A Retrospective Analysis of Severe Diaphyseal Tibial Fractures Treated With External Fixation

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ABSTRACT: This retrospective study examines consecutively treated tibial fractures managed with external fixation methods.

Introduction
External fixation as a method of fracture management has recently experienced a resurgence of interest. It is especially suited for tibial fractures, although use with other fractures is currently under active investigation. In the past, external fixation had been used for all types of tibial fractures; more recently, however, it has been reserved for unstable fractures, especially those with severe soft tissue injury. The advantages of external fixation include: stabilization of the fracture without further dissection or implants; maintenance of the mobility of joints above and below the fracture; ease of care of the soft tissues; and ease of nursing. The chief disadvantage of external fixation has been the problem of pin tract infection, with an incidence of 5% to 10%.

Clinical Material
The hospital charts of all patients with the diagnosis of diaphyseal tibial fractures, admitted to the Massachusetts General Hospital from January 1971 through September 1978, were screened. Fifty-eight fractures in 57 patients were treated by external fixation methods. Forty-one patients with 42 fractures were available for followup examination one to eight years after the injury (average: 3.8 years). Forty-four men and 13 women had fractured 33 right and 25 left tibias. Forty-seven were open fractures, and only 11 were closed. The patients ranged in age from 16 to 85 years (average: 28 years).

Fracture locations were evenly divided among the proximal, middle, and distal thirds of the diaphysis. Ninety-one percent of the fractures followed direct high energy trauma as defined by Bauer, et al. Motor vehicle incidents were responsible for 84% of the entire group. The comminuted transverse and short oblique fractures constituted the most common patterns seen, reflecting the severity of trauma. Several segmental fractures are included in the series, but only one longitudinal fracture. All but three of the fractures were moderately or markedly displaced, using the definition of Edwards.

Two-thirds of the patients had multiple injuries, primarily involving the musculoskeletal system, with other injuries evenly divided among the head, face, chest, and abdomen. About two-thirds of these multiple-injured patients had a major injury to the ipsilateral leg. Soft tissue injuries were similarly quite severe. Seventy percent of the fractures were open, and 77% of these were Type III injuries, as classified by Gustilo and Anderson.

Methods of Treatment
Open fractures were debrided and stabilized as soon as possible following admission. Antibiotics, most often cephalosporin, were initiated in the emergency room area. All external fixation devices were applied in the operating room. Fixation pins were inserted manually, without predrilling. These pins were dressed in the operating room, but thereafter treated without dressings and cleaned daily, unless incorporated within a cast.

None of the 11 Type I or Type II wounds required split-thickness skin grafting. Three of these wounds were closed primarily, and the remainder by delayed or

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secondary closure. One Type II wound did require a flap for final coverage. This was a special circumstance where compounding occurred through a previous split-thickness skin graft. Of the 33 Type III wounds that closed (including one death and two amputations), two were closed primarily, and the remainder by secondary closure, including 15 split-thickness skin grafts and 11 flaps.

Four methods of external fixation were utilized: pins and plaster—22 fractures (Fig. 1); Charnley—14 fractures (Fig. 2); Roger Anderson—six fractures (Fig. 3); and Hoffmann—16 fractures (Fig. 4). The Charnley and Roger Anderson methods are combined into one treatment group because of the similarity of their design, and for equivalent numerical comparison. Thus, three treatment groups were evaluated.

In the comminuted fractures, the fixators were used as neutralization devices. Where bone had been lost, the device held the fractures at or near normal length in a distraction mode. No compression was applied to
any of the P/P group, as this is a distracting technique by design.

External fixators were removed when the fracture was judged stable to clinical testing, or when significant loosening or pin tract infection required removal.

**Results**

**Soft Tissue Closure**

Fifteen Type III wounds were managed with the Hoffmann device, 14 by the C/RA method, and seven with P/P. When Type III wounds only were compared, the wounds managed with the Hoffmann device closed sooner than the other treatment groups, despite uniformly more severe soft tissue injuries in this category (Fig. 5).

**Bone Union**

No loss of alignment occurred until after removal of the fixator device. Alarmingly, 47% of the fractures showed worse alignment after device removal. No loss of apposition was evident after removal, despite the large variation and length of time each device was left
in place. The average duration of device application was 12 weeks, ranging from seven weeks for the P/P to 17 weeks for the H group.

Time to union, when no further fracture support was required, averaged 49 weeks. Forty-six patients progressed to union, while 12 did not. Healing times were 35 weeks for the P/P group, 45 weeks for the C/RA group, and 67 for the Hoffmann group. When similar soft tissue injuries were compared, the healing times for Type III wounds were 39 weeks for the P/P group, 59 weeks for the C/RA group, and 69 weeks for the H group. Finally, all markedly displaced fractures with Type III wounds showed a substantially delayed healing time, requiring 89 weeks in the C/RA groups and 85 in the H group (Fig. 6). No such injuries were treated by P/P method.

Thus, delayed union was the rule in our series. Only nine of 46 patients (20%) healed within the 24-week period acknowledged to be the upper limit of normal healing in tibial fractures. These nine patients mostly had closed injuries managed with the P/P method.

Twenty-nine additional procedures were required for bony union. Twenty-two grafts were performed in 15 patients, three of whom had associated fibular osteotomy. The average time to first bone grafting was 24 weeks. Four fractures underwent delayed internal fixation: two with compression plating, one with interfragmentary screw fixation, and one fracture with intramedullary nailing. Two nonunions were treated with electrical stimulation.

Complications

A failure of proper technical application was observed in 10 instances. In each instance no compression (where it could have applied) or inappropriate distraction was present. Although the P/P group represents a distraction technique, only one fracture was held overly distracted at the fracture site as judged by x-ray.

No Type I or Type II wounds and no closed fractures became infected in this series. No case of delayed internal fixation became infected, although in each case the internal fixation followed removal of the external fixator by several weeks.

The incidence of infection, as judged by the onset of redness, swelling, and purulent drainage, was 39% (21 of 54). Slightly more than one-half of these infections were related to pin tract infection. One-third of all of the infections were transient, in that they cleared readily with local treatment, pin removal, or antibi-
otics. The remainder were chronic infections (26% of the entire series), half of which were pin tract infections, and half, deep wound infections. A similar incidence of infection was seen in the C/RA and H groups, while the P/P group had very few infections (Fig. 7).

With appropriate treatment, including wound or pin tract debridement and prolonged antibiotics (usually six weeks), one-half of the patients with chronic infections stopped draining entirely, over a period of several years following the injury. The overall final incidence of persistent deep infection was 13%. Two patients with chronic drainage elected for amputation. In both instances, the involved extremity had major motor and sensory deficits. This gives an amputation rate of 8.5%, which is higher than reported in other series. 21,23

No pin tract infections occurred before six weeks. The average time to pin tract infection was 10 weeks with the C/RA group, compared to 14 weeks for the H treated group. Pin tract infections were not a problem with the P/P group, in which the pins were removed much earlier. Complications other than infection directly attributed to the pins were rare. No pin-related vascular injuries occurred. A saphenous nerve was injured, causing a mild persistent sensory deficit with paresthesias. One pin break (incorporated in the cast) occurred at five weeks, and one fracture occurred through a nonhealed pin hole after the fracture itself had gone on to union. Finally, one case of claw toe deformity required subsequent surgery.

Followup Review

Forty-eight patients were available for followup out of the original 57. Four patients had died, four patients underwent amputation, and two patients are still in the process of fracture treatment. Forty-two of the 48 patients were contacted for followup evaluation. The format of the evaluation was similar to Olerud and Karlston. 31 Radiographic alignment, rotational alignment, shortening of the extremities, and the incidence of venous swelling were tabulated. Twenty to 42 fractures were acceptable or better in the overall series. Only one—a closed fracture treated with the P/P method—was excellent. More P/P treated fractures were in the good category, as expected, since these fractures were generally less severe. C/RA and H treated fractures faired essentially the same in followup. Only six of 26 Type III wounds were acceptable or better; most were in the poor category.

The most frequent complaint was ankle and foot stiffness. Objectively, a high percentage of limited ankle and subtalar motion was found. Two of the diaphyseal fractures in this series extended into the ankle joint; however, even in those fractures without direct involvement of the ankle joint, stiffness occurred from soft tissue contracture. Pain at the fracture site was an infrequent complaint, noted in only eight of 42 cases. Even in those complaining of discomfort, it was severe in only one patient with persistent active drainage.

Shortening averaged 1.3 cm, with a maximal shortening of 3.3 cm. Shortening was more frequent in the more displaced and comminuted fractures. In such fractures treated with the H method, average shortening was 1.6 cm, compared with 2.4 cm for comparable fractures treated in the C/RA method. Clinically apparent rotational asymmetry was seen in four of 34 patients. In none of the four was rotational malalignment significant. A high incidence of angular deformity of the healed fractures was observed. Twenty-nine percent of the P/P group, 59% of the Charnley/Roger Anderson group, and 45% of the Hoffmann group demonstrated either 5° or greater of varus/valgus, or 10° of anteroposterior angulation. Fifteen of 42 patients gave a history of ankle swelling at the end of the day in the injured leg. Four required support hose for management.

Discussion

This series represents a collection of particularly severe tibial fractures. The three treatment method groups are not comparable, but the series falls naturally into two subgroups: the less severe fractures managed with the pins-in-plaster method; and the more severe fractures, managed with the Charnley or Roger Anderson external fixateur up until 1976, after which time the Hoffman fixateur was used exclusively.

The less severe group predictably did better than the latter group. The duration of fixation, healing time, and incidence of complications agree closely with the findings of Anderson, et al., in their series using the same pins/plaster method. It is the more severe group of fractures, especially the Type III, that represents the real challenge in management, and is a group predisposed to failure of treatment. 7,16,19

Infection—especially pin tract infections—and delayed union were prevalent in this study. Olerud and Karlstrom, on the other hand, have reported no pin tract infections in their series of tibial fractures. 3 Their attribute this absence of pin tract infections to the demonstrated stability of the Hoffmann double
It was in fact noted in the series reported here that pin tract infections did appear later with the Hoffmann method than with the others.

Olerud and Karlstrom report that both instances of internal fixation following external fixation in their series resulted in infection. Four of the 58 fractures in this series underwent delayed internal fixation without infection. The internal fixation, however, followed removal of external fixation by several weeks, which may explain the better result.

Bony union was prolonged in this study. Clearly, the fractures being dealt with are predisposed to prolonged healing. Nevertheless, the healing time in this study for the severe fractures—55 weeks—is considerably longer than that reported by Olerud and Karlstrom, 32 weeks. Several possible explanations exist for this discrepancy. The series here represents a more severe group of fractures, as evidenced by the increased number of flaps required to gain soft tissue coverage, and the increased number of amputations. The 17% incidence of poor external fixation technique most certainly contributed, as did the infection rate of 39%.

No pin tract infections occurred before six weeks in this study. Weiss, Roberts and Curtis urge that external fixation be thought of as “temporizing” measure to permit care of the soft tissues, rather than as “definitive treatment.” Accordingly, external fixation devices should be used to rigidly immobilize the reduced fracture, permitting care of the soft tissues. Subsequently, they should be removed in order to avoid pin complications, in favor of closed weight-bearing management, which appears to offer the best chance for early union.

The clinical outcomes of the tibial fractures reported here were generally functions of the severity of injury. Most were classified as poor or acceptable. These results are not as good as those reported by Olerud and Karlstrom, where most patients were in the excellent or good category. As in their series, ankle and subtalar stiffness was the most common complaint.

When comparing Type III wounds, the Hoffmann external fixateur appears to have several distinct advantages over the Charnley or Roger Anderson devices. In addition to the delayed appearance of pin tract infections, the Hoffmann-treated fractures appeared to gain soft tissue coverage more quickly and to experience less shortening.

The total incidence of amputations in this series—8.5%—is higher than reported elsewhere in the literature. The reason for this is that the external fixateur allows for stabilization and treatment of fractures that formerly would have undergone primary amputation. Clearly, careful thought must be given to the likelihood of salvaging a usable limb before the initiation of a prolonged and expensive course of treatment.

Conclusions

Pins incorporated into plaster is a satisfactory technique for less complicated tibial fractures.

Fracture union is slow and appears independent of the method of fixation used in this study. The more severe the fracture, the more prolonged the time to union. Therefore, the need for bone grafting can be anticipated and should be performed earlier than done in this series.

The Hoffmann device facilitates the soft tissue healing, provides a better neutralizing force to diminish shortening, and offers better biomechanical stability, when compared with the Charnley/Roger Anderson method.

Infection is a significant complication with external fixation methods. Pin tract infections developed later with the Hoffmann method than with other methods. Earlier removal of the external fixator, when possible, should also reduce the incidence of pin tract infections. Internal fixation of fractures treated initially by external fixation appears to carry no added risk of infection when at least a four-week interval is allowed for pin tract closure after removal of the fixator.

The fixation device may contribute to stiffness of ankle and foot motion, due to entrapment of soft tissues about the joint.

The final outcome of fracture management appears independent of the fixation device used; the outcome appears primarily related to the degree of the original soft tissue and bone trauma.

References