Abstract

**Purpose:** To introduce a technical tip for the preparation of tibial tunnel in PCL reconstruction to reduce the chance of popliteal artery injury and to decrease the duration of the surgery.

**Method:** Eighteen patients who underwent PCL reconstructions at our institution between 2016 and 2017 were included in this study. In all patients, the PCL tibial aim device inserted from anteromedial portal and its tip aimed 8-9 mm below shiny white fibers in PCL facet. The smooth guide pin then was inserted from anteromedial tibial cortex and advanced just to the posterior cortex but not through it, based on measurement of tibial tunnel length. Thereafter reaming was done over the guide pin. As the pin was engaged in the posterior cortex we were sure that it would not run before reamer to the popliteal fossa. We remove the pin when the reamer touched the posterior cortex and then continue reaming until reamer’s head appeared in the PCL facet. Other steps of standard arthroscopic PCL reconstruction were done. We did CT scan evaluation of all patients.

**Results:** The mean age of the patients in this study were 25(+-3y). The mean duration of surgery was 95 minutes. There was no vascular injury. The position of tibial tunnel in all cases were accurate. The mean distance between the center of the tibial tunnel to CGD (Champagne_glass Drop-off) the posterior cortex of tibia was 7.42 mm (range from 4.6 to 10.4 mm).

**Conclusion:** Our study showed that avoiding the penetration of posterior cortex of the tibia by means of the pin during tibial tunnel preparation for PCL reconstruction is a safe, reproducible and time saving technique. Using this technique eliminates the need for fluoroscopy during the procedure.

**Keywords:** PCL, knee, technique
Study Design: Case series; Level of evidence, 4

Introduction:
Posterior cruciate ligament (PCL) reconstruction is indicated in the patients with grade III PCL injuries and failed nonoperative treatment and in patients with combined ligament injuries involving the PCL (1). As the surgical techniques for PCL reconstruction have been evolved, the number of PCL reconstructions is increasing (2). One of the most feared complications during tibial preparation for PCL reconstruction is popliteal artery injury (3,4,5,6,7). Though it is an extremely rare complication, but it is a serious and possibly fatal one (3). Several techniques have been described in the literature to decrease the risk of vascular injury during PCL reconstruction including direct visualization (8), intraoperative imaging (8), using posteromedial safety incision to protect the neurovascular with fingertip (9), and entrance of the guide pin lateral to the tibial tuberosity (10).

In this study we reported a modified technique for tibial tunnel preparation to reduce the popliteal artery injury risk while preserving the accurate position of the tunnel.

Material and method:
Eighteen patients who underwent PCL reconstructions at our institution between 2016 and 2017 were included in this study. For each patient we got CT scan with standard sagittal and coronal views in 1-2 days postoperatively to evaluate the tibial tunnel placement (figure1). The distance between the center of the tibial tunnel to CGD (Champagne glass Drop-off) (figure2) (11) in the posterior cortex of tibia was measured. Main focus was the precision of the tibial tunnel
placement in sagittal plane. Although on Coronal views the location of the tibial tunnel exit was evaluated to confirm its mediolateral position in the PCL facet.

**Surgical Technique**

Under general anesthesia, each patient was placed in the supine position, and the affected knee joint was flexed at 90 degrees. First, standard arthroscopic examination of the knee joint was performed using the anterolateral and anteromedial portals. After complete examination of the intra-articular pathologies in the knee joint, the arthroscope was redirected toward the posteromedial (PM) compartment from the anterolateral portal through the intercondylar notch with the knee at 90 degrees of flexion. In a PCL-deficient knee, it is easy to pass the arthroscope from the anterolateral portal to the PM compartment through the intercondylar notch because the space between the PCL and the medial femoral condyle is widened. Thereafter, the PM portal was made in the point that calf muscles intersect hamstring muscle (figure 3-A) A shaver was introduced via the PM portal to clean the PCL fovea (figure 3-B).

The PCL tibial aimer was inserted from anteromedial portal and the tip was placed 8-9 mm below shiny white fibers in PCL facet (figure 4). Thereafter we entered the lens through posteromedial portal for determining the anatomic location of PCL. With the use of an aimer guide, the length of tibial tunnel is determined and the drill stopper would adjust accordingly (figure5). To confirm the exit point of the guide pin, the medial, lateral, and posterior edges of the PCL fovea were palpated using a guide tip. After confirming its placement, a small, longitudinal skin incision was made at the medial side to the tibial tuberosity. Then smooth guide pin was inserted from anteromedial tibial cortex approximately 3-4 cm below the joint line. The pin was angled at 55 degrees to the tibia and advanced to the posterior cortex but not through it. We stopped the pin just a little bit before reaching the aimer stopper and we wouldn’t go through
posterior cortex (figure 6), therefore, the pin was placed just short of the posterior cortex. Then we started the reaming and stopped just before going through posterior cortex (figure 7). We repeatedly move the reamer in and out, on the pin to make sure the pin doesn't get stuck in the reamer while reaming. We continue reaming until we reach the size of measured tibial tunnel, then the guide pin is extracted without removing the reamer. At the end, reaming continues until it comes out of the posterior cortex gradually under direct vision. We think that passing reamer through posterior cortex could be viewed and sensed much easier and more predictable than pin (figure 8).

The reamer was stopped just when its head appeared in the PCL facet. An angle curette or hook protector of tibial guide should be positioned to protect any neurovascular structures during the process of reaming. This way, the danger of pin passing the posterior cortex and the possibility of vascular injury is eliminated. Finally, the rasp was used to create a smooth acute angle at the anterior margin of the tibial tunnel.

Further standard steps of arthroscopic PCL reconstruction were performed afterwards. The guide pin for the PCL femoral tunnel was inserted 7 to 8 mm posteriorly to the distal border of the articular cartilage of the medial femoral condyle, which was between the 1- and 2-o’clock positions in a right knee and between the 10- and 11-o’clock positions in a left knee. Then a tunnel was made through the medial femoral condyle using a cannulated drill with an inside-out method.

The tibialis posterior allograft was used as the PCL graft. The graft was folded into a 2-strand graft (9-10 mm in diameter and 14-15 cm long). The end of each strand was sutured in a whipstitch fashion with a No. 2 vicryl suture. Then the graft was passed through the tunnel sand. The femoral side was fixed by endobutton and the tibial side was fixed using an absorbable
screw with proper tension.

**Results:**

Total of 18 patients underwent PCL reconstruction surgery in a period of 12 months. All the patients were operated by the same surgeon and the same surgical technique. The mean age of patients in this study were 25(+- 3y). The mean duration of surgery was 95 minutes. All of the tunnels were in the boundaries of PCL facet in coronal plane. The mean distance between the center of the tibial tunnel to CGD (Champagne_glass Drop-off) (11) was 7.42 mm (range from 4.6 - 10.4 mm). There was no neurovascular injury reported post procedure.

**Discussion:**

Posterior cruciate ligament (PCL) is one of the four main ligaments of the knee among Anterior, medial and lateral cruciate ligaments (2). The PCL is important in flexion and rotatory stability of the knee (12). When teared, it is responsible for a posterior drawer sign as well as rotatory instability in knee flexion (1,2,11). In order to correct this pathology, multiple surgical techniques have been proposed (9,10,8).

But one of the most feared complications of PCL-R is injury to the popliteal artery (3,4,5,7,6). There are some case reports mentioning vascular injury that need vascular intervention (6,4,3). Mean distance between popliteal artery and the posterior tibial cortex is less than 8 mm (13,7). Although in 76% of cases the popliteal artery moved away from tibial surface during flexion but flexed knee does not always confer safety (7,13). Vascular injury usually happens in three situations: during drilling the tibial hole, during shaving and manipulation of the tissues in the posterior capsule and during creating the posteromedial portal (3).
Sometimes, vascular injury could be a delayed-forming pseudo aneurysm or AV fistula which are not understood in the operation and the patient refers with pain and swelling signs (6).

Anatomic localization of popliteal artery, is lateral to the central axis in ninety-four percent and artery passes posterior to the popliteus tendon and posterior horn of the lateral meniscus (7).

Knee flexion is not always safe, because popliteal artery moved away from tibial during flexion only in seventy-six percent of cases (7).

It is very important for PCL reconstruction to create the tibial tunnel exactly in its anatomical location, ie, the center of the tunnel must be 7mm away from the top of the Champagne-glass Drop-off (CGD) (12,11,14). Putting the tibial tunnel in right anatomic position is associated with the risk of popliteal artery injury. There are several methods to reduce the risk of surgery including the direct visualization of PCL fovea landmarks and the drill bit exiting the bone (8), using C-Arm fluoroscopy (8,15), using posteromedial safety incision (9) and inserting the guide pin lateral to the tibial tuberosity (10).

Although these techniques are used widely, but each has its own drawbacks.

Intraoperative C-arm fluoroscopy is usually used for placement of the tibial tunnel guide pin during transtibial PCL reconstruction. However, intraoperative fluoroscopic identification of the tibial insertion area of the PCL is often impaired by tibial rotation and overlapping anatomic structures (8). Meanwhile there is risk of contamination and radiation exposure. It is time consuming and also increases financial costs (8).

In direct visualization PCL fovea landmark technique method, tip of pin is viewed in the anatomical location via posteromedial portal (8,16). This technique might be an alternative method to the fluoroscopic imaging technique for locating the anatomic tibial tunnel during transtibial PCL reconstruction. The sloping central depression between the medial and lateral
portions of the tibial plateau has been called PCL fovea, facet, or fossa (1,12,8,11). This technic is acceptable but the disadvantages are the risk of the movement of the pin during the operation, and diminished vision quality due to scar tissue.

Another method is use of safety incision for protecting tip of pin with finger but still there are worries about passing the pin next to finger beside the risk of penetrating injury to the surgeon’s finger and imposing an extra incision to the patient (9). In a cadaveric study, they showed placing the entrance of the tibial tunnel lateral to tibia tuberosity would reduce the probability of vascular injury (10). But it seems not to be an assuring method.

Ideally, tunnel placement should be centered one-quarter of the total facet length, anterior to the posterior cortex of the tibia (14,12,17). To achieve an anatomic insertion during a PCL reconstruction, the guide wire should be placed 7 mm anterior to CGD(Champagne_glass Drop-off (11) the posterior cortex of the tibia as measured along the PCL facet (figure8). Placement of the tibial tunnel in the anterior surface of the facet might put the posterior horns of both menisci at risk of injury (18). Placement of the tunnel more posteriorly will fail to reproduce anatomic characteristics of the PCL, endanger the neurovascular bundle, and make graft passage more difficult (18).

Therefore, the definition of reliable, arthroscopically identifiable anatomic landmarks would be of great value for proper positioning of the tibial guide pin in arthroscopic transtibial PCL reconstruction. The margin of the PCL fovea can be palpated with the tip of the tibial guide. Shiny white fibers of the posterior horn of medial meniscus, the posterior cortex and the medial and lateral borders of the PCL fovea are landmarks for the anatomic positioning of the tibial tunnel (2,8,14), assisting us to place the guide pin approximately 7 mm anterior to CGD(Champagne_glass Drop-off) (11) the posterior cortex(figure8). These landmarks are time
saving and not affected by tibial rotation and overlapping anatomic structures as it appears in fluoroscopic images (8). Furthermore, additional equipments are required for the intraoperative fluoroscopic images, and this could increase the cost, risk of contamination and radiation exposure.

Our study has several limitations. The number of patients in this series is relatively low. It was a retrospective case series of a technically challenging surgery with a learning curve. Therefore, results improve with more experienced surgeons and time. In addition, the follow up period is short. Future follow up of patients is necessary to evaluate the long term outcome of the procedure.

Our study showed that avoiding the penetration of posterior cortex of the tibia by means of the pin during tibial tunnel preparation for PCL reconstruction is a safe, reproducible and time saving techniques. Using this technique, there is no need for using fluoroscopy during this procedure. we believe, this new technique provides a safe and accurate approach for creating tibial tunnel and while maintaining the proper anatomical location, it eliminates our concern of vascular injury, reduce radiation exposure, reduce risk of contamination and also it is time saving and reproducible.

Future studies with long term results and larger population are required to improve the techniques that eliminate the need for fluoroscopy during tibial tunnel preparation with an improved outcome.

**Disclosure:**

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.
References


Figure 1: distance between the center of the tibial tunnel to CGD was measured


(17) Tomasz Piontek, Kinga Ciemniewska-Gorzela, Andrzej Szulc, Jakub Naczk, Martyna Wardak, Tadeusz Trzaska, et al., Arthroscopically assisted combined anterior and posterior cruciate

**Figure legends:**

Figure 1: distance between the center of the tibial tunnel to CGD was measured
Figure 2: the guide wire should be placed 7 mm anterior to CGD

Figure 3-A: PM portal

Figure 3-B: shaver via the PM portal

Figure 4: tip of tibia aimer was placed 8-9 mm below shiny white fibers in PCL facet

Figure 5: drill stopper would adjust according to length of tibial tunnel

Figure 6: stop the pin just a little bit before reaching the aimer stopper

Figure 7: reaming stop just before going through posterior cortex

Figure 8: passing reamer through posterior cortex could be viewed and sensed much easier and more predictable than pin
