Arthroscopic Lateral Meniscal Allograft Transplantation With the Key-Hole Technique

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Abstract: The efficacy of meniscus allograft transplantation (MAT) for the meniscus-deficient knee has been widely recognized as being excellent in terms of pain relief and functional improvement. Lateral MAT is usually performed with the bone bridge technique that uses a bone bridge connecting the anterior and posterior horns of an allograft. The slot position for the meniscal graft insertion is of great importance with the bone bridge technique, especially in the key-hole method. The purpose of this Technical Note is to describe lateral MAT using the key-hole technique in which an allograft with a bone bridge carved to accommodate the key-hole-shaped slot is properly secured to the slot.

Since the clinical results were reported after meniscal allograft transplantation (MAT) in 1989, numerous biomechanical, clinical studies about MAT have been published. MAT has been widely performed after total or subtotal meniscectomy in relatively young patients, and has been shown to reduce pain, improve function, and potentially delay the progression of cartilage degeneration.

Even though there are several graft fixation methods, it is known that bone fixation is superior to soft tissue fixation. Lateral MAT is usually performed with the bone bridge technique, because the anterior and posterior horns of the lateral meniscus are close to each other and there is a risk of tunnel communication in the bone plug technique using 2 tibial tunnels.

The slot position is of great importance with the bone bridge technique, especially in the key-hole method to restore the anatomic footprints of the anterior and posterior roots of the lateral meniscus. We describe the effective surgical technique of arthroscopic lateral MAT using the key-hole technique to secure the meniscal allograft to the slot and the peripheral rim properly (Video 1).

Surgical Technique

The surgical indications are shown in Table 1. Table 2 describes the pitfalls and tips of the present technique.

Intra-articular Preparation and Skin Incision

An arthroscope is introduced through the anterolateral portal, and a thorough examination is performed. The remnant meniscus is resected leaving 1 to 2 mm of bleeding peripheral rim, and the exact anterior and posterior root footprints are marked using an electrocautery (ArthroCare, Austin, TX). After diagnostic arthroscopy, a 4-cm longitudinal arthrotomy is made just lateral to the lateral border of the patellar tendon in line with the previous anterolateral portal. Then, a vertical incision is made using a routine posterolateral approach to expose the posterolateral capsule releasing from the lateral head of the gastrocnemius, and to repair the lateral meniscal allograft avoiding neurovascular injury. An elevator is used to release soft tissue adhesion between the anterolateral and posterolateral side to make the same interval.

Tibial Slot Preparation

The centers of the anterior and posterior root attachment sites are connected with a line using an electrocautery. With this line as a guide, a guide pin is inserted in the anteroposterior direction under the
lateral eminence of the tibial articular surface, and approximately 15° above the tibial slope (Fig 1). The guide pin inserted is confirmed to be positioned at approximately 8 mm under the articular surface of the lateral tibial plateau using C-arm fluoroscopy. After the guide pin, a 10-mm reamer (Arthrex, Naples, FL) is inserted to create a tibial hole (Fig 2). Then, a key-hole-shaped slot is made using our customized osteotome and dilator (Cellumed, Seoul, Republic of Korea) via the previous tibial hole (Fig 3). Beveling is arthroscopically performed at the posterior root area of the slot with a pituitary rongeur to achieve stable fitting of the allograft (Fig 4). Through an anterior arthrotomy, 2 suture passing wires with the loop positioned posteriorly for the leading suture for traction are passed through the posterolateral capsule in an inside-to-out fashion at superior and inferior of the remnant meniscus, and the ends of the suture passing wires are held by Kelly clamps (Fig 5).

**Graft Preparation**

Fresh-frozen and nonirradiated grafts are used in all cases, and graft size is determined preoperatively on anteroposterior and lateral radiographs with a scanogram for correction of magnification, as described in a previous paper. This modified method of measurement suggested that reducing the graft size by 5% using the method by Pollard et al. decreases the percentage of meniscal extrusion after MAT without any adverse outcome clinically or radiographically. The bone bridge that has a key-hole-shaped bone block is carved to match with the key-hole-shaped slot using a microsaw, rongeur, and burr on a back table. The posterior leading suture is placed 10 mm laterally from the posterior root for later traction and spreading using No. 2 Ethibond (Fig 6).

**Allograft Insertion and Fixation**

The graft, with the leading suture connected to the loop of each suture passing wire, is inserted into the joint through the anterior arthrotomy by pulling out the opposite side of the loop of the suture passing wire. The bone bridge is advanced into the key-hole-shaped slot, and the allograft is manually reduced under the condyle with a finger introduced via the arthrotomy under traction of the posterior leading suture through the capsule; finally, the whole lateral meniscus allograft is spread evenly (Fig 7). Occasionally, graft passage is facilitated by applying varus stress with the figure four position. Once the meniscal allograft is reduced, the knee is cycled 20 times to achieve its proper placement.
Viewing from the anterolateral portal, the posterior one-third and middle horn are repaired with 2 superior and 1 inferior obliquely arranged sutures in an inside-out fashion with double-armed needles containing nonabsorbable suture materials. Then, the leading sutures are tied on the capsule. This repair procedure allows the allograft to secure to the remnant meniscus and the capsule firmly. The anterior one-third is repaired with 3 or 4 direct sutures using No. 2 polydioxanone (Ethicon, Somerville, NJ) through the anterior arthrotomy in an outside-in fashion. Once graft fixation is confirmed with arthroscopy, the sutures are ligated. A final arthroscopic evaluation is performed to confirm the fixed posterior and anterior roots and tension of the entire lateral meniscus (Fig 8).

Discussion

The purpose of this Technical Note is to describe an arthroscopic lateral MAT with a key-hole technique. In carefully selected patients, MAT can restore nearly normal anatomy and biomechanics, provide successful pain relief, and improve function. A recent systematic review for MAT concluded that MAT successfully improved symptoms, function, and quality of life at 7 to 14 years of follow-up (Level IV evidence), and the overall failure rate is 10% to 29% at long-term follow-up. Kim et al. reported that the 10-year survival rate was 98.0% (95% confidence interval, 94.1%-100%), and the 15-year survival rate was 93.3% (95% confidence interval, 83.7%-100%) according to the Kaplan-Meier analysis after MAT.

In MAT, bone fixation better restores contact mechanics than soft tissue fixation, although there are no differences in pullout strength or functional results, and soft tissue fixation has more risk of graft extrusion than bone fixation. Even though soft tissue fixation alone is technically easier, several studies have reported that load transmission is superior when the graft is secured with bone fixation. In addition, Sekiya et al.
showed that the bony fixation group obtained significantly better range of motion than the suture fixation group at the final follow-up.

The medial and lateral menisci have distinct anatomic characteristics; the anterior and posterior horns of the lateral meniscus have a short distance between them, and there is a risk of tunnel communication in the bone plug technique using 2 tibial tunnels.\textsuperscript{11,14,15} Hence, lateral MAT has been preferred to perform the bone bridge technique that connects the anterior and posterior horns.\textsuperscript{14,17,18} There are several methods of the bone bridge technique including bone trough, key-hole, and dovetail techniques according to the configuration of the bone block and the tibial slot.\textsuperscript{6,7,17} Kim et al.\textsuperscript{18} suggested that the key-hole technique that provides firm press fit has superior stability even without pulling out sutures through the bone block to the proximal tibia than the bone trough technique. Regardless of the techniques, the tibial slot position is of great importance with the bone bridge technique, especially with the key-hole method.\textsuperscript{21,22} Anatomic placement of the meniscal allograft, especially of the anterior and posterior roots, is decisive for restoring biomechanics and improving longevity of the allograft (Table 2).\textsuperscript{11,22,23} A laterally centered slot would cause meniscal allograft subluxation as in the case of an oversized allograft, which leads to articular cartilage wear, whereas a medially centered slot would cause increased tension as in the case of an undersized...
allograft and could cause damage to the anterior cruciate ligament origin during drilling or beveling.\textsuperscript{21,22,24} Sekaran et al.\textsuperscript{25} revealed the nonanatomic placement of the posterior horn over 5 mm compared with the anatomic position that significantly altered the contact pressure, which may affect the ability to prevent cartilage degeneration. Choi et al.\textsuperscript{22} reported that the nonanatomic placement of the bone bridge was the main cause of midbody extrusion, and the midbody of the meniscal allograft would increase according to the degree of lateral placement of the bone bridge. They showed that the more closely the center of the bone bridge approached half of the whole tibial plateau, the less extrusion of the midbody occurred.\textsuperscript{22} Kim et al.\textsuperscript{23} supported that the relative anatomic positions of the anterior and posterior horns compared with the preoperative positions showed a mean change of less than 5 mm of absolute values and less than 5% of relative values in both the coronal and sagittal planes on magnetic resonance imaging after lateral MAT with the key-hole technique. However, they warned that the posterior horn could be slightly displaced more laterally in the coronal plane, because there is poor visualization of the posterior part, and interference by the guide and the posterior cruciate ligament made it difficult to place the guide medially.\textsuperscript{23} Differences in tibial posterior slope measurement are ranged from $15^\circ$ to $17^\circ$ on the lateral side, and from $5^\circ$ to $7^\circ$ on the medial side on the sagittal plane.\textsuperscript{26} Accordingly, the guide pin would be targeted to approximately $15^\circ$ higher than the horizontal surface of the tibial plateau during slot preparation (Table 2).\textsuperscript{21} We performed beveling at the posterior horn area of the slot with a pituitary rongeur trying to achieve more anatomic and stable fitting of the allograft (Table 2).

In conclusion, lateral MAT with the key-hole technique described here is an effective technique to restore relatively normal anatomy of the lateral meniscus and could be a curative procedure to delay articular cartilage degeneration.

Fig 7. (A) The bone bridge of the lateral meniscal allograft (black arrowhead) is advanced into the slot (black arrow) under traction of the posterior leading suture (white arrow) through the capsule on the right knee. (B) After the bone bridge (white arrow) of the lateral meniscal allograft (black arrow) is manually fitted via the arthrotomy under traction of the posterior leading suture, the whole medial meniscus allograft is spread evenly using the probe (white arrowhead).

Fig 8. Final arthroscopic evaluation viewing from the anterolateral portal is performed to confirm the fixed bone bridge (black arrow) of the right lateral meniscal allograft and tension of the entire lateral meniscus.

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