Fresh osteochondral allograft with soft tissue reconstruction for open knee trauma: A 20-year follow-up

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Accepted 15 November 2015; published online XXX

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Reconstructive intra-articular surgery for young active adults with significant bone loss is a complex problem. In patients deemed too young or active for joint arthroplasty, or when there is significant post-traumatic bone loss, bulk osteochondral allograft may be the most appropriate surgical option.

We present the case of a fresh osteochondral allograft (FOCA) of the lateral femoral condyle of the knee with soft tissue reconstruction, which survived for 20 years before subsequent simple conversion to a total knee arthroplasty (TKA).

The case

A 36-year-old male was involved in a road traffic accident in August 1991. He was riding a motorcycle at approximately 30 miles per hour (mph) that was hit by a car travelling at approximately 70 mph. He presented with multiple injuries, the most significant of which included a right open tibial fracture, and a right open femoral shaft and displaced lateral femoral condyle fracture. The tibial fracture was treated with an external fixator, debridement and delayed closure, while the femoral fracture was treated with skeletal traction. Traction was chosen due to the complexity of the injury and the presence of an ipsilateral total hip replacement, following a previous motorcycle accident 9 years earlier.

The patient recovered well from his injuries, but had persistent right knee pain and immobility due to non-union of the malaligned distal femoral fracture (Figure 1). The patient was referred for a second opinion to determine whether reconstruction was possible. Above-the-knee amputation had been discussed with the patient at his local institution.

In October 1992, a fresh bulk allograft from a cadaveric donor was used to reconstruct the patient's lateral femoral condyle, lateral meniscus, anterior cruciate ligament (ACL) and posterolateral soft tissue structures. The allograft was

harvested and transported directly to the operating theatre prior to implantation. The allograft was fixed using two cortical and three cancellous screws via a lateral parapatellar approach (Figure 2). The soft tissue structures were reconstructed, the donor ACL was sutured to the tibial remnants of the recipient ACL, and the lateral structures and meniscus were sutured through osseous tunnels to the surrounding soft tissues. The knee was mobilised, albeit protected by an ischial bearing calliper until bony union had occurred. At 3-month follow-up, the patient had a stable, pain-free knee with 0–120° of flexion. In 1999, a knee arthroscopy was performed to remove a symptomatic loose body and the knee recovered well. In August 2012, the patient complained of a grating feeling, pain within the joint and a limited exercise tolerance of 8 miles (his range of movement was preserved).

On 18 October 2012, a right TKA was performed on a stable knee, 20 years after the initial surgery. The procedure was undertaken through the original scar and a medial parapatellar approach was used, with quadriceps snip to aid exposure. All metalwork was removed and intramedullary referencing used for the femoral cuts. On entering the knee, the host medial femoral condylar cartilage and donor lateral condylar cartilage appeared identical macroscopically, with no obvious distinctions. Both condyles demonstrated Outerbridge grade 4 change, with areas of full thickness cartilage loss (Figure 3).¹ During preparation of the distal femur, it was macroscopically difficult to distinguish host and donor bone, with both solidly integrated with the bleeding surfaces (Figure 4). Microscopically, the bone tissue (Figure 5) showed good incorporation between the previous allograft and host osseous tissues. However, residual empty osteocyte lacunae were present, with evidence of osseous remodelling. Features of creeping substitution and bone replacement, alongside local fibrosis, were present in the form of osseous metaplasia, primarily around the blood vessels. The cartilage remained viable, despite some cartilaginous metaplasia,

Figure 1 Anteroposterior and lateral radiographs of the right knee at 6 months post-injury demonstrating non-union of the avascular lateral femoral condyle and pin sites from previous external fixator to the tibia.

Figure 3 Intraoperative photograph of the total knee arthroplasty at 20 years post-FOCA. Grade 4 chondral change is seen, demonstrating a well-integrated graft with viable cartilage and an intact (reconstructed) anterior cruciate ligament.

Figure 2 Anteroposterior and lateral radiographs 3 months post-FOCA demonstrating radiological union at the host-graft interface.

Figure 4 Cut surfaces of the femur showing macroscopic integration of the graft and host bone.

along with degeneration and surface cartilage fibrillation loss. No evidence of sepsis or neoplasia was seen.

Discussion

The use of FOCA for traumatic bone loss can have good long-term outcomes.² We show excellent clinical results for a large FOCA with soft tissue reconstruction for open trauma, where the only other treatment options offered to the patient at the time were fusion or above-the-knee amputation.

Successful treatment with FOCA relies on osseous and cartilaginous tissue viability, with the time from harvest to implantation and the stability of the construct vital. In this case, the team carrying out the reconstruction were also involved in graft harvest. The cadaveric donor was in a neighbouring hospital 14 miles away, and the patient lived 98 miles away, which meant that the patient could be brought to our institution within 3 hours and the surgical team could reach the cadaver for harvest within 1 hour. Consent had been obtained from both the deceased and their next of kin. The donor had undergone routine screening for transmissible diseases, including HIV types I and II and hepatitis B and C. The graft was harvested under sterile conditions.

Chondrocyte viability is directly related to graft preservation techniques and time to implantation. Fresh allograft achieves favourable long-term outcomes compared with cryopreserved grafts due to the latter's early chondrocyte loss.⁵ However, the use of fresh allograft is limited by the availability of a suitable donor and its reliance on a highly

Figure 5 Composite photomicrograph of histology: (1) Established and mature bone (B) is seen, with many empty osteocyte lacunae. Fragmentary cartilaginous surface tissue (C) is seen adjacent ($\times 40$). (2) Osseous metaplasia (om) is seen extending into devitalised cartilage around blood vessels (bv) ($\times 100$). (3) Around the blood vessels is a loose connective tissue matrix with rimming osteoblasts. Replacement of bone with viable osteocytes is noted, with many nucleated cells seen ($\times 100$). (4) Mature bone is seen, with many empty osteocyte lacunae (e) indicating dead bone, but with viable osteocytes (v) adjacent ($\times 100$). (All samples with an haematoxylin and eosin stain.)

organised transplant service. Risk of infection is also a concern, with levels of viral transmission comparable to those seen in packed red blood cell transfusion (1/500,000 for HIV, 1/100,000 for Hepatitis C and 1/60,000 for Hepatitis B).^{4,5}

Rigid fixation using a mix of cancellous and cortical screws, a harvest to implantation time of less than 24 hours and a well-sized FOCA matched to the recipients anatomy enabled excellent long-term clinical results.⁵ The surgeon harvested the whole knee joint with the capsule intact to prevent contamination. At the time of reconstruction, the surgeon dissected the graft to reconstruct the donor's deficient skeletal and soft tissue anatomy. This included the ACL, lateral meniscus and posterolateral structures. At the 20-year conversion to TKA, these

reconstructed tissues were macroscopically present, stable and intact. Microscopically, the tissues of the ACL and meniscus were well integrated with the recipient tissues and, although degenerate, had an appropriate structure.

At 20-year follow-up, host-graft bony union was evident both clinically and radiologically. Histology demonstrated bone integration, with creeping substitution and viable chondrocytes. Osteoarthritis was evident in both the (host) medial femoral condyle and (graft) lateral femoral condyle. A TKA was performed on macroscopically normal bony architecture.

Conclusions

A well-fixed FOCA with soft tissue reconstruction implanted in a timely manner is an excellent option for a young adult patient with significant bone loss around the knee. This technique allows for restoration of function and the ability to return to everyday activities. The technique is limited by the need for a well-organised transplant network and the ability to implant the graft urgently. These factors, along with the very low risk of viral transmission, may limit its use in the general orthopaedic community. We recommend this technique for a select group of young, well-motivated patients in whom large metal implants would not offer appropriate clinical solutions.

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