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Original Research

Sonographically Guided Posterior Cruciate Ligament Injections: Technique and Validation

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Abstract

Objective: To describe and validate a technique for sonographically guided posterior cruciate ligament (PCL) injections.
Design: Prospective, cadaveric laboratory investigation.
Setting: Procedural skills laboratory.
Subjects: Eight unembalmed, cadaveric, mid-thigh—knee specimens (4 left knees and 4 right knees) obtained from 4 male and 4 female donors aged 57 to 64 years (mean 60.8 years) with body mass indices of 27.7 to 36.5 kg/m^2 (mean 32 kg/m^2).
Methods: A 5-2—MHz curvilinear probe and a 22-gauge, 78-mm stainless steel needle was used to inject 2 mL of diluted blue latex into the PCL of each specimen using an in-plane, caudad-to-cephalad approach. At a minimum of 24 hours postinjection, each specimen was dissected to assess the presence and distribution of latex within the PCL.
Main Outcome: Presence and distribution of latex within the PCL.
Results: All 8 injections accurately delivered latex throughout the PCL, including the tibial and femoral footprints. In 2 of 8 specimens (25%), a small amount of latex was noted to extend beyond the PCL and into the joint space. No specimens exhibited evidence of needle injury of latex infiltration with respect to the popliteal neurovascular bundle, menisci, hyaline cartilage, or anterior cruciate ligament.
Conclusions: Sonographically guided intraligamentous PCL injections are technically feasible and can be performed with a high degree of accuracy. Sonographically guided PCL injections should be considered for research and clinical purposes to deliver therapeutic agents into the PCL postinjury or postreconstruction.

Introduction

Treatment recommendations for posterior cruciate ligament (PCL) injuries continue to evolve as clinicians learn more about the natural history of PCL injuries and improve techniques to manage them. Clinical research and experience pertaining to the management of PCL injuries has traditionally lagged behind that of the anterior cruciate ligament (ACL) due to the lower incidence of PCL injuries compared to ACL injuries [1]. However, PCL injuries are more commonly being recognized and account for up to one-fifth of all knee ligament injuries [1]. Although PCL tears occur more commonly in the multiligament-injured knee, Clancy and Sutherland suggested that up to 40% of PCL injuries are isolated [2]. There is much debate regarding the optimal treatment of PCL injuries, and multiple treatment algorithms have been published to guide operative versus nonoperative treatment [3-7]. However, the role of orthobiologic agents in the nonoperative treatment of PCL injuries remains relatively unexplored. Both platelet-rich plasma (PRP) and mesenchymal stem cells (MSCs) have been reported to promote ligament healing, and therefore may be appropriate to consider for nonsurgical or postsurgical treatment of these injuries [8,9].

The PCL originates from the lateral aspect of the medial femoral condyle and inserts into the proximal, posterior tibia just distal to the tibial plateau [10-12]. It serves as the primary restraint to posterior tibial translation, resisting 85% to 100% of a posteriorly directed knee force at both 30° and 90° of flexion [10]. The PCL is an intraarticular, extrasynovial structure 32 to 38 mm long, with an average cross-sectional area of 11 mm^2 along its length [11,12]. The average thickness of a normal PCL as determined by high-resolution ultrasound (US) is 4.5 $\pm$ 0.7 mm^2. The PCL femoral and tibial attachments are 3 times larger than its midsubstance, and the ligament itself can be divided into an

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anterolateral (AL) and posteromedial (PM) bundle based on ligament function in flexion and extension [7,13,14]. With the knee extended, as in our described technique, the PM bundle is tight and the AL bundle is lax [7,13,14].

Careful history taking is an essential part of evaluating the patient with a suspected PCL injury, as even patients with complete, isolated PCL tears may present with relatively subtle symptoms such as mild pain, stiffness, and a sense of swelling [15]. The posterior drawer test performed at 90° of flexion is the most accurate examination test for diagnosing a PCL injury, and palpation of the tibial plateau—medial femoral condyle step-off during the posterior drawer forms the basis for the most commonly used grading scheme [15-17]. In grade 1 tears, the tibial plateau remains anterior to the medial femoral condyle with manual posterior translation. In grade 2 tears, the tibial plateau is palpated flush with the condyle. In grade 3 tears, the plateau is posterior to the condyle [9,18]. Many authors believe that grade 3 PCL tears are virtually never isolated and that concomitant injury to the posterolateral corner should be highly suspected in this setting [19,20].

Nonsurgical treatment may be considered with isolated PCL injuries [1]. Given the increased interest in the direct application of cells, growth factors, scaffolds, and other regenerative treatments to promote healing of ligaments, exploration of practical methods to place needles or other implements into the PCL is warranted. Arthroscopically guided direct implantation is clearly feasible but is currently impractical for widespread application. US-guided and computed tomography (CT)—guided drainage of periligamentous PCL ganglion cysts has been successfully performed; however, techniques for direct PCL injection have not been described [21-23]. Relative to US-guided techniques, CT-guided needle placement requires the use of large, expensive equipment, while exposing the operator and patient to ionizing radiation [21,23,24]. Fluoroscopically guided PCL injections could be considered, but would not allow direct visualization of the ligament and would also expose the operator and patient to ionizing radiation.

Ultrasound may represent the optimal method for percutaneous placement of needles or similar devices directly into the PCL. High-resolution US is an inexpensive, noninvasive, and widely available imaging modality. Although US can accurately depict the extraarticular structures about the knee, the ability of US to evaluate the cruciate ligaments and menisci has been less consistent [25-31]. However, Sorrentino et al recently described a reproducible technique for US imaging of the PCL [32]. This technique involved placing the subject prone with the knee extended. The transducer is placed medial to the axis of the popliteal fossa, while the proximal end of the probe is pushed in a "heel—toe" maneuver. The ability to directly visualize the PCL using currently available US equipment and scanning techniques provides the opportunity to explore the potential utility for sonographically guided PCL injections, similar to what has been recently described with respect to the ACL [31]. Consequently, the primary purpose of this investigation was to describe and to validate a practical technique for sonographically guided PCL injection. We hypothesized that sonographic guidance could be used to accurately place a needle into the PCL with a posterior approach, as demonstrated by successful delivery of intraligamentous latex documented by dissection in an unembalmed cadaveric model. Clinically, the validation of a sonographically guided PCL injection technique provides the foundation for future exploration of percutaneous delivery of injectable therapeutic agents, including regenerative therapies, into the PCL to promote healing postinjury or postreconstruction [33].

Methods

Eight unembalmed, cadaveric, mid-thigh—knee specimens (4 left knees and 4 right knees; 4 male and 4 female) from 8 donors aged 57 to 64 years (mean 60.8 years) with body mass indices of 27.7 to 36.5 kg/m2 (mean 32 kg/m^2) were used for this investigation. All injections were performed by J.H. (4 specimens) and U.K. (4 specimens) using 22-gauge, 78-mm stainless steel needles and a Sonosite X-Porte portable ultrasound machine (Bothell, Washington) equipped with a 5-2 MHz curvilinear transducer. At the time of this study, both investigators had more than 5 years of experience in diagnostic and interventional musculoskeletal US, including US-guided knee injections. All injections were completed during a single session in the procedural skills laboratory at the primary author's institution.

Each specimen was placed and stabilized in a prone position with the knee extended and in neutral rotation. The transducer was placed in a sagittal plane just medial to the mid-sagittal axis and the depth adjusted to visualize the bony acoustic margins of the posterior tibia and femur (Figure 1). The probe was translated slightly medial or lateral to identify the PCL in its long axis. The PCL appeared as a thick, hypoechoic structure attaching to the posterior tibial margin just distal to the joint line. The proximal end of the transducer was "pushed in" (i.e., heel—toe maneuver) to reduce anisotropy and then rotated medially as necessary to ensure colinearity of the probe with the course of the PCL [34]. Slight tilting of the transducer to direct the beam medially was also used as necessary to further optimize the image. The popliteal neurovascular bundle was identified and its position considered throughout the procedure. Thereafter, a 22-gauge, 78-mm stainless steel needle was advanced using an in-plane, caudad-to-cephalad approach to enter the PCL along its posterior margin. Once the needle penetrated the PCL, intraligamentous placement was confirmed by