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Transtibial versus low anteromedial portal drilling for anterior cruciate ligament reconstruction: a radiographic study of femoral tunnel position

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Abstract

Purpose The purpose of this study is to compare femoral tunnel positions after ACL reconstruction by the transtibial (TT) approach versus the low anteromedial approach using radiographs from a single surgeon.

Methods The standard postoperative knee radiographs of 50 patients with an ACL reconstruction were studied. Two groups were determined according to the technique used. The low anteromedial portal group and the transtibial portal group. The femoral bone tunnel was identified radiographically, and its position determined in the lateral and A–P view. Coronal and sagittal obliquity of the tunnel was measured and compared among both groups.

Results In the sagittal plane, femoral bone tunnels averaged $54° \pm 6°$ for the TT technique and $59° \pm 12°$ ($p = 0.07$) for the low anteromedial portal technique. In the coronal plane, the bone tunnels drilled through the low anteromedial portal showed a significantly more oblique femoral tunnel position ($50° \pm 6°$) compared to TT drilling ($58° \pm 9°$), $p \leq 0.05$.

Conclusion Drilling the femoral tunnel through the low anteromedial portal resulted in a more oblique femoral tunnel position compared to the TT technique. Clinically, the low anteromedial portal may allow to better restore the anatomic orientation of the ACL.

Level of evidence Case series, Level IV.

Keywords Transtibial · Low anteromedial · Tunnel position · ACL reconstruction

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Introduction

Anatomic anterior cruciate ligament (ACL) graft positioning is considered a key factor for proper postoperative knee function and restoration of the physiological kinematics of the femorotibial joint in ACL reconstruction [5, 13, 27]. The optimal tunnel position for positioning the graft is still debatable. However, it is known that vertical tunnel positioning in the femur only restores anteroposterior stability, not rotational stability. Placing the femoral tunnel at a more oblique angle may add rotational stability and more effectively resist rotatory loads when compared to vertical tunnel placement [1, 4, 22, 23, 25].

The classic 2 portals or transtibial (TT) technique uses the anterolateral portal as the viewing portal and the anteromedial (AM) portal as the working portal. With this technique, however, the ACL footprint on the lateral wall of the intercondylar notch is poorly viewed because of the angle of the viewing portal, whereas, the AM portal allows direct visualization of the footprint. This limited view may result in inaccurate femoral tunnel placements and non-anatomic ACL reconstructions. Also, the TT drilling has a tendency to create femoral tunnels higher (closer to 12 o clock) as the orientation of the femoral tunnel is determined by the orientation of the tibial tunnel [2]. Da Silva et al. [27] showed that when using a TT technique, the centre of the femoral tunnel was most of the time in the

AM bundle footprint in the height of the femoral condyle. This would allow to restore better the antero-posterior translation but not rotational instability.

Since improper femoral tunnel placement is the most common cause of technical ACL reconstruction failure, there is a trend to change the surgical technique from the traditional TT portal technique to the low AM portal technique [24, 26]. In this study, the hypothesis was that the femoral tunnels that where drilled trough an AM portal would create a more oblique orientation compared to the TT technique.

Materials and methods

The standard postoperative knee radiographs of 50 consecutive patients who received primary ACL reconstruction from a single surgeon were studied. According to the intraoperative drilling technique of the femoral bone tunnel, two study groups were retrospectively designed. From 2008 to 2009, 25 consecutive patients who received primary ACL reconstruction with either ipsilateral patellar bone-tendon-bone autograft or ipsilateral hamstring tendon autograft were reconstructed using the TT drilling technique (Group 1). In 2010, based on favourable results in the literature utilizing the AM portal technique [14, 23, 26, 28], the author performed ACL reconstructions on 25 consecutive patients through August 2010 using a low anteromedial (low AM) portal technique (Group 2). The graft source was chosen individually for each patient depending on age, sex, size, activity level and personal preference. Femoral hamstring tendon graft fixation was accomplished using the ACL Tightrope (Arthrex Inc, Naples, Florida), while a RetroScrew® (Arthrex Inc, Naples, Florida) was chosen for tibial fixation. For bone-tendon-bone grafts, a cannulated titanium interference screw (Arthrex Inc, Naples, Florida) was used for fixation in both femoral and tibial tunnels.

For the TT technique, the knee was flexed to 90°, and a guide pin was placed using a tibial guide set at 55°. Correct anatomic location was assessed using the insertion of the anterior horn of the lateral meniscus as an anatomic landmark. A reamer was placed over the guide pin, and the tibial tunnel was reamed. The appropriate over-the-top femoral guide was placed through the tibial tunnel. A guide pin was advanced into the lateral femoral condyle under arthroscopic control. A cannulated reamer was introduced transtibially, and the femoral tunnel was created leaving, ideally, a 4-mm posterior wall as determined by the over-the-top guide [4].

For the low AM technique, the knee was placed in hyperflexion at 120°. A low AM portal was created under visualization using a spinal needle, making sure the portal would allow us a good access to the ACL femoral footprint. Under visual control, a guide pin was placed in the centre of the native femoral insertion of the ACL, and a cannulated reamer was used to create the femoral tunnel.

In all patients, radiographs were obtained on the first week postoperative with the knee close to extension, non-weight bearing, in the frontal and sagittal planes. All radiographs were scanned and digitally processed. Images were viewed and evaluated by two independent surgeons trained in ACL reconstruction and blinded for the drilling technique. Lateral radiographs were excluded from the evaluation when the femoral bone tunnel could not be identified reliably or when divergence of the medial and lateral posterior femoral condyle (i.e. internal or external rotation) measured more than 15 % of the anterior to posterior depth of both condyles. Coronal and sagittal obliquities of the tunnels were defined according to the method described by Bedi et al. [4]. Coronal obliquity was defined by the angle subtended between the tunnel and a horizontal axis defined by the lateral tibial plateau. Sagittal obliquity was defined by the angle subtended between the tunnel and longitudinal axis of the femur (Fig. 1). The location of the femoral insertion of the ACL was determined using the quadrant method [6]. In the lateral position, the femoral condyles are superimposed, and the sagittal depth of the femoral condyle is divided into four quadrants. The optimal insertion point is located within the most superoposterior quadrant (Fig. 2).

Statistical analysis

Descriptive statistics were performed according to standard methods including frequencies, means, standard deviations and ranges when appropriate. The Mann–Whitney test was used to compare differences in sagittal and coronal obliquities and quadrant location among the TT and AM group. Statistical analysis was performed using GraphPad, Prism software (GraphPad Software, La Jolla, California). Statistical significance was set at $p < 0.05$.

Results

A total of 40 radiographs were evaluated after ten radiographs were excluded for reasons described in the Sect. "Materials and methods." Twenty-three corresponded to the low AM portal technique and 17 to the TT technique. According to the radiographic measurements for the coronal femoral bone tunnel angulation, the bone tunnel angle averaged 50° ± 6° versus 58° ± 9° ($p \leq 0.05$) in low AM and TT groups, respectively. This indicated that the drilling for the femoral bone tunnel through the low AM portal resulted in a significantly more oblique position.

Fig. 1 Coronal obliquity was defined by the angle subtended between the tunnel and a horizontal axis defined by the lateral tibial plateau. The femoral bone tunnel angle was 58° ± 9° in the TT group versus 50° ± 6° in the low AM. Sagittal obliquity was defined by the angle subtended between the tunnel and longitudinal axis of the femur. The femoral bone tunnel angle was 54° ± 6° in the TT group versus 59° ± 12° in the low AM group

In the sagittal view, the femoral bone tunnel angle averaged 54° ± 6° versus 59° ± 12° ($p = 0.07$) in TT and the low AM groups, respectively. The quadrant method indicated that two cases following the TT technique had an anterior femoral ACL insertion. No anterior femoral tunnels were seen in the low AM technique.

Fig. 2 The femoral quadrant method to evaluate the femoral tunnel position on a lateral radiograph of the femur

Discussion

The most important finding in this study is that the anteromedial portal technique allows the surgeon to better restore the normal anatomic orientation of the ACL. Drilling the femoral tunnel through the low AM portal resulted in a tunnel that positioned the graft at a more oblique angle compared to the TT technique. In the frontal plane, drilling through the low AM portal resulted in a greater angulation of the femoral tunnel towards the medial wall of the lateral femoral condyle, reproducing the anatomic oblique orientation of the ACL. In the sagittal plane, although with no statistical significance, the graft was in a more posterior position compared to the TT technique. No tunnels were anterior when drilling through the low AM portal. Our results corroborate those published by Dargel et al. and Xu et al. who performed a radiographic evaluation of femoral tunnels after ACL reconstruction [12, 31]. Their findings suggested that drilling through the lower AM portal resulted in oblique grafts reproducing a more anatomic location of the ACL in the femoral footprint. Other studies utilizing CT scans or MRI corroborated our study by concluding that the AM portal technique produced a femoral tunnel with more obliquity compared with the TT drilling [3, 15]. Non-anatomic ACL reconstruction was significantly correlated with an inclination angle of greater than 55° [19]. However, other authors noted a substantially increased risk of short tunnels and posterior tunnel wall blowout [4, 8, 9, 10]. None of our patients presented this complication.

Radiographic evaluation of the tunnels may be suggested as a weakness of our study. Several investigations revealed that the accuracy and reliability of different measurement techniques are limited by the correct identification of the bone tunnel, inter-observer variability and the rotational projection of the femoral condyles [17]. While Sommer et al. [27] and Behrend et al. [5] reported that bone tunnels were easily detectable on lateral radiographs, Hoser et al. [18] emphasized that they were not able to determine the position of the femoral bone tunnel in 21.6 % of their cases. Furthermore, Cole et al. [10] reported that a single-plane lateral radiograph may not be an accurate predictor of the true tunnel position within the intercondylar notch, as the position of the tunnel entrance may not be precisely determined. In the present study, the femoral bone tunnel was visible in 80 % of our patients. According to Hoser et al. [18], evaluation of bone tunnel position would have been more accurate using computed tomography rather than plain radiographs. However, as computed tomography exposes the patient to increased radiation, standard postoperative radiographs appear to be a reasonable imaging modality for the assessment of bone tunnel position in patients undergoing primary ACL reconstruction. To avoid these pitfalls, Illingworth et el. [19] recently characterized a new method to evaluate ACL reconstruction tunnel position utilizing a combination of radiographs and MRI.

Limitations of this study are, as described previously, the evaluations of the tunnel done only by radiographs. When possible, MRI should be done to determine more accurately the position of the tunnel. Although this was a retrospective study ideally controlled, randomized study should be done when possible. Finally, the patients who were included in this study were treated by the same surgeon, although this diminished variability could also be considered as a limitation. Including more surgeons may determine whether the AM technique would lead to a better anatomic restoration to any orthopaedic surgeon.

Non-anatomic tunnel placement is the leading cause of non-traumatic failure after ACL reconstruction surgery [11, 16, 17, 20]. Reconstruction techniques are continually advancing as our understanding of the anatomy and function of the ACL expands [13, 21].

When using the TT technique, the tibial tunnel location dictates the femoral tunnel location [7]. Often, the femoral tunnel is placed outside the native insertion site resulting in abnormal biomechanics. Visualization and identification of bony landmarks are important components of performing an ACL reconstruction. The lateral intercondylar ridge (or resident's ridge) and the lateral bifurcate ridge should be identified prior to drilling the femoral tunnel. These landmarks are difficult to see when using the anterolateral portal as the viewing portal. In contrast, the low AM portal technique provides great exposure of these bony landmarks [29, 30].

This study is clinically relevant as it radiographically shows that drilling the femoral tunnel through the AM portal determines a more oblique graft that better resembles the anatomic orientation of the ACL.

Conclusion

Drilling the femoral tunnel through the low AM portal resulted in a more oblique graft compared to the TT technique that better resembles the anatomic orientation of the ACL.

Conflict of interest No conflict of interest to declare.

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