TREATMENT OF SEGMENTAL TIBIAL BONE LOSS BY DISTRACTION OSTEOGENESIS

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ABSTRACT

Objectives: *To assess the clinical outcome of reconstruction of segmental tibial defects by the technique of bone transport.*

Methodology: *This prospective, quasi-experimental study was conducted in Lady Reading Hospital and private hospitals of Peshawar, Pakistan from October 2009 to September 2011. Segmental losses of tibial diaphysis in 32 patients were 'regenerated' by bone transport.*

Results: *Radiological results were excellent in 24 (75%), good in 3 (9%), fair in 4 (12%) and poor in 1 (3%) patient. Clinical results were excellent in 19 (59%), good in 7 (22%), fair in 5 (16%) and poor in 1 (3%) patient. During follow-up there were 9 obstacles of pin/wire infections and 7 problems which required surgical intervention. At the last follow-up there were 6 true complications. The average fixator time (external fixator index) was 25.9 weeks and the average bone healing time was 26.1 weeks.*

Conclusions: *Distraction osteogenesis may be the best biological method of restoring the integrity of a bone in segmental bone loss.*

Key Words: *Distraction osteogenesis, Bone transport, Ilizarov ring fixator, Naseer-Awais fixator*

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INTRODUCTION

Treatment of large segmental bone defects is a difficult challenge for orthopeadic surgeons. Historically, amputation was the best option for many of these patients, but the demand for limb salvage has become more common. Current solutions include the use autogenous bone graft, vascularized fibular graft, allografts, chemical bone substitutes and Ilizarov bone transport. Autogenous bone graft is not advocated when the defect is over 4 cm as healing is incomplete because of graft resorption even in a good vascularized muscular envelope[1]. Free vascularized fibular graft has lost its significance since adequate hypertrophy of the incorporated fibular graft may take several years and fatigue/stress fracture is common[2]. The enthusiasm for the use of allograft has considerably decreased since processing techniques aimed at achieving safety and sterility adversely affect the properties vital for graft incorporation and healing[3]. Ceramic and chemical bone substitute, including allografts are clearly bio-incompatible as there is no union at the critical interface between living bone and inanimate materials[4].

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Ilizarov bone transport offers several distinct advantages[5,6]. First, the regenerate is living bone filling the whole width and regeneration occurs gradually from another site in the same bone. No donor site morbidity is present and there is biological union at the two living interfaces. Exact limb length can be restored. It is now recognized that distraction osteogenesis is most similar to intra-membranous ossification and is an excellent form of autograft, and may be the ultimate bone graft[7].

This study was undertaken to assess the clinical outcome of reconstruction of segmental tibial defects by the technique of bone transport.

METHODOLOGY

Thirty two patients, 25 male and 7 female (Table 1), were included in this two years prospective study conducted in Lady Reading Hospital and private hospitals of Peshawar,

Pakistan from October 2009 to September 2011. Only those patients with Paley's classification of non-union type B &C (Table 2)[6] were included in the study whose bone loss exceeded 4 cm. Patients who were unable to tolerate operation and maintain the external fixator device were excluded from the study. Patients lost to follow-up and those demanding premature fixator removal were also excluded. Informed consent for inclusion in the study was obtained from all patients.

In fifteen patients, with type B1 non-unions, Naseer-Awais (NA) fixator was used and in the other 17 patients with type B3 (n=7) and C (n=10) non-unions, the Ilizarov ring fixator was selected (Table 2). All the surgeries were done under general anesthesia and under image intensification to facilitate proper pin/wire placement. Both the NA and Ilizarov fixators were applied using standard techniques. In infected cases open debridement was done to totally remove the necrotic and infected segment and then proceeded with bifocal osteosynthesis to eliminate the bone gap using the Ilizarov frame. Thin 5 mm osteotome was used for the metaphyseal corticortomies as described by Ilizarov. Transport was started on the 7th day at the rate of ¼ mm 6 hourly and patients were instructed to clean the fixator and pin/wire daily with hydrogen peroxide solution using a cotton bud. Regular follow-up at fortnightly interval was strictly followed to monitor patient compliance and radiological progression of the transport process. When the end of the bone had docked, the maneuver called the accordion technique by Ilizarov was started[8]. The total duration of frame application, also called external fixator index, depended upon the length of bony defect. One third of the total treatment time accounted for the transport process and consolidation, healing and restoration of mechanical integrity accounted for the other two thirds.

FOLLOW-UP

All patients were followed for at least one year after the index procedure. Compliations were graded according to Paley classification[9]. During follow-up there were 9 obstacles of pin/wire infections which resolved either with medications or after fixator removal. There were also 7 problems which required surgical intervention. Five cases failed to unite even after 3 cycles of the accordion technique. They were bone grafted and kept in the fixator till the ends had united and the regenerate consolidated. In two patient 3 wires became very painful and had to be re-tensioned. The average fixator time (external fixator index) was 25.9 weeks and the average bone healing time was 26.1 weeks.

RESULTS

Outcome measures were based on radiological and clinical findings according to the criteria of Association for the Study and Application of the Method of Ilizarov (ASAMI)[10]. Radiological results were excellent in 24 (75%) patients and the length and mechanical integrity of their tibae was fully restored. Three patients (9%) had good radiological results with shortening of 2 to 9mm. In 4 (12%) patients the outcome was fair with mal-unions of $<10^{o}$and poor in 1 (3%) patient with non-union. Clinical results were excellent in 19 (59%) patients, good in 7 (22%), fair in 5 (16%) and poor in 1 (3%). Those with good clinical results had mild to moderate limping gait and those with fair outcome had persistent infection. The one poor result was a middle-aged diabetic whose docking site failed to unite even after grafting. He also showed delayed consolidation of the regenerate and had to wear a full-time tibial brace.

DISSCUSION

The later part of the last decade saw our province going through a very difficult and painful period. Bomb blasts devastated the lives of the entire spectrum of the society and Lady Reading Hospital was at center stage in looking after the injured. Majority of the patients were young men in the prime of their productive life and limb salvation became both a compulsion and a necessity.

We were familiar with the NA fixator since long and used it in type B1 aseptic tibial non-unions with intact fibula because of simplicity of application but the Ilizarov ring fixator was an altogether new experience. It was applied to the most difficult fractures (B3 & C) and the end results showed that without the ring fixator limb salvation would have been next to impossible. This was demonstrated by the fact that 75% of our patients achieved exact length and mechanical integrity without any complications which vindicated the overall efficacy of the bone transport technique. Paley and co-workers[9] and Sen et al[11] achieved somewhat better results but no doubt in a more controlled study than ours as nearly all our cases were due to bomb blasts. However, our study compares well with the local study carried out in Peshawar on the instant subject[12]. Docking site problems are an integral part of any gap non-union and need case to case management. The accordion technique of Ilizarov is based on the observation that the fibrous tissue surrounding the bone ends can be transformed into tissues capable of neogenesis and was necessarily adopted in each case. It consists of alternating

Table 1: Demographic characteristics of the patients (n=32)

S.No	Sex	Age	# type	Bone loss (mm)	Fixator	Time to heal (Weeks)	Complications
1	M	35	B1	42	NA	19	-
2	M	40	B3	58	Ilizarov	26	-
3	M	27	C	62	Ilizarov	28	Pin/wire infection
4	F	20	B1	46	NA	21	-
5	M	52	C	55	Ilizarov	25	Wire re-tension
6	M	25	B3	60	Ilizarov	27	-
7	M	22	C	61	Ilizarov	27	Pin/wire infection
8	M	45	B3	56	Ilizarov	32	Bone graft
9	M	32	C	58	Ilizarov	32	Bone graft
10	M	48	B1	45	NA	20	Pin/wire infection
11	M	30	B1	57	NA	25	-
12	M	18	C	60	Ilizarov	27	Wire re-tension
13	F	30	B1	48	NA	22	-
14	F	20	B3	57	Ilizarov	24	Pin/wire infection
15	M	30	B3	50	Ilizarov	21	Pin/wire infection
16	M	33	C	62	Ilizarov	28	Pin/wire infection
17	M	35	B1	48	NA	23	-
18	M	44	B3	60	Ilizarov	28	Wire re-tension
19	F	31	C	57	Ilizarov	25	Pin/wire infection
20	M	40	B1	47	NA	22	-
21	F	35	B1	48	NA	22	Pin/wire infection
22	M	25	B3	52	Ilizarov	30	Pin/wire infection
23	M	27	C	65	Ilizarov	36	Bone graft
24	F	18	B1	55	NA	31	-
25	M	37	B1	48	NA	22	-
26	M	33	B1	50	NA	35	Bone graft
27	M	22	B1	42	NA	18	Pin/wire infection
28	F	28	B1	52	NA	30	-
29	M	40	C	55	Ilizarov	25	Pin/wire infection
30	M	45	C	60	Ilizarov	40	Failure of union & Delay consolidation
31	M	25	B1	48	NA	22	-
32	M	20	B1	50	NA	23	Pin/wire infection

NA= Naseer-Awais

Table 2: Paley classification of Non-unions

A	**Aseptic non-union without bone defect**
A1	Atrophic
A2	Hypertrophic without deformity
A3	Hypertrophic with deformity
B	**Aseptic non-union with bone defect**
B1	Length of limb preserved with bone gap
B2	Segments in contact with shortening of the limb
B3	Combined shortening with gap
C	**Septic non-union**

compression and distraction at the docking site at the rate of ¼ mm 12 hourly for one week with 3-day stoppage in between. Pin/wire site are potentially infected and require special attention throughout the fixator application period. The technical rate of failure of wire loosening was somewhat high at 6.2% as compared to other studies[5,6]. It was most probably attributed to our inexperience in the earlier part of the study. In all atrophic non-unions, there is de-vascularization of the segments which require some form of biological stimulation. Traditional methods utilize local bone graft to provide this stimulus. According to the Ilizarov method, corticortomy followed by distraction, is the biological stimulus for neo-vascularization in the entire segment and the correctly applied external fixator introduces a mechanical environment which facilitates function. The revascularization and mechanical load has been shown by Ilizarov to reliably heal infected and atrophic non-unions[13].

CONCLUSION

Within the limitations of this study, it is concluded that Ilizarov bone transport may be the best biological method of reconstructing large bony defects.

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CONTRIBUTORS

IUB conceived the idea and planned the study. SSA & MG did the data collection and analyzed the study. All the authors contributed significantly to the research that resulted in the submitted manuscript.