably due to the fact that in their study fall were the most common cause of fractures, whereas in our study road traffic accidents were the major cause.

Type of treatment: 19 (55.9%) cases were treated by hip spica. This result, in agreement with other series that; mainly non-operative treatment is recommended for pediatric femoral fractures[5]. Operative treatment is recommended in the multiple-injured patients and Fixation devices used to anatomically stabilize pediatric femoral fractures[6].

Causes of fracture: 21 (62%) cases were road traffic accident. This result is in agreement with other series that; fractures of femur are usually due to direct violence e.g. road accident or a fall from height[2].

Duration of follow up: In this study, the follow up duration was 12months, while in other studies, the follow up ranged 18-48 months. The aim of this study is mainly to evaluate the rate of femoral overgrowth in first year of the healing process, not to determine the maximum period of femoral overgrowth, which is expected to continue until 2 years, but greatest bone overgrowth occurs in the first 6-12 months after union and less in the second year[7,8].

Accuracy of radiological assessment: In this study, the average of difference between x-ray and clinical methods was 4 mm. in other series reported that radiographic assessment is more accurate than Clinical assessment because Clinical measurement has an accuracy only to the nearest 5 to 10 mm while radiographically measurement is inaccurate by 2 to3 mm due to distortion by magnification[6].

The assessment in both methods confound to femur without tibia, in this study assessment of tibial length is excluded, because the overgrowth of tibia after femoral fracture is controversial. Edvardsen P, Syversen SM. Reported in his study that Growth of the tibia was not affected by the

femoral fracture[13]. Zwierzchowski TJ, Synder M, Domzalski M. Investigated in his study that The Overgrowth of the limb was observed only within of the femur, the legs were equal in every case[9].

Incidence of shortening; In this study, the incidence was 97% at time of union, whereas it fell to 26% after one year of union (The average of residual shortening was 0.5 cm) .This result is in agreement with Rockwood who stated that: The most common sequela after femoral shaft fractures in children is leg length discrepancy. The fractured femur may be initially short from overriding of the fragments at union; growth acceleration occurs to "make up" the difference, but often this acceleration continues and overgrowth occurs[7].

Rate of overgrowth per one year; In this study, the range by x-ray was 4-16 mm (average 8mm).whereas the range by clinical was 0-12mm (average 4 mm).

Kregor et al' used radiographical measurements and found that of cases had overgrowth with mean of 0.9 cm5 Nordin S. And FaishamW.I. used clinical measurement The average was 1.17 cm6, and Sulaiman A R, Joehaimy J, Iskandar M A, Anwar Hau M, Ezane A M, Faisham W. used CT scan .The femoral overgrowth was with a mean of 1.15 cm5. The difference in the result probably due to longer follow up (18-24 months) in other studies, or due to difference in methods for assessment.

Incidence of overgrowth by different methods; By x-ray, the incidence was 100% (overgrowth occurred in all cases were included in this study), whereas by clinical; it fell to 76.5%. Ward et al`s" used block test measurement and found the occurrence of overgrowth was 41.2% of cases[5]. according to MD Ros and W I Faisham overall femoral overgrowth by clinical measurement occurred in 77.4% of the children[6]. Radiographic and CT scanogram revealed that femoral overgrowth occur in 100% of cases[5].

Age and overgrowth per one year; the average of overgrowth was higher in children who were younger than 8 years (8.7 mm) than those who were older than 8 years (5.2 mm).This result was in agreement with Hougaard and Reynolds who were concluded that greater overgrowth in children between four and seven years old compared to those who were outside this age range and they found that the overgrowth decreases as the age increases[5], and Nordin S. found that the majority of children who sustained femoral shaft fractures before eight years of age equalized their limb length at the final follow-up. Griffin et al and Staheli reported similar findings[6].

Type of fracture and overgrowth; the highest average was in spiral and oblique (the averages of spiral, oblique, comminuted and transverse fractures were 8.3 mm, 8.3 mm, 8.0 mm and 6.2 mm respectively). Most researchers believe that no specific relationship exists between fracture type and overgrowth, but some have reported overgrowth to be more frequent after spiral, oblique, and comminuted fractures associated with greater trauma[7]. (Edvardsen P, Syversen SM.) Reviewed that Overgrowth was promoted by comminuted and long oblique fractures. According to Zwierzchowski TJ, Synder M and Domzalski M. The overgrowth was remarked in the cases of spiral fracture with overriding[9].

Dominancy and overgrowth In this study, the average of nondominant was slightly higher (averages in nondominant and dominant were 8.3mm and 7.8 mm respectively). In other studies is controversial; Meals, Kohan , Cumming and Nordin S. found that femoral overgrowth tended to be greater when the non-dominant limbs were injured6. whereas Zwierzchowski TJ, Synder M and Domzalski M. Reported that the overgrowth was remarked in fracture of the opposite site to dominant hand[9].

Site of fracture and overgrowth; In this study, the Average of overgrowth in proximal third more than middle and distal third (Averages in proximal, middle and

distal thirds were 8.8mm, 7.4 mm and 6.2mm respectively). Barfod et al and Staheli; found that proximal third fractures showed a significant overgrowth compared to middle and lower third fractures[6].

Shortening at time of union and overgrowth; In our study, in cases who had shortening less than 1 cm, the average of overgrowth was 7.5 mm, while those who had shortening more than 1 cm, the average was 9.6 mm. This result in contrast to most other series, according to Nordin S.; the initial shortening of femoral shaft at time of union has slight difference in the range of overgrowth, while Stephens, Hsu LC, Leong JC. Reported that excessive fracture overlap at the time of injury, but not at union, increases limb overgrowth[11]. Kohan L, Cumming WJ. Reported that the greater the initial shortening, the stronger appeared to be the stimulus for overgrowth. Aitkin suggested that an increase in shortening of a fractured bone induces more callus formation, a longer period of periosteal hyperaemia and epiphysis stimulation[12].

Type of fixation and overgrowth; In our study, the overgrowth occurred in both methods of fixation the average was higher in those cases that had been treated by spica rather than those with plate and screws (9.2 mm and 6.4mm respectively). This result in agreement with other studies; Sulaiman A R, Joehaimy J, Iskandar M A, Anwar Hau M, Ezane A M, Faisham W. Reported that overgrowth phenomenon can still occur even without length discrepancy caused by the trauma, and who were treated by anatomical 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[5]. Overgrowth occurs whether the fracture is short, at length, or over pulled in traction at the time of healing[7]. The greater mean of overgrowth of spica probably due to increase in shortening of a fractured bone that induced more callus formation, a longer period of periosteal hyperaemia and epiphysis stimulation[12].

## Conclusions and recommendation

1. Radiographic assessment is more accurate than clinical assessment.
2. In clinical measurement femoral overgrowth after femoral shaft fractures occurred in 76.5% of the children, with an average of 0.4 cm of overgrowth within the first 12 months of the fracture. In radiological measurement femoral overgrowth after femoral shaft fractures occurred in 100% of the children, with an average of 0.8 cm of overgrowth within the first 12 months of the fracture.
3. Incidence of femoral shortening following fracture femur was very high (97%) at time of union, but it decreased to (27%) after one year of union.
4. Those fractures sustained before the age of eight years had a greater tendency to correct shortening by bone overgrowth.
5. Spiral, oblique and comminuted fractures had higher ability to correct the shortening by bone overgrowth than transverse fractures.
6. Age, Site, type of fractures and Shortening at time of union, had significant influence on femoral shortening.
7. Sex and side of fractures had insignificant influence on femoral overgrowth.
8. Follow up in the first year after union is recommended (every six months) for children who are limping with shortening by radiological measurement of more than 2cm.
9. In managing femoral fracture in children, primary shortening is not recommended during operative procedure of reduction and plate fixation especially between 8 and 15 years of age, because the rate of overgrowth is not always predictable.

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