Immediate global reconstruction and bone transport over nail - a novel technique for post traumatic segmental bone loss of Tibia

Shashikumar Y¹, Ravishankar R², Gadiyar HB³, Mruthyanjaya M⁴

Abstract

Large skeletal defects of femur and tibia present a challenging reconstructive problem. Different methods of managing these defects exist but Ilizarov method of bone transport has been shown to be an exciting new method as it does not involve donor site morbidity.

We have done bone transport over an interlocking nail (Bone transport over nail, BTON) using Ilizarov frame in a patient with post traumatic segmental bone loss of tibia. Fracture union time was 12 months and patient returned to manual labour by 17 months from the time of injury. The bone transport result was excellent and functional result was good at the end of 20 months of follow up.

We conclude that distraction osteogenesis using Ilizarov frame over an interlocked nail (BTON) is an effective and reliable method of treating post traumatic segmental defects of tibia with minimal complications related to prolonged use of external fixation. However initial debridement must be radical and soft tissue coverage of exposed bone must be appropriate. Surgeon must be cautious with regard to deep infection.

Key words: BTON, Bone transport over nail, Type IIIb Tibia fracture, Ilizarov bone transport, Wound debridement.

Introduction

Large skeletal defects of femur and tibia present a challenging reconstructive problem¹. Different methods of managing these defects include conventional bone grafting, vascularized bone grafting and bone transport, but Ilizarov method of bone transport has been shown to be an exciting new method³ as it does not involve donor site morbidity.

Main disadvantage of Ilizarov method is the prolonged external fixation time which is associated with poor patient compliance and complications like pin tract infections and joint stiffness¹. In order to overcome the problems associated with prolonged external fixation time, we did bone transport over an interlocking nail (Bone transport over nail, BTON) using Ilizarov frame in a patient with post traumatic segmental bone loss of tibia. This technique of BTON is also called as “Monorail Technique.”

Case report

A 40 year old farmer sustained grade III B open segmental comminuted fracture of right tibia during chariot racing. He was brought to our hospital at the end of 3 hours. Examination in the casualty revealed that patient was hemodynamically stable. There was 25 cm by 15 cm lacerated wound over the anteromedial aspect at the junction of middle and distal third of tibia, muscles were significantly crushed and there was gross contamination with mud and grass. Underlying tibia was bared of periosteum, and there was comminution of the bone. In the casualty wound swab was taken for culture and sensitivity following which wound was generously irrigated and sterile dressing applied. Leg was splinted in a crammer wire splint and I.V antibiotics (Piperacillin + Tazobactum and Metronidazole) were administered.

By the end of 6 hours patient was taken to operation theatre. Under spinal anesthesia right leg was thoroughly washed with betadine scrub and irrigated with plenty of normal saline. The right leg was painted and draped. The wound was generously irrigated and sterile dressing applied. Leg was splinted in a crammer wire splint and I.V antibiotics (Piperacillin + Tazobactum and Metronidazole) were administered.
removed which resulted in circumferential bone loss of tibia of 8 cm.

After redraping the right leg, fracture of right tibia with segmental bone loss was stabilised using reamed stainless steel interlocking nail (360 mm long and 10 mm diameter) in static mode through split patellar tendon approach. Soft tissue defect over anteromedial aspect of tibia was covered with tibialis anterior and extensor digitorum longus muscles. Intravenous antibiotics were continued for 5 days followed by oral Cefuroxime for 3 weeks. At the end of 3 months, patient was taken to operation theatre and a 4 ring preconstructed Ilizarov ring with a foot frame was applied to the right tibia with interlocking nail in situ using 3 wires in the metaphyseal region and 2 wires in the diaphyseal region. Through anterior approach proximal metaphyseal corticotomy done by de Bastiani’s method. Distraction of corticotomy site started on tenth day at the rate of 0.25 mm 4 times a day. But unfortunately at 4 months there was premature consolidation of corticotomy and it was managed by forceful distraction under intravenous sedation and image intensifier control.

**Fig. 1.** 1a-X-ray showing the extent of segmental comminution of distal third of tibia. 1b-Check X-ray after debridement and stabilization showing about 10 cm of segmental defect of tibia with statically locked interlocking nail in situ

**Fig. 2.a.** Ilizarov frame in situ

**Fig. 2.b.** Corticotomy after removal of one of the proximal locking bolts.
This was again followed by distraction of corticotomy site at the rate of 0.25 mm 4 times a day. Throughout the distraction period patient was bearing more than 50% of weight on right leg using an axillary crutch on right side. X-rays of right leg taken at the interval of 4 weeks throughout the distraction period showed linear trabecular pattern of callus formation in the distraction gap. Docking was achieved at the end of 12 weeks (7 months from the injury date). Patient was allowed full weight bearing from the time of docking and “Callus massage” was done at the rate of 0.25 mm twice daily with 1 week of compression and 1 week of distraction alternatively for a period of 4 weeks. At the end of 8 months there was no evidence of union of docking site. Hence posterolateral bone grafting (PLBG) through Harmon’s approach with patient in near prone position and cortico-cancellous bone graft harvested from posterior iliac crest. Ilizarov frame was dynamised and patient was allowed full weight bearing and discharged home.

At the end of 2 months of PLBG (10 months from the injury date) there was complete consolidation of the regenerate and evidence of callus formation at the docking site and tibiofibular synostosis, hence Ilizarov frame was in the outpatient department. Patient was followed monthly for 4 months and there after once in 3 months. Complete radiological consolidation of docking site was achieved at 12 months from the time of injury.

**Result**

Total number of hospital admissions was 4 and number of inpatient days was 39 days. Muscle flap healed at 4 weeks. Duration of distraction phase was 3 months excluding 1 month of time after completion of latency period of 10 days due to premature consolidation. Average Distraction index (DI) was 0.37 months per cm, External fixation index (EFI) was 0.75
months per cm and Radiological consolidation index (RCI) was 1 month per cm. Union time was 12 months. Patient could do preinjury manual labour by 17 months from the time of injury. According to Paley’s evaluation of results of bone transport, bone result was excellent and functional result was good at the end of 20 months of follow up.

**DISCUSSION**

Skeletal defects, noncircumferential or segmental, may result from treatment of open fractures, debridement of osteomyelitis or nonunion and resection of tumours. They can be managed by bone grafting, Vascularised bone grafts or bone transport. In 1967, Vidal popularized the use of cancellous bone grafting in conjunction with EF to manage skeletal defect, but it was associated with significant donor site morbidity. Microvascular bone transfers, fibula or iliac crest are highly demanding and have many drawbacks like:
- Prolonged healing and remodeling time
- Refracture
- Osteopenia and Joint stiffness
- Only 69% of success rate
- Need for secondary surgical procedures in 15% of cases
Long bone defects greater than 6 cm can be managed with vascularised bone graft or bone transport using the Ilizarov external fixator.\(^1\) Ilizarov method of callus distraction is recommended for segmental bone defects of even more than 3 cm.\(^1\) It is a biological method with significant advantages like:
- Defect of any length can be treated.
- Long term immobilization is not required.
- Massive bone grafts are not required.\(^2,3\)

In order to reduce External fixator time, many orthopaedicians performed bone transport using an EF over IMN (BTON, Bone Transport Over Nail). Michael J Raschke et al first reported this technique of Bone transport over nail (BTON) using mononail distraction system over an unreamed intra-medullary nail in 4 patients with post traumatic bone defects. Transport was achieved in all 4 patients without angular or rotational deformity or limb length discrepancy (LLD).\(^4\)

Kocaoglu et al treated 13 patients with segmental bone defects resulting from chronic osteomyelitis using external fixation over intra-medullary nail. At a mean follow up of 47.3 months, 11 patients had excellent results in terms of both bone and functional assessments. External fixation index (EFI) was 13.5 days per cm and Radiological consolidation index (RCI) was 31.7 days per cm.\(^5\)

C.Kesemenli et al treated 19 patients with mean bone defect of 6.8 cm by using Ilizarov method of callus distraction. The external fixation index was 36.6 days per cm and mean recovery period was 4-8 months (16). But the disadvantage of this method is prolonged external fixation which leads to poor patient compliance and many complications associated with this method.\(^6\)

As recommended by Green SA, the external fixator was removed when the distraction gap was consolidated enough and corticalisation seen on at least 3 of the 4 sides as seen on anteroposterior and lateral radiographs, the cortices are 2 mm thick and uninterrupted across the distraction gap and the regenerate bone demonstrates uniform radiographic density between the density of the adjacent normal bone cortex and that of its medullary canal.\(^7\)

Paley et al compared the results of 29 patients treated with bone lengthening using bone transport over nail (BTON) with those of 31 patients treated with standard Ilizarov femoral lengthening. They found that average external fixation time was reduced by almost one half in BTON group and radiological consolidation index was significantly reduced. They concluded that lengthening over intra-medullary nail is a safe and reliable technique with advantages of decreased external fixation time, protection against refraction and earlier rehabilitation.\(^8\)

H.Vasan et al treated 51 patients having limbs with bone loss of traumatic and congenital origin or LLD using mono nail method (Unilateral EF over intra-medullary nail) (BTON). After achieving leg length, EF was removed and intra-medullary nail locked. Mean leg length was 5.5 cm. Mean EFI was 24.5 days per cm. Higher EFI in our case was due to retention of EF till the radiological evidence of bone union at docking site and tibiofibular synostosis after Postero lateral bone grafting [PLBG].

At the time of docking, bone grafting of the docking site is recommended in adults even though there is no evidence. In the series of Dendron’s et al of 28 patients of Ilizarov bone transport only 3 patients required bone grafting [19]. In our case after docking PLBG (Harmon's procedure) was performed and alternate comparison and distraction at weekly intervals (Callus massage) was done to enhance union.

There was no pin tract infection, as care of pin track was stringent as recommended by Paley et al and we removed Ilizarov frame at the earliest radiological evidence union at docking site and tibiofibular synostosis. There was no deep infection as opposed to 3.5-5% as reported by Paley et al\(^18\) and Silberg et al\(^20\) and 15% as reported by Simpson et al.\(^21\) Our patient underwent 2 surgeries with 8 cm of bone regeneration with EFI of 32.6 days per cm. Limb alignment was exactly comparable to opposite limb without any evidence of angular or rotational deformities.

Paley has classified complication into problems which can be treated nonsurgically, obstacles that were resolved with surgery and true complications which are residual permanent deficits at the end of treatment period. The problem of premature consolidation at corticotomy site was managed by forceful symmetrical distraction under intravenous sedation (Diazepam).

PLBG at docking site was done as a precaution to enhance union and hence cannot be considered as a surgical procedure to treat an obstacle. Patient had limitation of dorsiflexion of ankle and flexion contracture of toes inspite of fixation of foot frame to the Ilizarov fixator. This problem improved after frame removal. Patient was very much satisfied with our technique.

**Conclusion**

Distraction osteogenesis using Ilizarov frame over an interlocked nail (BTON) is an effective and reliable method of treating post traumatic segmental defects of tibia with minimal
complications related to prolonged use of external fixation. However initial debridement must be radical and soft tissue coverage of exposed bone must be appropriate. Surgeon must be cautious with regard to deep infection.

REFERENCES

17. Paley D, Maar DC. Ilizarov bone transport treatment for tibial defects. J. Orthop Trauma 14:76-85, 2000

Cite this article as: