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Arthroscopic evaluation of the ACL double bundle structure

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Abstract In order to describe the arthroscopic presence of the double bundle structure and to evaluate the value of different portals in knee arthroscopy, we assessed the AM and PL bundle anatomy. We prospectively examined the knees of 60 patients undergoing arthroscopic surgery for pathology unrelated to the ACL. Arthroscopy was performed in a two portal technique using an anterolateral (ALP) and an anteromedial (AMP) portal. With the arthroscope in the ALP, we could distinguish an AM and PL bundle in 28%. Switching the arthroscope to the AMP, differentiation of the bundles was possible in 67%. In all remaining cases visualization of the PL bundle was possible after retraction of the AM bundle. Use of AMP increased visualization of the PL bundle. It seems reasonable to perform arthroscopy for ACL reconstruction with the arthroscope in the AMP and to establish an additional medial working portal to increase the visualization of the femoral ACL insertion sites for optimal femoral tunnel placement.

Keywords Anterior cruciate ligament · Anteromedial bundle · Posterolateral bundle · Anatomy · Arthroscopy

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Introduction

Current techniques in ACL surgery have been associated with satisfactory long-term results in the majority of patients. However, there remains a considerable subset, up to 30% of patients, with unsatisfactory outcomes [2, 7]. Specifically, patients report problems relating to rotational instability and return to previous level of activity [3, 10]. It has been suggested that a more anatomical approach to restore the original ACL anatomy may benefit these patients [4, 17]. Some authors have advocated placing a single graft in a position closer to the oblique femoral attachment of the ACL [14, 15]. However, it is not possible to fully restore normal knee kinematics with a single graft, regardless of the position [13, 16]. The double bundle reconstruction technique (DBT) for ACL reconstruction aims at restoring the ACL anatomy with its two bundles and is gaining popularity [11, 17].

Anatomic studies have demonstrated the presence of two functional bundles within the ACL, the anteromedial (AM) and the posterolateral (PL) bundle [1, 8]. Although it is somewhat of a simplification, the double bundle description of the ACL is generally accepted as an anatomic model for understanding the complex structure and function of the ligament [6, 9]. However, the ACL double bundle structure is not readily seen during standard arthroscopy. The AM bundle often obscures the PL bundle, and it may appear that only one bundle is present without careful inspection.

The goal of this study was to describe the presence of the double bundle structure from an arthroscopic point of view, and to evaluate the value of different portals in knee arthroscopy. We hypothesize that the PL bundle can be better detected from the anteromedial portal. Based on these observations, surgical guidelines for reconstruction might be further refined.

Materials and methods

We prospectively examined 60 knees during standard arthroscopy. In each knee, the double bundle ACL structure was evaluated, along with the usefulnes of different portals for visualization. All knees that were included in the study had a previous X-ray and MRI in order to rule out any significant changes to the bone, and to ensure that the ACL was intact. All patients were less than 60 years and had no history of ACL injury. Surgical indications for the 60 total subjects examined included 31 cases treated for meniscal findings alone, 21 treated for articular cartilage findings alone, and 8 cases of a combined repair of meniscus and cartilage. There were 25 female and 35 male knees, 29 right knees, and 31 left knees included in the study. Age distribution ranged between 16 and 60, with an average age of 40.2 years.

Arthroscopy was performed with a 30° arthroscope using a two portal technique. Arthroscopy started with an anterolateral portal (ALP) located just lateral to the patellar tendon using the inferior pole of the patella as a vertical landmark, and an anteromedial portal (AMP) approximately 0.5 cm medial to the edge of the patella tendon, 1 cm superior to the joint line, and 1 cm inferior to the tip of the patella. For each knee, the ACL anatomy and the visibility of the PL bundle through the ALP and AMP were evaluated with and without retraction of the AM bundle according to the description of the two bundles by Girgis et al. [9] and Arnoczky [2]. Gross biomechanics of the two bundles using a probe were also assessed. For statistical analysis, we applied the chi square test.

Results

With the arthroscope in the ALP, we were able to distinguish the AM and PL bundle in 17 cases (28.3%) (Fig. 1). In the remaining cases ($n = 43$, 71.7%), the PL bundle was obscured by the AM bundle, and visualization was only possible with retraction of the AM bundle with a probe (Fig. 2). Switching the arthroscope to the AMP, differentiation of the AM and PL bundle without using a probe to retract AM was possible in 40 cases (66.7%) (Fig. 3). In the remaining cases ($n = 20$, 33.3%), visualization of the PL bundle was possible only after retraction of the AM bundle (Table 1). There was a statistically significant better visibility of the PL bundle using the AMP ($p < 0.05$).

The femoral insertion site of the ACL was semilunar at the inner surface of the lateral condyle. The centre of the PL bundle visualized more shallow than the centre of the AM bundle with the knee held in 90° flexion, while both insertion sites were oriented horizontally (Fig. 4). The AM bundle insertion was located at the anteromedial aspect of the tibial attachment. The PL bundle insertion was located at the posterolateral aspect of the tibial attachment with a close approximation of the PL bundle to the posterior root

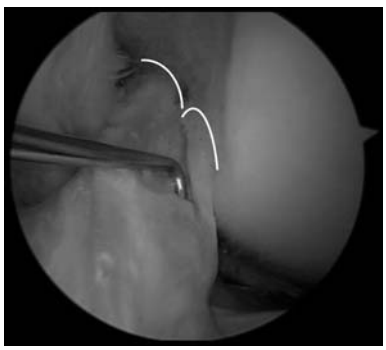

Fig. 1 Anterolateral portal: PL bundle without retraction of AM bundle

Fig. 2 Anterolateral portal: PL bundle with retraction of AM bundle, PL bundle loose with knee flexion

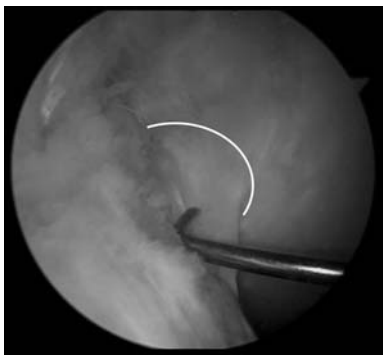

Fig. 3 Anteromedial portal: PL bundle without retraction of AM bundle

Table 1 Visualization of the PL bundle

	PL bundle
Anterolateral portal	$n = 17$ (28.3%)
Anteromedial portal	$n = 40$ (66.7%)*

* $p < 0.05$

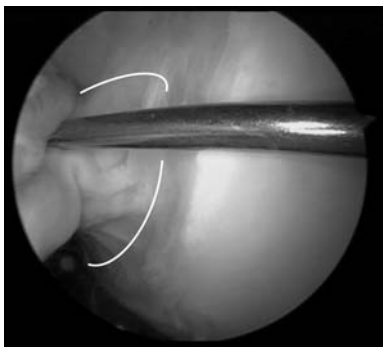

Fig. 4 Anteromedial portal: PL bundle without retraction of AM bundle

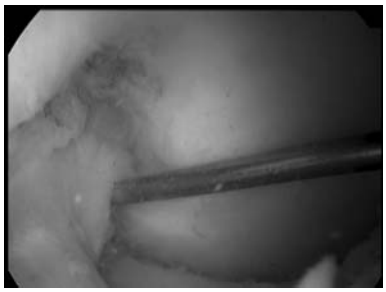

Fig. 5 Anteromedial portal: PL bundle tight with knee extension

of the lateral meniscus. Gross assessment using a probe while applying a flexion-extension motion pattern to the knee demonstrated a taut AM bundle throughout the range of motion and a tightening of the PL bundle with knee-extension (Figs. 2, 5). These tensioning patterns were consistent among all 60 cases.

Discussion

The principal finding of the present study was that it is possible to distinguish the double bundle structure in ACL anatomy as described by Girgis et al. [8] and Arnoczky [1] by applying a two portal knee arthroscopy technique. The hypothesis was supported by our results. The visualization of the ACL anatomy seems to be improved through the use of a medial portal. The anteromedial portal not only helps in visualization of the double bundle structure but also in distinguishing the AM and PL portions of the femoral attachment sites. Consistent with the literature, we found the PL bundle tightening when the knee is extended [6, 12]. This study is limited by the fact that we observed only ACL intact knees and did not consider cases with a torn ACL, where the anatomic position of the attachment sites is sometimes obscured by the knee injury and bony changes that occur between injury and reconstruction. Therefore, we stress the need for further arthroscopic evaluation of different portals in ACL reconstruction.

Conclusion

The clinical relevance of this study is that it can be beneficial to establish an additional medial working portal. The AMP can be used for the arthroscope and a better visualization of the femoral insertion site of the ACL at the inner surface of the lateral condyle and a precise femoral tunnel placement can be achieved [6]. Cha et al. [5] and Hara et al. [12] reported the use of an additional medial portal without any increase in morbidity to patients for ACL surgery.

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