Arch Orthop Trauma Surg (1986) 105:170–174

Archives of Orthopaedic and Traumatic Surgery

External Fixation of Tibial Shaft Fractures with Severe Soft Tissue Injuries by Hoffmann-Vidal-Adrey Osteotaxis

P. Rommens, P. Broos, and J. A. Gruwez

Department of General Surgery (Dir.: Prof. Dr. J. A. Gruwez), St. Pieters Hospital, Catholic University of Leuven, Belgium

Summary. The operative results in 65 patients with 66 tibial shaft fractures and severe soft tissue injuries, stabilized by an external fixation frame according to Hoffmann or Vidal-Adrey, are reviewed and the treatment principles are discussed. Four patients required secondary amputations. Fitfy-three patients could be followed up for an average of 23.2 months. The infection rate was 9.2% and nonunion was found in 11.1% of cases. Two patients had a refracture after removal of the fixation device. Twenty-three patients (42.6%) required one or more secondary operations. Of the 65 patients, 70.4% had very good or good end results, 16.7% acceptable, and 12.9% poor. External fixation according to Hoffmann or Vidal-Adrey affords excellent definitive stabilization in simple fractures of the lower leg with soft tissue injuries. In comminuted fractures of the lower leg with loss of bone fragments and severe tissue damage, external fixation is better used as a means of temporary stabilization until soft tissues permit definitive rigid stabilization.

Zusammenfassung. Die Operationsergebnisse von 65 Patienten mit 66 Tibiaschaftfrakturen mit ausgedehntem Weichteilschaden, die durch einen Fixateur externe nach Hoffmann oder Vidal-Adrey stabilisiert wurden, werden nachuntersucht und die Behandlungsprinzipien diskutiert. Bei 4 Patienten war eine sekundäre Amputation erforderlich. 53 Patienten wurden während eines durchschnittlichen Zeitraums von 23,2 Monaten beobachtet. Die Infektionsrate betrug 9,2%, Pseudarthrosen entwickelten sich in 11,1% der Fälle. Zwei Patienten hatten eine Refraktur nach Entfernung des Fixateur externe. Bei 23 Patienten (42,6%) waren eine oder mehrere Reoperationen erforderlich. 70,4% der Patienten zeigten ein sehr gutes bis gutes Endergebnis, 16,7% ein annehmbares und 12,9% ein schlechtes Ergebnis. Der Fixateur externe nach Hoffmann oder Vidal-Adrey stellt eine zuverlässige und definitive Stabilisierung für einfache Frakturformen am Unterschenkel mit Weichteilschaden dar. Bei komplizierten Frakturformen mit Verlust von Knochenfragmenten am Unterschenkel mit Weichteilschaden ist diese externe Stabilisierung eher eine vorläufige Lösung, bis die Weichteile eine definitive, rigide Stabilisierung zulassen.

Offprint requests to: Dr. med. Pol Rommens, Landwehr 27, 4300 Essen 16, Federal Republic of Germany

The indications for external fixation of the lower leg in fractures with severe soft tissue damage are no longer a matter for discussion. In 1907 the Belgian Lambotte emphasized the advantages of an external fixation device in the operative treatment of long bone fractures. In the 1950s Hoffmann [4] developed a newer system for external osteosynthesis which showed considerable technical improvement. In the 1960s Vidal [12] and Adrey [1] changed this into an external skeletal transfixion system.

In 1978 we revised the management of open tibial fractures at our center [9]. While almost all such fractures had previously been treated conservatively, all open fractures and fractures with soft tissue injuries now received primary wound care and primary or early operative stabilization. Up to 1983, 66 fractures had been stabilized with an external fixation device. Based on the experience of this 5-year series, the advantages and problems of this technique are discussed.

Patients and Methods

A series of 66 consecutive tibial shaft fractures with severe soft tissue injuries in 65 patients were stabilized by external fixation over a 5-year period (1978–1982) in the Department of General Surgery at the St. Pieters Hospital of the Catholic University of Leuven, and these fractures are reviewed. Excluded from this group were ankle joint fractures without a shaft component and tibial fractures occurring with open epiphyses.

The fractures were divided into closed, open-I, open-II, and open-III fractures, depending on the degree of soft tissue damage, in accordance with Tscherne [8].

In all open fractures primary operative wound exploration with resection of all necrotic soft tissue and wound cleaning was done. Primary wound closure was performed only if this was possible without placing any tension on the wound margins. Larger wounds were always left open. Great care was taken to cover the fracture with soft tissue. Myoplastic operations were not performed primarily. Cutaneous defects were postoperatively treated with synthetic skin substitute until secondary wound closure had taken place. Secondary mesh-graft skin transplantation was performed in 15 patients, four of whom needed several transplantations. Fasciotomy of all muscle compartments was done on seven patients to prevent a postoperative compartment syndrome. Prophylactic antibiotics were given to all patients immediately after admission and discontinued only after a 72-h period if the primary wound culture was sterile.

Fractures were stabilized with the Hoffmann frame in 38 cases and with the Vidal-Adrey frame in 28 cases. In all fractures the proximal and distal main fragments were attached by three pins; the intermediate fragments of the ten bifocal fractures were fixed with two pins. The skin incisions were made sufficiently large to avoid skin necrosis or pin-tract infections. Axial compression rods were used on simple fractures to increase stabilization. Primary bone grafting was not performed.

Postoperatively the operated limb was immobilized in an elevated position. Wound drains were removed only when the daily secretion had diminished to less than 20 ml. Wounds were checked daily, and synthetic skin substitute on cutaneous defects was changed every other day. In six patients necrotic bone fragments were removed secondarily; in three of them gentamicin-containing PMMA chains were placed as treatment for deep infection. In ten patients with comminuted fractures and cortical defects secondary bone grafting was performed. In five patients autologous bone grafting and additional decortication according to Judet was done; in three of them this was via a posterior approach to create tibiofibular synostosis.

Isometric quadriceps muscle training was started immediately postoperatively, mobilization on the knee and ankle joints only when wounds showed clean healing. Partial weight bearing on the operated limb was begun with active mobilization. Gradual weight bearing was started at different times, depending on the type of fracture and the fracture healing. Meticulous care was given to the skin around the pins by daily cleaning with alcohol. Patients were given instructions to continue this care at home.

The following findings were recorded postoperatively: wound problems, fracture consolidation time, functional recovery, knee and ankle joint function, complaints, infection, and nonunion. Anteroposterior and lateral radiographs were taken at 4-week intervals until consolidation was demonstrated radiologically. The end results were divided into good, acceptable, and poor. Patients were regarded as having good results if they had no complaints and a normal functional recovery of the operated limb; acceptable, if they had occasional complaints and a slightly reduced functional recovery of the operated limb; poor if they had severe pain, significantly reduced knee or ankle function, infection, and nonunion.

Results

The mean age of the patients was 34.8 years, with an age range of 16–28 years. The age distribution (Fig. 1) shows that 58% of the patients were younger than 30 years. The ratio of males to females was 3.4 to 1 (Fig. 2). Nearly 80% of the fractures were caused by traffic accidents, 13.7% by private accidents, and 7.5% by accidents at work. Motorcycle drivers (42.3%) and automobile drivers (36.5%) were by far the most frequent victims, pedestrians (11.6%) and bicyclists (9.6%) were rarely involved (see Figs. 3 and 4). Only 17 patients (38.2%) had no associated lesions; the most frequent trauma combination in other patients was craniocerebral trauma with tibial shaft fracture (19). Other patients had fractures in the upper extremities (17), fractures of the same limb (14) or other limb (13), and pelvic (11), thoracic (6), or abdominal (1) lesions (see Fig. 5). Thirty-five tibial fractures were situated in the middle third of the shaft (53.1%), 14 in the distal third (21.2%), and nine in the proximal third (13.6%); eight were bifocal fractures (12.1%; Fig. 6). More than 60% were comminuted or bifocal fractures; only 40% were single fractures (transverse, oblique, spiral; Fig. 7). Five fractures were closed (7.6%); six were open-I (9.1%), 25 open-II (37.9%), and 30 open-III (45.4%; see Fig. 8). Most of the patients in this series were young, male, traffic-accident victims with severe soft tissue injuries on the lower leg and accompanying complex tibial shaft fractures.

Twelve patients could not be reviewed. One 18-year-old severely injured hemophiliac died 3 weeks post-trauma due to septicemia. Two patients died within 1 month due to post-traumatic cerebral le-

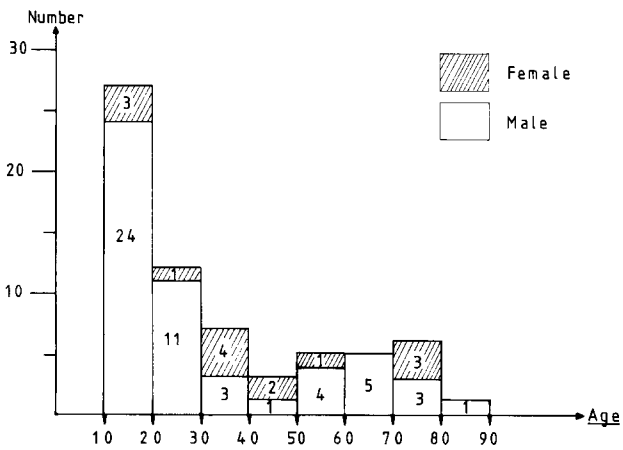

Fig. 1. Age distribution ($n = 66$)

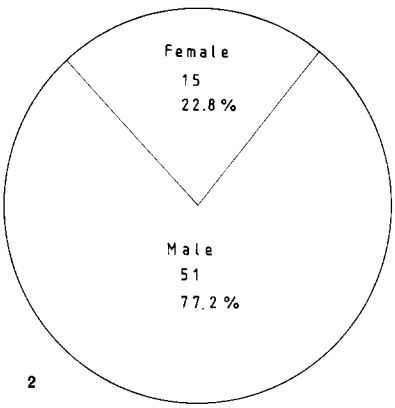

Fig. 2. Sex distribution ($n = 66$)

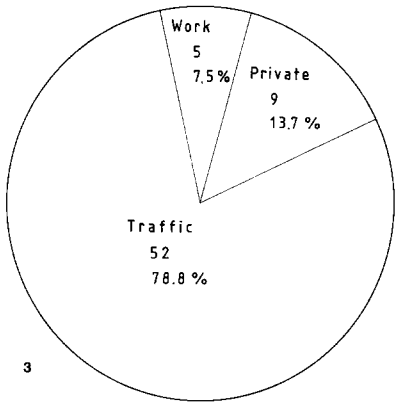

Fig. 3. Circumstances of accident ($n = 66$)

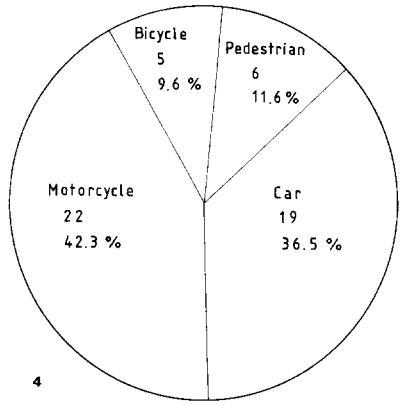

Fig. 4. Traffic accidents ($n = 52$)

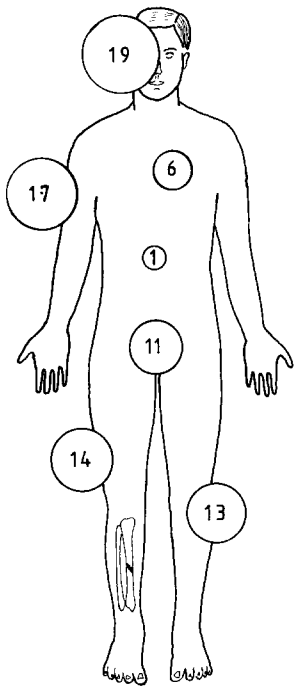

Fig. 5. Associated lesions

sions, and one patient died 7 months after injury of unrelated causes. Four patients required secondary amputation because of untreatable infection and soft tissue necrosis of the lower leg. In three of these patients an arterial reconstruction was done primarily; the fourth patient had insulin-dependent diabetes mellitus. Four patients were lost to follow-up. The remaining 53 patients with 54 tibial shaft fractures were followed up for an average of 23.2 months.

Fifteen patients (27.7%) had minor postoperative wound problems: minor skin necrosis, minor soft tissue necrosis, or mild pin-tract infections. Five patients (9.2%) developed osteitis, six (11.1%) developed pseudarthrosis, and two suffered refractures (3.7%) after the fixation device was removed (see Table 1).

Twenty-seven patients (59%) had no complaints, 11 patients had paresthesia over the wound more than 1 year after surgery (20.4%), eight patients complained of edema (14.8%), and eight reported pain at the fracture site upon weight bearing (14.8%; see Table 2).

Functional recovery is shown in Table 3. Thirty-three patients (61.2%) showed no muscle atrophy or edema when the operated limb was measured, while 12 patients (22.2%) had edema (circumference of the operated limb exceeded that of the other limb by more than 2 cm) and nine patients (16.6%) had quadriceps and/or calf atrophy exceeding 2 cm. Consolidation time is shown in Table 4. Seventeen fractures (31.5%) showed clinical and radiological consolidation within 4 months postoperatively, 25 fractures (46.3%) between 4 months and 1 year, and six fractures (11.1%) after more than 1 year; six other fractures (11.1%) developed pseudarthrosis.

Knee function is illustrated in Table 5. Forty-six patients (85.2%) had normal knee function, four patients (7.4%) slightly reduced ($<30°$) knee mobility, two patients (3.7%) moderately reduced ($<60°$) knee mobility, and two patients (3.7%) severely reduced ($>60°$) knee mobility.

Ankle function is shown in Table 6. Thirty-five patients (64.8%) had normal ankle function, 13 patients (24.1%) slightly reduced ($<20°$) ankle mobility, four patients (7.4%) moderately reduced ($<40°$) ankle mobility, and two patients (3.7%) severely reduced ($>40°$) ankle mobility.

The end results are given in Table 7. Thirty-eight patients (70.4%) had very good or good end results,

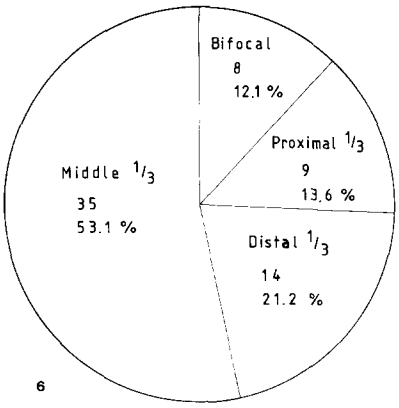

Fig. 6. Site of fracture ($n = 66$)

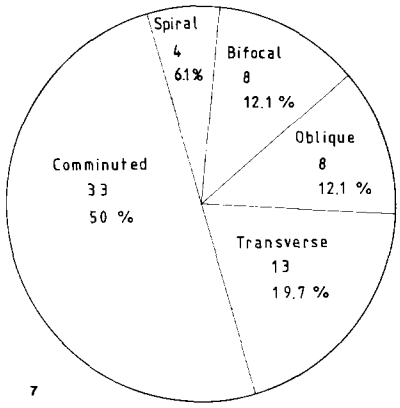

Fig. 7. Type of fracture ($n = 66$)

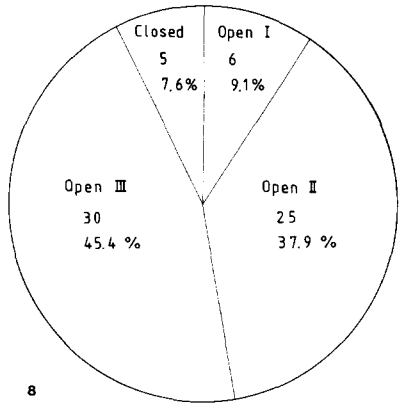

Fig. 8. Degree of soft tissue injury ($n = 66$)

Table 1. Postoperative complications

	No. of patients (%)
Minor wound problems	15 (27.7)
Pseudarthrosis	6 (11.1)
Osteitis	5 (9.2)
Refracture after removal of fixation device	2 (3.7)

Table 2. Subjective complaints

	No. of patients (%)
No complaint	27 (50)
Paresthesia over the wound	11 (20.4)
Edema	8 (14.8)
Pain	8 (14.8)

Table 3. Functional recovery

	No. of patients (%)
Normal	33 (61.2)
Edema (>2cm)	12 (22.2)
Quadriceps and/or calf atrophy (>2cm)	9 (16.6)

Table 4. Consolidation time

	No. of patients (%)
Within 4 months	17 (31.5)
Between 4 months and 1 year	25 (46.3)
More than 1 year	6 (11.1)
Pseudarthrosis	6 (11.1)

Table 5. Knee function

	No. of patients (%)
Normal	46 (85.2)
Slightly reduced	4 (7.4)
Moderately reduced	2 (3.7)
Severely reduced	2 (3.7)

Table 6. Ankle function

	No. of patients (%)
Normal	35 (64.8)
Slightly reduced	13 (24.1)
Moderately reduced	4 (7.4)
Severely reduced	2 (3.7)

Table 7. End results

	No. of patients (%)
Very good or good	38 (70.4)
Acceptable	9 (16.7)
Poor	7 (12.9)

nine patients (16.7%) acceptable, and seven patients (12.9%) poor end results.

Discussion

In all fractures with severe soft tissue injuries, the care of the soft tissues requires the greatest attention:

an aggressive primary wound debridement with excision of all dead tissue, sufficient drainage, and delayed closure of greater wounds [10, 11]. Despite rigid adherence to these treatment principles we had a rate of 9.2% deep infections in this series with 45.4% open-III fractures. A reliable comparison with other series is difficult. In different publications the rate of post-traumatic osteitis varies between 2.7% and 43% [2].

Mild pin-tract infections occurred in seven patients (12.8%). In no case did pin-tract infection lead to deep infection. Sufficient stability of the pins and large skin incisions can protect the patient from serious deep infections. Therefore, all pinholes of the external fixation device must be drilled by hand and not with a machine drill [5]. Skin incisions can also be enlarged secondarily to avoid skin tension or skin necrosis or to allow sufficient drainage.

In a series with more than 60% comminuted and bifocal fractures, we can expect a longer consolidation time for most of them. Other factors influencing consolidation time are the degree of soft tissue damage and stability [6]. Injured soft tissue compromises the circulation of the fracture area, and this is an importanct cause of delayed healing or nonunion of the fracture. In this series external fixation was removed in only eight patients before fracture consolidation. In two patients with pseudarthrosis secondary intramedullary nailing was performed, and two others received a secondary AO-plate osteosynthesis. Four patients were treated with a patellar tendon-bearing apparatus until fracture consolidation had occurred. External fixation remained in all other 48 patients up to the point of fracture consolidation, for a mean time of 26 weeks. Only in those patients with simple fractures for whom the external fixation device with compression rods could be used was primary fracture healing achieved [7].

By far, the greatest number of problems such as pin-tract infections, delayed union, and infection were seen in patients with comminuted fractures who had external fixation for prolonged periods. Although most of these problems could be resolved by secondary operations or nonoperative measures, our clinical experience showed that the stability of external fixation slowly decreases owing to osteoporosis around the pin tracts. The loss of stability inhibits primary fracture healing and causes delayed union or pseudarthrosis.

External fixation is without any doubt the method of choice in the treatment of open fractures and fractures with soft tissue damage. In fractures where intrafragmentary compression cannot be obtained, fracture stability can be increased by one or more additional lag screws [3], or external fixation can be used as a means of temporary stabilization until the soft tissues permit a definitive rigid stabilization together with an autologous cancellous bone transplantation.

Seventy percent of the patients had very good or good end results. This is superior to previous series of open fractures treated conservatively in our clinic. Despite rigid management principles, 13% of our patients had poor end results. Treatment of tibial shaft fractures with severe soft tissue damage remains a serious surgical problem that requires the greatest attention of the experienced surgeon to decontamination, wound care, and fracture stabilization [10].

References

1. Adrey J (1970) Le fixateur externe d'Hoffmann couplé en cadre. Etude biomécanique dans les fractures de jambe. Gead, Paris
2. Burri C (1974) Posttraumatische Ostitis. Huber, Bern
3. Burri C, Claes L (1981) Indikation und Formen der Anwendung des Fixateur Externe am Unterschenkel. Unfallheilkunde 84:177–185
4. Hoffmann R (1954) Osteotaxis, osteosynthese externe par fiches et rotules. Acta Chir Scand 107:72–80
5. Karlström G, Olerud S (1983) External fixation of severe open tibial fractures with the Hoffmann frame. Clin Orthop 180:68–77
6. Larsson K, van der Linden W (1983) Open tibial shaft fractures. Clin Orthop 180:63–67
7. Müller KH, Rahn BA (1983) Knochenheilung nach stabiler externer Osteosynthese. Unfallheilkunde 86:341–348
8. Oestern HG, Tscherne H (1984) Pathophysiology and classification of soft tissue injuries associated with fractures. In: Tscherne H. Gotzen L (eds) Fractures with soft tissue injuries. Springer, Berlin Heidelberg New York
9. Rommens P, Broos P, Theunis P, Willemen P, Gruwez JA (1985) The operative treatment of tibial shaft fractures: a review of 277 cases. Acta Chir Belg 85:268–273
10. Scharf W, Orthner E, Wagner M (1984) Behandlungsrichtlinien und Ergebnisse schwerst offener Unterschenkelbrüche. Unfallchirurgie 10:192–199
11. Tassler H (1981) Behandlungsprinzipien bei drittgradig offenen Frakturen des distalen Unterschenkels. Unfallheilkunde 84:509–513
12. Vidal J (1968) Notre expérience du fixateur externe d'Hoffmann a propos de 46 observations. Les indications de son emploi. Montpellier Chir 14:451–456

Received November 30, 1985