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TIBIAL SHAFT FRACTURES

A Comparison of Conservative Treatment and Internal Fixation with Conventional Plates or AO Compression Plates

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Out of a series of 207 consecutive fractures of the tibial shaft, 102 were treated conservatively, 64 fractures were treated by AO compression plate osteosynthesis and 41 by internal fixation using Eggers or Lane plates. The choice of method was independent of the extent of soft tissue damage. A follow-up examination of 199 fractures, with a mean observation time of 3.4 years, revealed residual malalignment in 21 per cent of conservatively treated cases and in 8 per cent after conventional plate fixation, while the AO method resulted in anatomical restoration of the axis of the tibia in all cases. However, removal of the compression plates was followed by re-fractures, early and late, in 11 per cent. Implant failure occurred in 5 per cent of both types of plate fixation, and 3 per cent of the conservatively treated cases redislocated. Infection developed in 5 per cent of closed fractures and in 11 per cent of open fractures treated by operative means. Of the conservatively treated cases, only 3 per cent of the open fractures developed infection. The risk of infection following acute internal fixation is thus four times greater than with conservative treatment. AO compression plate fixation shortened the time of fracture healing considerably. The rate of non-union after conservative treatment was 6 per cent in closed and 21 per cent in open fractures. Similarly in conventional plate fixation there was non-union in 8 and 24 per cent, respectively. Non-union was not encountered after AO compression plate osteosynthesis. It is concluded that AO plate osteosynthesis is justified in the treatment of open tibial shaft fractures and also useful in closed fractures when conservative treatment does not lead to stable reduction with a good alignment.

Key words: tibial shaft fractures; osteosynthesis, infection; osteosynthesis, non-union; internal fixation; AO compression osteosynthesis; Eggers plates; Lane plates

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The ideal treatment for tibial shaft fractures is still a controversy. The problems involved have been thoroughly described in a whole volume of *Clinical Orthopaedics and Related Research* (*Clin. Orthop.* 105, 1974) edited by A. Sarmiento, with contributions from several authors with solid experience in this field. Although the principles of the AO-group

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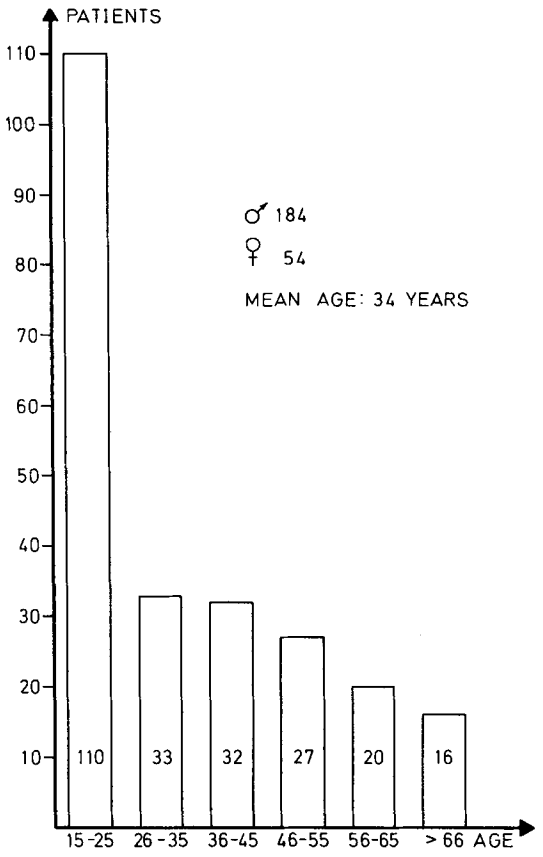

Figure 1. Age distribution of 238 patients with tibial shaft fractures.

(Müller et al. 1963, 1970) have been widely accepted in a number of European countries and the USA, relatively few papers have been published on the results of compression osteosynthesis in fractures of the tibial shaft (Infanger et al. 1971, Olerud & Karlström 1972, Rüedi et al. 1976, Solheim 1973, Smith 1974).

We therefore consider it of interest to compare the results of treatment with AO plates, conventional Eggers or Lane plates and conservative treatment.

PATIENTS AND METHODS

During the period July 1966 to April 1975, 238 patients, over the age of 15, with tibial shaft fractures, were treated as in-patients at the Department of Orthopaedic Surgery, Frederiksborg County Hospital, Hillerød, Denmark. The age distribution is shown in Figure 1.

The tibial shaft was defined as the area from 7 cm below the knee joint to 7 cm above the ankle joint. Table 1 compares the type of fracture and the cause of injury and it can be seen that the majority of comminuted and transverse fractures were caused by high velocity traumas. Multiple injuries including other severe fractures or body injuries were found in 55 patients.

Thirty-nine per cent were open fractures (93/238) and could be classified as follows: *Grade I:* simple skin perforation from within; *Grade II:* skin perforation from without including minor skin or muscle contusion; *Grade III:* extensive soft tissue damage with major loss of skin sometimes associated with lesions of vessels or nerves. Table 2 lists the open fractures according to the cause of injury; 74 out of 93 open fractures (80 per cent) were due to traffic accidents. The method of treatment is correlated to the cause of injury in Table 3 and to the type of fracture in Table 4. Thirty-one patients were treated with "other operative methods", including: interfragmentary compression with lag-screws in 16 cases, medullary nailing in 5, Rush-pinning in 4, cerclage wires in 3 and external fixation with Hoffman-apparatus in 2 cases. In one case a primary above-knee amputation was performed. This group of patients have been excluded from the follow-up, because the intention was to compare only conservative treatment and the two types of plate osteosynthesis.

The standard treatment of fractures of the tibial shaft has been conservative with closed reduction and immobilization in a high plaster cast. If conservative treatment did not lead to stable reduction with anatomical alignment, osteosynthesis was performed within the first 48 hours after admission. In the period 1966 to 1970, plate osteosynthesis was performed with open reduction and fixation of the fracture with conventional Eggers or Lane plates, followed by immobilization in a high plaster cast. Since 1970, AO compression plates have been used with open reduction and application of interfragmentary compression with lag-screws combined with neutralization plates, or axial compression plates of the AO type (Müller et al. 1970). In these cases, no cast was applied and immediate training for joint mobility was started, followed by early non-weight-bearing mobilization. Full weight-bearing was allowed in all groups when the fracture was considered united and normal muscle and joint function had been obtained.

All tibial shaft fractures whether open or closed have been treated according to these

Table 1. Type of fracture/cause of injury.

	Traffic accident	Fall	Work accident	Sports injury
Oblique fracture	34	35	9	11
Transverse fracture	39	1	2	21
Comminuted fracture	67	6	4	9

Table 2. Cause of injury/extent of soft tissue damage.

	Total no.	Open fractures			
		Grade I	Grade II	Grade III	Total
Traffic accident	140	26	37	11	74
Fall	42	7	1		8
Work accident	15	1	3	1	5
Sports injury	41	2	4		6
Total no.	238	36	45	12	93

Table 3. Cause of injury/method of treatment.

	Conservative treatment	Operative treatment		
		AO plates	Eggers/Lane plates	Other methods
Traffic accident	60	39	28	13
Fall	15	12	4	11
Work accident	6	4	2	3
Sports injury	21	9	7	4
Total no.	102	64	41	31

Table 4. Type of fracture/method of treatment.

	Conservative treatment	Operative treatment		
		AO plates	Eggers/Lane plates	Other methods
Oblique fracture	32	27	9	19
Transverse fracture	37	8	14	4
Comminuted fracture	33	29	18	8
Total no.	102	64	41	31

principles. In open fractures systemic antibiotics were administered routinely.

A clinical and roentgenological follow-up study of the knee, the ankle and the entire tibial shaft, in two planes, was performed in 199 of the 207 patients, treated according to these principles, after a mean observation time of 3.4 years (Figure 2). Three patients died during hospitalization and five patients were lost to follow-up.

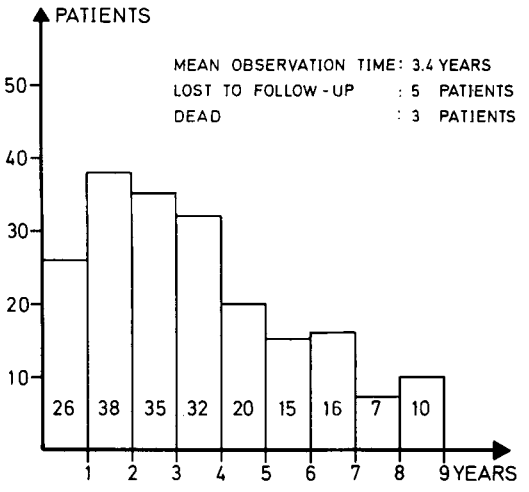

Figure 2. Period of observation at follow-up of 199 patients.

Table 5. General complications among 207 patients.

	Conservative treatment	Operative treatment
Cardio-pulmonary	2*	2
Pulmonary embolism		2*
Fat embolism	4	4
Phlebo-thrombosis	1	1
Peroneal palsy	2	2
Total no.	9	11
Died in hospital	1	2

* Fatal complications in 3 patients.

RESULTS

General complications (Table 5) were encountered in 10 per cent of the patients (20/207). There was no difference between the conservative and operative group. There were eight patients with fat embolism; seven had femoral shaft fractures and one multiple injuries. Three patients died in hospital; in two cases the cause was pulmonary embolism and in one case it was cardiopulmonary complications.

Local complications were encountered in 30 per cent of the patients (61/207). Dislocation following conservative treatment was seen in 3 per cent (3/102) leading to secondary osteosynthesis. Implant failure occurred in three cases after AO plate osteosynthesis and in two cases after conventional plate fixation—a total of 5 per cent (5/105). This was due to metal fatigue secondary to instability caused by a bone defect opposite the plate.

In Tables 6–8 the problems concerning infection and non-union are presented. It should be noted that the tables include three cases of above-knee amputation. All these were severe Grade III fractures, in which a rather heroic attempt had been made to save the limb. Two of the amputations were preceded by severe skin necrosis and one by deep infection.

Table 6. Local complications following conservative treatment.

	Closed fractures	Open fractures				Total no. of complications
		Grade I	Grade II	Grade III	Total	
No. of patients	64	11	23	4	38	
Skin necrosis or superficial infection	1	3	8	2	13	14
Osteitis	0			1	1	1
Non-union	4	2	5	1	8	12
Amputations	0			1	1	1
Total no.	5	4	11	3	18	23

Table 7. Local complications following AO-compression osteosynthesis.

	Closed fractures	Open fractures				Total no. of complications
		Grade I	Grade II	Grade III	Total	
No. of patients	37	16	7	4	27	
Skin necrosis or superficial infection	2	1	3	3	7	9
Deep infection	1	1	1	1	3	4
Osteitis	1				0	1
Amputation	0			2	2	2
Total no.	4	2	4	6	9	13

Table 8. Local complications following conventional plate osteosynthesis.

	Closed fractures	Open fractures				Total no. of complications
		Grade I	Grade II	Grade III	Total	
No. of patients	24	6	9	2	17	
Skin necrosis or superficial infection	3	1	3	2	6	9
Deep infection	0		1		1	1
Osteitis	1		1		1	2
Non-union	2		4		4	6
Total no.	6	1	8	2	11	17

Table 9. Results of follow-up of 199 patients.

	Conservative treatment	AO compression plates	Eggers/Lane plates
Patients treated	102	64	41
Patients followed up	100	61	38
Roentgenological findings:			
Shortening $\geq$ 2 cm	5	0	0
Malalignment *	21	0	3
Clinical findings:			
Ankle joint motion reduced $\geq 20°$	7	3	0
Pain/weather sensitivity	7	3	2
Knee/ankle complaints	5	1	3
Re-fracture	1	5	0
Total no. **	41	11	8

* Malalignment: valgus/varus-angulation $\geq 8°$ and/or curvation $\geq 15°$.
** Some patients had more than one complaint or objective finding.

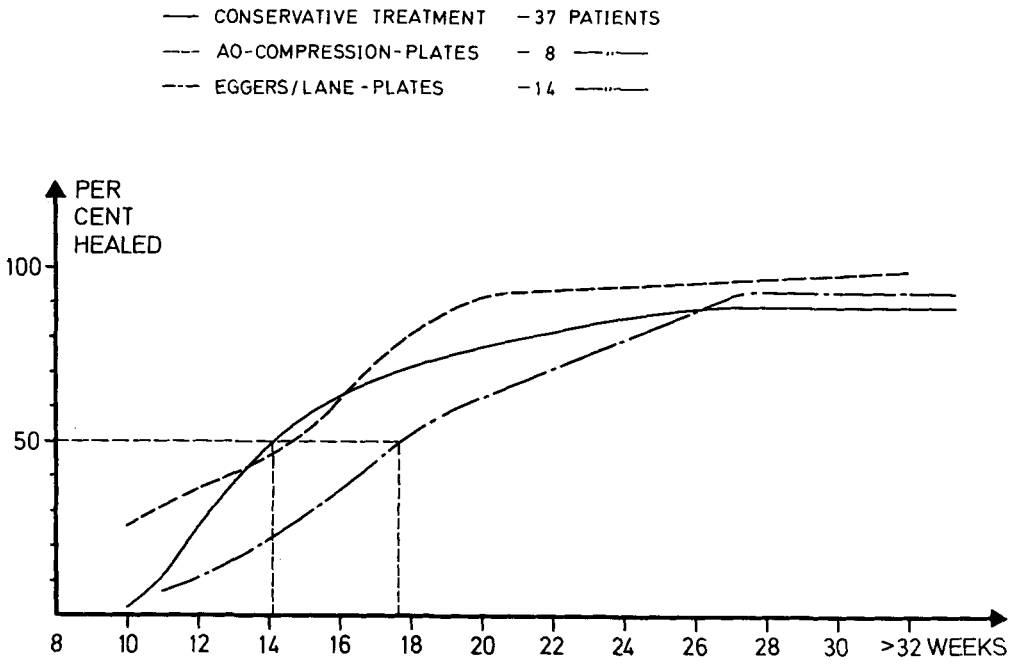

Figure 3. Healing time for transverse fractures.

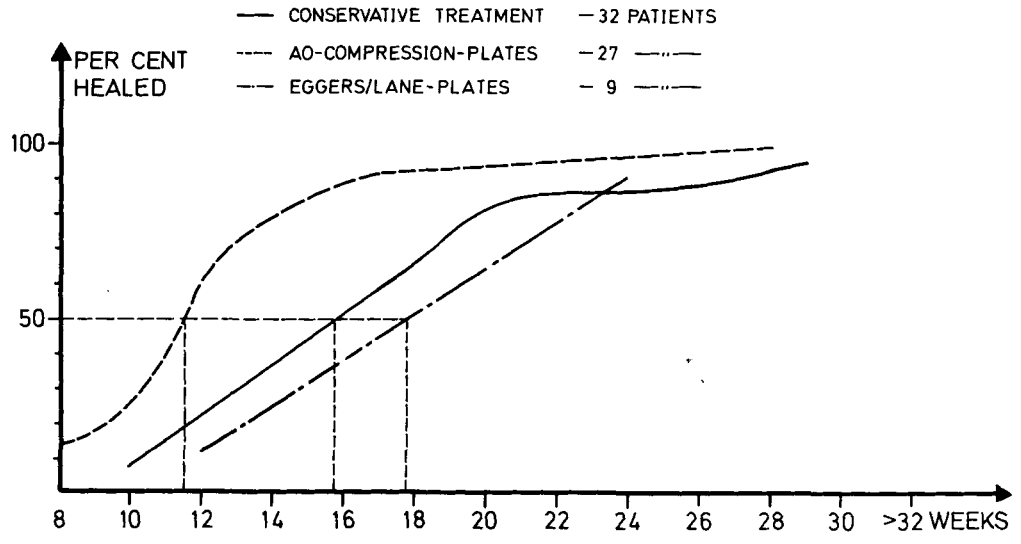

Figure 4. Healing time for oblique fractures.

As seen in Table 6 nearly all skin necrosis and infections, following conservative treatment, occurred among the open fractures. Non-union was encountered in 6 per cent (4/64) of closed fractures and in 21 per cent (8/38) of open fractures, but three of the latter were preceded by skin necrosis.

The local complications following AO osteosynthesis are listed in Table 7. In 27

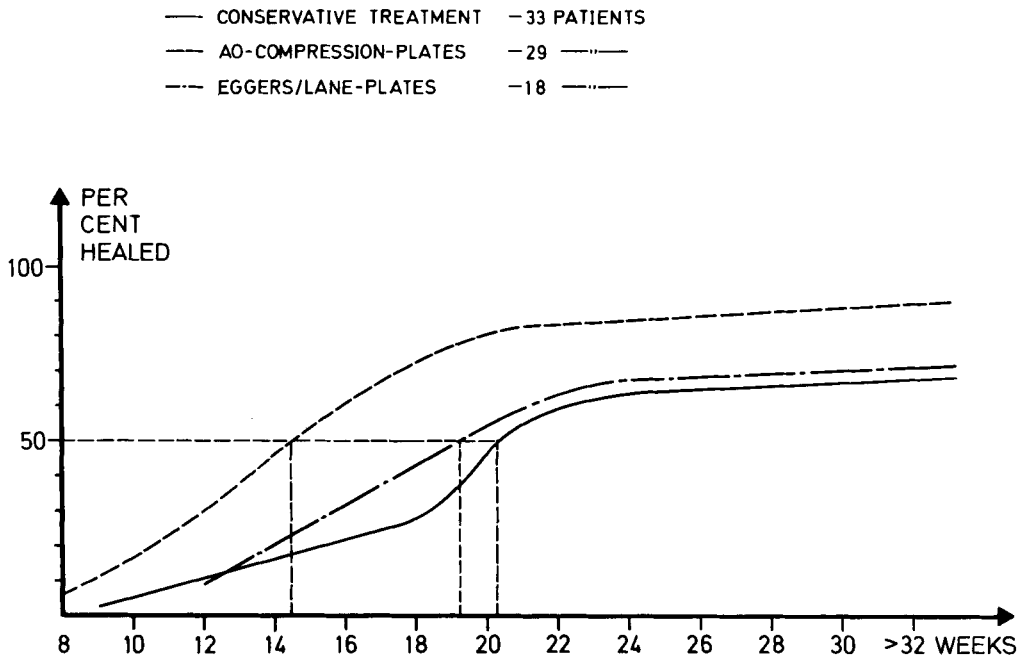

Figure 5. Healing time for comminuted fractures.

open fractures there were two late deep infections, both of which healed after removal of the implant. The third deep infection was the one mentioned leading to amputation, giving a total infection rate of 11 per cent (3/27). In 37 closed fractures the osteosynthesis was followed by one deep infection and one osteitis, both of which healed after 8 weeks and 13 months, respectively. The infection rate for closed fractures was thus 5 per cent (2/37). Non-union was not encountered after AO compression osteosynthesis.

In Table 8 it can be seen that local complications occurred in 11 out of 17 open fractures treated with conventional plates. The infection rate was 12 per cent (2/17) and both healed. The frequency of non-union was 24 per cent (4/17). In 24 closed fractures one late osteitis (4 per cent) was encountered, and two cases of non-union (8 per cent).

Fracture healing time. The radiological criteria for union in conservative treatment and conventional plate osteosynthesis was solid, bony bridging of the fracture line by periosteal and endosteal callus. Because of the so-called primary fracture healing obtained by the compression type of osteosynthesis it is difficult to define exactly when bony union has occurred. We have considered these fractures as healed when the fracture line was invisible between the 8th and the 16th week provided there was no formation of irritation callus, *or* if irritation callus which had appeared earlier had been transformed into solid fixation callus. As the different types of fractures do not involve similar problems of union we have illustrated the cumulative healing time for each group separately.

The majority of the transverse fractures (Figure 3) were treated conservatively and healing was obtained for 50 per cent of the fractures within 14 weeks. This was 3 weeks shorter than with conventional plate fixation. In oblique fractures (Figure 4) the healing time for

50 per cent of the fractures was 4 weeks shorter in the case of compression osteosynthesis compared with conservative treatment. The healing time for comminuted fractures (Figure 5) was markedly prolonged. Fifty per cent were healed 6 weeks earlier in the AO group compared to the other two groups.

Results of the follow-up study are listed in Table 9. The roentgenological examination showed malalignment in 21 per cent (21/100) after conservative treatment and in 8 per cent (3/38) after conventional plate fixation. The axis was restored in all cases after AO osteosynthesis.

Pain was present in 12 patients, but in six cases this was only slight discomfort related to changes in the weather.

Re-fracture was observed in 1 per cent (1/100) after conservative treatment and in 11 per cent (5/46) after AO compression osteosynthesis. The implant had been removed from 46 of the 61 patients attending the follow-up.

A total of 30 per cent of the patients (60/199) presented with complaints or objective findings. However, half of this number were patients treated for comminuted fractures.

DISCUSSION

The difficult problem in the treatment of tibial fractures is whether to operate and risk infection, which can follow any form of operation. Following conservative treatment of 64 closed fractures there were no severe infections; deep infection developed in 5 per cent of 61 patients treated with internal plate fixation. Among 38 cases of open fracture there was one deep infection following conservative treatment, whereas 11 per cent of 44 patients treated by internal fixation developed deep infection. These infection rates are similar to those reported in other comparable series of closed fractures (Infanger et al. 1970, Karlström & Olerud 1974, Olerud & Karlström 1972, Rittmann et al. 1970, Rüedi et al. 1976). As for open fractures, however, our figures, like Rüedi et al.'s (1976), are lower than those presented by others (Bauer & Hulth 1973, Smith 1974). Primary open fracture treatment undertaken as an early acute procedure increased the risk of infection four-fold, but all these infections eventually healed and the fractures united, although the course was prolonged. According to Aho & Hakkarainen (1974) and Smith (1974) the infection rates may be reduced considerably if the internal fixation is delayed for 2–3 weeks in open as well as in closed fractures.

Concerning the problems of fracture union we found that transverse fractures united fairly rapidly with conservative treatment. Oblique and comminuted fractures showed a prolonged healing course as has been pointed out by Nicoll (1974). Considerable time was gained, however, by the use of compression osteosynthesis, while with conventional plate osteosynthesis the healing time was the same as with conservative treatment. There was no non-union after AO compression osteosynthesis, whereas with conservative treatment there was 6 per cent non-union in closed fractures and 21 per cent in open fractures. Conventional plate fixation involved 8 per cent non-union in closed fractures and 24 per cent in open fractures. The literature contains only a few papers concerning this problem. Smith (1974) reported 30 per cent with delayed union ($\geq$ 26 weeks) after primary internal fixation of closed fractures and 48 per cent in open fractures, but again these figures were considerably reduced when using delayed osteosynthesis. Rüedi et al. (1976), however, found 4 per cent with delayed union in closed fractures and 13 per cent in open fractures applying the dynamic compression plate (DCP).

In our series 5 per cent implant failures

were seen in both types of plates, which agrees well with the findings of Olerud & Karlström (1972), but this figure is slightly higher than that stated by Rüedi et al. (1976). The implant failures were however all due to metal fatigue because of instability caused by gaps in the fracture line opposite the plate. The number of failures did not exceed our frequency of secondary displacements after conservative treatment.

Malalignment leads to changes in the load distribution of the joint surface and late development of osteoarthritis may result. One of the aims of osteosynthesis is therefore anatomical alignment. Twenty-one per cent of the fractures were malaligned following conservative treatment and 8 per cent after conventional plate fixation. After AO plate fixation anatomical alignment was achieved in all cases.

Removal of the AO plates 1 year after application was followed by 11 per cent re-fractures. This is about three times as many re-fractures as are stated by Olerud & Karlström (1972) and more than twenty times the figures of Rüedi et al. (1976). Nearly all re-fractures were caused by new relevant traumas during sporting activities, such as soccer. Three of the re-fractures occurred after 1–2 years; the remaining two occurred within 2 months of implant removal.

In conclusion, we find that AO compression osteosynthesis is justified in the treatment of open tibial shaft fractures and is also a useful tool in cases of closed fractures, because of anatomical reduction, safe union and a shorter healing time in spite of an increased infection rate. This disadvantage might be overcome by delayed osteosynthesis and by application of the plate on the lateral aspect of the tibial shaft covered by muscles. As mentioned by others, however, (Bauer & Hulth 1973, Karlström & Olerud 1973, Wade 1970) the AO method may be a dangerous tool, and we feel that the use of this method must be restricted to experienced orthopaedic surgeons. In our series of patients osteosynthesis with conventional Eggers or Lane plates was not superior to conservative treatment, which is still the method of choice whenever it is possible to retain reduction and good alignment.

REFERENCES

Aho, A. J. & Hakkarainen, S. (1974) Closed leg fractures. *Acta chir. scand.* **140**, 457–465.

Bauer, G. & Hulth, A. (1973) Kompressionsosteosyntes enligt AO vid underbenets diafysfrakturer bör överges. *Svenska Läk.-Tidn.* **70**, 4752–4753.

Infanger, K., Fenner, A., Cadalbert, M. & Schamaun, M. (1971) Ergebnisse der operativen Behandlung der Unterschenkel-Schaftfrakturen anhand von 230 Fällen. *Helv. chir. Acta* **3**, 311–316.

Karlström, G. & Olerud, S. (1973) Har stabil plattosteosyntes av tibiafrakturer något berättigande? *Svenska Läk.-Tidn.* **70**, 4754–4755.

Karlström, G. & Olerud, S. (1974) Fractures of the tibial shaft. *Clin. Orthop.* **105**, 82–115.

Müller, M. E., Allgöwer, M. & Willenegger, H. (1963) *Operative Frakturenbehandlung*. Springer, Berlin, Göttingen, Heidelberg.

Müller, M. E., Allgöwer, M. & Willenegger, H. (1970) *Manual of internal fixation*. Springer, Berlin, Heidelberg, New York.

Nicoll, E. A. (1974) Closed and open management of tibial fractures. *Clin. Orthop.* **105**, 144–153.

Olerud, S. & Karlström, G. (1972) Tibial fractures treated by AO-compression osteosynthesis. *Acta orthop. scand.*, Suppl. 140.

Rittmann, W. W., Matter, P. & Allgöwer, M. (1970) Behandlung offener Frakturen und Infektionshäufigkeit. *Acta chir. Austr.* **2**, 18–21.

Rüedi, T., Webb, J. K. & Allgöwer, M. (1976) Experience with the dynamic compression plate (DCP) in 418 recent fractures of the tibial shaft. *Injury* **7**, 252–257.

Smith, J. E. M. (1974) Results of early and delayed internal fixation for tibial shaft fractures. *J. Bone Jt Surg.* **56**-B, 469–477.

Solheim, K. (1973) Tibial fractures treated according to the AO method. *Injury* **4**, 213–220.

Wade, P. A. (1970) ASIF compression has a problem. *J. Trauma* **10**, 513–515.

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