Bone Transport over the Plate for the Segmental Bone Defect of Tibia

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Segmental bone defects of the tibia present a challenging problem for the orthopedic trauma surgeon. These injuries are often complicated by soft tissue defects and infection. Many techniques are reported, from bone graft to bone transport. To our knowledge, bone transport over the plate in the distraction site has not been described for the treatment of tibial bone defect. We report an instance including procedure and subsequent complications after bone transport over the plate, to restore a tibial bone defect.

Keywords: Osteogenesis, Distraction; Tibia; Wounds and injuries

INTRODUCTION

Segmental bone defects of the tibia present a challenging problem for the orthopedic surgeon. The anatomy and physiology of the tibia predisposes it to healing problems, while concomitant soft tissue loss greatly increases the risk of complications. A variety of treatment strategies have been described such as bone graft, induced membrane techniques, vasculized fibula graft, as well as bone transport and bone transport over the nail. Transport over an intramedullary device has been advocated by several authors to better allow the surgeon to control length and alignment during transport, in addition to the increased rigidity of the construct, which ultimately allows for earlier removal of the external fixator [1]. However, the procedure is not foolproof. Problems with pin site infection, joint stiffness due to prolonged external fixator, and docking site nonunion can all occur. Most authors consider prolonged external fixation, history of previous pin tract infections, and extremely proximal or distal segmental defects as contraindications for the use of intramedullary fixation [2,3]. Plate-guided bone segment transport has been described to successfully treat defects in the femur [4].
We treat large tibia bone defects using locked plating and bone transport with a mono external fixation frame. This technique allows correction of length and alignment, stabilizes the limb, and facilitates earlier external fixator removal than bone transport over the nail. It also offers the opportunity to additionally compress and stabilize the transported segment at the time of docking by using additional locking screws through the plate.

**CASE REPORT**

A 44-year-old man experienced a crush injury to the right lower extremity resulting in a Gustilo–Anderson grade IIIB open tibia fracture with segmental bone loss (Fig. 1). Initially, he visited a local medical center where he was treated with serial debridement, with removal of all devitalized tissue, and bone fragments, and the placing of an external ring fixator. Three months after injury, the patient was referred to our hospital. Initial open wound was covered by split thickness skin graft (Fig. 2). There were no clinical infection signs and laboratory tests were all in normal range. Reconstruction of the tibial bone defect was undertaken using bone transport combined with minimally invasive plate osteosynthesis. The external ring fixator was removed and a monorail external fixator on anteromedial side was placed, as well as the segment of the planned corticotomy. Before corticotomy, defect site intraoperative tissue biopsy was done and shows no infection. The corticotomy was made at the middle third of his tibia (Fig. 3). Bone transport began 10 days status post corticotomy at a rate of 1 mm per day in four 0.25 mm increments. The duration of the transport period was 92 days and total time in external fixation was also 92 days. The total defect length was 86 mm with our ex-fix index (duration of external fixation per centimeter of bone lengthened) was 9.4 day/cm. The transported segment was docked and fixed to the plate with a single percutaneous screw and autogenous bone graft from iliac crest, while the external fixator was removed simultaneously.

The reason for choosing this technique was first, the patient had already been in an external fixator for a pro-

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**Fig. 1.** 44 years old male gross photo and radio-graghs of right tibia open (Gustilo-IIIB) diaphyseal fracture.

**Fig. 2.** Rt. tibia open fracture gross photo and X-rays at first visit our hospital. Skin defect was covered by split thickness skin graft.
Fig. 3. Showing minimally invasive placement of 4.5 mm laterally based locking plate with mono frame external fixator for transport.

Fig. 4. Intraoperative infected tissue and post debridement defects about 70 mm.

Fig. 5. Showing minimally invasive placement of 4.5 mm laterally based locking plate with mono frame external fixator for transport at distraction site.

Fig. 6. Tibia radiographs showing radiographic union.
londed period and wanted a treatment option that mini-
mized time in a fixator. Second, long duration of external
fixator pins are at risk for intramedullary sepsis if trans-
port over an intramedullary nail was to be performed.

After 9 months complications arose. Docking site
nonunion and pus discharge at the previous wound site
occurred. To address these issues, bone resection around
the docking site was done about 70 mm and anti-mixed
cement beads and block were inserted (Fig. 4). Six months
later, with no further infection symptoms and sign pres-
ent, laboratory test and re-transport was done. Cause this
patients defects was large (about 70 mm) and previous
large auto bone graft was done, we performed another
bone transport at distraction site. The corticotomy was
made at the distal tibia distraction site (Fig. 5). The dura-
tion of the second transport period was 82 days, the total
defect length was 70 mm, and our ex-fix index was 11.7
day/cm. After second transports, he was able to make a
full weight bearing approximately 9 months from time
of bone grafting. Solid radiographic union was obtained
approximately 2 years from the date of transport initia-
tion (Fig. 6). Paley-Marr functional score was good (mild
limitation in ankle range of motion) and the patient was
satisfied with his functional outcomes.

DISCUSSION

Tibial bone loss is a difficult problem to treat for the
orthopedic trauma surgeon. External fixation with and
without bone grafting, the Papineau technique, vascular
pedicle grafts, induced membrane techniques, and dis-
traction osteogenesis are all described techniques for deal-
ning with these difficult problems. Autogenous bone grafts
have been used for the management of bone defects up to
8 to 10 cm [5,6]. However, this method requires large vol-
umes of graft, which brings donor site problems such as
pain and hematoma. For the more it takes a long time for
union and weight bearing. Stress fracture and junctional
nonunion is common [7].

The mean success rate for segmental bone defects
treated by free vascularized bone graft is 69% and 15% of
the cases required secondary surgical treatment [8]. It is
worth noting that this procedure requires microsurgery
techniques and long-term immobilization and bracing,
which in themselves stress fracture risk at the graft site.

Masquelet et al. [9] reported a series of 35 cases of bone
reconstruction of large diaphyseal defects performed in
two stages. In weight bearing on diaphyseal segments nor-
mal walking was possible at 8.5 months on average.

Distraction osteogenesis, dynamic process of bone for-
mation in which new bone forms in a bone gap through
slow distraction, was suggested by Ilizarov for the treat-
ment of segmental bone defects. It can be done for large
defects greater than 10 cm. The treatment of bone defects
by callus distraction is a biological method. Advantages of
this technique include the ability to correct deformity and
lengthen an extremity simultaneously, eliminating donor
site morbidity seen with autologous grafting techniques or
free tissue transfer, the ability to treat massive defects, and
the ability of the patient to bear weight with an external
fixator during treatment. However, complications of this
procedure include pin tract infections, broken wires, joint
contractures, junctional nonunion, and malunion. Dis-
traction osteogenesis, using Ilizarov technique, requires
almost 2 months in fixation for every centimeter of defect
reconstructed in a single-level transport [10,11].

Bone transport using a monorail fixator over an in-
tramedullary nail is a technique that has been used with
success by multiple authors. Advantages of this technique
are multiple. A statically locked intramedullary nail
maintains anatomic length and alignment and ensures
subsequent docking of the transported segment. The in-
creased stability of the intramedullary device reduces the
stability required by the external fixator. Interlocking of
the transported segment allows protection of the regener-
ated callous and compression at the docking site. Finally,
the external fixation device can be removed once docking
has occurred, thus greatly reducing the total time a pa-
tient is required to be in a frame with lengthening indices
reported of just under 1 month per centimeter lengthened
[12]. However, concern for increased infection rates with
this method of transport still exist if performed after a
prolonged period of external fixation. In 2009, Oh et al.
[13] described their method of limb lengthening using a
submuscular locking plate and a unilateral external fixa-
tor. Limb lengthening was performed in 10 patients who
were unsuitable for limb lengthening over an intramed-
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ullary nail. The authors’ indications for lengthening using this technique were skeletal immaturity, bony deformity, narrow intramedullary canals, and joint contracture. Target length was achieved in all their patients (mean of 4.0 cm) and their mean duration of external fixation was 61.6 days (45-113 days). They concluded that limb lengthening with a submuscular locking plate can successfully be used in children with anatomy not suitable for nailing [13].

Our case exhibited bone transport over the plate. This technique reduces the external fixation periods and procedural stages. But still, infection and nonunion at the docking site are major complications of this technique. In cases of segmental bone defect of the tibia where the cause is an initial high energy injury (open contaminated wound) and there is compromised soft tissue, given the nature of these injuries and despite the use of appropriate tissue transfers and other wound coverage, the risk for nonunion at the docking site is high.

In our case, where even the pin site for transport was clean, infected nonunion developed. The reason of infected nonunion may be derived from initial open contaminated wound and incomplete removal of contaminated soft tissue and bone. When performing this technique, thorough debridement of contaminated wound and a clean pin site is necessary. We advise to always be cautious about infection and to keep the patient informed of this.

In conclusion, with the bone transport over the plate method, treatment of segmental bone defects can obtain biological bone consolidation and does not require immobilization. Be aware of infection and nonunion and thorough debridement of contaminated wound and care of the pin site is needed. Corticotomy at the distraction site is one of the safest techniques in distraction osteogenesis and is one option to treat complications.

REFERENCES