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SEGMENTAL TIBIAL SHAFT FRACTURES

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A series of 54 cases with multiple fractures of the tibia is reported. Sixty-eight per cent of the group were pedestrians hit by a car. Fifty-two per cent were open fractures. Osteosynthesis was performed in 33 cases, whereas 21 were treated conservatively. Plate osteosynthesis was accomplished in 23 cases, seven had intramedullary nailing, and two were treated by Hoffmann's external fixation device. Only one patient sustained a severe complication, viz., deep wound infection and osteomyelitis; however, even this infection was transient. All fractures healed except those sustained by two patients who died within 3 months; these deaths were, however, without any causal relationship to the osteosynthesis. One patient had a traumatic vascular lesion concomitant with the fracture, and his leg was amputated 3 days after the injury. Another patient had his leg amputated 1 year after his accident, in this case also because of injury to the vessels and nerves. It was concluded from the present series that segmental or multiple tibial shaft fractures do not entail more complications nor do they exhibit a slower rate of union than simple tibial shaft fractures if the treatment is individualized and due consideration is given to the soft tissue injury.

Key words: fracture; segmental fracture; tibia

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In spite of recent achievements in operative fracture treatment, tibial shaft fractures still present many problems, and the end results are not completely satisfactory. The AO-method for compression osteosynthesis, generally considered to be the most suitable, has also met with some opponents who maintain that in transverse fractures of the tibial shaft this method ought not to be used (Bauer & Hulth 1973) or its use restricted (Karlstrøm & Olerud 1973).

The importance of a sound policy as regards treatment of tibial shaft fractures is obvious, especially considering the high incidence of these fractures.

The aim of the present study was to investigate the current treatment and the end results in a special type of tibial shaft fracture, viz., segmental or multiple fractures. Publication of this paper was found justified because segmental fractures are rarely encountered, and very few authors have published materials of their own on the subject. Furthermore, multiple tibial shaft fractures may, as mentioned later under the heading Discussion, involve a number of problems as regards vascularization of the ring fragment, and also as regards operative technique. That multiple tibial shaft fractures are of current interest is clearly

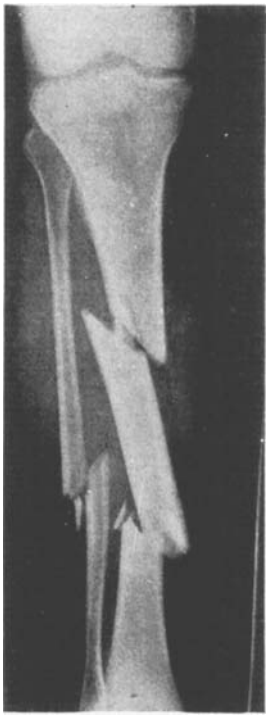

Figure 1. Front view of a typical two-level segmental fracture.

demonstrated by these fractures being chosen for AO-documentation when the Scandinavian section of the AO-group was established.

Segmental fractures can be defined as diaphyseal or even metaphyseal ring fractures in which the cancellous circumference of a tubular bone is fractured at two or more separate levels, thus forming intermediate ring fragments, but excluding butterfly fragmentation. The intermediate fragment or fragments may well be comminuted, the decisive criterion for inclusion in the series was the presence of two or more definite fracture lines.

MATERIAL

During the 5-year period 1968–1972, altogether 639 fractures of the shaft of the tibia were treated in adults (i.e. over 14 years) at Ullevål Hospital, Departments II and III. Of these, 54 (8.5 per cent) were segmental shaft fractures. The number of tibial shaft fractures treated operatively by osteosynthesis was 302 (47.3 per cent) in the whole group as against 33 (61.1 per cent) of the segmental fractures.

The observation period can be seen from Table 1. Approximately 70 per cent were observed for more than 6 months, and all complicated cases were followed until the ultimate result was clear.

Table 1. Observation period.

Months	No.	Per cent
< 3	8	14.8
3–5	8	14.8
6–12	8	14.8
> 12	30	55.6
Total	54	100.0

There was a slight preponderance of men in the age groups 15–24 and 25–44, otherwise the sex and age distributions were fairly even.

Traffic injuries predominated as the cause of the injury (68.1 per cent), followed by industrial accidents (9.2 per cent). All traffic injuries were pedestrians hit by a car. Concomitant and rather serious lesions were frequent (57 per cent) with head injuries topping the list (33 per cent).

The treatment given is shown in Table 2. Open fractures totalled 28 cases (51.9 per cent), and 14 of these fractures were operated. Initially non-operative treatment was generally preferred, as demonstrated by the fact that 64 per cent of the patients with segmental tibial shaft fractures were treated by skeletal traction. There was also a tendency for osteosynthesis to be used more frequently in closed rather than in open fractures (19 out of 26 as against 14 out of 28), but osteosynthesis was not considered contraindicated in open fractures if the soft tissue injury was minor.

In the present series the majority of segmental tibial shaft fractures had a rather unfavourable location prognostically, the lower fracture being located in the distal half of the tibia in 44 cases (81.5 per cent). Comminution of the intermediate fragment was found in 18 cases (33.3 per cent). Consequently the chances of a rapid and uncomplicated healing were slim in the present material (Table 3).

The rate of union will be seen from Table 4. Thirty-two fractures (59.3 per cent) healed within 6 months. Slow union, i.e. healing after more than 6 months, was found in 11 cases (20.4 per cent), and non-union in only one patient. Slow union or non-union did not seem to have any causal relationship to operative or

non-operative treatment, but on this point the material is not definitely conclusive, because there are so few patients in each group.

Operative and late complications are shown in Table 5. A serious complication occurred in one case only; a patient sustained osteomyelitis of short duration, possibly induced by the operation. The infection healed with antibiotics without any revisional surgery being required.

Fat embolism was not seen in the present material. One patient had his leg amputated shortly after admission, because of vascular injury, peripheral nerve injury and subsequent septicaemia. A second patient was amputated one year after the injury, because of disturbed sensibility, pes equinus, and shortening of the leg.

Minor complications, such as superficial wound infection, thrombophlebitis, pressure sores from the plaster etc., occurred in 11 cases (33.3 per cent). Open fractures had an overall complication rate which by far exceeded closed fractures, but again the groups are small and chance factors may have influenced.

Table 2. Treatment of segmental tibial shaft fractures.

Method	Open fractures	Closed fractures
Skeletal traction and plaster	14	7
Skeletal traction and ostcosynthesis	6	9
Primary plate osteosynthesis	4	4
With plaster	1	–
Without plaster	3	4
Intramedullary nailing	2	5
Cerclage	–	1
Osteotaxis (Dr. Hoffmann's method)	2	–
Total	28	26

Table 3. Treatment related to site of fracture and comminution of intermediate fragment(s).

Method	Site of distal tibial fracture		Comminution of intermediate fragment(s)
	Proximal ½	Distal ½	
Skeletal traction and plaster	5	16	4
Skeletal traction and osteosynthesis	4	11	5
Primary plate osteosynthesis	1	7	5
Intramedullary nailing	–	7	3
Cerclage	–	1	–
Osteotaxis (Dr. Hoffmann's method)	–	2	1
Total	10	44	18

Table 4. Rate of union of segmental tibial shaft fractures.

Time (months)	Open fractures	Closed fractures	Treatment:	
			Operative	Non-operative
Less than 4	4	10	11	3
4–6	9	9	13	6
7–12	2	1	–	3
More than 12	6	2	5	3
No information	2	3	–	3
Slow union	8	3	5	6
Non-union	1	–	–	1

Table 5. Complications of operative treatment of segmental tibial shaft fractures.

Nature of complication	Open fractures	Closed fractures
Wound infection	3	–
Osteomyelitis	1	–
Haematoma/bleeding	–	2
Shortening of the leg	2	1
Thrombophlebitis	–	1
Pressure sore from the plaster	2	–
Comminution of fragment by intramedullary nailing	–	1
Total	8 (57 %)	5 (26 %)

Thirty-three fractures were operated *in toto;* 14 open and 19 closed.

RESULTS

Assessment of clinical end results

The criteria for evaluation were:

Full restitution: No subjective complaints; full working capacity to the same extent as before the injury and/or no functional impairment. In addition, no detectable disability at follow-up.

Some functional impairment: Any subjective complaints of joint stiffness, muscular atrophy or weakness or minor sequelae of any kind not, however, seriously incapacitating working ability or the function of the wounded extremity. Verification of corresponding findings at the follow-up.

Poor results: Amputated limb or any other major sequelae leading to poor function.

The clinical end results evaluated as above are presented in Table 6. In 29 cases the functional results were classified as quite satisfactory, the patients had no complaints, and full restitution was clearly achieved.

Fourteen patients had some minor complaints; seven suffered from slight joint stiffness of the ankle, five had a minor atrophy of the calf muscles, in no instance, however, exceeding 1 cm when measuring the maximum circumference of the leg. All these five patients felt weakness of the leg, but managed to do their jobs without difficulties. Two patients had an outward rotational displacement of the lower leg amounting to 5° and close on 10°, respectively, but neither of them wanted operative correction.

The clinical results in the two amputees were poor, but the results could, in our opinion, hardly be ascribed to therapeutic failures; they were consequent upon the serious injuries sustained.

Information was lacking as regards four patients; they had moved to other districts and could not be traced.

Altogether 79 per cent of the patients treated had an acceptable outcome of their injury and the treatment received,

Table 6. Clinical results of treatment of 54 segmental tibial shaft fractures.

Evaluation	No.	Per cent
Full restitution	29	53.7
Some functional impairment	14	25.9
Amputation	2	3.7
No information	4	7.4
Total	49	90.7

Five patients (9.3 per cent) died from causes which could not be ascribed to the osteosynthesis.

if the number of patients with some functional impairment is added to the group with highly satisfactory results.

DISCUSSION

When undertaking the present study it was anticipated that segmental fracturing of the tibial shaft might involve special problems, these fractures often being caused by serious and direct traumatic injury of the leg, as would be the case, for instance, when a pedestrian is hit by a car. It was obvious that accidents of this kind could entail serious soft tissue injury, which might complicate surgical treatment and also delay bone union.

Multiple fractures can also lead to a poor vascular supply of the intermediate fragment or fragments or even avascularization. The same might result from intramedullary nailing if the ring fragment is twisted and thus deprived of nourishing vessels. An avascular intermediate fragment, totally separated from adjoining soft tissue was seen in one case in the present series; it was replaced, however, and ultimately healed as a bone graft.

Predominantly operative treatment of tibial shaft fractures meets with some opposition (Bauer & Hulth 1973, Karlström & Olerud 1973), although several recent reports claim favourable results (Tscherne et al. 1967, Zimmermann 1967, Decoulx et al. 1969, Zucman & Maurer 1970, Solheim & Bø 1973).

In the present series of 54 consecutive segmental tibial shaft fractures, an initially non-operative treatment was considered essential. The high incidence of serious concomitant injuries (57 per cent) and the frequent serious soft tissue injuries in these patients are factors favouring a non-surgical approach for at least 1 week after the injury. Open fractures, in our opinion, should be even more cautiously treated until the serious risk of deep infection or osteomyelitis has subsided.

In two-level tibial shaft fractures intramedullary nailing is the method of choice if applicable, because this procedure secures re-alignment and usually yields rigid fixation of both fractures, thereby enabling the patient to exercise his muscles and joints after a short immobilization period, an essential part of the after-treatment of fractures (Olerud & Karlström 1972). An additional, and in fact essential, benefit is that extensive skin incisions over the fracture are avoided in closed intramedullary nailing. In some cases a two-step intramedullary nailing may be advantageous (Zucman & Maurer 1969); a thin nail is used initially with no reaming or only very cautious reaming, and later the nail is re-

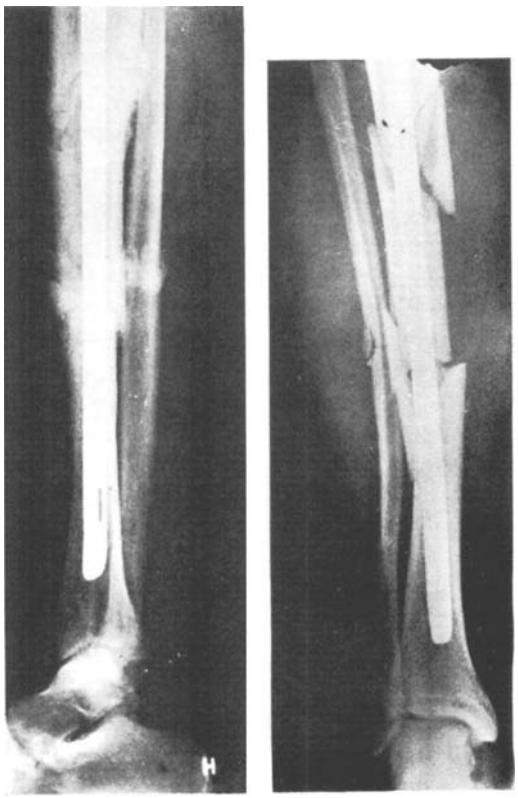

Figure 2. Segmental tibial shaft fracture treated by a thin intramedullary nail.

Figure 3. Severe crush fracture of the tibial shaft after stabilization with Hoffmann's fixation device.

placed by a thicker one after more extensive reaming, when the fractures are somewhat consolidated. This procedure was used in four cases in this series.

In metaphysial fractures, however, intramedullary nailing is not used, and in this series AO internal fixation was preferred in such cases, sometimes with additional external fixation in plaster. This treatment was especially satisfactory in proximal metaphysial fractures, which usually heal within 6–8 weeks, and in which adverse reactions to plaster immobilization are consequently seldom encountered.

The present material was not suitable for evaluation of the important question as to whether primary or supplementary external fixation using plaster would influence future ankle movement.

In this series, irrigation of the wound with saline solution and local application of broad-spectrum antibiotics were recommended. Usually suction drainage of the wound was applied. Prophylactic systemic use of antibiotics was not considered justified.

Hoffmann's external fixation device was used in two patients in this series, and this procedure is considered to be the method of choice in fractures with associated severe soft tissue injury. This is illustrated by the following case.

Case report. A man aged 38 had his leg completely crushed in the middle third of the tibial shaft in a severe car accident. The vascular supply and innervation, however, remained intact. Hoffmann's equipment was applied in two

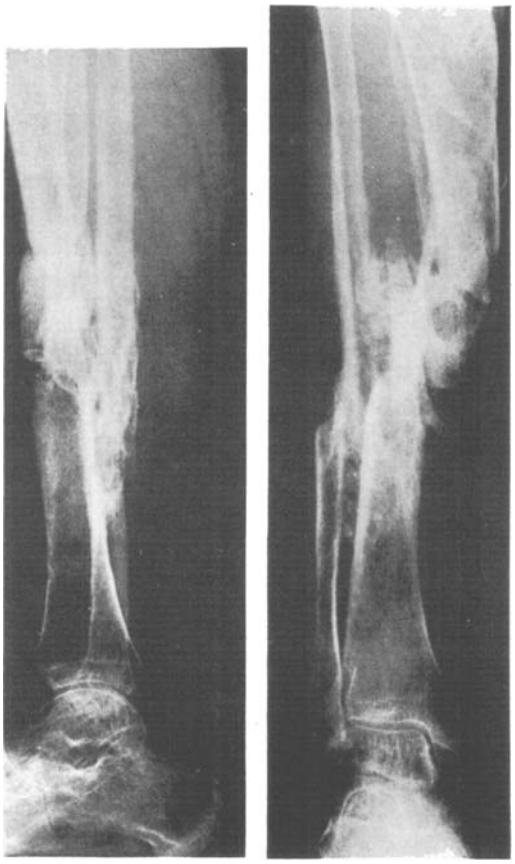

Figure 4. Same case after healing. A non-disabling lateral displacement of the distal fragment is present.

different planes. One set loosened after 5 months and was removed; the other was removed after an additional 3 months, whereupon bone grafting was carried out through a dorso-lateral incision and the leg was immobilized in plaster and ultimately the fracture healed.

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