Accuracy of Ultrasound-Guided Versus Fluoroscopically Guided Contrast-Controlled Piriformis Injections

A Cadaveric Study

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Objective. The purpose of this study was to compare the accuracy of ultrasound-guided piriformis injections with fluoroscopically guided contrast-controlled piriformis injections in a cadaveric model. ***Methods.*** Twenty piriformis muscles in 10 unembalmed cadavers were injected with liquid latex using both fluoroscopically guided contrast-controlled and US-guided injection techniques. All injections were performed by the same experienced individual. Two different colors of liquid latex were used to differentiate injection placement for each procedure, and the injection order was randomized. The gluteal regions were subsequently dissected by an individual blinded to the injection technique. Colored latex seen within the piriformis muscle, sheath, or both was considered an accurate injection. ***Results.*** Nineteen of 20 ultrasound-guided injections (95%) correctly placed the liquid latex within the piriformis muscle, whereas only 6 of the 20 fluoroscopically guided contrast-controlled injections (30%) were accurate ($P = .001$). The liquid latex in 13 of the 14 missed fluoroscopically guided contrast-controlled piriformis injections and the single missed ultrasound-guided injection was found within the gluteus maximus muscle. In the single remaining missed fluoroscopically guided contrast-controlled piriformis injection, the liquid latex was found within the sciatic nerve. ***Conclusions.*** In this cadaveric model, ultrasound-guided piriformis injections were significantly more accurate than fluoroscopically guided contrast-controlled injections. Despite the use of bony landmarks and contrast, most of the fluoroscopically attempted piriformis injections were placed superficially within the gluteus maximus. Clinicians performing piriformis injections should be aware of the potential pitfalls of fluoroscopically guided contrast-controlled piriformis injections and consider using ultrasound guidance to ensure correct needle placement. ***Key words:*** fluoroscopy; injections; piriformis; ultrasound.

It has been suggested that between 6% and 8% of low back pain cases can be attributed to piriformis syndrome.[1] The constellation of symptoms caused by piriformis syndrome includes pain in the region of the sacroiliac joint, greater sciatic notch, and piriformis muscle, palpatory tenderness over the piriformis muscle, and occasionally sciatica.[2] Symptoms are frequently exacerbated by walking, stooping, or lifting. Signs include gluteal tenderness to palpation, pain with stretching of the piriformis muscle, and occasionally a positive Lasègue sign, gluteal atrophy, and gluteal weakness.[2]

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Diagnostic studies such as electromyography, computed tomography, and magnetic resonance imaging can be used to assist in the diagnosis of piriformis syndrome.[2] Treatment options include physical modalities, stretching and strengthening exercises, and injections.[2]

Originally, piriformis muscle injections were performed "blindly" in the office by physicians.[2] However, because of the small size of the piriformis muscle, its deep location, and its proximity to important neurovascular structures, the use of image guidance has been recommended to improve accuracy and reduce risk. Techniques using fluoroscopy with contrast control, ultrasound, computed tomography, and magnetic resonance imaging have all been described.[3–12] In a small cadaveric investigation, Smith et al[10] used ultrasound guidance to inject diluted blue latex into the piriformis muscle sheath of unembalmed cadavers. Confirmation of the correct injection location was performed via dissection of the cadaver and identification of the blue latex in the piriformis muscle sheath. Additionally, the researchers performed the cadaveric ultrasound-guided injections while in a fluoroscopy suite, and radiopaque dye was used with real-time fluoroscopy to confirm accurate needle placement. Although this investigation described the ultrasound-guided technique and documented the validity of the procedure, formal determination of injection accuracy was not performed.

Currently, many clinicians use fluoroscopy with contrast control to perform piriformis injections, although the popularity of ultrasound guidance may be increasing. Our review of the literature did not reveal any previous studies determining the accuracy of either fluoroscopically guided or ultrasound-guided injections, nor were there any studies comparing the accuracy of various guidance techniques. Therefore, the purpose of this study was to compare the accuracy of ultrasound-guided piriformis injections with fluoroscopically guided contrast-controlled piriformis muscle injections.

Materials and Methods

The study was conducted at the Mayo Clinic Procedural Skills Laboratory in the Stabile Building of the Mayo Clinic. The study was approved by the Biospecimens Subcommittee of the Mayo Clinic Institutional Review Board.

Ten unembalmed cadavers were used for this study. None of the cadavers had a history of surgery or major procedures in the posterior gluteal region. A single investigator (M.F.B.H.), experienced in both ultrasound-guided (4 years) and fluoroscopically guided contrast-controlled (5 years) piriformis muscle injections, performed all injections. Each cadaver was assigned an identification number and was randomly assigned to receive either a right ultrasound-guided piriformis muscle injection and a left fluoroscopically guided contrast-controlled piriformis muscle injection or a left ultrasound-guided piriformis muscle injection and a right fluoroscopically guided contrast-controlled piriformis muscle injection. To control for potential operator × injection accuracy effects, the distribution of sides was balanced so that 5 right piriformis muscles were injected via ultrasound imaging and 5 right piriformis muscles were injected via fluoroscopy. This was repeated on the left side. The investigator who performed the injections was given instructions indicating which type of injection was to be performed on the respective side of each cadaver. The investigator then performed the requested injections. When the investigator thought he had correctly placed the needle into the piriformis muscle, 2 mL of a 50% diluted blue latex solution was injected.

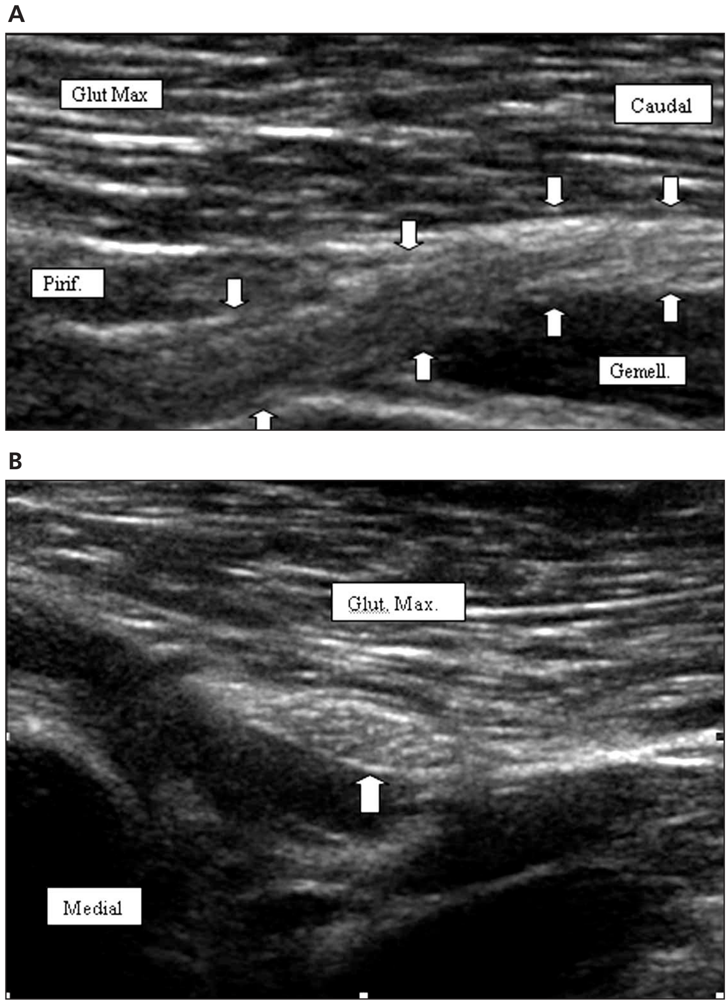
On completion of the first set of 20 injections, a second set of injections was performed, also in random order. The same investigator performed fluoroscopically guided contrast-controlled piriformis muscle injections into the muscles previously injected with ultrasound guidance and ultrasound-guided piriformis muscle injections into the muscles previously injected with contrast-controlled fluoroscopic guidance. A new set of instructions indicating which type of injection was to be performed on either side of each cadaver was provided to the investigator. A new random order was used for the second set of injections. A 50% diluted pink latex solution was used. Before initiation of this study, 1 of the researchers (J.S.) performed a test injection of the piriformis muscle under ultrasound guidance with 4 mL of fluid, followed by revisualization of the piriformis muscle with ultrasound imaging 30 minutes later. No change in the piriformis muscle morphologic characteristics was detectable. As a result, it was determined that performing 2 injections into the same muscle would not invalidate the study. However, the possibility of an order effect was considered, and on completion of data collection, statistical analysis to detect this effect was performed.

After the completion of all 40 injections, the cadavers were dissected by 2 investigators (J.T.F. and J.S.) who were blinded to the type of guidance technique used for each injection. The locations of the blue and pink latex were recorded. Latex seen within the piriformis muscle, sheath, or both was considered accurate placement (hits), whereas all others were considered inaccurate (misses). The information was compiled for analysis to determine the accuracy of each injection guidance technique and to compare the accuracy between the 2 injection guidance techniques.

Ultrasound-Guided Piriformis Muscle Injection Technique

We used the ultrasound-guided piriformis muscle injection technique described by Smith et al.[10] The cadaver was placed in the prone position, and the buttock region was scanned with a Xarioa ultrasound machine (Toshiba America Medical Systems, Inc, Tustin, CA) equipped with a 6–3 MHz curvilinear array transducer. The transducer was placed horizontally across the posterior superior iliac spine and slowly moved caudally down the sacroiliac joint until the posterior inferior iliac spine was visualized. The transducer was then slowly moved just inferior to the posterior inferior iliac spine, at which point the ilium would disappear from view, indicating the beginning of the greater sciatic notch. The piriformis muscle was identified as the muscle belly originating off the deep sacral surface and coursing caudolaterally within the notch. The piriformis muscle was visualized in the transverse and longitudinal orientations, and passive hip internal and external rotation was used to assist in confirming piriformis identification when necessary. The sciatic nerve was identified, and its course was noted (Figure 1). Any variations in the course of the sciatic nerve were recorded by the injector. Anatomic variations of the sciatic nerve, such as piercing the piriformis muscle rather than lying deep to it, were noted. After the piriformis and the pertinent surrounding anatomy were thoroughly imaged, the medial aspect of the piriformis was imaged in a longitudinal orientation as it emerged from the sacrum. A 22-gauge 3.5-in spinal needle was advanced under direct ultrasound guidance in a medial-to-lateral direction, passing just lateral to the lateral sacral margin, until the piriformis muscle was penetrated (Figure 2). Two milliliters of the appropriate colored latex solution was then injected into the piriformis muscle under direct ultrasound guidance, and the needle was removed.

Figure 1. Sonograms of the left sciatic nerve in the longitudinal (**A**) and transverse (**B**) orientations. Arrows indicate sciatic nerve; Gemell, gemellae; Glut Max, gluteus maximus; and Pirif, piriformis.



Fluoroscopically Guided Contrast-Controlled Piriformis Muscle Injection Technique

The cadaver was placed in the prone position, and the C arm was positioned to obtain an anteroposterior view of the sacrum and hip joint on the side to be injected. The relevant osseous anatomy was reviewed and variants noted. The second and third sacral segments (S2 and S3, respectively) were identified. Using a posterior approach, a 22-gauge spinal needle was advanced toward the lateral border of the sacrum at the S2-S3 level until bone was contacted. The needle was then redirected 1 cm lateral to the S2-S3 sacral border and advanced 1 cm in an anterior direction. Two milliliters of an iohexol contrast agent (Omnipaque 180; GE Healthcare, Princeton, NJ) was injected under direct fluoroscopic visualization. The injector then assessed the dye pattern for consistency with intrapiriformis injection. More specifically, an intrapiriformis dye pattern was characterized by a narrow band of dye spreading from the needle tip toward the greater trochanter (Figure 3). The needle depth was adjusted in an anteroposterior direction until the appropriate dye pattern was visualized. Once a satisfactory contrast pattern was visualized, 2 mL of the appropriately colored latex solution was injected into the piriformis muscle, after which the needle was removed.

Outcome Measures

The primary outcome measure was the presence or absence of colored latex within the piriformis muscle belly, sheath, or both. The secondary outcome measure was the presence or absence of colored latex within the sciatic nerve.

Statistics

The estimated proportions of successful piriformis muscle injections of the 20 ultrasound-guided injections and the 20 fluoroscopically guided contrast-controlled injections were compared with the sign test, a nonparametric analogue to the McNemar test for matched proportions.

To compare the order effect of ultrasound-guided piriformis muscle injections (eg, before or after fluoroscopically guided contrast-controlled piriformis injections), the success rate of the 10 ultrasound-guided piriformis injections performed before the fluoroscopically guided contrast-controlled piriformis injections were compared with those performed after the fluoroscopically guided contrast-controlled piriformis injections by a sample χ^2 test. The same analysis was done to determine the order effect on the fluoroscopically guided contrast-controlled piriformis injection success rate.

Figure 2. Sonogram of intrapiriformis muscle needle placement. Arrows indicate piriformis muscle; circle, needle tip; ISCH, ischium; LAT, lateral; and MED, medial.

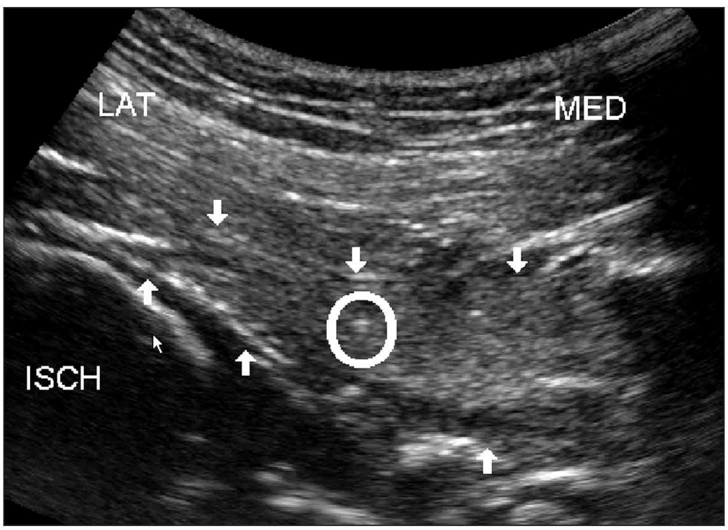
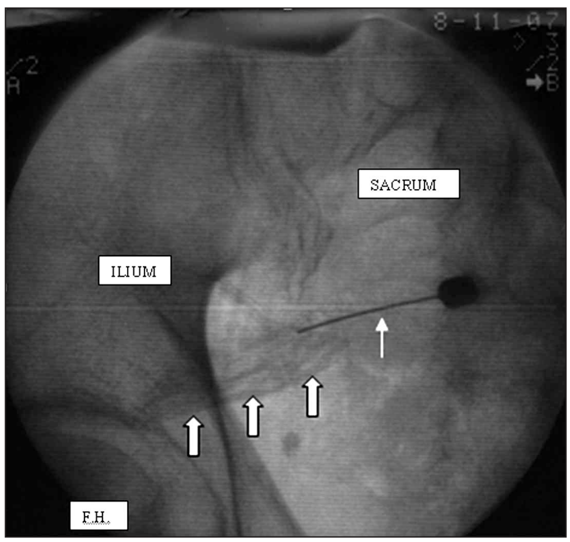


Figure 3. Characteristic radiopaque dye pattern considered to represent intrapiriformis muscle needle placement. FH indicates femoral head; large arrows, radiopaque dye; and small arrow, needle.



Given a sample size of 20 paired piriformis muscles, there was 80% power to detect a difference in the proportion of success of 46% or greater.

Results

All 40 injections (20 ultrasound guided and 20 fluoroscopically guided contrast controlled) were completed by a single investigator (M.F.B.H.). Between 1 and 3 mL of the radiopaque contrast agent was used during the fluoroscopically guided contrast-controlled piriformis injections depending on whether the appropriate contrast pattern was found immediately or required needle repositioning.

The postinjection cadaveric dissections revealed that 19 of the 20 ultrasound-guided injections (95%) correctly placed the liquid latex within the piriformis sheath, muscle, or both, whereas 6 of the 20 fluoroscopically guided contrast-controlled injections (30%) were correctly placed. The difference in successful piriformis injections between the ultrasound-guided and fluoroscopically guided contrast-controlled injection techniques was statistically significant ($P = .001$). No significant order effect was detected ($P = .625$).

The liquid latex in 13 of the 14 missed fluoroscopically guided contrast-controlled piriformis injections and the single missed ultrasound-guided injection was found in the gluteus maximus muscle. In the remaining missed fluoroscopically guided contrast-controlled piriformis injection, the liquid latex was found in the sciatic nerve.

During the ultrasound examination of the buttock region before each injection, identification of the sciatic nerve was attempted, and its course in relation to the piriformis muscle was determined. The ultrasound examination did not detect an anomalous sciatic nerve course in any of the cadavers. Specifically, the ultrasound examination did not show the sciatic nerve passing through or superficial to the piriformis. These findings were confirmed at dissection.

Discussion

To our knowledge, no previous study has determined the relative accuracies of fluoroscopically guided contrast-controlled and ultrasound-guided piriformis injections. Our findings in this cadaveric model indicate that ultrasound-guided piriformis injections are significantly more accurate than fluoroscopically guided contrast-controlled injections when performed by an experienced clinician. Only 30% of fluoroscopically placed injections were accurate, compared with 95% of ultrasound-guided injections.

Our results have important clinical implications. Evaluation and treatment of buttock pain syndromes remain challenging for clinicians. Piriformis injections are often performed diagnostically and therapeutically to assist in the treatment of patients with buttock and variable back and leg pains. Several authors have proposed the use of fluoroscopy with contrast control to perform piriformis injections with or without electromyographic or nerve stimulator assistance.[2–7,11] Regardless of whether electromyographic or nerve stimulator assistance is used, fluoroscopically guided piriformis injections depend on the presence of a characteristic intrapiriformis contrast pattern to confirm intrapiriformis needle placement. Interestingly, the fluoroscopic dye patterns visualized in this study were all consistent with intrapiriformis injections, yet postinjection dissection indicated that this was not the case. The liquid latex was found in the gluteus maximus in 93% of the missed injections. Considering the near parallel arrangement of the more superficially lying gluteus maximus fibers and the more deeply lying piriformis muscle fibers, it is not surprising that the appearance of contrast within these muscles may be quite similar. These findings indicate that the use of a radiopaque dye pattern to confirm correct intrapiriformis muscle needle placement can be misleading.

A single fluoroscopically guided contrast-controlled piriformis muscle injection resulted in the introduction of liquid latex into the sciatic nerve, which equates to a 5% intrasciatic nerve injection rate. Whether this would have occurred if the injection had been performed on an unsedated live patient is unknown. However, this incident warrants mention and should lead the clinician to exercise caution when using a guidance modality that cannot image soft tissues. In fact, the potential of hitting the sciatic nerve may contribute to the substantial miss rate of fluoroscopically guided contrast-controlled piriformis muscle injections because most clinicians would rather err on the side of an injection superficial to the piriformis rather than one that results in a neurologic complication. In our study, this may have been one explanation for the high miss rate on the superficial side of the piriformis (within the gluteus maximus) as opposed to the deep side of the piriformis (within the sciatic nerve).

Visualization of the sciatic nerve was attempted during ultrasound examination of the gluteal region before each ultrasound-guided piriformis muscle injection (Figure 1). Because of the depth of the sciatic nerve and the presence of isoechoic structures in the surrounding region, identification can occasionally prove difficult. In this study, however, the sciatic nerve was not visualized within or superficial to the piriformis muscle. These findings were corroborated by anatomic dissection. Because of the 12% to 21% incidence of an anomalous sciatic nerve coursing through or superficial to the piriformis muscle, the ability to visualize the sciatic nerve is beneficial when planning and performing a piriformis muscle injection.[13,14]

Ultrasound imaging has several attributes that make it an attractive soft tissue injection guidance modality. Ultrasound provides excellent soft tissue images of structures such as muscles, fascial planes, and important neurovascular structures, which enhance the accuracy of needle placement and assist in the prevention of complications such as neurovascular injection. The surface of osseous structures can also be imaged with ultrasound, which allows their use as landmarks for the localization of soft tissue structures. The ability of ultrasound to provide real-time imaging assists in anatomic structure identification and proper needle placement. In addition, ultrasound does not expose the patient or clinician to ionizing radiation. This is a particular advantage in pregnant patients or those in whom radiation exposure is contraindicated. Ultrasound also does not require injection of a contrast agent, thus reducing cost and preventing potential contrast agent–related complications.

Some limitations are worthy of consideration when considering the results of this investigation. First, a single investigator performed all injections. The investigator was pain medicine fellowship trained, is board certified in pain medicine, and has extensive procedural experience with both fluoroscopically guided and ultrasound-guided procedures. In consideration of the relatively poor accuracy of the fluoroscopically guided piriformis injection, it is worth noting that he had several years' more experience with the fluoroscopic than with the ultrasound technique. Nonetheless, the results of this investigation may not be applicable to other clinicians with different training and experiential backgrounds.

Second, this investigation used unembalmed cadavers rather than live participants. The study necessitated 2 injections in each piriformis muscle and "surgical" confirmation of injectate placement via dissection, a design that could not be completed in live individuals. We do not think that the use of cadavers appreciably affected our results. Our contrast patterns were similar to those seen in live individuals, so it is unlikely that the cadaver model biased the results against fluoroscopy. On the contrary, the inability to take full advantage of the dynamic soft tissue imaging capabilities of ultrasound may have negatively biased the accuracy of the ultrasound technique. For example, the inferior gluteal artery as imaged via Doppler techniques may be used in live persons as a reference mark for the inferior border of the piriformis muscle as well as the location of the sciatic nerve. In summary, we think that the results of this study appear to be transferable to the clinical setting.

In conclusion, in the cadaveric model used in this investigation, ultrasound-guided piriformis muscle injections were significantly more accurate than fluoroscopically guided contrast-controlled piriformis injections. Most inaccurate fluoroscopically guided injections were placed within the gluteus maximus, whose muscle fibers can resemble the piriformis after contrast agent injection. When injecting the piriformis muscle, clinicians should consider the use of ultrasound guidance to assist in accurate intrapiriformis needle placement.

References

1. Halin R. Sciatic pain and the piriformis muscle. Postgrad Med 1983; 74:69–72.

2. Benzon H, Katz JA, Benzon HA, Iqbal MS. Piriformis syndrome: anatomic considerations, a new injection tech-

nique, and a review of the literature. Anesthesiology 2003; 98:1442–1448.

3. Betts A. Combined fluoroscopic and nerve stimulator technique for injection of the piriformis muscle. Pain Physician 2004; 7:279–281.

4. Fishman S, Caneris O, Bandman T, Audette J, Borsook D. Injection of the piriformis muscle by fluoroscopic and electromyographic guidance. Reg Anesth Pain Med 1998; 23:554–559.

5. Fishman L, Dombi G, Michaelsen C, et al. Piriformis syndrome: diagnosis, treatment, and outcome—a 10-year study. Arch Phys Med Rehabil 2002; 83:295–301.

6. Fishman L, Andersen C, Rosner B. Botox and physical therapy in the treatment of piriformis syndrome. Am J Phys Med 2002; 81:936–942.

7. Fishman L, Konnoth C, Rozner B. Botulinum neurotoxin type B and physical therapy in the treatment of piriformis syndrome: a dose finding study. Am J Phys Med 2004; 83:42–50.

8. Fanucci E, Masala S, Sodani G, et al. CT-guided injection of botulinic toxin for percutaneous therapy of piriformis muscle syndrome with preliminary MRI results about denervative process. Eur Radiol 2001; 11:2543–2548.

9. Filler A, Haynes J, Jordan S, et al. Sciatica of nondisc origin and piriformis syndrome: diagnosis by magnetic resonance neurography and interventional magnetic resonance imaging with outcome of resulting treatment. J Neurosurg Spine 2005; 2:99–115.

10. Smith J, Hurdle MF, Locketz AJ, Wisniewski SJ. Ultrasound-guided piriformis injection: technique description and verification. Arch Phys Med Rehabil 2006; 87:1664–1667.

11. Hanania M. New technique for piriformis muscle injection using a nerve stimulator. Reg Anesth 1997; 22:200–202.

12. Huerto A, Yeo SN, Ho KY. Piriformis muscle injection using ultrasonography and motor stimulation: report of a technique. Pain Physician 2007; 10:687–690.

13. Beason L, Anson BJ. The relation of the sciatic nerve and its subdivisions to the piriformis muscle. Anat Rec 1937; 70:1–5.

14. Pecina M. Contribution to the etiological explanation of the piriformis syndrome. Acta Anat 1979; 105:181–187.