CASE REPORT

Management of large segmental tibial defects using locking IM nail and absorbable mesh

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SUMMARY

Tibia accounts for the majority of open fractures with long segmental defects. The management of such defects imposes several challenges due to their associations with extensive soft tissue damage and high infection risk. In this report, we describe a new technique for the reconstruction of tibia in a young patient with 10 cm defect. The patient had a history of Gustilo Anderson type IIIB open fracture following a motorcycle accident. He was initially managed with multiple debridements and application of an external fixator. The defect was treated with the insertion of an antibiotic-coated intramedullary nail along with posterolateral bone grafting using an absorbable mesh. Six months postoperative, radiological assessment showed excellent callus formation diffusely around the intramedullary nail along with optimal alignment. The preliminary follow-up data are quite encouraging and the technique described in our case can be considered as a reasonable option in managing long segmental bone defects.

his large tibial defect. The patient had a history of significant bone loss in his right tibia following a Gustilo Anderson type IIIB open tibial fracture in a motorcycle accident in January 2012. He was

BACKGROUND

It is estimated that fractures with significant bone loss account for 0.4% of fractures in patients admitted to hospital and 11.4% of all open fractures. Because of its site and position, tibia accounts for two-thirds of such fractures.¹ Tibial fractures with extensive segmental bone loss are often associated with significant soft tissue loss and impose great challenge for orthopaedic surgeons. The bone loss usually results from high-energy injuries; road traffic accidents, motorcycle crashes and falls from heights.²

There are several treatment approaches that can be considered in the management of large segmental tibial defects including various types of bone grafting, bone transport with distraction osteogenesis and amputation. The effectiveness of these operative techniques has been reported with considerable variation among clinical studies.³⁻⁴

A few recent studies have reported the success of using a titanium mesh cage and a resorbable polymeric membrane with bone grafting for the management of tibial fracture with segmental bone loss.³⁻⁵ In this case report, we present the advantages and challenges of managing a 10 cm tibial defect using an absorbable mesh, posterolateral bone grafting and an intramedullary locking nail.

CASE PRESENTATION

A healthy man in his early 20s presented to our hospital in October 2012 for the management of

Figure 1 (A) Anteroposterior and (B) lateral view X-rays show 10 cm tibial defect with a Taylor spatial frame in place. The distal fragment is 4 cm in length while the proximal fragment is approximately 26 cm.

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initially treated at the trauma hospital with multiple debridements and application of a Taylor Spatial Frame along with 4 cm acute limb shortening which left his tibia with 6 cm segmental defect.

The patient underwent multiple plastic surgical procedures including gastrocnemius muscle flap and skin grafting. The patient was managed in another centre where the foot frame was adjusted to achieve a plantigrade foot position. Flexor tenotomy of all right foot toes was performed followed by K-wires fixation in the neutral position to protect the toes from flexion contractures during limb lengthening to restore the 4 cm of shortening.

At the presentation to our institution, the patient was healthy with no other medical problems. He was a non-smoker and was on no regular medications. The patient had a Taylor Spatial Frame on his right lower leg with two proximal and one distal rings plus foot frame. Neurological and vascular status of the right lower limb was normal. Anteroposterior and lateral X-rays were taken which showed a 10 cm right tibial defect (figure 1).

Various treatment options were discussed with the patient including bone transport using the classic Ilizarov technique and

insertion of an antibiotic coated nail into the tibia and utilisation of an absorbable mesh with the autologous graft across the defect. The patient decided to proceed with the intramedullary nailing technique and bone grafting.

TREATMENT

The operation was performed in December 2012.

Surgical procedure

Under general anaesthesia, both legs were prepped and draped in a standard fashion to the level of the hip. The patient received 1 g of rocephin intravenously as well as 500 mg of tranexamic acid prior to surgery. We made a 2 cm incision proximal to the right greater trochanter and then used the awl to enter the trochanter and passed a guide wire down it. We used the RIA (Reamer/Irrigator/Aspirator)⁶ bone grafting system from Synthes using a 12-mm reamer from the right femur. We took approximately 120 cc of excellent bone graft. We then proceeded to collect another 150 cc of bone graft from the left femur (figure 2).

Figure 2 (A) Excellent autologous bone graft was obtained from both femurs using the Reamer/Irrigator/Aspirator system. (B) The preparation of the antibiotic nail.

Figure 3 (A) The insertion of the antibiotic nail. (B) The nail in place and the insertion of the absorbable mesh.

At this point, the patient received another 1 g rocephin followed by 1 g vancomycin and 160 mg gentamicin. Two 6 mm half pins were placed in the lateral proximal tibia and attached to a monotube clamp. Another monotube clamp was attached distally to 10 mm threaded rods which were connected to holes in the foot plate. This maintained our length and rotation and allowed us to remove the proximal rings as well as the distal ring with the exception of the foot ring. We measured the tibia and it was elected to use a 10 mm titanium meta tibial nail from Smith & Nephew with a 34 cm length.

We mixed two packages of Simplex cement with 320 mg gentamicin + 3 g vancomycin powder. The liquid cement was then injected into tubing and the 10 mm titanium nail was inserted into the tubing to coat the nail with antibiotic cement. We drilled three distal locking holes and left the proximal holes free from the tubing. We then made a 2 cm incision in the patellar tendon immediately proximal to the tibial tubercle. We did sequential reaming to 13.5 mm in the proximal fragment. We then took our nail and passed it through the proximal fragment

and then gently pushed it through the soft tissues to line up with the distal fragment. The nail was placed 5 mm from the ankle joint. We placed three 5 mm locking screws in the three distal locking holes and an additional three 5 mm locking screws in the proximal locking holes.

We then removed the monolateral fixator, and decided that the stability was reasonable enough to leave the fixator off. We proceeded to remove the foot frame as well as all the wires in the five toes. We placed the leg in a slightly lateral position to enable us to mark the posterolateral border of the skin graft site and we used this as the distal portion of our posterolateral incision and extended it proximally to the midfibular region.

Subsequently, we developed a plane between the soleus and peroneal muscles to expose the fibula and subperiosteally clear the fibula of any soft tissues to promote bone grafting. We started proximal to the defect where there was normal tibia and developed the fascial plane between the fibula and tibia to expose the posterior aspect of the distal end of the proximal fragment of the tibia. There was considerable scar tissue in this

Figure 4 (A) Anteroposterior and (B) lateral views of the patient right leg postoperatively showing excellent alignment.

Figure 5 (A) Anteroposterior and (B) lateral X-rays at six months post operatively, show excellent callus formation across the tibial defect and bridging the fibula.

Table 1 Comparison of the advantages and limitations of various treatment options in segmental bone loss tibial fracture

Treatment options	Advantages	Limitations
Distraction osteogenesis	<ul style="list-style-type: none"> Widely used procedure with high successful rate More cost effective than bone grafting⁸ 	<ul style="list-style-type: none"> Lengthy procedure High complications rate including infections and failure of docking site union⁹
Autologous bone grafts	<ul style="list-style-type: none"> Shorter healing time than distraction osteogenesis Lower risk of rejection than allografts 	<ul style="list-style-type: none"> Complications include malunion, non-union, graft fracture and infection¹⁰ Several surgeries may be needed to achieve the desired outcome¹¹
Structural allografts	<ul style="list-style-type: none"> Stability achieved earlier than other procedures¹² 	<ul style="list-style-type: none"> Very high risk of infection and complication Supply demand Used primarily for cancer reconstruction cases
Amputation	<ul style="list-style-type: none"> Radical treatment with shorter rehabilitation time Can prevent worse outcome like disseminated infection and death 	<ul style="list-style-type: none"> Patient disability Poor quality of life¹³

area and we were able to carry on distally along the antibiotic impregnated nail to the level of the proximal end of the distal tibia. We cleared the tissues laterally, anteriorly and posteriorly to the distal 2 cm of the proximal tibia and the same area of the distal tibia.

We then took a 10×10 cm absorbable mesh from KLS Martin⁷ and placed it in a hot water bath to mould it in a cylindrical fashion (figure 3). The mesh is made of PDLLA (poly-d-l lactic acid) and is expected to be fully absorbed within 12–24 months. We attached sutures to the graft and then using right angle clamps, pulled the sutures anteromedially around the nail and then dragged the mesh around so that the mesh was continuous from medial to the fibula and around the nail coming out posteriorly. We then took our bone graft from the two femur reamings and packed them from the proximal to the distal tibia and circumferentially around the nail with the mesh holding into position. We extended the graft across to the posterior aspect of the fibula. A #1 vicryl was used to loosely close the peroneal and soleus muscles.

OUTCOME AND FOLLOW-UP

The patient was kept in the hospital for 1 week. Postoperatively, he was mobilised with crutches non-weight bearing in a long leg cast. All of his wounds were clean and healthy. X-rays were taken 2 days following the surgery (figure 4).

Two weeks postoperatively, the patient presented with a sero-sanguineous dark brown discharge from the distal aspect of the wound. The patient was seen in the emergency room and blood tests like complete blood count, C reactive protein, erythrocyte sedimentation rate (all normal), culture and sensitivity were performed. The patient was admitted to hospital for 5 days. Intravenous antibiotics were given and dressings were changed daily. Culture and sensitivity results showed *Pseudomonas aeruginosa*. The infection resolved within a few days. The patient was sent home on oral ciprofloxacin for 1 week.

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Figure 6 The patient's leg before and after surgery.

Six weeks following the surgery, the patient's long leg cast was removed. The patient had no pain or drainage. He was advised to continue to be non-weight bearing and to use removable Vacoped boot.

Three months postoperatively, the patient was comfortable, his wound was completely healed and his knee and ankle were quite stable. The patient was advised to return to full weight-bearing and encouraged to move his right ankle along with several physiotherapy sessions to strengthen his muscles. figure 5 shows anteroposterior and lateral X-rays of the right tibia 6 months following the surgery.

DISCUSSION

Reconstruction of post-traumatic large bone defects is often quite difficult and challenging especially when associated with extensive soft tissue damage and infection. Several treatment options are now considered in the management of long segmental tibial fractures including bone grafting both autologous and allogeneic, distraction osteogenesis using the Ilizarov technique and amputation. Each of these techniques has its own pros and cons (table 1) and has variable outcomes depending on the fracture type, degree of bone loss and patient condition.

Attias *et al*³ and Cobos *et al*⁵ have reported the success of using a titanium mesh cage with autologous iliac crest bone graft in managing five cases of tibial fractures with bony defects of 8–12 cm.

Traditionally, the iliac crest was considered to be the 'gold standard' source of bone graft material. However, it has been shown to be associated with a high rate of complications including donor site morbidity and pain, nerve injury and infection.¹⁴ Recently published papers have favoured the use of RIA to harvest the autologous bone graft from the femur or the tibia over the conventional iliac crest harvesting.¹⁵ The RIA system was proved to be safer and of a better biological content. It also provides more copious amounts of bone graft making it a better source of autologous graft in constructing long bone defects.¹⁶

The use of absorbable membranes in managing bone defect is widely established for periodontal and craniomaxillofacial surgeries. Several animal studies have supported the efficacy of using them in managing segmental bone loss.¹⁷ Meinig *et al*⁴ reported the success of using a resorbable polylactide membrane with internal fixation in the treatment of multiple cases with segmental bone defect.

In our case, we aimed to combine three important and recent concepts in managing the patient's large tibial defect: first posterolateral tibial bone grafting which provides greater vascularity and healing due to the larger muscle soft tissue envelop along with the advantage of grafting to the fibula for more stability. Second, the bone grafts were obtained using the RIA system from both femurs providing a large amount of excellent graft. Finally, we used an absorbable mesh in holding the bone graft around the antibiotic coated nail and this can provide better healing and outcome since it allows less interference with bone vascularisation than in using titanium or other non-absorbable mesh cages.

Despite its encouraging results, this technique can be associated with some risks including infection and long operative time which can predispose the patient to deep venous thrombosis. Despite the highly strict hygiene guidelines in our hospital and high infection control measures which were taken into account during the operation, the patient developed *P aeruginosa* infection in 2 weeks postoperatively. Fortunately, the infection appeared to be superficial and the patient recovered completely within 4 days.

In managing complex conditions as the one described in our case, one of the important factors that are needed to be taken into account is the patient's psychological status. Long-term disability with potential risk of losing the person's leg can have substantial effect on the patient mental status especially in young patients in their early 20s and 30s. In our case, the patient was happy to do a single procedure that allowed early range of motion of the ankle and reduced his time in a circular external fixator by at least 1 year. figure 6 shows photographs of the patient's leg before and after surgery.

Learning points

- ▶ The technique described in our case can be considered as a reasonable alternative in managing long segmental bone defects.
- ▶ There is lack of high-quality clinical studies exploring the efficiency of absorbable and non-absorbable mesh cages with bone grafting in managing complex tibial bone defects.
- ▶ Individualising the treatment and taking into consideration the patient's psychology are essential in managing these kinds of cases.

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Competing interests None.

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