Partial bone loss treatment using parietal bone transportation

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SUMMARY

Objective: This study describes the bone transportation technique for partial bone defect, and shows clinical and radiological results of a series of patients treated by using this method. **Material and Methods:** Nine patients with partial bone defect were treated (six tibia and three femur). Every patient had infection and nonunion. The initial procedure was to stabilize the bone, followed by a partial corticotomy on the healthy bone adjacent to the defect, in order to create a fragment to be distracted. This fragment was fixed by olive wires, which were conected to the thread rod. We used fibula transport for tibial lateral defect in two patients. The latency time, speed and rhythm of distraction were the same as approved by Ilizarov. **Results:** Infection and nonunion were resolved, and the bone gap was filled in all cases. The most frequent problems were skin infection at the pin site and hypotrophy. **Conclusion:** The partial bone defect treated by parietal bone transport was an effective soluction for all patients with infection and nonunion, filling the gap in all cases.

Keywords: Ilizarov Technique; Osteogenesis; Bone regeneration; Pseudarthosis.

INTRODUCTION

Bone injury caused by appendicular skeleton traumas, specially those induced by high-energy transmission agents, such as many car-car and car-pedestrian accidents[7,8], can be complicated by consolidation delay, infected and noninfected pseudarthrosis, abnormal consolidation, and bone defect[21]. The treatment for bone defects is challenging and has led many researchers to search appropriate solutions for the different types of lesion. The so-called segmentary lesions correspond to a cylindrical defect with involvement of the whole bone circumference. Lesions affecting at most 50% of the circumference with remaining viable bone are called partial bone defects[11].

The so-called parietal transportation technique where small bone fragments are used to repair partial bone defects is one of the therapeutic alternatives. The viable bone segment contiguous to the bone defect is preserved, and a bone fragment is created in the healthy area surrounding the bone defect and transported, according to Ilizarov's method, to repair the bone defect.

Few reports of the use of the parietal transportation technique in the management of a partial bone defect are available in medical literature, with reduced casuistics [2,6].

The present study aims to describe the peculiarities of the technique and present the results of a series of patients treated by the parietal bone transportation technique.

CASUISTICS

From March 1994 to February 2000, 9 patients with parietal defect of the tibia or femur, all with active infection and pseudarthrosis, were treated. All patients underwent one or more surgical procedures. Only patients with chronic bone lesion and no neurological lesion were included in the present study. One patient (#6) had pseudaneurysm of the posterior tibial artery induced by the Schanz screw used in the external fixator applied during a previous surgery. Pseudaneurysm ressection was followed by primary terminotermianl anastomosis of the artery.

At the beginning of treatment patients' age ranged from 22 to 40 years, with a mean age of 28 years. Seven male and two female patients were included in the present study (Table1).

The most frequent cause of the bone defect was street accidents (8 patients). One patient developed infection following a correctional surgery to repair an angular deformity of genu valgum (patient #6); in this case, the bone defect followed bone sequestra ressection (Table 1).

The site of the bone defect was the femur in three patients (patients # 4, 5, and 7) and the tibia in six patients. The extent of the parietal bone defect ranged from four to twelve centimeters, with a mean of 7.5 centimeters, measured along the vertical axis of the bone on the initial radiograph.

Study carried out by the Medical Sciences School of Santa Casa of São Paulo, Department of Orthopedics and Traumatology.

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METHOD

The surgery for fixator placement and use of parietal transportation began with debridement of inviable tissue. The Ilizarov apparatus was used in eight patients. Schanz screws and 1.8-mm threads were used to fix the circular apparatus to the bone. The standard fixator consisted in two rings proximal to the lesion, one next to the bone defect and the other next to the joint, arranged in the same way. In case of femoral lesions, two arches for Schanz screws were used and not the two proximal rings. In the patient #2, only one proximal ring was used in the tibia because the lesion involved the proximal metaphysis. In the patient #6 a unilateral linear device of the modular tubular outer fixator with stainless steel tubes was used. Grooved rods of the Ilizarov apparatus attached to a pin with fasteners of the Ilizarov fixator were added (Figure 1).

Order	Sex	Age	Bone	Side	Initial diadnosis	Osteosynthesis	Additional surgery	Loss in cm
1	m	29	Tibia	D	III B	external fixator	1	6,5
2	f	37	Tibia	D	III B	external fixator	1	6,5
3	f	22	Tibia	D	III A	external fixator	0	6,5
4	m	24	Femur	D	II	Intramedullary nail	1	12
5	m	21	Femur	D	III B	Plate	0	10
6	m	40	Tibia	E	Genum valgo	Osteotomia e placa	1	7
7	m	30	Femur	E	III B	Plate	2	8
8	m	29	Tibia	D	III B	external fixator	0	7
9	m	24	Tibia	D	II	Plate	0	4

Source: S.A.M.E. Santa Casa de Misericórdia de São Paulo
Observation: The initial diagnosis column identifies the bone exposure upon fracture, based upon the Classification of Gustão & Anderson. Exception: Patient # 6 who present osteomyelitis following tibial osteotomy

***Table 1** - Identification of patients with partial bone loss treated with parietal bone transportation.*

Following stabilization of bone segments, parietal corticotomy was carried out so as to obtain the fragment to be transported. This procedure required two small parallel longitudinal skin incisions (approximately 3 cm) and one transverse incision (2 cm in the longitudinal measurement of the fragment). A chisel was inserted in each incision by direct striking the hammer. The bone fragment removal was completed with concomitant rotation of the chisels (Figure 1). The bone fragment was fixed by olive wires for traction. When low resistance was found in the bone while passing the thread, a smooth thread was used with three thread folds of 60° in a form of a triangle so as to increase the contact surface between the thread and the bone.

The threads drawing the transported fragment were passed orthogonally with a slope of 45 ° from the transverse section of the bone; the latter corresponded exactly to the greater axis of the parietal bone defect (Figure 1). In three patients, only one thread was used to carry out the bone transportation (patients # 2, 4, and 5). The thread was connected to the apparatus with the help of screwed grooved rods.

In two patients the lateral transportation of the fibula was carried out (patients # 8 and 9). Following the placement of the Ilizarov apparatus in the tibia, two or three olive wire were inserted through the fibula toward the tibia. Two small skin incisions were carried out on the skin over the fibula in the region corresponding to the length required to fill the gap. Chisels for percutaneous osteotomy were inserted, their medial translation being possible. The progressive traction of the olive wires extending from the fibula to the tibia was carried out with grooved rods attached to small flags connected to the external fixator (Figure 2).

In all cases a latency period of 7 days was allowed before the beginning of bone transportation. The transportation speed was 1 mm/day, divided into four sections for all patients.

We discontinued the transportation when the transported segment occupied the bone defect. The fixator remained static until consolidation of the transported fragment within the bone defect, ossification of the regenerated bone, and consolidation of pseudarthrosis. The fixator was removed always in the surgery room under intravenous anesthesia.

RESULTS

In all patients the pseudarthrosis was healed following bone transportation and stabilization of the external fixator. The radiological examination showed that the gap was filled in all patients. The patients of this series do not show any current clinical evidence of active infection (Table 2).

The main complication seen in the patients treated with this technique was skin infection in the area surrounding the threads and pins. This complication was seen in all cases and was treated with local measures. Neither the pins nor the threads were replaced because of infection.

In three patients (# 1, 6, and 7) complementary surgical pro-

***Figure 1A** - Lateral radiograph of the tibia showing the bone loss induced by necrotic bone resection following osteosynthesis with infected plate.*

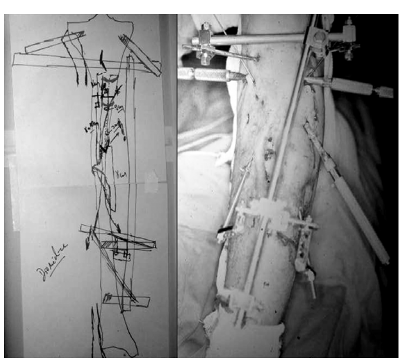

***Figure 1B** - Operative planning and clinical characteristics when the three osteotomes produced the bone fragment to be transported.*

***Figure 1C** - Radiographic characteristic of the transported fragment and the regenerated bone during osteotaxis for bone loss filling.*

***Figure 1D** - Clinical and radiographic characteristic following the end of treatment.*

cedures were required for ressection of the tissue between the transported bone fragment and the target-bone. In these cases, after transportation was completed, the regenerated bone had a slow evolution. Autologous spongy bone was added to the region of the regenerated bone (Table 2). The need for a complementary thread to provide compression between fragments was present in three patients (#2, 4, and 7) in whom transportation was carried out through a traction thread.

DISCUSSION

The method of transportation of a bone fragment due to local segmentary defect with concomitant distration at the corticotomy site is successfully used to save a limb that would be otherwise sacrificed[18,21,24]. A variant of this technique is the transportation of a small bone fragment so as to fill a gap of approximately 50% of the bone diameter and is called parietal transportation[2,11]. Ressection of viable bone occupying the intact cortical bone, thus converting a partial defect into a segmentary defect, in order that the technique of conventional bone transportation be used, seems to us nonsense: removal of healthy bone when healthy bone is exactly that which is lacking. The main advantage of the parietal transportation is bone formation even in the presence of infection. Few studies have been published, showing their results with the technique of the parietal transportation; however, all studies published in literature included smaller casuistics than that of the present series. In 1992, Aronson[2] reported the recovery of one patient with cavity osteomyelitis treated with cortical fragment transportation.

Different synthesis materials can be used in the stabilization of the bone segment for parietal bone transportation.

Figure 2A - *Radiographic characteristic when the patient was first seen. Infected open fracture with bone sequestra, precariously fixed with an external fixator.*

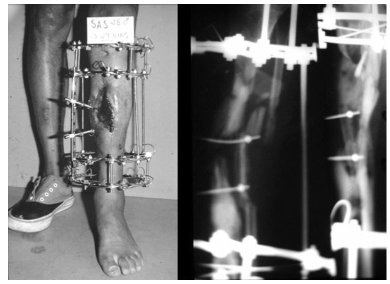

Figure 2B - *Clinical and radiographic characteristics following debridement, placement of the external fixator and beginning of the segmentary fragment transportation of the fibula for the bone loss filling.*

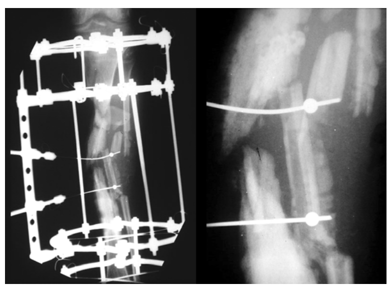

Figure 2C - *Radiographic characteristic during therapy. Transported bone occupying the bone loss.*

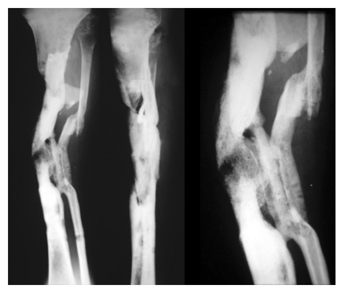

Figure 2D - *Final radiographic characteristic with bone loss filling, consolidation of the regenerated bone from osteotaxis of the fibula and ossification of the pseudarthrosis focus in the tibia.*

Order	Additional surgery number of inteventions	Transported bone	Bone loss filling	Presence of infection	Consolidation
1	1	Tibia	yes	no	yes
2	1	Tibia	yes	no	yes
3	0	Tibia	yes	no	yes
4	1	Femur	yes	no	yes
5	0	Femur	yes	no	yes
6	1	Tibia	yes	no	yes
7	2	Femur	yes	no	yes
8	0	Fibula	yes	no	yes
9	0	Fibula	yes	no	yes

Source : S.A.M.E. - Santa Casa de Misericórdia de São Paulo

Table 2 - *Table showing the order number, patient's initials, number of additional surgical interventions required following fixator placement, bone-source of the transported fragment, filling or nonfilling of bone loss, presence or absence of infection and consolidation of pseudarthrosis. Identification of patients with partial bone loss treated with parietal bone transportation.*

The Ilizarov apparatus is a circular external fixator that determines stable osteosynthesis, thus making the support of the body weight during walking and movement of adjacent joints possible. Both conditions described here are indispensable in the use of the Ilizarov method[15]. This fixator is also versatile and can be used for concomitant correction of deformities, fracture consolidation, and bone transportation[1,19]. In this group of patients, however, one of the cortical bone was contiguous and could be used to enhance intrinsic stability of the lesion, the use of unilateral fixators being possible[23]. We indicated fixators of the circular type for the majority of patients. However, the indication of a unilateral external fixator does not raise any concern in this series of patients.

Despite the fact that many variables play a role, the satisfactory evolution of bone transportation is based upon a preliminary procedure: the corticotomy. This will be the site of newly formed bone and how the bone fragment is produced determines the treatment outcome. The literature clearly shows that osteotomy should cause the least trauma as possible[4,9,10,22]. The blood flow in the bone submitted to corticotomy is triplicated within approximately 17 weeks, which, according to Aronson et al in 1989[3], could account for the high rate of infection resolution. In parietal transportation, the vascularization of the transported fragment is essential despite the fact that the fragment is derived from the cortical bone of a long bone or from a fibula segment. According to this technique, corticotomy should be careful since a sudden movement of the chisel can remove the periosteum from this small bone, thus adversely affecting its blood supply and even inducing the formation of bone sequestra. If the latter results, the bone defect will be aggravated as well as the tissue defect.

A period of seven days, on average, should elapse before the movement can be started and could be extended to 14 days in cases of severe tissue injury[8,15,16,17]. In the present study, the transportation was started seven days following corticotomy. This can be one of the reasons for hypotrophic regenerated bone, radiographically confirmed during the transportation follow-up in three patients. We believe that a longer latency period should be indicated before the beginning of osteotaxis in cases of transportation for partial bone defect with severe soft tissue injury.

The ideal speed of distraction is 1 mm/day, divided in four daily sessions[15].

As for the bone transportation of the parietal fragment, the precepts recommended by Ilizarov should be rigorously complied with. In addition, the surgeon should pay attention to some particularities:

- The thread to be used to draw the parietal fragment can be of the olive or twisted type in different shapes. One can choose the more practical olive type when the fragment to be transported has a thick cortical bone. In contrast, in cases where the cortical bone is less resistant, such as those with reactive hyperemia in response to infection or established osteoporosis, the folded threads assure a greater contact surface, with less pressure against the cortical wall. Therefore, the risk for loosening of the transported fragment is reduced.

- The use of two crossed threads, arranged along the defect axis, assures the direction to be followed. However, the passage of the two threads is technically difficult. One must remember that the angle formed by the threads increases over the time and the movement is reduced by milimeters along the longitudinal axis. This means that a milimeter of the rod movement corresponds to a shorter movement of the bone fragment.

- When one uses a thread for transportation of the corticomytreated fragment, the bone fragment reaches the partial bone defect end distant from the bone adjacent to the bone defect. We used the passage of a new thread with an olive or a folded one so as to produce compression between the fragments of the transported bone against the bone defect border.

During follow-up of patients who underwent bone transportation, the physician should pay attention to the painful complaints, the early sign of possible synthesis loosening[13,21]. Plain radiographs is used to follow the transportation evolution[14]. Bone visibility is adversely affected in the region of the metallic ring. In the patients of this series, oblique radiographs were used in association with anteroposterior and lateral projections to follow the treatment evolution.

The main complication seen during treatment was skin infection in the area surrounding the threads and pins. All patients developed infection at some time during treatment that was treated with local measures, daily dressings, and topical antibiotic therapy. This is also the most frequent complication described in literature in cases where external fixators have been used. We agree with Camilo (2003)[5] about the fact that mechanical cleaning of the pins is essential with both saline solution and polivynilpyrrolidone-iodine (PVPI) being appropriate.

Another complication found in the present series was the presence of hypotrophic regenerated bone. Three of our patients needed an additional autologous bone graft in the region of the regenerated bone. This was probably due to the tiny vascularization of the transported fragment. The prolonged use of the fixator causes the patients a lot of discomfort. The patients adapt to the use of the fixator very well but the use of the fixator leads to a marked deterioration in the quality of life some months later[20,25,26]. One must emphasize that the treatment is temporary. In the patient with infected pseudarthrosis, the quality of life is adversely affected with walking limitation and the need of dressings on the fistula.

The partial bone transportation technique used to treat infected partial bone defects led to satisfactory results with consolidation of pseudarthroses and infection resolution in all cases.

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