Prognosis of Fracture of the Tibia in Children

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Abstract
In this study the features of auto-correction of deformities and prognosis of overgrowth after the fracture of tibia in children were investigated.

Ninety cases, 62 boys and 28 girls with an average of 7.3 years were followed up. Sixty four cases were closed fractures and 26 were open. The follow-up period was between one to 13 years, with an average of 4 years. Conservative treatment was used in 81.2% and surgery in 18.8%.

Results: All cases except one achieved bone union with an average of 77.3 days. Bone union in closed fractures was 64.4 days for group A (aged 5 and under), and in open fractures 85.2 for group C (aged between 9 and 12). Overgrowth occurred in 96% of group A with an average of 9.4 mm and in group C 54%, 4.2 mm. Auto-correction of varus and valgus deformities occurred in 92% of group A and 70% of group C, also found in 83.1% of anterior and posterior convex deformities at the time of union, 87.5% of which exhibited auto-correction.

Conclusion: Overgrowth occurred within two years after the injury, continuing to four years before it almost stopped. We observed good results in auto-correction of deformities when angles of varus and valgus deformities were 10 degrees or less, and in anterior and posterior convex deformities 20 degrees and under. Age had no influence in correcting anterior and posterior convex deformities, but the infants excelled over other age groups in correcting varus and valgus deformities.

Introduction
Fractures in children tend to be treated easily since union generally goes well. However, some fractures take longer than expected to unite, and can develop deformity, overgrowth and shortening. A typical case is fracture of tibia. Therefore, research on the treatment of tibia fractures in children and their outcome is still actively discussed. Anteromedial subcutaneous soft tissue is scarce in the lower leg making open fractures more likely. Yet we still do not have a full knowledge of the features and limits of the auto-correction ability of deformities, or the extent and prognosis of overgrowth and shortening. We retrospectively reviewed these issues in our cases of fractures of tibia in children aged twelve and under over the past thirteen years.

Objectives
Over the previous thirteen years from 1988 to 2000 we treated 112 limbs in 112 cases of children aged 12 and under for fractures of the tibia. All were treated at our hospital. In this study, 90 cases with a minimum one-year follow up were investigated. Forty-eight injuries were caused by traffic accidents and 23 were sports injuries. These were the two major causes of fractures and constituted 78.8% of the total. Sixty-two cases were...
boys and 28 were girls. Ages ranged from 2 to 12 years old, with the average age being 7.3 years. The follow-up period was between one to 13 years, with an average of 4 years.

**Type of Fracture**

Fracture of tibia associated with the fibula occurred in 50 cases (55.6%); there were also 40 isolated fractures of the tibia (44.4%) and no isolated fractures of the fibula. There were 45 cases (50.0%) of oblique fractures; 30 cases (33.3%) of transverse fractures; in the fracture site 40 (44.4%) were central. Sixty four cases were closed fractures and 26 were open, thus making the ratio of closed and open fractures about 2:1. According to the Gustilo classification\(^1\) (Table 1) for open fractures, 8 cases (30.8%) were type 1; 8 (30.8%) were type 2; 5 (19.2%) were type 3a; and 5 (19.2%) were type 3b.

**Classification by Age Group**

Cases were classified into three age groups: Group A for children aged 5 and under; Group B between 6 and 8; and Group C between 9 and 12. There were 30 cases (33.3%) in Group A, with an average age of 3.9 years. There were 47 cases (52.2%) in Group B, with an average age of 7.1 years. Group C had 13 cases (14.4%) with the average age of 11.3 years.

**Study Method**

1) Roentgenography

Conditions for roentgenography were: the distance to the X-ray tube film was set more than 180cm to keep a low leg tight against the cassette and to have a small enlargement ratio: 50 KV; 50 mA for electric current: and 40ms ° 80ms for radiation time. At the time of injury, en face as well as profile views of injured limb were projected in the lying position. During the studies, both sides of both lower legs were projected simultaneously using a parallel projection line in a standing position.

2) Judgment of union

Bone union was judged to have occurred at the point when bridging bony callus roughly matched the level of bone cortex on the roentgenogram. However, full weight bearing on the leg was only permitted about one month later.

3) Measurement method

We followed the Nunoda's method\(^2\) for measuring lower legs on the X-ray images; the major axis of femur was defined as the length from superior margin of the femoral head to the inferior margin of the medial femoral condyle; that of tibia, from the tibial intercondylar eminence to the mid-point of the distal tibial articular surface. Angles were measured by taking four mid-points in the shaft.

4) Thermography

Thermography was applied in 24 cases; 16 of those

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Gustilo classification</th>
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<tbody>
<tr>
<td>Type 1</td>
<td>Small wounds of 1 cm or less caused by low-velocity trauma, such as the protrusion of a fragment of bone out from within or by a low-velocity bullet passing in from without with minimal damage to soft tissue.</td>
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<tr>
<td>Type 2</td>
<td>Wounds extensive in length and width but with little or no avascular or devitalized soft tissue and relatively little foreign material.</td>
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<tr>
<td>Type 3</td>
<td>Wounds of moderate or massive size with considerable devitalized soft tissue or foreign material or both, or traumatic amputation.</td>
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<tr>
<td>Type 3a</td>
<td>Wounds with extensive soft tissue laceration or flaps, or wounds of high-energy trauma but with adequate soft tissue to cover the fractured bone.</td>
</tr>
<tr>
<td>Type 3b</td>
<td>Wounds with extensive soft tissue injury or loss with periosteal stripping and bone exposure.</td>
</tr>
<tr>
<td>Type 3c</td>
<td>Open fractures associated with arterial injuries requiring repair.</td>
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![Fig. 1 Measurement method](image-url)
were closed fractures and 8 were open. Measurement was carried out every two to six weeks starting from the first week after injury, for a minimum of six weeks and a maximum three and a half years. The equipment used for this measurement was a Thermodracer TH 1106 combined with a highly sensitive infrared ray detector. Conditions for measurement were in line with criteria of the Japanese Society of Thermology, after resting the patient quietly in a dorsal position for twenty minutes (Table 2). Two cases were added with stress thermo given by cooling the air with a fan.

5) Treatment

Conservative treatment was used most often with 73 cases (81.1%) and surgical treatment was chosen in 17 cases (18.9%). Surgery was performed when conservative treatments, such as closed reduction of the fragments, was impractical. Surgery was indicated for 13 cases treated with percutaneous pinning, 3 of external fixation and 1 plate fixation.

6) Statistical data processing method

The student t-test was used as a parametric method for a group whose quantitative values demonstrated a Gauss distribution, and whose sample size was about the same as that of a group to be compared. The Wilcoxon test was used as non-parametric method to assess the difference between the two groups that showed a non-Gaussian distribution.

Further, to compare the three age groups (A, B, C), variance analysis and the Kruskal-Wallis test were used with P<0.05 defined as indicating a significant difference.

Results

1) Union

All cases, except one case of Gustilo type 3b, achieved bone union with an average 77.3 days (45 ~ 108 days).

The average number of days to union in closed fractures was: 64.4 days for Group A; 78.6 for Group B; and 77.8 for Group C. In open fractures, it was: 71.4 days for Group A; 86.6 for Group B; and 85.2 for Group C. Union in closed fractures was fastest in Group A. Open fractures showed a tendency for delayed union. In the variance analysis, significant differences were recognized between Groups A, B and C in open fractures (P<0.05).

Of fracture sites in the distal area, Group A needed 69.6 days to union; Group B 84.9; and Group C 88.6. In the central area, Group A needed 60.3 days to union; Group B 75.3; and Group C 74.7. There were no significant differences between the fracture sites. According to age group, however, Group A showed significantly faster achievement of union compared with the other two groups for both distal and central fractures (P<0.05).

There was no significant difference in the methods of treatment between conservative treatment with 73.7 days and surgical treatment with 78.5 days.

4) Thermogram and ossification

While the skin temperature of the injured side, when bony callus appeared, was between 33 ~ 34°C (average 33.5), the temperature on the uninjured side during the same period was 28.5 ~ 32.5°C (average 30.7). The differences in temperatures were between 1.5 ~ 4.5°C (average 3.0). The difference became less than 1°C within 28 ~ 105 days (average 60 days). When the formation of bony callus was active, the skin temperature of the fractured region increased considerably compared with the non-fractured side. This discrepancy decreased as the skin temperature dropped along with the maturation and ossification of the callus (Fig. 2). During the period when the skin temperature increased, while there was no clear difference between closed and open fractures, the surgically treated cases showed a tendency to prolong the period of elevated skin temperature compared with the conservatively treated cases.

2) Growth of the major axis

Following Staheli’s report5, we defined that at the time of follow-up the growth beyond the non-injured leg as overgrowth and a level of 3 mm and above was considered as overgrowth. Overgrowth was recognized in 77 cases (85.6%). The maximum was 21mm with an average of 6.3mm.

Overgrowth and each factor

1) Age at the time of injury: Frequency of overgrowth in Group A was 29 cases (96.7%) with an average of 9.4mm; in Group B, 41 cases (87.2%) with an average of
When the formation of bony callus was active, the skin temperature of the fractured region increased considerably compared with the non-fractured side.

![Diagram of Thermogram and Ossification]

**Fig. 2** Thermogram and ossification

When the formation of bony callus was active, the skin temperature of the fractured region increased considerably compared with the non-fractured side.

**Fig. 3** Overgrowth of the tibia in three groups

Group A comparing with both group B and group C had significantly higher frequency and degree of overgrowth.

6.2 mm; and in Group C, 7 cases (53.8%) with an average of 4.2 mm. The younger the patients, the higher both the frequency and degree of overgrowth became. In addition, Group A when compared with both Groups B and C, had a significantly higher frequency and degree of overgrowth (P < 0.05) (Fig. 3).

2. Types of fractures: There was no difference in frequency of overgrowth: 86.6% for the closed fractures and 82.6% for the open. However, in terms of the extent of overgrowth, Group A showed a significantly larger degree in open fractures (P < 0.05): 6.1 mm in the closed fractures and 10.7 mm in the open fractures. In closed fractures, the extent of overgrowth in Group B was 6.7 mm and Group C 4.3 mm. In open fractures, the extent of overgrowth of Group B was 5.7 mm, and in Group C this was 4 mm. This illustrates that Group A had a significantly larger degree of overgrowth at 10.7 mm in open fractures (P < 0.05) compared with Groups B and C. In addition, the overgrowth of the Gustilo type I was 6.1 mm; type II was 5.7 mm; and type III was 9.1 mm. Type III showed slightly larger volumes than types I and II, but there was no significant difference.

3. Fracture site: 66.6% were proximal fractures with an average overgrowth of 12.0 mm; 72.3% were distal fractures with an average of 6.0 mm; and 57.5% were central fractures with an average of 6.6 mm. As these figures
indicate, there was no significant difference in frequency and extent of overgrowth between the fracture sites.

3) Relationship to the treatment method: In the cases of surgical treatment, overgrowth occurred in 82.4% of cases with an average of 8.7 mm; in conservative treatment this occurred in 78.1% of cases with an average of 5.1 mm. The surgical treatment cases showed a strong significant difference both in frequency and degree (P < 0.01).

4) Influence on femur: The overgrowth of more than 3 mm on the femur was recognized in 21 out of 77 cases (27.3%) with a maximum overgrowth of 16 mm and the average of 4.2 mm. Group A had 6 out of 29 (20.7%) with the average overgrowth of 3.2 mm; Group B had 12 out of 41 cases (29.3%) with the average of 3.9 mm; and Group C, 3 out of 7 cases (42.9%) with the average of 3.5 mm. In open fractures, Group A had 2.8 mm of growth volume; Group B 4 mm; and Group C had none. In closed fractures, Group A had 3.6 mm; Group B 3.7 mm; and Group C 3.5 mm. This shows there were no significant differences between the three groups (Fig. 4).

5) Deformity at the time of union

Varus deformity was found in 40.0% of the cases, and valgus in 43.3%, showing no significant difference in the frequency of incidence in both types.

1) Varus deformity:

Was recognized in 40.6% of closed fractures with angles of: 6.8 degrees in Group A; 5.4 degrees in Group B; and 6 degrees in Group C. In open fractures, 38.5% of the cases showed varus deformities with angles of: 5.5 degrees in Group A; 4.7 degrees in Group B; and there was no incidence in Group C. The incidence frequency indicated no clear difference between closed and open fractures, nor between the three age groups A, B and C.

2) Valgus deformity:

Was recognized in 39.1% of the closed fracture cases with angles of: 3.6 degrees in Group A; 4.7 degrees in Group B; and 5 degrees in Group C. The deformity was recognized in 53.8% of the open fractures with angles of: 11.3 degrees in Group A; 6 degrees in Group B; and 5 degrees in Group C. Open fractures showed a higher incidence of the deformity compared with closed fractures, and there was a significant difference between the two (P < 0.05). Among the age groups, only the open fractures in Group A had an angular deformity of more than 10 degrees, indicating a significant difference compared with groups B and C (P < 0.05).

3) Anterior and posterior convex deformity

Posterior convex deformity was seen more at 60% than the anterior convex deformity at 17.8%. There was a significant difference between the two (P < 0.05).

Anterior convex deformity was seen in 14.1% of the closed fractures with angles of: 6.2 degrees in Group A; 3 degrees in Group B; and none in Group C. In open fractures, 26.9% showed anterior convex deformity with angles of: 7 degrees in Group A; 3.3 degrees in Group B; and none in Group C.

Posterior convex deformity was found in 59.3% of the closed fractures with angles of: 14 degrees in Group A; 6.8 degrees in Group B; and 9.1 degrees in Group C. In open fractures, 61.5% showed some posterior convexity deformity with angles of: 9.3 degrees in Group A; 5.7 degrees in Group B; and 2 degrees in Group C. There were no significant differences in the incidence frequency...
of anterior and posterior convex deformities among the groups in closed and open fractures. Deformities during the union showed an angle of less than 10 degrees in all cases.

4) Auto-correction of varus and valgus deformity.

These deformities were recognized in 89.6% of the cases at the time of union, but 79.7% of those exhibited auto-corrections before the final follow-up.

① Relationship to age at time of injury: Auto-correction was recognized in 92.0% of Group A; 73.5% of Group B; and 70.0% of Group C. This made the ratio in Group A significantly higher than Groups B and C (P<0.05). The angle of correction of the deformity was less than: 15 degrees in Group A; 12 degrees in Group B; and 13 degrees in Group C. There was little difference between the three groups (Table 3).

② Relationship to the types of fractures: Auto-correction occurred in 66% of open fractures and 84.3% of closed fractures. The appearance of more auto-corrections in closed fractures made no significant difference.

5) Auto-correction of anterior and posterior convex deformity

Anterior and posterior convex deformities were found in 83.1% at the time of union. 87.5% of which exhibited auto-corrections at the time of our final follow-up.

① Relationship to age at time of injury: Auto-correction was recognized in 91.3% in Group A; 84.8% in Group B; and 87.5% in Group C. There was no significant difference among the three groups. The angle of correction of the deformity was less than: 18 degrees in Group A; 16 degrees in Group B; and 20 degrees in Group C. All three groups had a great ability for correction and there was little difference between them (Table 4).

② Relationship to the types of fractures: Auto-correction occurred in 76.4% of open fractures and 91.4% of closed fractures. The better result of closed fractures made no significant difference.

Case Presentation

Case 1. A four-year-old boy (Group A, closed fracture.). This case presented a six-year history over which a limb-length discrepancy persisted. It was a closed distal transverse fracture. We treated it conservatively applying a plaster cast. It took 83 days to union. Six years after the injury, 17mm of overgrowth persisted. The angles of varus deformity of 12 degrees and that of posterior convex deformity of 3 degrees at the time of injury were corrected to 3 and 0 degrees respectively (Fig. 5).

Case 2. A three-year-old (Group A, open fracture.). This was a 10-year process that required lengthening of the uninjured leg to cope with the overgrowth. This child had an oblique fracture of Gustilo 3a type, and a complication involving a femoral fracture. It took 79 days to union. Two years after the injury an overgrowth of 19mm in the tibia and 14mm in the femur required us to conduct a limb lengthening on the uninjured leg. Ten years since the injury there remains a leg-length discrepancy of 4 mm, but there is no problem in daily life. Angles of varus deformity and that of anterior convex deformity, both at 10 degrees at the time of injury, were corrected to 5 and 2 degrees respectively (Fig. 6).

Case 3. A nine-year-old boy (Group B, closed fracture.). This was a six-year case history with protracted union. After recognizing the closed distal oblique fracture a plaster cast was applied. It took 136 days to union. Six years after the injury, the discrepancy in limb-length was 4mm and correction of the deformity continues to go well (Fig. 7).

Case 4. A six-year-old boy (Group B, Open fracture.). This was a six-year process with a residual discrepancy in leg-length due to a protracted union. It was a Gustilo 3b type with an oblique fracture in the middle of the diaphysis. A plaster cast was applied after traction. During traction, the discrepancy of the fractured region was 5 mm and 101 days were needed to union. At the age of 12, the boy still has an 11mm discrepancy in leg-length due to overgrowth (Fig. 8).

Case 5. A seven-year-old boy (Group B, open frac-
Fig. 5 Case 1 of overgrowth, four-year-old boy (Group A, closed fracture)
A. At time of injury  B. At 20 weeks after the injury  C. At 6 years after the injury.

Fig. 6 Case 2 of overgrowth, three-year-old boy (Group A, open fracture)
A. At time of injury  B. At 2 years after the injury
C. Leg lengthening  D. At 10 years after the injury.

ture.). This was an eight-year case history with an incidence of pseudarthrosis after internal fixation. It was a Gustilo 3b type with a distal transverse fracture. On the day of injury, internal fixation using a k-wire was performed. After surgery bone union did not occur and in the sixth month sequestrectomy, bone grafting and external skeletal fixation were performed. In ten months following the surgery, bony callus formation occurred and the patient started walking with braces. However, the child had repeated refractures and four years after the injury moved to another hospital to have a vascularized bone graft. We understand that three more years
were needed to finally obtain a stable bone union (Fig. 9).

Considerations

The anteromedial lower leg has a frequent incidence of open fractures due to the lack of soft tissue, often causing difficulties in treatment. This is true in both children and adults. Bartlett et al. compared cases of open fractures of tibia between adults and children, and reported the higher ability of children to restore soft tissue along with earlier union compared to adults. However, many reports state that union requires a longer than expected time, even for children. We also need to acknowledge
the difficult case of the seven-year old boy with an open fracture (Gustilo 3b type) mentioned above.

1) On Union

With reference to the timing of union in pediatric open fractures of tibia, Kai et al.\(^5\) reported that the greater the degree of wound, the slower the time to union. Buckley et al.\(^6\) reported five months. Cullen et al.\(^7\). Iioka et al.\(^8\) reported the average period to be four months. They also pointed out that time to union tends to be considerably protracted in tibial fractures compared with other fracture sites in children. Our experience in open fractures showed an average of 2.7 months to the formation of bridging bony callus, except one case that developed pseudarthrosis, which was earlier than the average periods reported by other investigators. However, the period needed to obtain union strong enough to bear weight was three to four months, mostly in accordance with the other reports. Hope\(^9\) reported the incidence of pseudarthrosis at 7.5%, which suggests, just like the report by Kennedy et al.\(^10\) in adult cases, that the occurrence of open fractures in lower leg in children hindered bone formation due to the scarcity of soft tissues compared with closed fractures, with the outcome of delayed bone union. School children (Groups B+C) had about two-weeks' delay in bone union compared with the infants (Group A). This clearly indicates a difference in the period needed to bone union according to age, even among children's fractures. Such an observation has not been made until now, and this is an important point to be considered when administering treatments.

This research seems to be the first to report the use of thermography for analyzing the recovery process of fractures. The anterior surface of tibia is close to the body surface and there is little soft tissue, making it a good place to apply thermography. In the process of forming a bony callus, the skin temperature increases more on the injured side than on the uninjured side, and the difference between the two tends to disappear at the time of union. This information was very useful to understand the local hemodynamics. There was a tendency for the increased skin temperature to have a protracted duration, especially in fractures with strong displacement and abundant formation of bony callus; with strong enlargement of soft tissues; and with surgical treatment. Haberman et al.\(^11\) argued that the skin temperature reflects the range of blood flow volume, inflammation and metabolic activities, which supports our findings using thermography. Thermography is a useful auxiliary test in understanding objectively the state of blood flow, bony callus formation and union after the fracture of tibia.

2) On Overgrowth

Aitken et al.\(^12\) attributes the overgrowth after the

![Fig. 9 Case 5 of pseudarthrosis, seven-year-old boy (Group B, open fracture)](image)

A. At time of injury  B. At 24 weeks after the injury  C. Bone graft  D. At 1 year after the injury.
fracture of tibia in children to the increase in blood flow to the injured limb, which stimulates the epiphyseal plate for a prolonged period. The results of thermography obtained in this research can be considered to have endorsed this view objectively to a certain extent.

There have been different reports on overgrowth and when this occurs after fractures of tibia in children: Rang et al. reported it to be after one year and eight months; Reynolds et al. three years; Sato five years; Nunoda reported that within three months after the injury, the growth rate reached its peak, and normalized forty months after injury. Shimada et al. stated that discrepancy in limb-length persisted after the overgrowth ended. Matsuno et al. argued that the discrepancy was temporal. None of the research referred to the peak-time after the fracture. According to this study, overgrowth reaches its peak in one to two years after the fracture and almost stopped at four years. This result suggests that it seems difficult to correct the limb-length discrepancy after four years, and requires surgery to correct, depending on its severity.

There have been several reports on the relationship between overgrowth and age: Shannak et al. reported that the younger the patient, the more striking the relationship was with the average of 4.35 mm; Murayama et al. said that overgrowth was greatest among patients aged between 3 and 10 with a maximum overgrowth of 15 mm; Inoue et al. said overgrowth was strongest at 2 to 7 years with an average of 4.8 mm; Greiff reported that the peak was between the ages 3 to 5, and that the average extent of overgrowth was 4 mm for boys aged 11 years and younger and for girls 8 years and younger. According to this study, the largest overgrowth of 9.4 mm was found in Group A of 5 years and younger, which indicates that we should monitor overgrowth in cases of childhood fractures over a long period.

On the relationship with the types of fracture, Bohn et al. stated that overgrowth was more likely to occur in open fractures. In our cases, the overgrowth in closed fractures was 5.7 mm, while in open fracture it was 6.8 mm. showing no difference in frequency between the two. Buckley, however, stated that 10% of open fractures had overgrowth of more than 10 mm. In our cases as well, 33% of open fracture had more than 10 mm of overgrowth. The level of overgrowth is higher in open fractures.

With regard to the effects of treatment methods, Murayama, Fukubayashi, Reynolds reported that surgery tended to cause overgrowth; Tanaka et al. reported that, among surgical cases, invasive surgeries other than a percutaneous Kirschner wire, showed a larger extent of overgrowth. In our cases as well, plate fixation showed a remarkable level of overgrowth. Therefore, even where surgical methods are necessary, we should select the least invasive methods as far as possible.

In overgrowth of femur in closed fractures, Inoue reported that it was recognized in 18% of cases; and Murayama recognized this in 30%. It was 29.1% in our cases, showing no great difference from the previous reports. This means that a change in hemodynamics can possibly reach the femur on the same side of the leg. The thermogram image supports this assumption, since the skin temperature of the inferior extremity of the femur increases until a bony callus starts to form in tibia.

3) Auto-Correction of Deformity

Referring to the varus and valgus deformities, Buckley, Murayama, and Nunoda et al. reported that auto-correction was possible as long as the deformity angulation was 10 degrees or less at the time of union.

In this study, both varus and valgus deformities showed the same trend toward capability of correction, Group A exhibited excellent auto-correction capability, followed by Group B and then Group C, indicating that as age progresses the capability is reduced. In anterior and posterior convex deformities, auto-correction went well within an angle of 20 degrees, regardless of age. This indicates that even in the same category of flexion deformities, we can expect a good result in correcting anterior and posterior convex deformities, while we need to ensure that the angle of residual deformities for varus and valgus deformities should not be greater than 10 degrees.

Conclusion

1) We reviewed 90 cases of fracture of tibia in children for union, overgrowth and the auto-correction of deformities.

2) The union (formation of bridging bony callus) required 77.3 days overall; 73.6 days in closed fractures; and 81.1 days in open fractures. Infants showed the fastest union among the age groups. Open fractures took longer. We recognized pseudarthrosis in one case (1.1%), and protracted healing in 9 cases (10.3%).

3) A thermogram revealed an increase in skin tem-
perature at the fracture region when bony callus was being actively formed, showing a difference in temperature compared to the uninjured side. This difference, however, disappeared during union. The more damage to soft tissues, the longer the period of elevated skin temperature.

4) Overgrowth occurred in 77 cases (85.5%). The frequency and extent of overgrowth was most outstanding in the following categories: Group A in the age group: the open fracture in the fracture type; and surgical method in the treatment methods. In some cases, overgrowth was also recognized in the femur.

5) Overgrowth developed within two years after the injury and continued to the fourth year before it almost stopped.

6) We observed good results in auto-correction of deformity when the angles of varus and valgus deformities were 10 degrees or less, and in anterior and posterior convex deformities 20 degrees or less. Age had no influence in correcting anterior and posterior convex deformities, but the infants excelled over other age groups in correcting varus and valgus deformities.

References
