Treatment of tibial and femoral bone loss by distraction osteogenesis

Experience in 28 infected and 14 clean cases

Dimitrios Polyzois, George Papachristou, Kostas Kotsiopoulos and Spyros Plessas

42 patients with diaphyseal bone defects (25 tibial and 17 femoral) who were treated by radical debridement and bone transport are reviewed. Their mean age was 35 (10–64) years and there were 29 men. 19 patients had active infections with drainage and 9 were previously infected. After resection of the infected and necrotic bone, the intercalate defect averaged 6 (3–12) cm. The mean duration of treatment was 10 (20–52) months. Regeneration of the distraction gap was achieved in all 42 patients. Union at the target zone was achieved in 38, and in the remaining 4 cases consolidation was achieved by application of autogenous bone grafts. The infection was eradicated in all 28 patients treated for bone defects associated with infection, without the need for a second operation. Complications were not severe and did not affect the final results. Residual malalignment remained in 2 patients, 1 femur and 1 tibia, with 10° and 8° of varus deformity, respectively. The final leg-length discrepancy never exceeded 1.5 cm. Residual fixed flexion of the knee was left in 5 cases, but never exceeded 10°. Loss of 5° to 10° of dorsiflexion of the ankle join remained in 7 patients. There were no intraoperative or postoperative neurovascular damage or compartment syndrome. Psychological intolerance was seen in 1 young patient. All patients, but 3 returned to their previous occupation. Bone transport is a simple and safe method for successful treatment of diaphyseal bone defects.

4th Orthopaedic Department, "KAT" Accident Hospital, Athens, Greece. Correspondence: Dr. D Polyzois, 3 Vrassida St. Athens 11528 Greece. Tel +30-1-722 8408. Fax -723 7840

The traditional procedures to bridge segmental bone gaps include autogenous bone grafting, the Papineau technique (Green et al. 1983), posterolateral bone grafting (Reckling et al. 1980), transplantation of allograft bone (Mankin et al. 1983) and fibula pro-tibia procedures (May et al. 1989). These procedures, however, usually require multiple surgical interventions, prolonged period of treatment and no weight bearing, and the achieved functionis often unsatisfactory. Recently, by using vascularized bone grafts (Salbian et al. 1987, Weiland 1981) or by transporting a segmental bone fragment across the gap (according to Ilizarov technique), the results have been much improved (Ilizarov 1975, Aronson et al. 1989, Paley 1989, Alonso 1990).

The Ilizarov circular external fixator which was originally designed in the early 1950s, is a modular device which allows controlled axial loads to be applied at the zone of osteogenesis (Kenwright et al. 1986). It consists of numerous individual pieces, allowing more than 700 configurations (Golyakovsky 1993). The system uses thin wires that are placed in different planes and are secured to modular rings under tension. These thin wires act as small springs within a more rigid system of rings and connecting rods. The system provides stability against angular, rotational and translational displacements, while it is relatively flexible in axial direction. By the use of the unique stopper wires and hinges between the rings the Ilizarov external fixator allows multiplanar and multidirectional corrections of deformities (Paley 1989).

We report our results with the Ilizarov method, for the treatment of long bone defects of various etiology.

Patients and methods

During the last 10 years, we operated on 42 patients with diaphyseal defects (25 tibial and 17 femoral). The mean age was 35 (10–64) years and 29 were men. The commonest etiology was open fractures and complications of surgically treated fractures (Table 1).

19 patients had active infections with drainage and 9 were previously infected. The majority of the patients had undergone several previous operations in-

Table 1. Etiology of bony defect in patients undergoing distraction osteogenesis

Etiology	No of cases
Open fractures	21
Complications of surgically treated fractures	12
Gun shots	3
Chronic osteomyelitis	5
Congenital pseudarthrosis	1
Total	42

cluding compression plating, intramedullary nailing, external fixation, bone grafting and plastic operations. Many patients had shortening and angular or rotational deformity. After resection of the infected and necrotic bone, as determined by radiologic and intraoperative findings, the intercalated defect averaged 6 (3–12) cm.

Using the Ilizarov external fixator device the bone segments proximal and distal to the intercalate defect were fixed in good alignment (angular or rotational deformities were corrected at this time). A bone fragment of adequate length was then created by corticotomy (Figure 1). 7 to 10 days after the corticotomy the bony fragment was gradually transported axially across the defect until it's leading edge reached the other side of the defect (the target zone). The transportation was achieved by means of stopper wires and inclined rods, or by a transporting central ring connected to the bone fragment by two or more wires. The new gap created behind the transported fragment was regenerated by distraction osteogenesis. When the transported fragment arrived at the other end of the defect, compression was applied or sometimes variations of compression (distraction cycles) to induce osteogenesis.

In 4 patients with extensive bone loss (7–2 cm), 2 bone fragments, 1 proximal and 1 distal, were transported toward the center of the defect. By this bifocal transportation filling of the defect was accelerated (Figure 2). In 7 patients with defects less than 5 cm the limb was shortened and the gap was closed acutely during the operation. A corticotomy was then performed and the limb was re-lengthened to it's original length.

In 5 cases after removal of all the infected and necrotic bone, a bone bridge was left. In these cases a bone fragment of partial circumference created by corticotomy of the neighboring bone was transported. In one patient, after debridement and resection of all necrotic and infected bone and soft tissues, a large segmental defect was left in his right tibia. To fill this gap, a longitudinal fragment of the fibula was transported towards the tibial defect. In this way, the fibula was actually doubled. The procedure was completed by application of bone grafts at both ends of the gap.

Soft tissue loss associated with bone defects were left open to drain. As the bone segment was transported, it carried with it its surrounding soft tissues, thus coverage was achieved without plastic operations.

Antibiotics were administered for 2 days postoperatively. To maintain adequate dorsiflexion by stretching the Achille's tendon, all patients were encouraged to immediate weight bearing.

The protocol of the Association for the Study and Application of the Method of Ilizarov (ASAMI, Paley

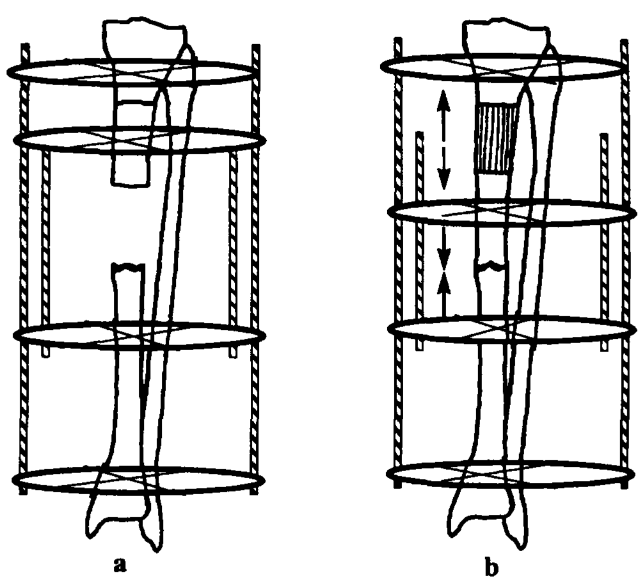


Figure 1. The assembly for bone transport. (A) The bone segments proximal and distal to the intercalated defect are fixed in good alignment. Proximal to the intercalate defect a corticotomy is performed. (B) The created fragment is transporting gradually across the gap until it's leading edge arrives to the opposite side of the defect.

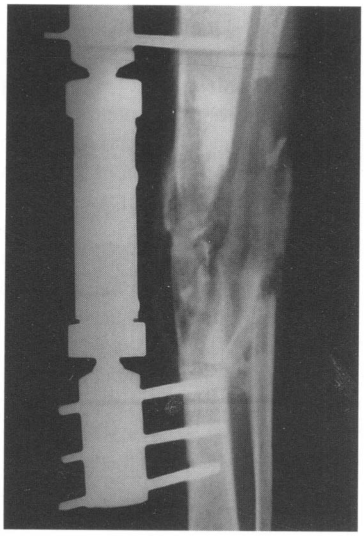
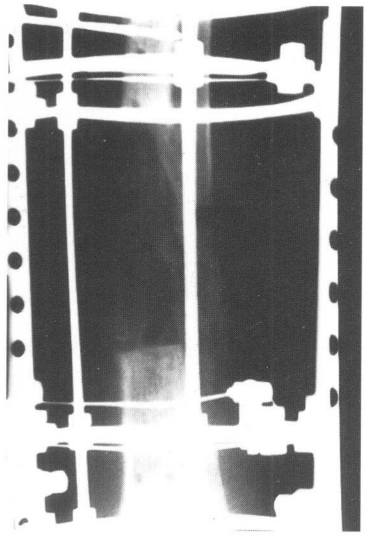
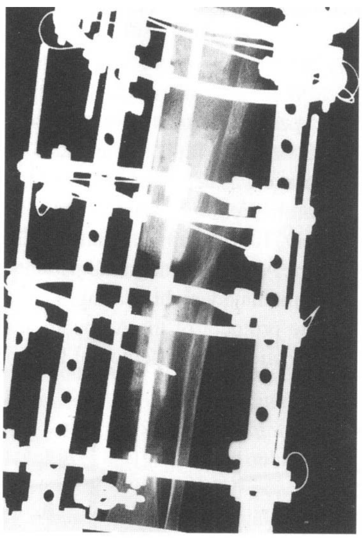


Figure 2. Severe post-traumatic osteomyelitis in an 18-year-old man.



A 9.5-cm gap, was created after wide excision of all infected and necrotic tissues.



Transportation of 2 bony fragments from either side of the gap towards the center was performed.

Final result after the fixator was removed at 6 months.

et al. 1989) was used to evaluate the results. All patients were examined periodically and radiographs were taken to assess the alignment, the progress of bone healing and signs of infection.

Results

The mean time of hospitalization was 4 (2–18) weeks, and the mean time of treatment was 10 (5–18) months. The mean follow-up was 38 (20–52) months.

Bone healing: Regeneration of the distraction gap was achieved in all 42 patients. Union at the target zone was achieved in 38 cases and was not related to the length of the bony defect. In 1 patient (the first case) the failure of union at the target zone was, probably, due to incomplete removal of eburnated and atrophic bone. In 3 other patients union was not achieved because of poor contact of the bony surfaces at the target zone. In these 4 cases consolidation was achieved by "freshening up" the bone ends, and application of autogenous bone grafts. In 2 cases, axial deviation of the transported fragment was corrected by replacing the wires that fixed the transported fragment. The infection was eradicated in all patients without a second operation.

Residual malalignment remained in 2 patients, 1 in the femur and 1 in the tibia, with 10° and 8° of varus deformity, respectively. There was no case of refracture either at the zone of the regenerate or at the target site. No final leg-length discrepancy exceeded 1.5 cm.

Function: All but 3 patients returned to their previous occupation and daily activities. 2 of the 3 patients who were not able to return to their occupation had neurovascular problems before surgery and the third had an extensive anterior compartment muscular loss.

Stiffness of the knee and ankle occurred often during bone transportation, but after removal of the fixator, rehabilitation resulted in full motion in most cases. 5 patients had residual fixed flexion of the knee, but in no case it exceeded 10°. Loss of 5°–10° of dorsiflexion of the ankle joint remained in 7 patients. 11 patents had persistent moderate pain that diminished activity or disturbed sleep. This pain resolved gradually in all patients within 1 year after the removal of the fixator.

Pain at the sites of the wires and at the region of distraction was a common problem during transportation of the intercalate fragment. Pin tract infection was the commonest complication, it occurred in 38 out of 442 total inserted wires (9%). Pin tract infections settled by local treatment, oral antibiotics and an increase in wire tension, but in 5 patients it was necessary to replace some wires. There was no pin tract osteomyelitis. Edema of the leg and foot was always present during bone transportation. Psychological intolerance was seen in 1 young patient. He required encouragement and support to maintain the frame until the end of the treatment. It is important to be careful in selecting a patient for treatment with the Ilizarov external fixator. There were no neurovascular complications or compartment syndromes.

Discussion

The Ilizarov method of treatment of diaphyseal bone defects allows immediate weight-bearing and has few failures and few complications (Paley et al. 1989). However, several technical problems can arise if the details of the technique are not followed precisely. We believe that it is important for successful results to excise all the infected and necrotic tissues. In our first patient no union was achieved at the target zone, probably due to incomplete removal of eburnated and atrophic bone. At the beginning of our experience, we had a tendency to create small gaps. In the later cases, we excised any infected and necrotic bone until bleeding bone appeared at the resection surfaces. With the current clinical experience, it is evident that regeneration of bone at the distraction zone can be obtained safely. Therefore, infected or necrotic and avascular bone at the site of the bony defect shaould be radically removed. Green (1983) noted a high incidence of nonunion at the target zone and he found it necessary to apply iliac bone grafts in 6 out of his 14 patients. In our series, the incidence of nonunion was low. It is obvious that wide resection of all infected and avascular tissues resulted in a high rate of union. Wide debridement, probably not only accelerated healing, but also helped to eradicate infection. In contrast to this, Ilizarov noted that successful eradication of the infection can be achieved after only partial resection of the infected bone. Although the possibility of future recurrence of the infection cannot be excluded, it is important to note that none of our 28 cases, treated for bone defects associated with infection, showed any signs of flare up at the latest follow-up (20–52 months). Eradication of the infection was achieved without using antibiotics for long time. We adopted Ilizarov's recommendation not to use antibiotics in the treatment of infected nonunions or osteomyelitis.

For successful bone transportation it is important to maintain the bone ends in good and stable alignment. To provide stability and to avoid axial deviation during distraction, the fixator in our cases usually required 2 rings proximally, 1 in the intercalate segment and 2 distally.

An important factor for union is to achieve good contact of the bone ends when the leading edge of the transported fragment gets to the opposite side of the defect. A poor contact in 2 of our cases was the probable cause of nonunion. We employed several techniques to ensure good bone contact, such as shaping the resection surfaces parallel to each other, or modeling the bony segments in such a shape that the one was invaginated into the other. In some cases, with oblique bony surfaces, lateral compression was applied by using special stopper wires. In addition, to obtain good contact of the bone surfaces at the target zone, the direction of the transporting fragment must be controlled precisely. In 2 patients we had to replace the wires that were fixing the transporting fragment to correct it's orientation. The importance of controlling the movements of the transporting bone fragment has also been emphasized by other authors (Ilizarov 1989, Alonso et al. 1990, Goliakovsky et al. 1993).

In conclusion, the Ilizarov method offers many advantages over traditional techniques of treatment of segmental defects of long bones. The method addresses the bone defect, soft tissue loss, infection, deformity and leg length discrepancy simultaneously. In our cases, the complications were not severe and did not affect the final results. The clinical results were encouraging and we believe that bone transport is the simplest and safest method for the successful management of diaphyseal bone defects.

References

Alonso J, Regazzoni P. The use of the Ilizarov concept with the AO/ASIF tubular fixator in the treatment of segmental defects. Orthop Clin North Am 1990; 21(4): 655-65.

Aronson J, Harrison BH, Steward CL, Harp JH. The histology of distraction osteogenesis using different external fixators. Clin Orthop 1989; 241: 106-16.

Aronson J, Johnson E, Harp J. Local bone transportation for treatment of intercalary defects by the Ilizarov technique. Clin Orthop 1989; 243: 71-9.

Cattaneo R, Villa A, Catagni M, Tentori L. Treatment of infected and non-infected non-union by Ilizarov compression. Rev Chir Orthop 1985; 71: 223-9.

Christian EP, Bosse MJ, Robb G. Reconstruction of large diaphyseal defects, without free fibula transfer in grade IIIB tibial fractures. J Bone Joint Surg (Am) 1989; 71: 994-1004.

Dagher F, Roukoz, S: Compound tibial fractures with bone loss treated by the Ilizarov technique. J Bone Joint Surg (Br) 1991; 73: 316-21.

Debastiani G, Aldegeri R. Limb lengthening by callus distraction (callotasis).J paediatr Orthop 1987; 7: 129-34.

Golyakhovsky V, Frankel V: Operative manual of Ilizarov techniques. Mosby, New York 1993

Green SA, Dlabal TA. The open bone graft for septic nonunion. Clin Orthop 1983; 180: 117-24.

Ilizarov GA. Basic of transosseus and distraction osteosynthesis. Ortop Travmatol Protez 1975; 10: 7-15.

Ilizarov GA: Fractures and non-unions. In External fixation and functional bracing (Eds. Coombs R., Green S, Sarmiento A) Aspen, London1989: 347.

Ilizarov GA. Angular deformities with shortening. In External fixation and functional bracing (Eds. Coombs R., Green S, Sarmiento A) Aspen, London1989: 347- 57.

Ilizarov GA.The tension - stress effect on the genesis and growth of tissues: Part I. The influence of stability of fixation and soft tissue preservation. Clin Orthop 1989; 238: 249-81.

Ilizarov GA.The tension - stress effect on the genesis and growth of tissues: Part II. The influence of stability of fixation and soft tissue preservation. Clin Orthop 1989; 238: 263-85.

Kenwright J, Richardson JB, Goodship AE. Effect of controlled axial micromotion on healing tibia fractures. Lancet 1986; 2: 1185-7.

Kojimoto H, Yasui N, Goto T, Matsuda S, Shimomura Y: Bone lengthening in rabbits by callus distraction. The role of periosteum and endosteum. J Bone Joint Surg (Br) 1988; 70: 543-9.

Mankin HJ, Dopplet S, Tonford W: Clinical experience with allograft implantation. The first ten years. Clin Orthop 1983; 174: 69-86.

May LW, JupiterJB, Weiland AJ: Current concept review. Clinical classification of post- traumatic tibial osteomyelitis. J Bone Joint Surg (Am) 1989; 71: 1422-8.

Paley D, Catagni MA, Villa A. Ilizarov treatment of tibial non-unions with bone loss. Clin Orthop 1989; 241: 146-65.

Reckling FW, Waters CH:. Treatment of non-unions of fractures of the tibial diaphysis by posterolateral cortical cancellous bone-grafting. J Bone Joint Surg (Am) 1980; 62: 936-41.

Weiland AJ. Current concepts review: Vascularized free bone transplants. J Bone Joint Surg (Am) 1981; 63(1): 166—9.