

Sonographically Guided Proximal Tibiofibular Joint Injection

Technique and Accuracy

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Objective. The purpose of this investigation was to describe a technique for sonographically guided proximal tibiofibular joint (PTFJ) injections and compare its accuracy with that of palpation guided injections in a cadaveric model. **Methods.** A single experienced operator completed 12 sonographically guided and 12 palpation guided PTFJ injections in unembalmed cadavers. The injection order was randomized, and all injections were completed with diluted colored latex. Coinvestigators blinded to the injection technique dissected each specimen and graded the colored latex location as accurate (in the PTFJ), accurate with overflow (within the PTFJ but also in other regions), or inaccurate (no latex in the joint). For statistical analysis, all injections placing latex within the PTFJ were considered "accurate," whereas "inaccurate" injections resulted in no PTFJ latex. **Results.** All 12 sonographically guided PTFJ injections accurately placed latex into the PTFJ (100% accuracy), whereas only 7 of 12 palpation guided injections (58%) placed latex within the PTFJ ($P = .01$). All 5 inaccurate palpation guided injections were superficial and inferior to the PTFJ. Four of 12 accurate sonographically guided PTFJ injections (33%) showed some overflow into the adjacent anterior musculature, whereas 5 of the accurate palpation guided injections (42%) resulted in overflow into the anterior musculature (1), knee joint (2), or both (2). **Conclusions.** This cadaveric investigation suggests that sonographic guidance can be used to inject the PTFJ with a high degree of accuracy and should be considered superior to palpation guidance. Clinicians should consider using sonographic guidance to inject the PTFJ for diagnostic or therapeutic purposes when clinically indicated. **Key words:** injection; knee; sonography; tibiofibular.

Abbreviations

PTFJ, proximal tibiofibular joint

Received November 3, 2009, from the Departments of Physical Medicine and Rehabilitation (J.S., J.T.F., J.K.L.), Radiology (J.S.), and Orthopedic Surgery (B.A.L.), Mayo Clinic College of Medicine, Mayo Clinic Sports Medicine Center, Rochester, Minnesota USA. Revision requested November 25, 2009. Revised manuscript accepted for publication December 10, 2009.

This research was funded by the Mayo Clinic Department of Orthopedic Surgery.

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The evaluation and treatment of lateral knee pain remains clinically challenging, particularly in the absence of major trauma.¹⁻³ Etiologies include iliotibial band syndrome, lateral meniscal conditions (tears, instability, and cysts), tibiofemoral joint osteoarthritis, popliteus tendinopathy, and patellofemoral pain syndrome.^{1,4-6} The proximal tibiofibular joint (PTFJ) is an uncommon but well-recognized potential source of lateral knee pain.¹⁻⁶ The PTFJ is a diarthrodial synovial joint through which the medial fibular facet articulates with the posterolateral tibia.^{1,3,7-9} It is an inherently stable joint because of its bony congruity, capsuloligamentous and muscular supports, and protected position behind the tibia.^{1,3,6-8,10} Small but significant translations and rota-

tions occur within the PTFJ during normal knee and ankle motions, serving 3 important functions: (1) dissipation of torsional loads applied at the ankle, (2) absorption of lateral tibial bending moments, and (2) and transmission of up to one-sixth of the body's weight during daily activities.^{7,8,11-14} These attributes render the PTFJ susceptible to repetitive stresses that may result in symptomatic osteoarthritis or hypermobility due to attrition of supporting structures.^{2,8,9,15,16} Consequently, multiple authors have recently reported pain arising from the PTFJ in the absence of major trauma.^{1,3-6,9,15}

Identifying the PTFJ as the source of lateral knee pain is problematic because of a low index of suspicion and variable clinical presentation.^{1,4-6} Symptoms are nonspecific and may include lateral or anterolateral knee pain, lateral calf pain, an antalgic gait, difficulty climbing stairs, hamstring pain or tightness, knee weakness, and symptoms of instability.^{1,4,5,15} Although pain may be elicited by fibular head palpation, PTFJ mobilization, or ankle dorsiflexion-plantarflexion in a flexed knee position (resulting in painful PTFJ motion), the sensitivity and specificity of these clinical findings remain indeterminate.^{1,5,6,9,17,18} Whereas plain radiography, computed tomography, magnetic resonance imaging, and bone scans generally show abnormalities in patients with proven PTFJ pain, these imaging modalities lack sufficient specificity to prospectively identify symptomatic individuals.^{3-5,16} Consequently, several authors have advocated PTFJ injections to diagnose and treat pain arising from this region.¹⁹⁻²²

Because of the complex anatomy of the PTFJ, image guidance is recommended to ensure accurate injectate placement.^{13,21,22} Fluoroscopic approaches require expensive and at times cumbersome equipment and expose the operator and patient to ionizing radiation.²³⁻²⁷ Furthermore, the need for contrast incurs the additional risk of contrast agent reactions and may reduce the space available within the small PTFJ for subsequent diagnostic or therapeutic injection.^{7,22-27} Computed tomographic guidance is also limited by machine size, cost, and availability, and also exposes the operator and patient to ionizing radiation and the potential for contrast agent reactions if contrast is used.²⁸

Sonography has been increasingly used to guide diagnostic and therapeutic joint injections in the musculoskeletal system.^{24,26,27,29,30} Sonography is a portable, radiation-free, low-cost imaging modality that provides real-time imaging of bony surfaces, articulations, and adjacent soft tissue and neurovascular structures. However, to our knowledge, only 1 previous description has been published outlining a sonographically guided approach to PTFJ injection.³¹ Unfortunately, specific details regarding the technique are not included in the description, and the accuracy of the technique has not been investigated.

The primary purpose of this investigation was to describe a technique for sonographically guided PTFJ injections using a cadaveric model. A secondary goal was to prospectively compare the relative accuracy of sonographically guided versus palpation guided PTFJ injections. We hypothesized that sonographic guidance could be used to place injectate within the PTFJ with 100% accuracy and that sonographically guided PTFJ injections would be significantly more accurate than palpation guided injections. Clinically, accurately placed sonographically guided PTFJ injections would provide a favorable option for image guided injectate placement to evaluate and treat patients presenting with lateral knee pain.

Materials and Methods

General

The primary author (J.S.) injected the PTFJs of 24 unembalmed cadavers in a randomized fashion using both sonographically and palpation guided techniques. Injection accuracy was subsequently determined by study coinvestigators blinded to the injection technique. All injections were completed in the Mayo Clinic Procedural Skills Laboratory, and cadaveric specimens were obtained through the Department of Anatomy's Mayo Foundation Bequest Program. Fresh-frozen specimens were thawed at room temperature immediately before the study. At the time of the investigation, the senior author had more than 5 years of experience in musculoskeletal sonography, including sonographically guided PTFJ injections. The project was approved by the

Mayo Clinic's Bio-Specimens Subcommittee of the Institutional Review Board.

Anatomic Specimens

Twenty-four unembalmed knee specimens were used. No specimen had signs of prior surgery, trauma, or major deformity about the knee. Specimens were labeled 1 through 24, and the age, sex, body mass index, and side (left versus right) were recorded for each donor. Specimens were used for the investigation on the basis of availability and therefore were not necessarily paired (ie, left and right knees from the same donor).

Equipment

All procedures were completed using an iU22 ultrasound machine with a 17–5 MHz linear array transducer (Philips Healthcare, Bothell, WA), and 25-gauge 38- or 50-mm stainless steel needles.

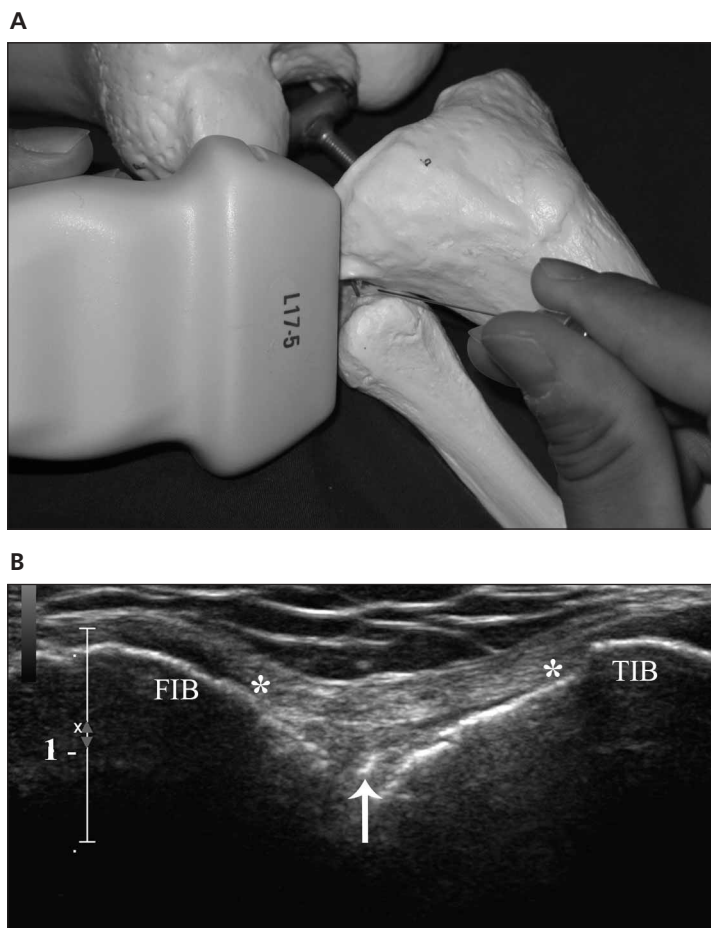
Injection Procedures

Each specimen was injected using either a sonographically guided or palpation guided approach, as determined by a computer-generated randomization scheme. All injections consisted of 1.5 mL of 50% water-diluted colored latex. Pilot studies determined that this dilution facilitated ease of injection while allowing sufficient latex hardening to assess injectate accuracy via dissection.

Palpation guided PTFJ injections were completed as follows: The specimen was placed in an oblique side-lying position with the anterior PTFJ facing the ceiling. The knee was flexed to 20° to 30° degrees to widen the anterior PTFJ through relaxation of the fibular collateral ligament and biceps femoris tendon, and this position was maintained via rolled-up towels or bolsters.^{8,9,12,13,18} After the location of the PTFJ was identified via palpation and a mark was placed on the skin indicating its location, a 25-gauge 38-mm stainless steel needle was introduced through the mark, perpendicular to the skin and along the PTFJ joint line (Figure 1). One or 2 needle repositioning attempts were allowed to facilitate optimal needle placement during the procedure. Thereafter, 1.5 mL of 50% diluted colored liquid latex was injected into the PTFJ.

Sonographically guided PTFJ injections were completed as follows: Initial positioning was similar to that described for the palpation guided technique. The fibular head was palpated, and the lateral end of the transducer was placed over the fibular head. The medial end of the transducer was oriented toward the inferior patellar pole, aligning the long axis of the transducer perpendicular to the typical orientation of the PTFJ.^{1,6,7,12,13} While the lateral end of the transducer was anchored on the fibular head, the medial end of the transducer was rotated clockwise and counterclockwise to produce the best visualization of the PTFJ.³¹ This maneuver

Figure 1. A, Transducer and needle position for proximal tibiofibular joint injection. The needle is advanced between the fibula (left) and tibia (right) via a short-axis (ie, out-of-plane) approach, appearing sonographically as an echogenic dot (see **B**). Left is lateral; right, medial; top, cephalad; and bottom, caudad. **B**, Correlative sonographic view showing the needle tip within the PTFJ, appearing as an echogenic dot (arrow) deep to the anterior superior proximal tibiofibular ligament (asterisks). FIB indicates fibula; and TIB, tibia. Top is superficial/anterior; bottom, deep/posterior; left, lateral; and right, medial.



was necessary because of the large interindividual variation in PTFJ angulation.^{1,6,7,12,13} In this position, the thick anterior superior tibiofibular ligament could be visualized and served as a landmark for the joint space.^{1,6,10,32} Once the PTFJ was visualized, the needle was advanced under direct sonographic guidance into the PTFJ using a short-axis (ie, out-of-plane) approach with the needle shaft aligned perpendicular to the long axis of the transducer (Figure 1B). Once in the PTFJ, the needle tip appeared as an echogenic dot on the sonographic screen, lying deep to the anterior proximal tibiofibular ligament (Figure 1B). After the needle position was confirmed, 1.5 mL of 50% water-diluted colored liquid latex was injected under direct sonographic guidance, typically observing PTFJ distension near the end of the injection.

Assessment

At a minimum of 24 hours after injection, the coauthors dissected each specimen to assess injectate placement. The coauthors were blinded to the technique used for each injectate placement. Injections were graded as accurate (in the PTFJ), accurate with overflow (in the PTFJ but also elsewhere), or inaccurate (no latex in joint). For those injections that were accurate with overflow or inaccurate, the location of the injectate outside the PTFJ was recorded.

Statistics

Descriptive statistics were used to report the results of sonographically and palpation guided PTFJ injections. For cases in which injections were accurate with overflow or inaccurate, the frequencies with which nontarget structures were affected by the injectate were calculated. To compare the relative accuracy of sonographically guided versus palpation guided PTFJ injections, injection results were converted to an ordinal scale (1, accurate; 2, accurate with overflow; and 3, inaccurate). For statistical analysis, the “accurate” and “accurate with overflow” categories were combined and considered “accurate” because of the presence of injectate in the PTFJ. Differences in the rates of accurate versus inaccurate injections between the sonographically and palpation guided groups were assessed for significance using a 2-tailed Fisher exact test, with significance set at $P < .05$.

Results

The accuracy results are presented in Table 1. All 12 sonographically guided PTFJ injections (100%) accurately placed latex into the PTFJ, whereas only 7 of 12 palpation guided injections (58%) delivered any latex into the joint ($P = .01$). The 5 inaccurate palpation guided injections (42%) delivered latex anterior and inferior to the articulation within the adjacent muscular tissues.

Eight sonographically guided PTFJ injections delivered all the latex into the PTFJ (67% of 12 injections), whereas in the remaining 4 cases (33%), latex was found not only in the joint but also in the anterior musculature adjacent to the joint. Only 2 palpation guided injections delivered all the latex into the PTFJ (17%), whereas 5 of 12 (42%) placed latex both within the joint and into adjacent structures (1 in the anterior musculature, 2 in the knee joint, and 2 in both the anterior musculature and the knee joint).

Discussion

To our knowledge, this investigation represents the first formal description and accuracy assessment of sonographically guided PTFJ injections. Our results confirm that sonographic guidance can be used to inject the PTFJ with a high degree of accuracy. Using the technique described herein in our cadaveric model, we were able to place latex in the PTFJ with 100% accuracy. Furthermore, the sonographically guided technique was significantly more accurate than the palpation guided technique (100% versus 58% accuracy; $P = .01$). Although palpation and fluoroscopic guidance have been used to inject the PTFJ, to our knowledge, no prior investigations have formally examined the accuracy of these techniques.^{19,20-22} The results of this study and the many advantages of sonography confirm the successful clinical application of sonographically guided PTFJ injections at our institution during the past 4 years.

Four of 12 accurate sonographically guided PTFJ injections (33%) also placed some latex into the anterior muscular adjacent to the PTFJ. The quantity of latex in all cases was small and likely represented latex leakage from the PTFJ during or after the injection. Although most authors would agree that the PTFJ is a small and variably

Table 1. Accuracy of Sonographically and Palpation Guided PTFJ Injections

Technique	Accurate, n (%)	Accurate With Overflow, n (%)	Inaccurate, n (%)
Sonographically guided (n = 12 knees)	8 (67)	4 (33)	0 (0)
Palpation guided (n = 12 knees)	2 (17)	5 (42)	5 (42)

sized articulation, formal investigations regarding the volume of the PTFJ are lacking.^{1,6,7,13,16} On the basis of prior cadaveric and clinical experience, we elected to inject 1.5 mL of diluted latex to ensure that we delivered a sufficient volume to detect and assess during dissection. It is likely that this volume overdistended the PTFJs in some cadaveric specimens and therefore leaked anteriorly along the needle path. Although a small quantity of anterior overflow is unlikely to confound the interpretation of a diagnostic or therapeutic PTFJ injection, in our clinical practice, we only inject enough volume to distend the PTFJ as visualized sonographically.

All 5 inaccurate palpation guided injections placed latex anterior and inferior to the PTFJ, whereas 4 of 7 accurate injections (57%) also placed latex within the tibiofemoral (ie, knee) joint (Table 1). As previously stated, to our knowledge, the accuracy of palpation guided PTFJ injections has never been assessed. The results of our palpation guided PTFJ injections appropriately reflect the difficulty of placing a needle into this small, anatomically complex joint, despite the ability to easily palpate the fibular head.^{1,6,7,33}

Without the use of image guidance, the operator must judge needle depth based on experience and “feel.” The inaccurate, superficially placed injections likely resulted from the inability to feel the needle drop into the articulation on the initial pass. With subsequent manipulation, the operator moved the needle inferiorly until the needle advanced. Unfortunately, the needle had advanced into the musculature adjacent to and inferior to the PTFJ. Conversely, the finding of latex within the tibiofemoral joint in 4 cases of successful PTFJ injection may reflect overpenetration of the PTFJ with the needle. In these cases, the operator may have advanced the needle deeper than necessary to ensure that the needle entered the PTFJ. By placing the needle into the posterior aspect of the PTFJ, the opera-

tor may have increased the chances of latex flowing into the tibiofemoral joint via the subpopliteal recess, which has been shown to communicate with the PTFJ 27.5% of the time.³³

Several study limitations are noteworthy. First, clinicians may choose to exercise caution when extrapolating our cadaveric results to patients. However, in our opinion, it is unlikely that our comparison between sonographically guided and nonguided PTFJ injections would yield markedly different results in patients. Nonetheless, future investigators may wish to confirm the current results using sonographically guided PTFJ needle placement with fluoroscopic contrast-controlled validation in patients referred for PTFJ injection. Second, a single operator (J.S.) performed all injections in this investigation. At the time of the study, the operator had approximately equal experience performing palpation guided (7 years) and sonographically guided (6 years) PTFJ injections. Although the use of a single operator experienced in the two techniques may be considered a study strength, it is unknown whether these results would be reproduced by an operator with less or unequal experience with the two techniques (eg, no experience with palpation guided injection versus 3 years of experience with sonographically guided injection). It is interesting to hypothesize that sonographic guidance would be considerably more advantageous for an operator skilled in sonographically guided interventions but unfamiliar with nonguided PTFJ injections. This hypothesis warrants further investigation. Third, we used only 12 unembalmed cadavers for each injection technique. With the 100% success rate of the sonographically guided PTFJ injection, it is unlikely that injecting more specimens would have altered the primary findings of this investigation. However, we do recognize that given our sample size of 12 specimens, the exact binomial 95% confidence intervals for the accuracy rate of our injection technique are 75% to 100%. Fourth,

our cadaveric specimens were free from major deformity, prior surgery, or severe arthritis. Thus, it is possible that the accuracy rate of sonographically guided PFTJ injections may be reduced when these conditions are present. We believe the key to success in these cases is the flexibility that sonography provides for accessing the PTFJ from a variety of different directions.

In conclusion, this cadaveric investigation suggests that sonographic guidance can be used to inject the PTFJ with a high degree of accuracy and should be considered superior to palpation guidance. Clinicians should consider using sonographic guidance to inject the PTFJ for diagnostic or therapeutic purposes when clinically indicated.

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