Bone Transport of Tibia by Performing Z-Osteotomy Using Convenvtional External Fixator

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ABSTRACT:

BACKGROUND:

This is a descriptive study to evaluate the outcome of forty patients with bone loss in tibia using conventional (mostly monoaxial) external fixation device, based on principles of distractive osteogenesis.

OBJECTIVE:

To prove the effectiveness of conventional external fixation device in distraction osteogenesis in tibia successfully and simply.

PATIENTS AND METHODS:

Forty patients with bone loss of 4 to 10.5 centimeters in tibia between March 2003 and March 2011 were treated, ages (15-65years), 6:34 female to male ratio .In 30 patients site of bone loss was in the lower third of tibia while in 4 patients was in the middle third of tibia and in the remaining 6 patients it was the upper third of tibia. The cause of defects in tibia was fracture due to road traffic accident (20cases), bullet injury to leg (8cases), gap nonunion (8) and infected non unions (4 cases) respectively. Conventional external fixation device were used in all cases using the principles of z-osteotomy and results were evaluated according to Association for Study and Application of Ilizarov Method (A.S.A.M.I.) scoring system.

RESULTS:

According to ASAMI scoring system, functional results were achieved as excellent in 20 patients (50%), good in 10 (25%), fair in 8 (20%) and poor as 2 (5%) without failure. while bone results achieved excellent 18 (45%), good 14(35%), fair 6 (15%), poor 2(5%) without failure and bone loss in upper tibia has more chance and excellent result than in lower part.

CONCLUSION:

Conventional external fixation devices can be used to achieve distraction ontogenesis in tibia bone defects successfully, as it is cheap, safe and simple assembly.

KEY WORDS: distraction osteogenesis, bone transport, A.S.A.M.I. scoring system.

INTRODUCTION:

Distraction osteogenesis is used not only for limb lengthening but also as a means of filling segmental defect in bone [(1)] .Bone transport is a new useful operation described by Ilizarov .With the advent of bone transport, the surgeon can boldly resects the entire avascular bone & create a large defect. The procedure consists of corticotomy at one end of the long segment of the bone. The intercalary segment is transported; the gap is closed by two methods: gradual method and acute docking method[(2)]. Acute shortening of more than 4 cm can cause the development of tortuous vasculature & actually produce a low flow state with detrimental consequence. Open soft-tissue wounds when acutely compressed can become notably bunched and dysvascular, with the development of significant edema & the possibility of additional tissue necrosis and infection[(3).] Numerous techniques have been used to fill these defects including autologous cancellous bone graft, allograft, ipsilateral vascularized fibular transport, bone transport & free vascularized fibular graft[(4).] In the new modification of internal bone transport technique, the bone is axially transported also by internally placed transport pulley system[(5).]

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Microvacular techniques to transfer the fibula with its blood supply and sometimes with skin and muscles proved to be useful in overcoming large skeletal defects, but are highly demanding and having some drawbacks [6]. The advantage of ipsilateral vascularized fibular transport is that the fibular segment retains its vascularity without the need for micro vascular dissection or anastomosis [7]. Ilizarov experimentally showed that when gradual distraction tension stress applied to the corticotomy site, the vascularity of the entire limb is increased, which in turn enhances the ability of the bone ends to unite[8]. Because of difficulty in managing posttraumatic segmental bone defects and the resultant outcome, amputation historically was the preferred treatment[9]. For the hypertrophic non-union Ilizarov recommended compression to increase formation of repaired callus and vascularity, while for atrophic nonunion with diffuse infection or sequestrated bone, open resection of the infected segment is performed and bifocal compression is used[10, 11].

Cylindrical titanium mesh cage packed with a composite of cancellous allograft and demineralized bone matrix and stabilized with statically locked intramedullary nail is another method of treating bone loss [12].

PATIENTS & METHODS:

Between March 2003 and March 2011, 40 patients (6 females 34 males) with bone loss ranging from 4-10.5 cm in tibia treated in Sulaimani teaching and causality hospitals. Their age ranged from 15-65 years old. Site of the defects in 30 patients in the lower 1/3, one of these it was intra-articular in which ankle arthrodesis done for him Figure 1-6.

Figure1: Shows wooden block under the shorter site and scar tissues of previous operations.

Figure 2: Plain radiograph of left leg A.P. view showing intra-articular nonunion of lower end left tibia with a screw of previous operation.

Figure 3: The intercalary segment is transported toward the gap.

Figure 4: Corticalised distraction and united docking sites. The ankle is arthrodesed.

Figure 5: Full weight bearing with the external fixator and no more wooden block.

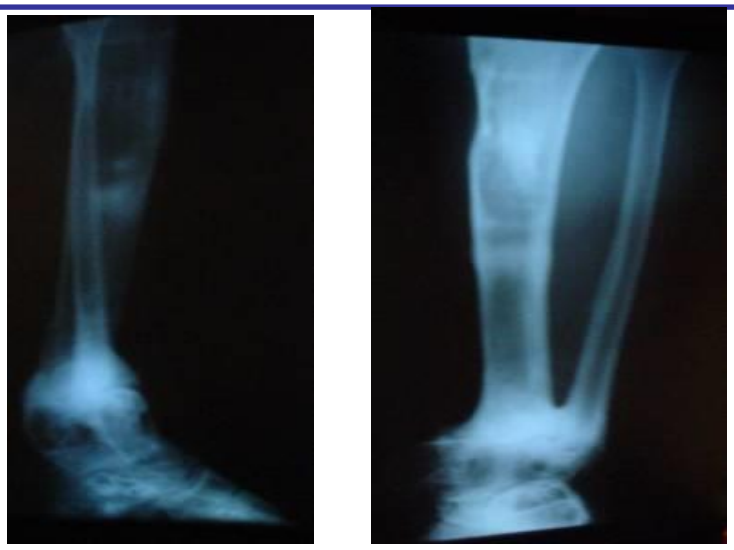

Figure 6: Plain Radiograph of the left leg A.P. and Lateral views after removal of the external fixator.

In 6 patients the sites of bone loss were in the upper 3rd while in the remaining 4 patients the site of bone loss was in the mid-3rd of tibia in which for one of them bifocal bone transport was done as there was 10.5cm bone loss .

After taking informed written consent from patient, the conventional monolateral external fixator frame were preassembled, for all of the cases, except for one of them in which ankle arthrodesis done by using bilateral external fixator and Den Ham pins instead of Schanz pins.

In preoperative radiograph of the leg, two radiopaque markers were used to localize most proximal and most distal parts of the tibia which is helpful in application of external fixator and minimizing the use of fluoroscope intraoperatively.

The site of the defect was exposed & all unhealthy bone and any dead tissue was removed, the fibula is fixed internally by K-wire. After frame application the alignment is checked by fluoroscope and a separate incision was used to perform osteotomy proximal to the defect if the defect in the distal 1/3, distal to the defect if the defect in the proximal 1/3 of the tibia and bifocal osteotomy when the defect in the middle of the tibia & it is massive gap. The osteotomy done by using a drill bit 3.2 mm on T-shaped handle for doing multiple holes in a Z-shaped manner by using sharp 5mm osteotome and hammer.

Distraction started manually 3 days post-operatively, the intercalary segment transported toward the gap1mm daily, in four divided doses i.e.0.25mm each 6 hours.

RESULTS:

In the current study out of 40 patients, 6 patients (15%) were female and 34 patients 85% male.Thier age ranged between 15-60 years. The causes of defects was fracture tibia by Road Traffic Accident in 20 cases (%50),bullet injury in 8 cases(%20),gap non-union in 8 cases(%20) and infected non-union in 4 cases (%10).The average length of bone loss was 5.86±1.71 cm ranging from 4-10.5 cm Table 1.

Table 1: Showing age and amount of bone loss in tibia.

	Minimum	Maximum	Mean± Std. Deviation
Age (Years)	15	65	29.20±10.6
Amount of bone loss in Tibia/cm	4	10.5	5.86± 1.171

The results were divided into bony and functional **table 2**, bony result was excellent in 18 patients (45%), good in 14 patients (35%), fair in 6 patients (15%) and poor in 2 patients (%5) while functional result was excellent in 20 patients (% 50),good in 10 patients (25 %) ,fair in 8 (20 %)and poor in 2 patients (5),no failure as none of them ended by amputation.

Regarding the site of bone loss it was in lower third of tibia in 30 patients, middle third in 4 patients while in the remaining 6 patients the site of bone loss was in the upper third of tibia.
Complications: 1. Common peroneal nerve injury causing foot drop 2 cases 5%.
2. Skin loss 20 cases 50%.
3. Limb length inequality was observed in 4 patients with maximum 10 mm discrepancy 10%and 36 patients 90% having no discrepancy.
4. Infection at compression site 4 cases10%.
5. Reflex sympathetic dystrophy 4 case10%.
6. Stiffness of knee joint 2 cases 5%.Ankle stiffness 4 cases10%.
7. Inability to return to their job 2 cases5%.
8. Refracturing 2 cases 5%.

The average fixator time was 6 months and average bone transport was 6 cm.

Table 2: Association for the Study and Application of the Methods of Ilizarov (ASAMI) scoring system [13,14].

Bone Results	
Excellent	Union, no infection, deformity < 7°limb length discrepancy <2.5cm
Good	Union+ any two of the followings No infection ,deformity <7 ° limb length discrepancy < 2.5cm
Fair	Union + only one of the following. No infection, deformity <7° limb length discrepancy <2.5 cm .
Poor	Non-union /refracture /union + infection +deformity< 7 ° + limb length discrepancy >2.5 cm.
Functional Results	
Excellent	Active, no limp, minimum stiffness (loss of < 15 ° knee extension/<15° dorsiflexion of ankle), no Reflex Sympathetic Dystrophy, Insignificant pain.
Good	Active with one or two of the followings ; Limp, stiffness, R.S.D., insignificant pain.
Fair	Active with three or all of the followings ; Limp, stiffness, R.S.D., significant pain.
Poor	Inactive (unemployment or inability to return to daily activities because of injury).
Failure	Amputation.

Table 3: Is showing the results according to the site of bone loss.

Results	Site of defect			P values
	Lower 3rd N (%)	M 3rd N (%)	U 3rd N (%)	
Bony result Poor Fair Good Excellent Total	 1(50.0) 5(83.3) 9(64.3) 15(83.3) 30(75.0)	 0(0.0) 1(16.7) 1(7.1) 2(11.1) 4(10.0)	 1(50.0) 0(0.0) 4(28.6) 1(5.6) 6(15.0)	0.367
Functional result Poor Fair Good Excellent Total	 0(0.0) 7(87.5) 7(70.0) 16(80.0) 30(75.0)	 1(50.0) 0(0.0) 1(10.0) 2(10.0) 4(10.0)	 1(50.0) 1(12.5) 2(20.0) 2(10.0) 6(15.0)	0.243

Statistical analysis of data was done by SPSS program and the p-value was not significant because the sample size was small (40) cases and further divided into smaller groups; poor, fair, good and excellent.

Table 4: Comparison of different studies.

Study	Sample size	Bone Results (%)				Functional Results (%)				Returning to work (%)
		Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor	
Sanders et al. [15]	15	48	21	5	26					62.5
Dendrison et al. [16]	27	50	28	4	18	26	41	15	18	82
Sangkaew C [17]	21	81	14.3		4.7	85.7	14.3			
Sahibzada AS et al [18]	20	60	10	15	15	35	40	20	5	
Mohammad et al.[14]	32	56	22	6	16	63	19	9	9	72
Our study	40	45	35	15	5	50	25	20	5	70

DISCUSSION:

Conventional external fixator was used in the study because it was available and cheap and easy assembly. Open reduction and internal fixation of fibula done by K-wire (if the fibula was broken) to give you more stability and to guide the transported tibial segment toward the gap and minimize chance of malalignment as it was in 20cases (50%) due to Road Traffic Accident and 8 cases ((20%) due to bullet injury while in 8 cases (20%) of gap nonunion and 4 cases (10%) of infected nonunion the fibula was united when we received the cases. Monolateral (unilateral) external fixator ,except in one case in which bilateral external fixator and Den Ham pins used instead Schanz pins as there was intra-articular nonunion at the lower end tibia and ankle arthrodesis was done. So by using monolateral external fixator to anteromedial

aspect of the shin which is a safe corridor and it is less cumbersome to the patient during walking.
Low energy osteotomy done using drill bit 3.2 mm in diameter on a T-shaped handle for doing multiple holes in a Z-shaped manner using 5 mm sharp osteotome and hammer. Manual osteotomy done instead of using electric saw to avoid and minimize chance of thermo-necrosis which delays chance of osteogenesis. In two cases functional results were poor so they could not return back to their daily activity because of injury, the cause behind that was the obligatory shortening of the muscle length, suggesting that adaptive changes had occurred at the level of transported muscles which affect both routine and maximal effort capabilities[19].
Z- Osteotomy is done in the study because of creating wider osteoblastic surface to stimulate more rapid osteogenesis at distraction site and the limbs of the Z are preserving the alignment of the segments .Patient selection and education regarding the duration of treatment, emotional, financial and social support are absolutely essential[20].
The personality of a tibial nonunion is determined by a number of factors including bone loss, radiographic appearance and stiffness as they relate to the nonunion biology, deformity, soft tissue envelope and patient factors including diabetes, smoking and neuropathy[21].
Percentage and chance of excellent results were observed to be higher in patients having tibial bone loss in the lower 3rd of the bone than those having bone loss in the upper 3rd so they had better prognosis for bone transportation because osteotomy site in the proximal metaphysis of the tibia has more rapid osteogenesis at the distraction site. In our study(50%)of the cases were due to road traffic accident, this is because of rapid increase in the number of the cars in the country due to improvement of economy of the people as there is no more embargo on Iraq before establishing developed traffic system.
Multiplaner Ilizarov external fixator and uniplanner monofixator has been used for bone transport but none has been proven to be free of complications. A study done by Sangkaew C showed that average bone transport of 5.6 cm and average fixator time was 8 months in 21 patients[17] he used conventional external fixator in his study while in our study average bone transport is 6 cm and average fixator time is 6 months which means shorter average fixator time this is due to the fact that by performing Z shaped osteotomy wider osteoblastic surface will be stimulated so there will be more rapid osteogenesis of the destruction site. Using Ilizarov fixator Dendrinoset et al achieved healing in 9.6 months with 6 Cm bone transport in 28 patients16.While Pash et al studied 11 patients and reported average 6.7 Cm bone in 14 months by using Naseer and Awias external fixator [22] . In current study average bone transport of 6 Cm and average fixator time was 6 months. So the result is comparable to both convesional and Ilizarov fixator.
Regarding the 20 cases with skin loss the skin is closed by undermining and epithelialization done in 18 cases according to Ilizarov principle in which in bone transport histogenesis of entire limb tissues will takes place including skin tissues ,while in 2 cases partial thickness skin graft done.

CONCLUSION:

Conventional monolateral external fixator can be used for compound comminuted fracture tibia with bone loss because it is cheap , safe, available and fast assembly time
Correction after reduction is possible, so even without using image intensifier , if the patient sent to x-ray preoperatively with markers at the proximal and distal ends of the broken tibia one can imagine the position of the pins and you can correct the reduction with the next wound debridement according to the radiological finding .

Recommendations:

In every case of compound comminuted fractured tibia with or without bone loss the external fixator should be applied in a manner not to prevent bone transport whenever needed .If fibula is broken it should be fixed by intramedullary K. wire to give more stability to the transported tibial fragment .

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