Reliable Anatomic Femoral Tunnel Positioning for Anterior Cruciate Ligament Reconstruction Using a Novel Femoral Aiming Guide

Shehzaad A. Khan,*† FRCS, and Tim Spalding,‡ FRCS
Investigation performed at University Hospitals Coventry and Warwickshire National Health Services Trust, UK; Cleveland Clinic London, London, UK

Background: Anterior cruciate ligament (ACL) tunnel placement has been long debated for many years. Femoral tunnel mal-position is the commonest technical error resulting in early ACL laxity and failure. There are many different methods to achieve accurate femoral tunnel position. In this video, we describe use of a novel femoral jig aiming device to drill a reliably and easily reproducible femoral tunnel for primary ACL reconstruction (ACLR).

Indications: This femoral jig aiming device is indicated for all patients undergoing primary ACLR with any graft chosen by the surgeon. This jig is particularly useful for the inexperienced and low volume ACLR surgeon.

Technique Description: An appropriate graft is harvested and prepared according to preferred techniques and the diameter of the graft to be inserted in the femoral tunnel is measured. The femoral notch is prepared, ensuring appropriate tissue is cleared to view the apex of the deep cartilage (ADC). The Infinity anteromedial (AM) femoral guide (Conmed), is inserted through the AM portal and hooked onto the notch just proximal to the ADC. In deep flexion, the guide wire is advanced and the tunnel reamed, aiming to preserve 2.0 to 2.5 mm of bone.

Results: 19 consecutive patients were operated on. There were no complications during the intra- and postoperative period. There have been no reported failures or graft ruptures. All tunnels (100%) were centered in the footprint. The mean tunnel position was 25:20 on the superimposed Bernard-Hertel grid with tight grouping.

Discussion/Conclusion: We have shown that this new femoral guide accurately locates the femoral tunnel close to the AM bundle position and gives a reliable and reproducible femoral tunnel position, thereby reducing the risk of intra-operative error. This may assist accuracy of tunnel position for surgeons starting out performing ACLR or for low-volume surgeons.

Patient Consent Disclosure Statement: The author(s) attests that consent has been obtained from any patient(s) appearing in this publication. If the individual may be identifiable, the author(s) has included a statement of release or other written form of approval from the patient(s) with this submission for publication.

Keywords: knee; arthroscopy; ACL; ACL reconstruction; ligament

VIDEO TRANSCRIPT

In this video, we present the use of a novel femoral jig aiming device to drill a reliable and easily reproducible femoral tunnel for primary anterior cruciate ligament reconstruction (ACLR).

Author disclosures are listed here. Of note, the lead surgeon is one of the designers involved with a product in this technique presentation.

BACKGROUND

ACL tunnel placement has been long debated for many years. The importance of placing the ACL tunnels within the native footprint has shown to restore normal knee kinematics with better restoration of tibial translation and rotational stability.[1,8,9] Early laxity and failure is typically related to poor surgical technique, contributing to almost 80% of cases requiring revision ACLR.[7] The Multicentre ACL Revision Study (MARS) group found technical error to be the issue in 60% of cases,[11,12] the commonest technical error being femoral tunnel mal-position in 80% of such cases.[7,12]

There are several well described and documented methods to achieve an accurate femoral tunnel position. These

Video Journal of Sports Medicine (VJSM®), 4(5), 26350254241233595
DOI: 10.1177/26350254241233595

include using femoral offset aimers from a transtibial tunnel, the "clock-face" concept, and utilization of anatomical landmarks such as the intercondylar and bifurcate ridges, and the insertion footprint itself. A reliable and well documented landmark is the apex of the deep cartilage (ADC).[5,13] This anatomical position represents the proximal and anterior margin of the articular cartilage on the lateral femoral condyle.[5]

Arthroscopically, this is easily identified as the deep and high corner of the posterior lateral femoral condylar cartilage.[5] This is best visualized through the anteromedial (AM) portal.

We now describe the use of a new femoral jig aimer device, which uses the ADC as a reference point, to drill a reliable and easily reproducible femoral tunnel for primary ACL reconstruction. We have validated the technique by evaluation of resultant tunnel position on 3D CT scans.

TECHNIQUE DESCRIPTION

The femoral guide (Conmed) comes in 2 different configurations, left and right. Each guide is also labeled 7/8 or 9/10 to accommodate the different graft diameters. This provides an offset to preserve 2.0 to 2.5 mm bone to ensure the tunnel does not blow out posteriorly.

The animation shows the spade tip wire (Conmed) first passed retrograde into the guide outside the knee so it is ready for advancing. This wire has the advantage of allowing 1 step accurate measurement of the femoral condyle for when passing the graft, by allowing the spade tip to hook on the femoral cortex. The offset hooked lip and the crescent-shaped base of the guide helps naturally position the guide firmly on the lateral wall of the notch, giving an accurate and reproducible position every time.

In this video the technique is demonstrated in the left knee. First, the ACL is debrided and the femoral footprint identified viewing from the anterolateral portal. The radiofrequency probe can be used to outline the insertion site and this is best viewed from an accessory medial portal. In some patients, the oval footprint of the ACL can be clearly identified and an intended position close to the AM bundle insertion site can be marked. The posterolateral bundle insertion and the AM bundle area are noted with the mid footprint identified. In this video, we are marking the intended position but the footprint is not readily visible in everyone.

The femoral guide is then inserted through the accessory portal, hooked over the deep part and the notch just proximal or anterior to the articular cartilage margin. The knee is then flexed to full flexion supporting the foot on a second foot support and the spade tipped drill which is pre-mounted in the guide can then be advanced onto the femur, and we note that it hits the previously marked point. The spade tip of the drill is used to hook on the lateral femoral cortex to measure the depth and an appropriate femoral tunnel then reamed: usually 20 mm for hamstring tendons and 25 mm for patella tendon grafts as shown here. A lead suture is passed and the tunnel inspected to show a thin proximal or deep margin. For the tibial tunnel, the guide is placed level with the posterior margin of the anterior horn lateral meniscus and drilled appropriately. In this patient, a patellar tendon graft is used, passing the bone block through the tibial tunnel into the femur—fixation is achieved using the EZ-start screw (Conmed). The knee is cycled to make sure there is no side wall or roof impingement on the graft, prior to tibial fixation.

RESULTS

For validation, 19 consecutive patients were operated on by the lead author using this guide.

The demographics are shown in this slide. It is important to note that for smaller diameter hamstring grafts the 5 mm offset guide was used, whereas for larger diameter grafts and patella tendon grafts the 7 mm offset guide was used, preserving 2.0 to 2.5 mm of bone referenced off the ADC.

Tunnels were evaluated between 2 and 12 weeks follow-up with a 3-dimensional (3D) computed tomography (CT) scan. The 3D reconstruction images were created and manipulated to remove the medial half of the femur and positioned to show the lateral wall of the notch in a true lateral orientation. The center of the femoral tunnel was identified using a circle and central dot, after which the Bernard-Hertel grid[3,15] was superimposed allowing measurement of the tunnel with coordinates expressed as percentages from proximal to anterior and proximal to distal.

Evaluation showed that all tunnels were centered within the footprint. The mean tunnel position was 25:20 on the superimposed Bernard-Hertel grid. As shown on the image, there was tight grouping of all the tunnels. The larger grafts, patellar tendon, and allografts were centered slightly more distal and anterior as would be expected when using the larger 7 mm offset femoral guide to accommodate the bone block.

There were no complications during the intra- and postoperative period. There have been no reported failures or graft ruptures in this series.

*Address correspondence to Shehzaad A. Khan, FRCS (Tr & Orth), University Hospitals Coventry and Warwickshire National Health Services Trust, Clifford Bridge Road, Coventry CV2 2DX, UK (email: shehzaad_khan@hotmail.com).

†University Hospitals Coventry and Warwickshire National Health Services Trust, Coventry, UK.

‡Cleveland Clinic London, London, UK.

Submitted December 20, 2023; accepted January 30, 2024.

One or more of the authors has declared the following potential conflict of interest or source of funding: T.S. is a consultant advisor to Conmed USA and receives royalties for products from Conmed including the guide described in the study; is on a speaker panel for Smith and Nephew, Joint Operations, and Episurf; and is in the medical advisory board for Episurf Sweden and Orthonika UK. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

DISCUSSION

We have described a technique using a novel femoral guide which produces a reliable and reproducible femoral tunnel in the footprint, near the AM bundle position (AMB).

We recognize that it is impossible to truly re-create the broad, native tibial and femoral insertions with a cylindrical graft. However, we know that placing tunnels within the native footprint restores better restoration of tibial translation and rotational stability.[1,8,9] Movement of the femoral footprint more centrally from AMB has shown increased re-rupture rates and higher contact stresses on the graft.[2,4,10,14]

The ADC landmark has been shown to be a stable, reliable and reproducible reference point for femoral tunnel placement in cadaveric, 3D magnetic resonance imaging (MRI) and 3D CT studies.[5,6,13] We find it is an easily identifiable landmark with little ambiguity and has a relatively consistent distance from the center of the femoral footprint. Our technique uses the bone next to the ADC as a reference point for the Infinity femoral aimer to reliably place the femoral tunnel in or close to the AMB. Furthermore, Zhang et al[16] showed the ADC was a good landmark for femoral tunnel positioning in remnant preserving ACLR. This has the advantage of saving potential proprioceptive fibers in the remnant in addition to saving surgery time by keeping the remnant.

CONCLUSION

In conclusion, although there is still a debate on the optimum tunnel position, there is no debate on its importance and surgeons should use all available tools and anatomical landmarks to reliably position the femoral tunnel. The described femoral guide may not necessarily be useful for experienced and high volume ACLR surgeons, but it can reduce variability for new surgeons or for low volume surgeons. The guide gives a reliable and reproducible femoral tunnel position, thereby reducing the risk of intraoperative error.

Thank you for your attention and we acknowledge the contributing design surgeons.

ORCID iD

Shehzaad A. Khan https://orcid.org/0000-0002-9364-5072

REFERENCES

1. Amis AA, Jakob RP. Anterior cruciate ligament graft positioning, tensioning and twisting. *Knee Surg Sports Traumatol Arthrosc*. 1998;6:S2-S12. doi:10.1007/s001670050215.
2. Balendra G, Jones M, Borque KA, Willinger L, Pinheiro VH, Williams A. Factors affecting return to play and graft re-rupture after primary ACL reconstruction in professional footballers. *Knee Surg Sports Traumatol Arthrosc*. 2022;30(7):2200-2208. doi:10.1007/s00167-021-06765-8.
3. Bernard M, Hertel P, Hornung H, Cierpinski T. Femoral insertion of the ACL. Radiographic quadrant method. *Am J Knee Surg*. 1997;10(1):14-21; discussion 21-22.
4. Borque KA, Laughlin MS, Pinheiro VH, Jones M, Williams A. Rebranding the ''anatomic'' ACL reconstruction: current concepts. *J ISAKOS*. 2023;8(1):23-28. doi:10.1016/j.jisako.2022.11.001.
5. Hart A, Han Y, Martineau PA. The apex of the deep cartilage: a landmark and new technique to help identify femoral tunnel placement in anterior cruciate ligament reconstruction. *Arthrosc J Arthrosc Relat Surg*. 2015;31(9):1777-1783. doi:10.1016/j.arthro.2015.03.026.
6. Hart A, Sivakumaran T, Burman M, Powell T, Martineau PA. A prospective evaluation of femoral tunnel placement for anatomic anterior cruciate ligament reconstruction using 3-dimensional magnetic resonance imaging. *Am J Sports Med*. 2018;46(1):192-199. doi:10.1177/0363546517730577.
7. Kamath GV, Redfern JC, Greis PE, Burks RT. Revision anterior cruciate ligament reconstruction. *Am J Sports Med*. 2011;39(1):199-217. doi:10.1177/0363546510370929.
8. Kato Y, Ingham SJM, Kramer S, Smolinski P, Saito A, Fu FH. Effect of tunnel position for anatomic single-bundle ACL reconstruction on knee biomechanics in a porcine model. *Knee Surg Sports Traumatol Arthrosc*. 2010;18(1):2-10. doi:10.1007/s00167-009-0916-8.
9. Kato Y, Maeyama A, Lertwanich P, et al. Biomechanical comparison of different graft positions for single-bundle anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2013;21(4):816-823. doi:10.1007/s00167-012-1951-4.
10. Kim SJ, Song SY, Kim TS, Kim YS, Jang SW, Seo YJ. Creating a femoral tunnel aperture at the anteromedial footprint versus the central footprint in ACL reconstruction: comparison of contact stress patterns. *Orthop J Sports Med*. 2021;9(4):232596712110018. doi:10.1177/23259671211001802.
11. MARS Group; Wright RW, Huston LJ, et al. Descriptive epidemiology of the Multicenter ACL Revision Study (MARS) cohort. *Am J Sports Med*. 2010;38(10):1979-1986. doi:10.1177/0363546510378645.
12. Morgan JA, Dahm D, Levy B, Stuart MJ; MARS Study Group. Femoral tunnel malposition in ACL revision reconstruction. *J Knee Surg*. 2012;25(5):361-368. doi:10.1055/s-0031-1299662.
13. Shi W, Zhang J, Meng Q, et al. The apex of the deep cartilage is a stable landmark to evaluate the femoral tunnel position in ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2023;31(1):256-263. doi:10.1007/s00167-022-07090-4.
14. Śmigielski R, Zdanowicz U, Drwięga M, Ciszek B, Williams A. The anatomy of the anterior cruciate ligament and its relevance to the technique of reconstruction. *Bone Jt J*. 2016;98-B(8):1020-1026. doi:10.1302/0301-620X.98B8.37117.
15. Xu H, Zhang C, Zhang Q, et al. A systematic review of anterior cruciate ligament femoral footprint location evaluated by quadrant method for single-bundle and double-bundle anatomic reconstruction. *Arthroscopy*. 2016;32(8):1724-1734. doi:10.1016/j.arthro.2016.01.065.
16. Zhang K, Meng Q, Zhang J, et al. The apex of the deep cartilage is a stable landmark to position the femoral tunnel during remnant-preserving anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2023;31:5932-5939. doi:10.1007/s00167-023-07656-w.