Protection of the Medial Femoral Condyle Articular Cartilage During Drilling of the Femoral Tunnel Through the Accessory Medial Portal in Anatomic Anterior Cruciate Ligament Reconstruction

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Abstract: Accurate positioning of the femoral tunnel in the native femoral anterior cruciate ligament (ACL) footprint requires drilling through an accessory medial portal (AMP). The AMP is located far medial and at a low level. Despite the benefits of drilling through the AMP, it is possible that the drill bit head will injure the articular cartilage of the medial femoral condyle as it slides along the guide pin to the femoral insertion of the ACL. Because more surgeons are now performing anatomic ACL reconstructions and shifting from transtibial drilling toward transportal drilling, the risk of this injury might be increasing, especially during the beginning of their learning curve. To avoid such injury, a bio-interference screw sheath is used. It is inserted through the AMP over the guide pin until it reaches near the medial wall of the lateral femoral condyle. The drill bit is inserted over the guide pin and through the bio-interference screw sheath. Using the bio-interference screw sheath not only protects the articular cartilage of the medial femoral condyle but also protects the medial meniscus, posterior cruciate ligament, and skin of the AMP from injury because of the close proximity of the drill bit head to these structures during transportal drilling.

The cruciate ligaments have been recognized since ancient Egyptian times in the famous Smith Papyrus (333 BC). Now, and after understanding the exact insertion sites of the anterior cruciate ligament (ACL), anatomic ACL reconstruction has become the treatment of choice whenever one is considering ACL reconstruction surgery. Anatomic ACL reconstruction is gaining more and more preference among knee and sports medicine specialists. Surgical techniques involve single- and double-bundle reconstructions.

Accurate positioning of the femoral tunnel in the native femoral ACL footprint requires drilling through an accessory medial portal (AMP). The AMP is placed far medial and at a low level (just above the medial meniscus).1-3 Drilling the femoral tunnel through the AMP provides more flexibility for accurate positioning of the femoral tunnel in the native femoral ACL insertion site compared with transtibial drilling, which lacks this advantage.4-6

The far medial position of the AMP has 2 important advantages. The first is that it reaches the native femoral ACL insertion site, which is located at a lower level on the medial wall of the lateral femoral condyle, just posterior to the lateral intercondylar ridge (resident ridge).1,2,7,8 In this area both anteromedial (AM) and posterolateral (PL) bundles are separated by the bifurcate ridge.7 In comparison, transtibial drilling only allows drilling of the fem-
oral tunnel at a higher position on the medial wall of the lateral femoral condyle away from the native femoral ACL footprint.\textsuperscript{7,9,10}

The second advantage is that the drill bit becomes closer to the perpendicular axis\textsuperscript{3} of the medial wall of the lateral femoral condyle (transverse drill angle, i.e., the angle at which the tunnel intersects with the lateral notch wall) and thus creates an appropriately sized oval aperture\textsuperscript{8} of the tunnel (in the anteroposterior [AP] axis) rather than a large oval aperture (in the AP axis). A large oval aperture that results from drilling through a more central (not far medial) portal produces an oversized mismatched femoral tunnel aperture in reference to the native femoral ACL footprint site size. In addition, the location of the AMP at a lower level just above the medial meniscus and at a knee flexion angle of about 100° allows one to establish an appropriately sized proximodistal axis femoral aperture rather than a large proximodistal axis femoral aperture. A large proximodistal axis femoral aperture that results from transtibial drilling produces an oversized mismatched femoral tunnel aperture in reference to the native femoral ACL footprint site size (Fig 1). This was confirmed in a recent study that showed a mean femoral insertion site size of 8.9 mm for width (AP axis), 16.3 mm for length (proximodistal axis), and 136.0 mm\textsuperscript{2} for area and, when a 9-mm drill bit and a transverse drill angle of 40° were used, the aperture seemed to best match the native ACL footprint when drilling was performed at a knee flexion angle of 102°.\textsuperscript{11}

Despite the previously mentioned benefits of the location of the AMP, it still carries a risk for major complications (Table 1). It is highly possible that the drill bit head will injure the articular cartilage of the medial femoral condyle as it slides along the guide pin, traveling the distance from the AMP to the femoral insertion of the ACL (Fig 1). This is especially true when the AMP is far medial, when the diameter of the drill bit head is large, when the intercondylar notch is narrow, or when the AM tunnel is placed deep in the notch at the posterior end of the lateral femoral intercondylar wall.\textsuperscript{3,4,12}

Because more and more surgeons are now performing anatomic ACL reconstructions and shifting from transtibial drilling toward transportal drilling, the risk of injury to the articular cartilage of the medial femoral condyle might be increasing, especially during the beginning of their learning curve.\textsuperscript{3} In addition, the incidence of articular cartilage damage to the medial femoral condyle during anatomic double- or single-bundle ACL reconstruction has not been accurately recorded yet.\textsuperscript{12}

Damage to the medial femoral condyle articular cartilage during transportal drilling of the femoral tunnel in anatomic ACL reconstruction is a serious and ominous complication that would be very disadvantageous to the patient and might compromise the whole procedure\textsuperscript{12} (Fig 1). Thus protection of the articular cartilage of the medial femoral condyle during anatomic ACL reconstruction is of paramount importance.

Few reports have dealt with how to protect the articular cartilage of the medial femoral condyle during transportal drilling of the femoral tunnel in anatomic ACL reconstruction. Transportal drilling carries additional risks of injury to the medial meniscus\textsuperscript{4} and posterior cruciate ligament (PCL) and violation of the skin of the AMP by the drill bit head because it passes very close to these structures.

In this study, we present our technique for protection of the medial femoral condyle articular cartilage during transportal drilling.

Table 1. Main Risks of Drilling Femoral Tunnel Through AMP in Anatomic ACL Reconstruction

<table>
<thead>
<tr>
<th>Risk Description</th>
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<tr>
<td>Injury to the articular cartilage of the medial femoral condyle by the drill bit head</td>
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<tr>
<td>Injury to the medial meniscus by the drill bit head</td>
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<tr>
<td>Injury of the PCL by the drill bit head</td>
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<tr>
<td>Violation of the skin of the AMP by the drill bit head</td>
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Fig. 1. Articular cartilage injury to the medial femoral condyle caused by the drill bit head during drilling of the femoral tunnel through the AMP in anatomic ACL reconstruction. The guide pin is in the AMP, the arthroscope is in the central portal, and the right knee is flexed 100°, with the patient in the supine position.
SURGICAL TECHNIQUE

Instruments

The following standard knee arthroscopic and ACL instruments are used: 4-mm 30° arthroscope, camera, recording system, shaver, pump, light source, monitor, powered drill, and ACL reconstruction set. In addition, a bio-interference screw sheath (Arthrex, Naples, FL) is used.

Technique

Under general or spinal anesthesia, the patient is placed in a supine position with the knee flexed at 90° or, alternatively, the leg is placed in a leg holder and flexed freely at the extremity of the table.

A 3-portal approach to the knee is used, with a standard anterolateral portal and central medial portal in addition to the AMP. The anterolateral portal is positioned above the joint line just lateral to the lateral border of the patellar tendon. The central portal is created under arthroscopic visualization through the lateral portal with a spinal needle. The spinal needle should be in the center portion of the notch in the coronal plane and in the lower third of the notch in the proximal-to-distal direction. The central portal is positioned slightly above the joint line and just medial to the medial border of the patellar tendon. The AMP is designed to be far medial (approximately 2 cm medial to the medial border of the patellar tendon) and at a low level (superior to the medial joint line and just above the medial meniscus). Using all 3 portals as viewing and instrumentation portals allows for complete visual-
ization of the entire ACL and its femoral and tibial insertion sites.¹

To harvest the semitendinosus and gracilis tendons to make a quadrupled graft, a 1- to 2-inch oblique incision is performed about 3 inches distal to the inferior pole of the patella and 2 inches medial to the tibial tuberosity.¹

The femoral tunnel is drilled through the AMP under direct visualization through the central medial portal. The knee is flexed to 100°, and the guide pin is inserted through the AMP and drilled either through the center of the AM or PL bundle footprint in double-bundle ACL reconstruction or at a point located in the center between the footprint of the AM and PL bundles in single-bundle ACL reconstruction. At this point, the surgeon has to check the distance between the guide pin and the articular cartilage of the medial femoral condyle, and often he or she will find that this distance is too small¹² (Fig 2).

To avoid injury to the medial femoral condyle articular cartilage by the head of the drill bit, we use a bio-interference screw sheath that was originally designed for inserting a bio-interference screw in a femoral tunnel or a similar cannula. This bio-interference screw sheath is available in different sizes, from 7 to 10 mm (Fig 3). The appropriate size is selected, preferably measuring 1 mm larger than the size of the drill bit that will be inserted through the sheath (Video 1). The bio-interference screw sheath is then inserted through the AMP over the guide pin until it reaches near the medial wall of the lateral femoral condyle (Fig 4). The appropriately sized drill bit for the femoral tunnel is inserted over the guide pin and through the bio-interference screw sheath to drill the femoral tunnel (Fig 5).

The bio-interference screw sheath protects the articular cartilage of the medial femoral condyle from injury that might occur from advancing the drill bit of the femoral tunnel over the drill guide close to the articular cartilage of the medial femoral condyle (Table 2). The sheath has other important advantages including protection of the medial meniscus, PCL, and skin of the AMP from injury by the drill bit head because of the close proximity of the drill bit head to these structures during transportal drilling of the femoral tunnel in anatomic ACL reconstructions (Table 2).

Between July 2009 and January 2012, 87 anatomic single-bundle ACL reconstructions were performed by the same surgeon (A.A.). In the beginning of the learning curve, the previously described technique was not used in 45 patients (group A), whereas this technique was used in the subsequent 42 patients (group B). Using this technique in group B resulted in...
0 injuries to the medial femoral condyle articular cartilage, medial meniscus, PCL, or skin of the AMP. In contrast, not using this technique in group A resulted in 3 injuries to the articular cartilage of the medial femoral condyle, 2 injuries to the medial meniscus, and 8 injuries to the skin of the AMP.

**DISCUSSION**

Injury to the articular cartilage of the medial femoral condyle by the head of the drill bit during anatomic ACL reconstruction is a serious complication and will compromise the functional result of the whole procedure. Thus all efforts should be made to avoid such a complication.

More and more surgeons are shifting toward performing anatomic ACL reconstructions through an AMP after long periods of performing nonanatomic ACL reconstructions using transtibial drilling. Early during their learning curve, surgeons have to be aware of injury to the articular cartilage of the medial femoral condyle by the head of the drill bit.

To reach the anatomic ACL femoral insertion site and to create a femoral aperture that closely matches the native ACL femoral aperture, drilling through the far medial AMP is mandatory. A recent study showed that the mean femoral insertion site size was 8.9 mm for width, 16.3 mm for length, and 136.0 mm² for area. It also showed that the drill bit diameter, transverse drill angle, and knee flexion angle can all affect femoral tunnel aperture morphology in medial portal drilling during ACL reconstruction, and the authors concluded that when a 9-mm drill bit and a transverse drill angle of 40° were used, the aperture seemed to best match the native ACL footprint when drilling was performed at a knee flexion angle of 102°; deviations from this angle in either direction resulted in increasing tunnel area mismatch compared with the baseline aperture. The authors emphasized that the relation between drilling orientation and aperture morphology is critical knowledge for surgeons performing ACL reconstruction.

To my knowledge, few published articles have described techniques to avoid injury to the articular cartilage of the medial femoral condyle by the head of the drill bit.

**TABLE 2. Advantages of Drilling Femoral Tunnel Through Bio-Interference Screw Sheath Through AMP**

| Protection of articular cartilage of medial femoral condyle from injury by drill bit head |
| Protection of medial meniscus from injury by drill bit head |
| Protection of PCL from injury by drill bit head |
| Protection of skin of AMP from violation by drill bit head |

![Figure 5](image-url)
the drill bit during transportal drilling. Pitfalls and solutions for the use of the AM portal for the ACL femoral socket were described by Lubowitz in 2009; he explained how, with the “composite” acorn reamer preloaded with a Beath pin and placed through the AMP at a previously marked centrum of the ACL femoral socket on the lateral wall of the femoral intercondylar notch and with the knee at 90° flexion, the flutes of the unconstrained reamer (Beath pin not yet seated) may be placed around and past the medial femoral condylar cartilage, avoiding iatrogenic cartilage damage, which may occur when placing the reamer over a seated Beath pin (constrained reamer) or which may occur when placing the reamer after knee hyperflexion. Siebold et al in 2010 described a similar technique called the guide pin maneuver to avoid damage to the articular cartilage of the medial femoral condyle during anatomic double-bundle ACL reconstruction.

Other authors studied the possibility of injury to the subchondral bone plate of the lateral femoral condyle and the PL soft-tissue structures while drilling the femoral tunnel through the AMP at different knee flexion angles and in high and low AM portals. They concluded that the low knee flexion angles when drilling femoral tunnels through the far AM portal might yield potential risks of damage to the common peroneal nerve and the posterior articular cartilage of the lateral femoral condyle and that the risks would be decreased at higher degrees of knee flexion.

Advantages of the technique described in this study are that it not only protects the articular cartilage of the medial femoral condyle from damage by the drill bit head during transportal drilling but also protects the medial meniscus and PCL and prevents violation of the skin of the AMP. There are no potential risks when using the bio-interference screw sheath for protection of the medial femoral condyle articular cartilage during drilling of the femoral tunnel through the AMP in anatomic ACL reconstruction.

Limitations of this technique are few. The first limitation is the difficulty of inserting the bio-interference screw sheath in very narrow notches. The second is the lack of availability of these special cannulae in every arthroscopic ACL reconstruction setting.

In summary, using a bio-interference screw sheath or a similar cannula protects the articular cartilage of the medial femoral condyle from being injured by the drill bit head when drilling the femoral tunnel through the far medial AMP in anatomic ACL reconstruction. Using this technique provides additional protection of the medial meniscus, PCL, and skin of the AMP. Using this technique routinely is beneficial for surgeons during their early learning curve when they start shifting from transtibial drilling to transportal drilling in anatomic ACL reconstruction.

REFERENCES