The femur: a good alternative source of bone graft using a new reamer system when options run out

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ABSTRACT Following a post-traumatic incident, orthopaedic surgeons often struggle to look for an abundant source of alternative bone graft because the bone defect is too big or when nonunion is refractory to treatment. We present two cases where the patients' bone grafts were harvested from the healthy femur. This process involved the use of a new intramedullary reamer, which allowed the bone graft to be harvested simultaneously during the reaming process.

Keywords: bone defect, bone graft, chronic osteomyelitis
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INTRODUCTION

Bone grafts are traditionally taken from sites such as the fibula and pelvis. When large amounts of graft are needed, whether for repeat procedures or in primary surgery, the alternative has been to use allografts or synthetic bone substitutes, both of which have problems associated with their use. We present the femur as an alternative source of bone graft, obtained through the use of an integrated reamer/irrigator/aspirator, and demonstrate its use and complications in two cases of reconstruction after complex trauma.

CASE REPORTS

Case 1

A 27-year-old Nepalese man, a motorcyclist who was involved in a head-on collision with another motorcyclist in Nepal on November 5, 2008, sustained an open fracture of the left tibia. He was sent to a local hospital where the wound was debrided and an external fixator was applied. He was evacuated by air to Singapore as he was working as a Gurkha policeman for Singapore then.

The patient's first hospitalisation in Singapore was to address the extensive soft tissue injury, including skin loss over the region of the left proximal tibia, which measured 20 cm × 30 cm. Radiographs of the patient, taken at initial presentation show the loss of the entire anterolateral and anteromedial proximal tibial cortices (Fig. 1a). He then underwent multiple debridements and negative pressure dressing for his open fracture (Fig. 1b). A month later, the patient's own medial gastrocnemius muscle was used as a pedicle flap to cover the posterior proximal tibial cortex, and a split-thickness skin graft was grafted over the flap donor site (Fig. 2). Radiographs in Figs. 3a & b show the developing tibial nonunion in the third and sixth months post injury, respectively. The external fixator was removed in the fourth month and changed to a full cast.

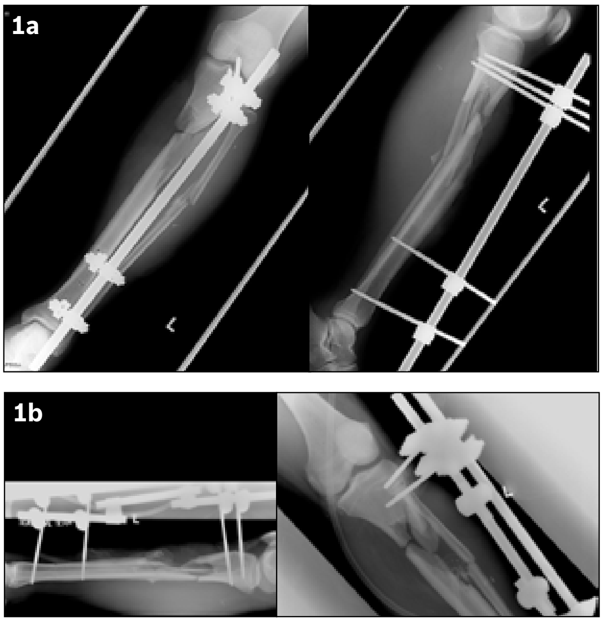

Fig. 1 Case 1: (a) Radiographs of the tibia and fibula taken at initial presentation show the external fixator inserted in Nepal. (b) Anteroposterior and lateral radiographs show the tibia and fibula after multiple debridements and negative pressure dressing.

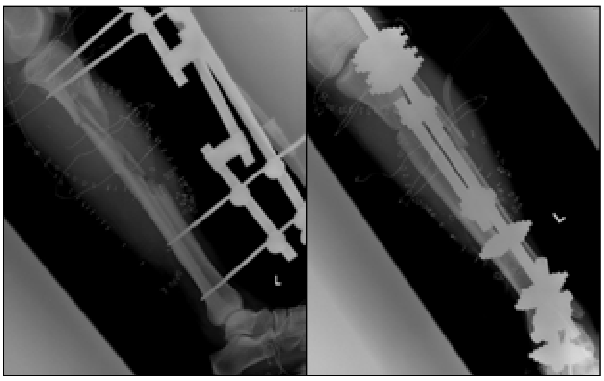

Fig. 2 Case 1: Radiographs taken one month after initial presentation show the anteroposterior and lateral views of the tibia and fibula following soft tissue reconstruction using a gastrocnemius flap.

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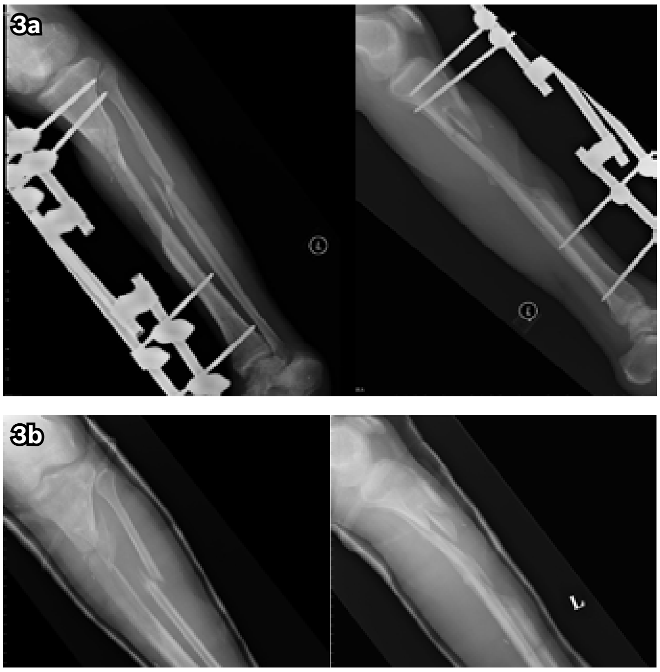

Fig. 3 Case 1: Radiographs following soft tissue reconstructive surgery, taken at (a) three and (b) six months post discharge, show the developing nonunion of the tibia and fibula.

Fig. 4 Case 1: Preoperative photograph shows the patient's left tibia with the healed gastrocnemius flap.

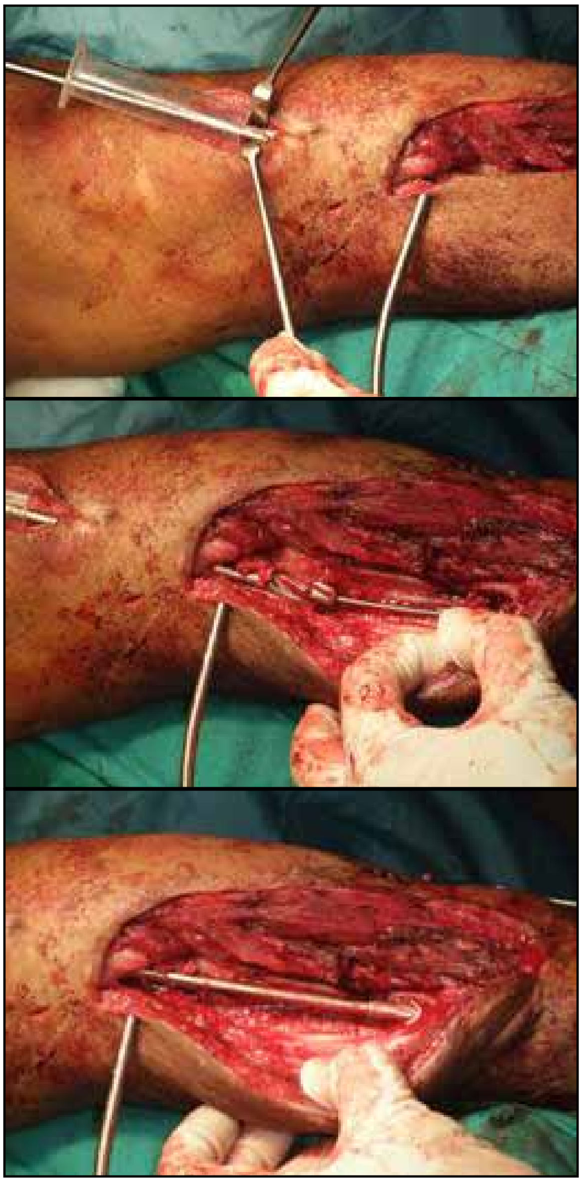

Fig. 5 Case 1: Operative photographs show the introduction of a standard reamer from the proximal to distal segment of the tibia, with the guidewire *in situ*.

The patient eventually agreed to an open reduction and reconstruction of the tibial nonunion eight months after his injury. Fig. 4 shows the preoperative state of the lower leg with the well-healed gastrocnemius flap. The surgery was performed via an anterolateral approach, by lifting up the previous gastrocnemius flap while taking great care to preserve its vascularity. The fracture nonunion site was debrided thoroughly, as fibrous tissue had become stuck in the medullary canal. We proceeded to introduce the guidewire in a retrograde fashion, and the medullary canal was reamed to size (Fig. 5). We concurrently harvested bone graft from the ipsilateral femur using the integrated intramedullary reamer.

Approximately 100 mL of bone graft from the femur was harvested to fill the huge cavity that resulted from bone loss of the anterolateral and anteromedial proximal tibial cortices (Fig. 6). The harvested bone graft was more than sufficient to fill the cavity. The patient was able to regain stable motion, within the range of 0–110 degrees. His wounds have also healed. The final radiographs (Fig. 7) illustrate the reduction and intramedullary fixation with the harvested bone graft *in situ*. The patient was discharged home with partial weight-bearing using crutches.

Case 2

On December 14, 2007, a 53-year-old Chinese man, who was the driver of a car in a head-on collision with a minivan, sustained multiple injuries after the accident. His injuries included a closed comminuted segmental fracture of the right femur, aortic dissection, flail chest and pan-facial fractures. Fig. 8a shows the initial radiographic findings of the right femur. The patient underwent damage control stabilisation with external fixator to the fractured femur (Fig. 8b) due to his unstable haemodynamic condition. The patient subsequently underwent definitive fixation with a distal femoral locking plate using a bridging

Fig. 6 Case 1: Operative photograph shows the harvested bone graft being packed into the cavity at the nonunion fracture site.

Fig. 7 Case 1: Radiographs show the reduction and intramedullary fixation, with the harvested bone graft *in situ*.

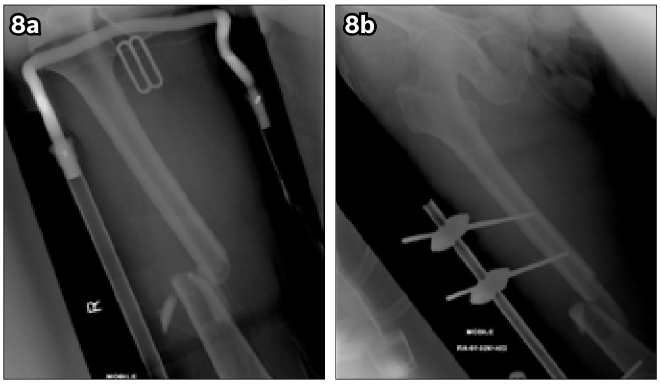

Fig. 8 Case 2: (a) Anteroposterior radiograph taken as the patient was ushered to the operating room shows fracture of the right femur. (b) Radiograph shows the patient's right femur after external fixation.

Fig. 9 Case 2: Radiographs show the patient's right femur fracture after bridge plating.

technique (Fig. 9). However, this was complicated by nonunion and loosening of the implants (Fig. 10). As a result, he underwent autogenous bone grafting and application of the external fixator on July 4, 2008, which was unfortunately complicated by osteomyelitis (Fig. 11). He received prolonged intravenous antibiotics and underwent repeated debridements.

After normalisation of the patient's inflammatory markers and presumed infection control, the fibrous union was removed and an intramedullary nailing was inserted with an antibiotic cement spacer on March 25, 2009 (Fig. 12). This was done to promote capsular sheath formation around the cement, which has been touted by Masquelet[1] to have osteogenic potential. On July 7, 2009, we harvested bone graft from the patient's contralateral femur using the integrated reamer. The cement spacer was carefully removed via a longitudinal slit incision made in the capsule that encased the cement. After careful dissection and removal of the cement, the harvested bone graft was packed into the large bone gap. Fig. 13 shows the postoperative radiographs of the patient's right femur after the procedure. The patient was discharged home well with no morbidity or pain from the donor site. His wounds have also healed.

DISCUSSION

The reamer (Fig. 14) used in the two cases presented here is manufactured by Synthes, and its technical guide states that *"the technique for use of the integrated reamer is very similar to that of standard femoral intramedullary nailing of the femur. The use of a traction table is optional, but a radiolucent table is an absolute necessity."* The patient is typically placed in a supine position on the table and exposed from the midriff downwards. After standard cleaning and draping, the skin incision is marked out at a point indicated by the bisection of a line drawn from the anterior superior iliac spine to the operating table, with a line along the lateral side of the long axis of the femur, passing through the tip of the greater trochanter. An incision of length 4–5 cm is made longitudinally. The subcutaneous fat and fascia are split, and the greater trochanter is located. The greater trochanteric entry point is utilised and opened with standard entry techniques.

Fig. 10 Case 2: Radiographs show nonunion and loosening of the implants six months after plating.

Fig. 11 Case 2: Radiograph shows the right femur after application of the external fixator and bone grafting.

Fig. 12 Case 2: Radiograph shows the inserted intramedullary nail, with a cement spacer gap left *in situ*.

Fig. 13 Case 2: Postoperative radiographs show the patient's right femur.

Fig. 14 Photograph shows the reamer/irrigator/aspirator system.

A long guidewire is then threaded into the femoral canal. The position of this wire is checked with an image intensifier to ensure that it is well-centred.

The length and width of the medullary canal are measured to determine the appropriate length of the reamer tubing and the width of the reaming tip. At this point in time, theatre assistants set up the reamer based on the dimensions obtained. There are two tube assembly lengths available – 360 mm (used in femurs shorter than 350 mm) and 520 mm (used in femurs longer than 350 mm). Before reaming can commence, it is important to attach the irrigation bags and collecting canister. The reamer is then advanced into the medullary canal in the standard fashion, with the patient's skin protected. Irrigation and aspiration can commence once the reamer/aspirator tip is seen on the image intensifier to be inside the medullary canal. Proceduralists are cautioned against reaming when there is no irrigation or aspiration as this cools the reamer heads and removes the harvested bone graft from the medullary canal. Periodic checks to ensure that the reamed graft is aspirated into the collection canister should be conducted, with reaming to be stopped when no aspiration is detected. Reaming can stop once the desired depth/amount of graft has been harvested. Irrigation should be stopped once the reamer has been withdrawn from the patient's femur. Harvested bone can then be retrieved from the collection canister, which incorporates a filtration device and measuring scale. A plunger is carefully inserted to prevent spillage and to compress the collected bone graft within the canister. The inner filter can then be removed together with the bone graft. This is then expressed into any appropriately sized container, ready for use.[2]

In treating patients with large bony defects, important considerations include the restoration of length and alignment, as well as reconstruction of the bony defect. Traditional methods of treating such injuries include standard bone graft harvest, implantation techniques, bone transport with the use of an Ilizarov frame and even below knee amputations. Bone transport procedures and below knee amputations come with their own sets of limitations and problems that are beyond the scope of this paper to discuss. Traditional bone grafting techniques with internal fixation for such large bony defects frequently present the challenge of a lack of an abundant source of suitable bone graft, especially in situations where bone has already been harvested from the usual donor sites.

The integrated reamer/irrigator/aspirator system used in our patients provides a unique advantage that allows us to overcome these challenges. This system allows for the simultaneous reaming and harvesting of bone from the intramedullary cavity of the femur, from either the affected or the contralateral leg, which thus far has not been a source of bone graft.[3] With the use of this reamer, a large quantity of finely morselised, autogenous bone graft, which is frequently more abundant than what would normally be obtained from iliac crest bone harvesting, can be obtained with relative ease. This can sometimes prove to be invaluable, especially in cases where the iliac bone has already been used in treating either the primary injury or other concomitant injuries that require bone graft harvest, such as in Case 2. In addition to the large source of potential bone graft, the bone produced seems to result in biomechanically superior callus formation (at least in laboratory studies) – a property that can only prove beneficial.[4] The reamer has the additional advantage of having an integrated irrigation system, which allows for a lower intramedullary pressure and temperature.[5-7] Essentially, this translates to lower rates of bony necrosis, and hence, better and greater volume of viable bone for grafting, as well as the added beneficial side effect of lower rates of systemic fat embolism. This is useful if this system is used as the reamer in the intramedullary fixation of fractures, such as in Case 1.

In conclusion, pelvic crest bone graft harvesting is the gold standard, but the need for a separate incision, as well as limitations in the amount of bone that can be safely harvested, means that we sometimes remain limited in our ability to deal with large bony defects. With the use of the integrated reamer/irrigator/aspirator system, there is a marked increase in the pool of bone open to harvesting for grafting.

REFERENCES

1. Pelissier PH, Martin D, Baudet J, Lepreux S, Masquelet AC. Behavior of cancellous bone graft placed in induced membranes. Br J Plast Surg 2002; 55:596-8.
2. Reamer/Irrigator/Aspirator (RIA) – Synthes. In: Synthes Holding [online]. Available at: http://www.synthes.com/sites/NA/Products/Trauma/IntramedullaryNailingSystems/Pages/Reamer_Irrigator_Aspirator_RIA.aspx. Accessed January 29, 2013.
3. Nichols TA, Sagi HC, Weber TG, Guiot BH. An alternative source of autograft bone for spinal fusion: the femur: technical case report. Neurosurgery 2008; 62(3 Suppl 1):E179.
4. Hammer TO, Wieling R, Green JM, et al. Effect of re-implanted particles from intramedullary reaming on mechanical properties and callus formation. A laboratory study. J Bone Joint Surg Br 2007; 89:1534-8.
5. Van Gorp CC, Falk JV, Kmiec SJ Jr, Siston RA. The reamer/irrigator/aspirator reduces femoral canal pressure in simulated TKA. Clin Orthop Relat Res 2009; 467:805-9.
6. Husebye EE, Lyberg T, Madsen JE, Eriksen M, Røise O. The influence of a one-step reamer-irrigator-aspirator technique on the intramedullary pressure in the pig femur. Injury 2006; 37:935-40.
7. Higgins TF, Casey V, Bachus K. Cortical heat generation using an irrigating/aspirating single-pass reaming vs conventional stepwise reaming. J Orthop Trauma 2007; 21:192-7.