

# Segmental Tibial Defects

## Comparing Conventional and Ilizarov Methodologies

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Forty-four consecutive patients with segmental debridement defects of the tibia had limb-salvage surgery. Twenty-one patients (Group I) were managed using methods as described by Ilizarov. Twenty-three patients (Group II) underwent conventional treatment with massive cancellous grafts and tissue transfers. Total wound consolidation and infection arrest took place after the first treatment in 71% of the Ilizarov wounds and 74% of the conventionally treated wounds. The major complication rates were 33% and 60% for Groups I and II respectively. The patient population at highest risk for failure was the compromised host treated conventionally (44%). The cost for retreatment and overall success rate (95%) were the same for both groups. Ilizarov reconstructions averaged nine fewer hours in the operating theater, 23 fewer days in the hospital, five fewer months' disability (17 months versus 22 months), and a savings of nearly \$30,000 per application.

Since June 1981, 678 patients with infected nonunions have entered prospective treatment protocols on the authors' adult osteomyelitis service, providing experience with a diverse therapeutic armamentarium and, in turn, a less-restrictive patient selection process. During the past ten years, the number of primary amputations and palliative treatment regimes at the authors' center have declined 58% to 73% respectively. The two-year disease-free interval after treatment has remained 94% (n = 620). In 1992, 82% of all patients seeking treatment at the authors'

service were offered limb salvage. The key to this level of confidence has been a marked decrease in surgical morbidity.

In 1988, the authors began a prospective study to assess the role of distraction methodologies in the management of infected tibial defects. Patients were staged according to the Cierny/Mader classification system<sup>1</sup> wherein the condition of the host is stratified. A patient with a normal physiologic response to infection and surgery is designated an A-host; a compromised patient is classified a B-host and will have either local (B<sup>L</sup>), systemic (B<sup>S</sup>), or combined (B<sup>S,L</sup>) deficiencies in wound healing. A C-host is an A-host or B-host wherein the morbidity of treatment is believed to be greater than that caused by the disease itself. These latter patients are not surgical candidates and are either palliated with oral antibiotics or simply observed.

The protocol begins with patient selection. To enter the limb-salvage arm, the prognosis for cure must be reasonable, the treatment safe, and the outcome beneficial in form and function. The patient must demonstrate a willingness to cooperate in every way. Host deficiencies are identified and corrected whenever possible. Patients older than the age of 40 years are examined and observed by an internal medicine consultant specializing in perioperative patient management. If the patients are cleared for surgery and pathogens have been established, antibiotics are started 24 hours preoperatively and continued until debridement cultures are reported.

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The details of the authors' antibiotic program have been published elsewhere.<sup>1</sup>

At surgery, all ischemic and necrotic hard tissues were excised. Reconstruction was initiated by Day 7. In study Group I, 21 long-bone defects were reconstituted using transport or distraction methodologies as described by Ilizarov.<sup>3,4</sup> At debridement, limbs were stabilized with the circular fixator. On Day 5, one or two percutaneous cortical osteotomies were made above and/or below the defect. After the lag phase, segments were slowly distracted. The bone forming spontaneously in the gap(s) (regenerate bone) matched the overall defect length. Cortex-to-cortex docking sites were grafted (bone or marrow); cancellous sites were merely curetted just before compression. If, after debridement, a soft-tissue defect exposed vital structures (vessel, nerve, tendon, *etc.*) and/or hollow bone segments (previous intramedullary nail), free tissue transfers were performed and the bone transported beneath this coverage.

As a control (Group II), the authors studied a consecutive group of 23 patients treated conventionally from 1986 through 1988.<sup>2</sup> Reconstructions used tissue transfers and transpositions, massive cancellous grafts, and combinations of internal and external fixation. The results, cost-effectiveness, and morbidity of the two methods were compared to bring the guidelines for patient selection into perspective.

MATERIALS AND METHODS

Segmental defects in the Ilizarov group (Group I) averaged 6.5 cm (Table 1). The completed re-

TABLE 1. Segmental Tibial Defects

Defect (cm)	Ilizarov (Group I) No.	Conventional (Group II) No.
4	6	4
6	8	6
8	3	4
10	3	4
≥12	1	5
	21	23

TABLE 2. Patient Morbidity

Procedure	Ilizarov (Group I) No.	Ilizarov (Group II) No.
Transfusions	18	217
Bone grafts	10	40
Tissue transfers (muscle/bone)	3 (3/0)	24 (16/8)
Fibular transpositions	0	19
Marrow injections	4	0

constructions required 18 units of blood and 17 adjunctive surgical procedures (Table 2). Thirty-four primary pathogens were isolated. Forty-eight percent of the wounds were polymicrobial. Patients averaged 2.4 weeks of parenteral and three months of oral antibiotic therapy to suppress pin-tract sepsis during transport. Seven patients (33%) suffered major complications, including a 19% stress fracture rate (Table 3). There were few (15%) regenerate complications with distractions 5 cm or less. As the distance at each corticotomy site increased to or beyond 6 cm, 50% of patients (four of eight) developed either a regenerate failure or stress fracture. The case presented in Figures 1 through 7 illustrates the technique of hard- and soft-tissue "closure" using the Ilizarov method.

In Group II (control), the average segmental defect treated was 8.5 cm (Table 1). These patients underwent reconstructions requiring 217 units of blood and 83 adjunctive procedures (Table 2). Four patients required staged composite free tissue transfers using a latissimus dorsi muscle and the contralateral fibula. There were 44 primary pathogens and 12 (57%) polymicrobial wounds. Systemic antibiotics were given parenterally for

TABLE 3. Complications

Problem	Ilizarov (Group I) No.	Conventional (Group II) No.
Fracture	4	6
Infection	1	5
Flap loss	1	3
Regenerate delay	1	0
Short ≥ 2.0 cm	0	2
Ototoxicity	0	2
Percent complications	33%	60%

Infections designate problems at sites outside the debridement construct (pin sites, donor sites, *etc.*).

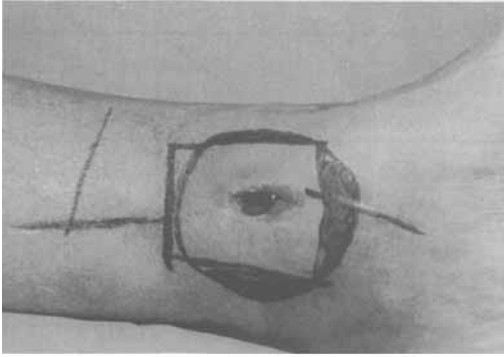


FIG. 1. Infected nonunion distal tibia with chronic ankle joint sepsis and compromised soft-tissue envelope. The open sinus is shown.

six weeks. Fourteen patients (60%) suffered major complications including stress fracture (Table 3).

### RESULTS

Total wound consolidation and infection arrest took place after the first treatment in

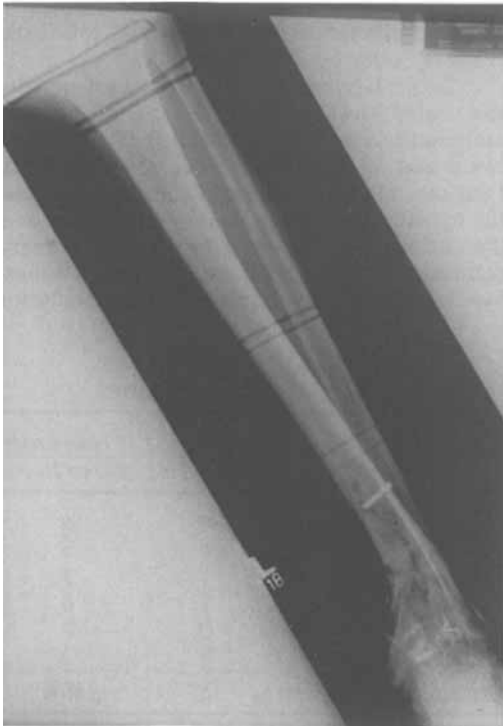


FIG. 2. Radiograph of tibia before surgery.

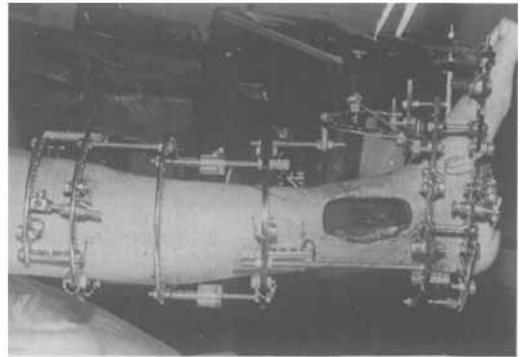


FIG. 3. A 10-cm hard- and soft-tissue defect after debridement and circular frame completion.

71% of the Ilizarov and 74% of the conventionally treated wounds (Table 4). Infected nonunions ( $n = 5$ ) and persistent drainage ( $n = 1$ ) affected control patients (Group II). Two of the eight vascularized bone transfers required ancillary procedures to gain union.

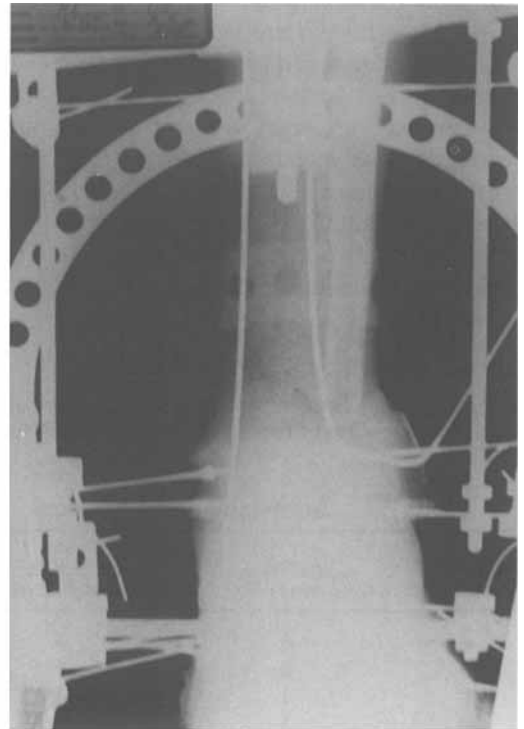


FIG. 4. A radiograph of the tibial defect shows alignment before transport.

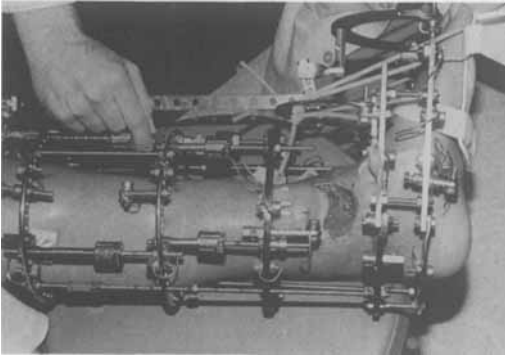


FIG. 5. The open defect closes during transport as the soft tissues are recruited to join each osseous segment. Note the exposed stent wire (anterior) just before its removal.

Regenerate disturbances (n = 4) and docking site nonunions (n = 2) affected the transport group. When staging criteria were assessed, the patient population at highest risk for failure (Table 5) was the B-host treated conventionally (44%).

The Ilizarov group averaged fewer days in the hospital (26 days vs. 49 days), fewer hours in the operating theater (17 hours vs. 26 hours), and shorter disability times (17 months vs. 22 months). Disability ended when the patient returned to ambulation without support. The average total cost of therapy was \$85,000 and \$113,000 for the Ilizarov and conventional groups, respectively. These rates included the surgical and medical fees, hospital bills, and outpatient therapies including nursing care and antibiotics. A cost of living index was not applied to Group II figures (1986/1988 vs. 1988/1990).

There was one death in each group from unrelated causes. One hundred percent of the limbs in surviving patients were salvaged. The average cost of retreatment (\$36,000) for first protocol failures, and overall success rates (95%), were the same for both groups. Follow-up time has been two or more years.

### DISCUSSION

Expanded physiologic and biochemical knowledge has made it possible to broaden

the indications for surgical therapy to include patients who are at a much higher risk for developing postoperative wound disturbances. It is the surgeon's responsibility to understand and modulate the basic principles of host defense as the indications for surgery widen. Ilizarov applications, staged reconstructions, careful preoperative screening, innovative surgical approaches, and a seasoned team effort have allowed a steady increase in the percentage of B-hosts in the authors' treatment protocols. In 1992, 62% of the authors' patients had documented wound-healing deficiencies.

In this small series of 44 patients, the B-host success rates statistically equaled those of the A-host group (Table 5). In the authors' experience, a similarity in healing rates between these two host categories implies a low physiologic demand on the patient. The rela-

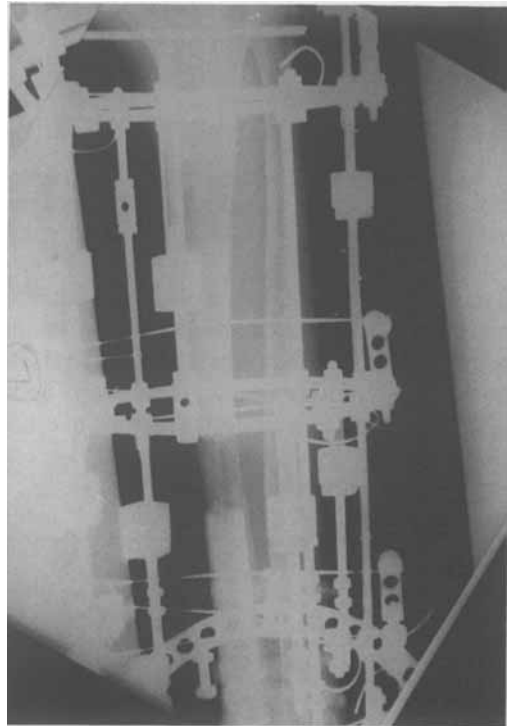
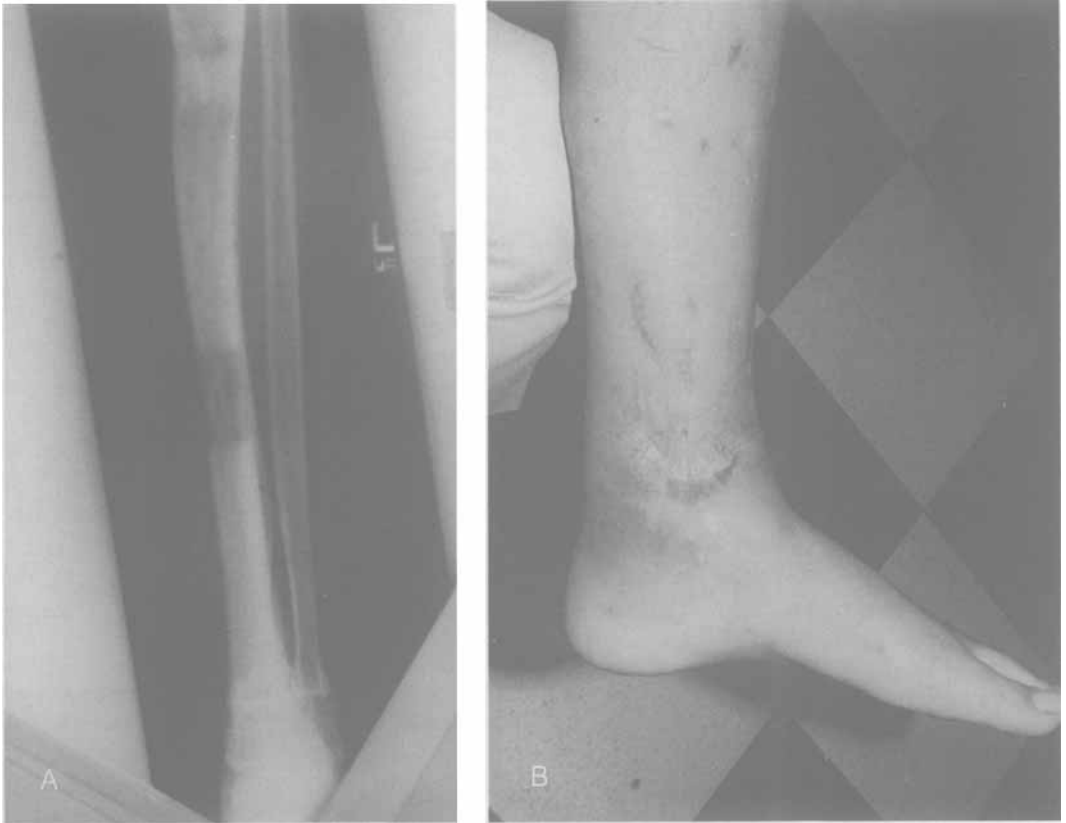


FIG. 6. A bifocal transport nearly doubled the overall rate of distraction, thus accelerating wound closure.



FIGS. 7A AND 7B. The completed reconstruction with excellent alignment, contour, regenerate consolidation, docking, site union, and soft-tissue coverage.

tive morbidity scale, as seen in Table 6, depicts a much larger experience with five reconstructive options; equal A-host and B-host complication/success rates were seen only in the top two options wherein live tis-

sues are simply positioned, compressed, and immobilized. The ratio of A-hosts and B-hosts in Groups I and II was 8/13 and 10/13 respectively. This was a remarkably homogeneous series of consecutively treated tibial defects (1986–1990).

The Ilizarov method has several advantages over conventional reconstructions.

TABLE 4. Success Rates

<i>Ilizarov</i>		<i>Conventional</i>	
<i>Problems</i>	<i>No.</i>	<i>Problems</i>	<i>No.</i>
Regenerate	4	Nonunion	5
Nonunion	2	Infection	6
Death	1	Death	1
Success	71%	Success	74%

Infections designate persistence/recurrence at primary site.

TABLE 5. Wound Failures (Host Factors)

<i>Method</i>	<i>A-Host</i>	<i>B-Host</i>
Ilizarov	25%	31%
Conventional	17%	44%

The percentage of reconstruction sites suffering regenerate or flap failures, nonunion, and/or graft loss.

TABLE 6. Relative Morbidity

<i>Surgical Morbidity</i>	<i>Treatment Options</i>
Low	Bone transpositions Distraction osteogenesis (Ilizarov)
High	Cancellous grafts Papineau grafts "Free" bone transfers (microvascular)

A relative morbidity scale comparing experiences with five reconstructive options in more than 900 osseous reconstructions from 1981 to 1992.

First, the bone regenerate is exactly the right size for the anatomic site. Massive cancellous grafts undergo a 20 to 40% volume loss in B-hosts;<sup>5</sup> fibular transfers require years of hypertrophy to reach a 1:1 volume match. Second, wound margins are approximated by these methods—soft tissues are recruited by the transport segment(s). Wounds heal by secondary intention. Seventy-seven percent of the control group required soft-tissue reconstructions. Only three of the 21 Ilizarov patients (14%) required coverage at the docking site. Finally, transfusions and ancillary procedures were few in the Ilizarov group.

For the authors, the limits of these distraction methodologies are often determined by the psychologic profile of the individual, as patient cooperation is the key to the process of slow, gradual tension histogenesis.<sup>3,4</sup> The patient's support group and the length of the defect are two other important variables. To avoid complications, each regenerate length should be less than 6 cm in the posttraumatic, adult tibia. Large defects may not qualify for treatment. If two or three serial corticotomies cannot be performed because of compromised and/or deficient residual bone stock, the method would be limited accordingly. Thus far (January 1993), all tibial defects greater than 12 cm have been managed conventionally in the adult tibia.

Reconstructions of large debridement defects of the tibia are difficult to manage and,

at times, discouraging to patients and physicians. To maximize the potential for salvage, a rigorous patient selection algorithm is essential. Each therapeutic option must take into consideration various host factors, anatomic restraints, physician skills, and institutional resources. For hard- and soft-tissue defects of 2 cm to 12 cm, the authors prefer the methods of Ilizarov when conditions indicate either method. In 1992, 52 nonunions were treated by their service—Ilizarov methodologies were applied to 24%. However, 79% of the 19 segmental defects (average, 8 cm) were reconstructed with transports rather than grafts or flaps.

### CONCLUSION

Segmental tibial defects are successfully reconstructed using conventional and Ilizarov methodologies. The final result in the two treatment groups were the same. The Ilizarov group proved faster, safer in B-hosts, less expensive, and easier to perform. Nevertheless, the minimal need for patient cooperation and an early patient independence make conventional therapy the preferred treatment when any one distraction site exceeds 6 cm in patients with suboptimal psychologic and/or support group profiles and when the zone of injury is otherwise prohibitive.

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