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นิพนธ์ต้นฉบับ Original Article

Results of the Ilizarov Technique for Treatment of Infected Non-Union of the Tibia

การรักษาภาวะกระดูกหน้าแข้งหักแล้วไม่ติดร่วมกับมีการติดเชื้อ โดยใช้วิธีของ Ilizarov

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กลุ่มงานออร์โธปิดิกส์ โรงพยาบาลราชบุรี

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ABSTRACT

Infected non-union of the tibias were treated with resection of the necrotic bone and distraction osteogenesis in 11 patients, are ranged from 1 to 58 years old. Non-union, infection, shortening and deformity were all addressed simultaneously. All patients had perfomed bone lengthening by using bone transportation technique in which a bone fragment is moved toward the site of non-union, leaving a defect that is bridged by distraction osteogenesis. The average length of the bone defect was 3.9 centimeters.

The infection was eradicated in all patients before the fixator was removed. The mean duration of treatment by fixator was 8.2 months. The mean time to union was 13 months. The mean duration of follow-up was 16 months. The bone results were excellent in 9 patients and good in 2. The functional results were excellent in 1 patients, good in 8 and fair in 2.

บทคัดย่อ

ผู้ป่วยที่มีภาวะกระดูกหน้าแข้งหักแล้วไม่ติดร่วมกับมีการติดเชื้อ จำนวน ๑๑ ราย อายุระหว่าง ๑ ถึง ๕๘ ปี ได้รับการผ่าตัดเอากระดูกตายและติดเชื้อออก แล้วยืดกระดูกให้งอกออกมาชนและติดกันได้โดยใช้เครื่องยึดตรึงกระดูกภายนอกด้วยวิธีของ Ilizarov

จากการศึกษาพบว่า ความยาวกระดูกที่หายไปโดยเฉลี่ย 3.9 เซนติเมตร ระยะเวลาที่ต้องใส่เครื่องยึดตรึงกระดูกภายนอกโดยเฉลี่ย 8.2 เดือน ระยะเวลาที่ใช้ในการทำให้กระดูกติดโดยเฉลี่ย ๑๓ เดือน ระยะเวลาที่ใช้ในการติดตามดูแลผู้ป่วยโดยเฉลี่ย ๑๖ เดือน

ผลการรักษาปรากฏว่า ทุกรายได้รับการรักษาจนกระดูกติดและพ้นจากการติดเชื้อ โดยในแง่ของกระดูกได้ผลดีเยี่ยม ๙ ราย ผลดี ๒ ราย ในแง่การใช้งานได้ผลดีเยี่ยม ๑ ราย ผลดี ๘ ราย ผลปานกลาง ๒ ราย

Introduction

Infected non-union of the tibia has always been a challenge to orthopaedic surgeons. Bone union is not usually obtained until the infection has been eradicated, and there are usually coexisting problems of deformity, loss of bone, leg-length discrepancy, and soft-tissue damage. The problem of reestablishment of leg length is formidable. The leg-length discrepancy may be treated with an extensive operative exposure and a technically demanding procedure[1] that does not allow early mobilization and weight bearing. Thus, it may be associated with disuse osteoporosis, soft-tissue dystrophy, and persistent infection in the presence of implants. Better results have been reported with staged reconstruction with either immobilization of the limb in a plaster cast or external fixation and bone grafting.[2,3] Open cancellous bone (Papineau) grafts have been used successfully to fill tibial defects.[4] Some of the best results have been achieved with vascularized free-tissue transfers.[5,6] Most patients managed with these methods have multiple operations and a long period before consolidation of the graft. Non-invasive methods are not recommended when osteomyelitis or a bone defect is present.

G. A. Ilizarov and his colleagues have developed a technique for the treatment of chronic osteomyelitis and bone defects created by extensive debridement. Their method, known as distraction osteogenesis, simultaneously addresses deformity, shortening, loss of bone, function, osteoporosis, and soft-tissue atrophy. We report here the results of the use of this technique for Infected non-union of the tibia.

Materials and Methods

From 1997 - 2001, distraction osteogenesis, including resection of necrotic bone, was used in 11 patients who had infected non-union of the tibia. Seven patients had been treated initially in our department ; the other four had been treated elsewhere and were subsequently referred to our institution for treatment of the non-union and infection. Contraindications of the Ilizarov method were severe damage of the tibial nerve, mental disease, including senile dementia ; and anticipated poor cooperation of the patient.

There were 7 men and 4 women, mean age was 25 years (range 1 to 58 years) (Table 1). All patients' medical record and roentgenograms were reviewed. The protocol of the Association for the Study and Application of the Method of Ilizarov[7,8] was modified and used to standardize the reviewed process.

All fractures were diaphyseal or metaphyseal. A fracture that had been ununited for less than six months was defined as a non-union if the wound was open and infected and there was exposed dead bone or metal. A fracture was also considered to be ununited (a non-union) if, after six months, there was clinically apparent motion at the site of the fracture ; formation of a sinus, indicating the presence of dead bone or sequestration ; or extensive osteomyelitis. On the basis of the AO classification,[9] there were seven non-unions with quiescent infection and no drainage and four non-unions with infection and drainage (Table 1).

The mean loss of bone was 2.4 centimeter (range, 1 to 5 centimeters) before the debridement and 1.6 centimeters (range, one to three centimeters) from the resection. The mean total loss of bone was 3.9 centimeters (range, 2 to 8 centimeters) (Table 2).

All patients were managed with resection of the osteomyelitic bone and internal lengthening (bone transport). The extent of the resection was determined preoperatively according to plain roentgenograms. However, if the appearance of the bone was not satisfactory intraoperatively, the resection was more extensive than had been anticipated on the basis of the preoperative studies.

A segment of bone was created by corticotomy of either the proximal or the distal part of the tibia (Fig. 1), and this segment was gradually transported (1 millimeter per day) within the surrounding soft tissues to the other side of the defect (Fig. 2). Patients were achieved compression at the level of the non-union (Fig. 3) eventvally.

The interval between the corticotomy and the beginning of the bone transport was five to seven days (Table 2). No specific criteria were used to determine exactly when the bone transport should be started ; the usual time was the seventh postoperative day, but there were variations depending on the quality of bone at the level of the corticotomy.

Antibiotics were administered preoperatively and postoperatively for 14 to 60 days. The duration of antibiotic treatment depended mostly on wire-track infection in each case.

The duration of hospitalization ranged from 14 to 150 days (mean, 85 days). The total duration of treatment by fixator ranged from 2 to 14 months (mean, 7.4 months) (Table 2).

Results

The average duration of follow-up was 16 months (range, 3 to 40 months) (Table 1). The results were divided into bone results and functional results.

The bone results were determined according to four criteria : union, infection, deformity, and leg-length discrepancy. The fracture was considered to be united when it appeared so roentgenographically, when there was no motion at the site of the fracture after loosening of the connecting rods or the fixation bolts of the wires, and when the patient was able to walk without pain and had a feeling of solidity of the limb.

Excellent bone result was defined as union, no infection, deformity of less than 7 degree,[10] and leg-length inequality of less than 2.5 centimeters ; a good result was union plus any two of the other three criteria ; a fair result was union plus one of the other criteria ; and a poor result was non-union or refracture, or union but none of the remaining three criteria that are required for an excellent result. According to this criteria, the bone result was excellent in 9 patients and good in 2.

The functional results were based on five criteria : a noteworthy limp, stiffness of either the knee or the ankle (a loss of more than 15 degrees of full extension of the knee or of 15 degrees of extension [dorsiflexion] of the ankle in comparison with the normal, contralateral ankle), soft-tissue sym-

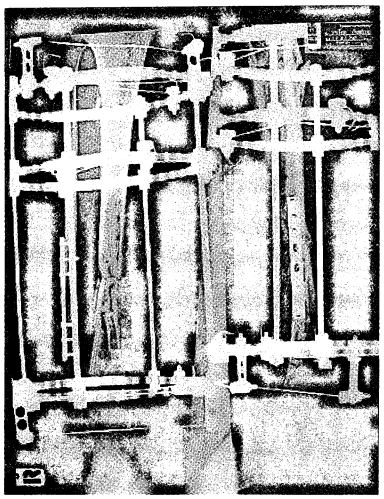

Fig. 1 Anteroposterior and lateral roentgenogram of the tibia after ilizarov external fixator. The corticotomy was in the proximal part of the tibia.

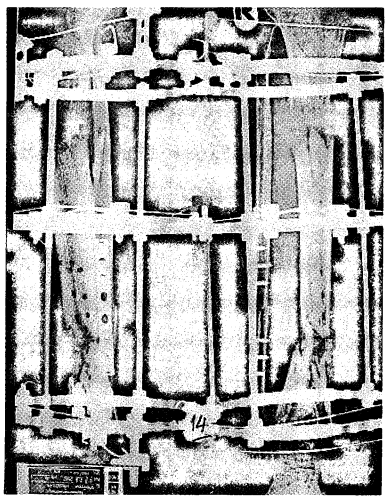

Fig. 2 Anteroposterior and lateral roentgenogram showing that internal lengthening of the tibia has progressed toward bridging of the non-union gap.

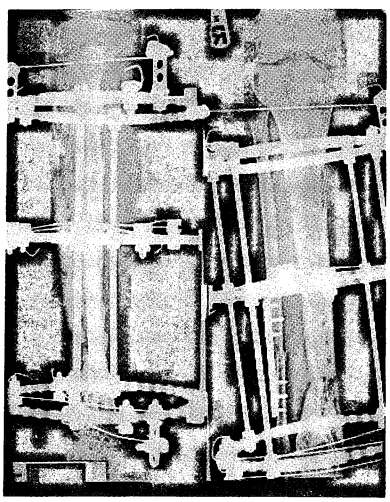

Fig. 3 Anteroposterior and lateral roentgenogram showing the intercalary segment has approached the target segment and distraction osteogenesis occurred.

pathetic dystrophy, pain that reduced activity or disturbed sleep, and inactivity (unemployment or an inability to return to daily activities because of the injury).

The functional result was considered excellent if the patient was active (that is, not inactive according to the definition just given) and none of the other four criteria, good if the patient was active plus one or two of the other criteria, fair if the patient was active plus three or four of the other criteria, and poor if the patient was inactive regardless of whether other criteria were present or not. According to these criteria, the functional result was excellent in 1 patient, good in 6 and fair in 4.

The complications that occur during and after treatment with distraction osteogenesis can be classified as problems, obstacles, or true complications.[11] A problem is a difficulty that arises during the distraction or consolidation period and that has fully resolved, after non-operative intervention, by the end of the treatment period. An obstacle is a difficulty that arises during the distraction or con-

Table 1 Data from the preoperative and most recent follow-up evaluations

Case	Sex, Age (Yrs.)	Type of Infection	Asso-ciated Injuries	Contrac-ture	No. of fract. to Treat.	Prev. Ops.	Duration of Follow-up (Mos.)	Bone Result				Functional Result				
								Union	Infect	Deform. (degree)	Short (cm.)	Limp	Rigid.	Dys-trophy	Pain* Grade	Grade Inactivity
1	M, 32	Drain	-	-	1	3	12	+	-	Valgus 5	-	-	-	-	1	-
2	M, 27	Non-drain	-	-	8	3	6	+	-	Valgus 5	-	+	-	-	2	-
3	F, 19	Non-drain	-	-	1	1	13	+	-	Varus 5	-	+	-	-	2	-
4	M, 12	Drain	Muscle loss	Ankle Stiffness	1	3	25	+	-	Valgus 5	1	+	Ankle Knee	-	2	-
5	M, 58	Non-drain	-	-	1	2	24	+	-	Varus 5	1	-	Ankle	-	1	-
6	M, 26	Drain	Abdomen	-	2	2	17	+	-	-	-	-	Ankle	-	2	-
7	F, 37	Non-drain	-	-	2	3	8	+	-	Valgus 5	-	+	Ankle	-	2	-
8	M, 42	Non-drain	-	-	1	2	9	+	-	Varus 5	-	+	-	-	1	-
9	F, 16	Drain	-	-	1	3	14	+	-	Varus 10	2	+	-	-	1	-
10	M, 1	Non-drain	-	-	1	1	3	+	-	Varus 5	-	+	-	-	2	-
11	F, 7	Non-drain	-	-	1	3	40	+	-	Valgus 10	2	+	-	-	2	-

1 indicates no pain ; 2, mild pain that does not interfere with activities or sleep ;

3, moderate pain that reduces activities or disturbs sleep ; and 4, severe pain.

Table 2 Treatment and Complications

Case	Bone Defect (cm)			Durat. Of Antibiotic Treatment (Days)	Time from Debride. To Distract. Osteogen. (Days)	Durat. Of Hospital-zation (Days)	Time from Applic. To Removal of Fixator (Mos.)	Amount of Lengthen-ing (cm)	Consol. Of Distract. Site	Time to Union (Mos.)	Complications		
	Sponta-neous	Iatro-genic	Total								Treated Non-Op. with Fixat. in Place	Treated Op. With Fixat. In Place	Treated after Removal of Fixat.
1	2	2	4	50	7	70	11	4	Normal	12	Wire infect.	-	-
2	2	2	4	14	7	14	5	4	Normal	6	Wire infect.	-	-
3	3	2	5	30	7	30	8	5	Normal	13	-	-	Pain ankle
4	3	1	4	20	7	130	4	4	Normal	29	Wire infect.	Non-union docking site	Stiff ankle & knee
5	5	3	8	30	7	140	14	8	Normal	15	Wire infect.	-	Stiff ankle
6	2	1	3	25	7	40	8	3	Normal	16	Wire infect.	-	Stiff ankle Pain ankle
7	2	1	3	40	7	50	8	3	Normal	8	Wire infect.	-	Stiff ankle
8	1	1	2	60	7	130	7	2	Normal	9	Wire infect.	-	-
9	1	1	2	30	7	100	7	2	Normal	11	Wire infect.	-	Pain ankle
10	2	1	3	60	5	80	2	3	Normal	3	Wire infect.	-	-
11	3	2	5	30	5	150	7	5	Normal	26	Wire infect.	-	Pain ankle

solidation period and that has fully resolved, after operative intervention, by the end of the treatment period. A true complication is any local or systemic difficulty that occurs during distraction or consolidation and remains unresolved at the end of the treatment period, or any such difficulty that occurs thereafter.

All 11 patients had a total of 19 complications (10 problems, 1 obstacle and 8 true complications). There were no intraoperative complications, such as neurovascular damage due to insertion of pins, and no compartment syndrome due to the corticotomy.

Signs of infection appeared around some of the pins in 10 patients, these signs resolved with local care and systemic administration of antibiotics, and we did not need to remove the pins prematurely.

One patient (case 4) had non-union at the point where the transported fragment docks with the target fragment. This was treated by packing some cancellous bone graft around the docking site.

There are 7 cases with joint pain and stiffness. All this true complication improved by conservative treatment.

Discussion

It is often difficult to achieve union and eradicate an infection at the same site. A diagnosis of non-union can be made when at least six months have elapsed after the time of the fracture and any evidence that the fracture will not unite. An infection at the site of non-union tends to be chronic, because it is associated with an organism that is resistant to most antibiotics[12] and because many patients who have an infection at the site of non-union have additional scarring after unsuccessful operative attempts to eradicate the infection or treat the non-union. The infection is more likely to be eradicated if all of the necrotic bone is resected completely. However, such extensive resection makes the bridging of the bone ends more difficult to achieve. Furthermore, a non-union that is associated with an infection is almost always also associated with deformity, leg-length discrepancy, joint stiffness, disuse osteoporosis, and soft-tissue atrophy.

Distraction osteogenesis is done in an attempt to address all of these problems simultaneously. In all of our patients, the infection had been successfully eradicated before the fixator was removed. Although the possibility of a future flareup cannot be excluded, the absence of signs of infection in all patients at a minimum of two years after the operation is impressive.

Consolidation of the non-union in our patients was generally satisfactory, but one case (case 4) had non-union at the point where the intercalary fragment docks with the target fragment. For this reason, it was necessary to pack a small cancellous bone graft around the docking site in this patients.

In the current series, the functional results seemed to be inferior to the bone results. However, it should be emphasized that our series included some of the most severe non-unions with Infection that had been treated with this method. An excellent bone result, even in a patient who has a severe infection, does not guarantee a good functional

result. The functional result is affected by the condition of the nerves, muscles, vessels, joints, and -- to a lesser degree -- the bone. In view of the minor and major complications and the time involved, the decision to choose distraction osteogenesis must be weighed carefully and must be considered with regard to the current success rate with lower-extremity prostheses. Loss of muscle alone is a rare indication for amputation ; it is possible to debride extensively and still leave enough muscle to provide adequate function. Injury of vessels alone is also a rare indication for amputation in a limb that did not require amputation immediately after severe trauma. Distraction osteogenesis is associated with marked improvement of the blood supply.[13] Severe nerve injury, especially damage of the tibial nerve associated with motor and sensory loss, is a common indication for amputation.

All of the patients were able to walk and bear weight immediately after the application of the circular frame, this is an essential principle of this method.

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