

Case Report

Needle Placement for Piriformis Injection Using 3-D Imaging

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Piriformis syndrome is a pain syndrome originating in the buttock and is attributed to 6% – 8% of patients referred for the treatment of back and leg pain. The treatment for piriformis syndrome using fluoroscopy, computed tomography (CT), electromyography (EMG), and ultrasound (US) has become standard practice. The treatment of Piriformis Syndrome has evolved to include fluoroscopy and EMG with CT guidance. We present a case study of 5 successful piriformis injections using 3-D computer-assisted electromagnetic needle tracking coupled with ultrasound. A 6-degree of freedom electromagnetic position tracker was attached to the ultrasound probe that allowed the system to detect the position and orientation of the probe in the magnetic field. The tracked ultrasound probe was used to find the posterior superior iliac spine. Subsequently, 3 points were captured to register the ultrasound image with the CT or magnetic resonance image scan. Moreover, after the registration was obtained, the navigation system visualized the tracked needle relative to the CT scan in real-time using 2 orthogonal multi-planar reconstructions centered at the tracked needle tip. Conversely, a recent study revealed that fluoroscopically guided injections had 30% accuracy compared to ultrasound guided injections, which tripled the accuracy percentage. This novel technique exhibited an accurate needle guidance injection precision of 98% while advancing to the piriformis muscle and avoiding the sciatic nerve. The mean (\pm SD) procedure time was 19.08 (\pm 4.9) minutes. This technique allows for electromagnetic instrument tip tracking with real-time 3-D guidance to the selected target. As with any new technique, a learning curve is expected; however, this technique could offer an alternative, minimizing radiation exposure.

Key words: Piriformis, electromagnetic, ultrasound, fluoroscopy, injection, 3-D imaging.

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The piriformis muscle originates from the anterior surface of the S2-S4 vertebrae, the capsule of the sacroiliac joint, and the gluteal surface of the ilium near the posterior surface of the iliac spine. It traverses laterally through the greater sciatic foramen, becomes tendinous, and inserts along the piriformis fossa at the medial aspect of the greater trochanter of the femur. The sciatic nerve, posterior femoral cutaneous nerve, gluteal nerves, and gluteal vessels pass below the piriformis muscle (1-2).

Piriformis syndrome is a pain syndrome originating

in the buttock, which constitutes the diagnosis of 6% – 8% of patients referred for the treatment of back and leg pain (3). This can occur as a result of anatomic abnormalities, secondary to trauma, infection, or surgery (1, 4-5). Often, laminectomy may result in the formation of scar tissue that impinges on the nerve root and shortens the sciatic nerve, rendering it prone to repeated tension and trauma by the piriformis muscle (2). Patients with piriformis syndrome often complain of buttock pain with or without radiation to the ipsilateral leg.

The treatment of piriformis syndrome includes physical therapy combined with the use of medications such as muscle relaxants, anti-inflammatory agents, and analgesics to reduce spasms, inflammation, and pain. Local anesthetic and steroid injections may break the pain and muscle spasm cycle in patients who do not respond to conservative therapy. Piriformis muscle injections can be and have been performed blindly, but newer techniques involve identification of the piriformis muscle with muscle electromyography (EMG) with the guidance of computerized tomography (CT), a nerve stimulator, and fluoroscopy with or without nerve stimulator guidance (6).

METHODS

This study was approved by the Institutional Review Board. A written informed consent was also obtained from the patients scheduled for a piriformis injection.

Patients

Inclusion criteria were patients aged 18 – 90 years with prior (“historic” image sets) CT or magnetic resonance image (MRI) scans of the lumbar spine and pelvis. Pre-procedural CT or MRI scan sets with axial images were transferred from a compact disc and loaded into the computer-assisted image guided navigation system (PercNav, Philips Healthcare, Toronto, Canada).

Patient 1

A 62-year-old woman presented to the pain clinic with difficulty sitting on her left side and pain while walking. Her pain at times radiated inferiorly, and posterior of the left knee. She had a history of 2 previous back surgeries which resulted in instrumented fusion of L3 through L5, and a lumbarized S1 vertebral body. Additionally, she was previously diagnosed with ischial bursitis, left piriformis syndrome, mechanical back pain, and possible facetogenic back pain due to facet osteoarthritis at L5-S1. Previous treatment included physical therapy, acupuncture, chiropractic adjustment and traction, and lumbar/sacral injections. The patient benefited from pharmaceutical management which included hydrocodone-acetaminophen 7.5 mg/325 mg as needed for severe pain. The patient’s pain score on the visual analog scale (VAS) had been 8/10. After the procedure, the patient’s VAS pain score was 2/10. The patient had an MRI of her lumbar spine within the year prior to this procedure.

Patient 2

A 75-year-old man presented with chronic low back pain with intermittent radiation to the proximal

upper extremity of the left leg. An MRI of his lumbar region revealed dislocation of the L1-L2, L2-L3, and L3-L4 interspaces, as well as multilevel foraminal narrowing bilaterally. The patient had been diagnosed with mechanical back pain, facet back pain, vertical pain symptoms in the left upper leg, and chronic deconditioning. Pharmaceutical management included ibuprofen, tapentadol, meloxicam, and gabapentin for pain. The patient’s preprocedure VAS score was 5-10/10, and his postprocedure VAS score was 2/10.

Patient 3

A 62-year-old woman presented to the pain department with chronic bilateral buttocks pain. She was diagnosed with pelvic insufficiency fracture, chronic myofascial pain, left piriformis pain, and osteoporosis. The patient underwent a caudal epidural steroid injection and physical therapy, neither of which delivered significant relief. Additionally, the patient did not benefit from pharmaceutical management, which included hydrocodone-acetaminophen 7.5 mg/325 mg as needed for severe pain, oxycodone-acetaminophen 7.5 mg/325 mg, and nabumetone. However, the patient is currently taking gabapentin 200 mg, and ibuprofen 800 mg. The patient’s preprocedure VAS score was 6-10/10 and her postprocedure VAS score was 1/10. Prior to her procedure, a CT and MRI of her lumbar spine were reviewed.

Patient 4

A 62-year-old woman presented to our pain department from a referring pain clinic with a history of chronic low back pain and left lower extremity pain. Conservative and interventional therapy had not provided her with significant pain relief. The patient’s pharmaceutical management included gabapentin 300 mg, celecoxib 200 mg, methocarbamol 750 mg, and oxycodone-acetaminophen 5 mg/325 mg. The patient indicated a preprocedure VAS score of 9–10/10 and a postprocedure VAS score of 2–3/10. The CT and MRI of her lumbar spine were reviewed prior to the procedure.

Patient 5

A 66-year-old woman presented with chronic low back pain, degenerative disc disease, and lumbar radiculopathy. Her previous procedures to relieve chronic pain include epidural steroid injection, transforaminal epidural steroid injection, medial branch block –left L3-L4, L4-L5, L5-S1, and radiofrequency ablation. The patient’s current pharmaceutical management included gabapentin 900 mg for her chronic pain. The

patient's preprocedure VAS score was 9/10, and her post-procedure VAS score was 7/10. An MRI of the patient's lumbar spine was reviewed prior to the procedure.

Treatment

The patients were placed in the prone position on the fluoroscopy table located in the procedure room with appropriate monitors attached. A patient tracker patch was then applied to the lumbar region and used as a dynamic reference frame to compensate for movement with respiration.

An electromagnetic (EM) field generator (Northern Digital Inc., Waterloo, Ontario, Canada) was mounted on a 3-joint articulated arm and placed over the patient in close proximity to the target. A registration was used

to map the preprocedure CT or MRI images to the patient. A 6-degree of freedom EM position tracker was attached to the ultrasound probe that allowed the system to detect the position and orientation of the probe in the magnetic field. Internal reference points were identified with an ultrasound probe (iU22 Philips Healthcare, Bothell, WA) and matched with points from the historic CT or MRI scan. A minimum of 3 points were needed to register the ultrasound image with the CT or MRI scan. The right and left posterior superior iliac spine (PSIS) as well as the L-5 spinous process were used as landmarks for registration (Figs. 1 and 2). The tracked ultrasound probe was used to find the PSIS, and the image button "Freeze" was selected.

Each landmark was denoted on both the frozen

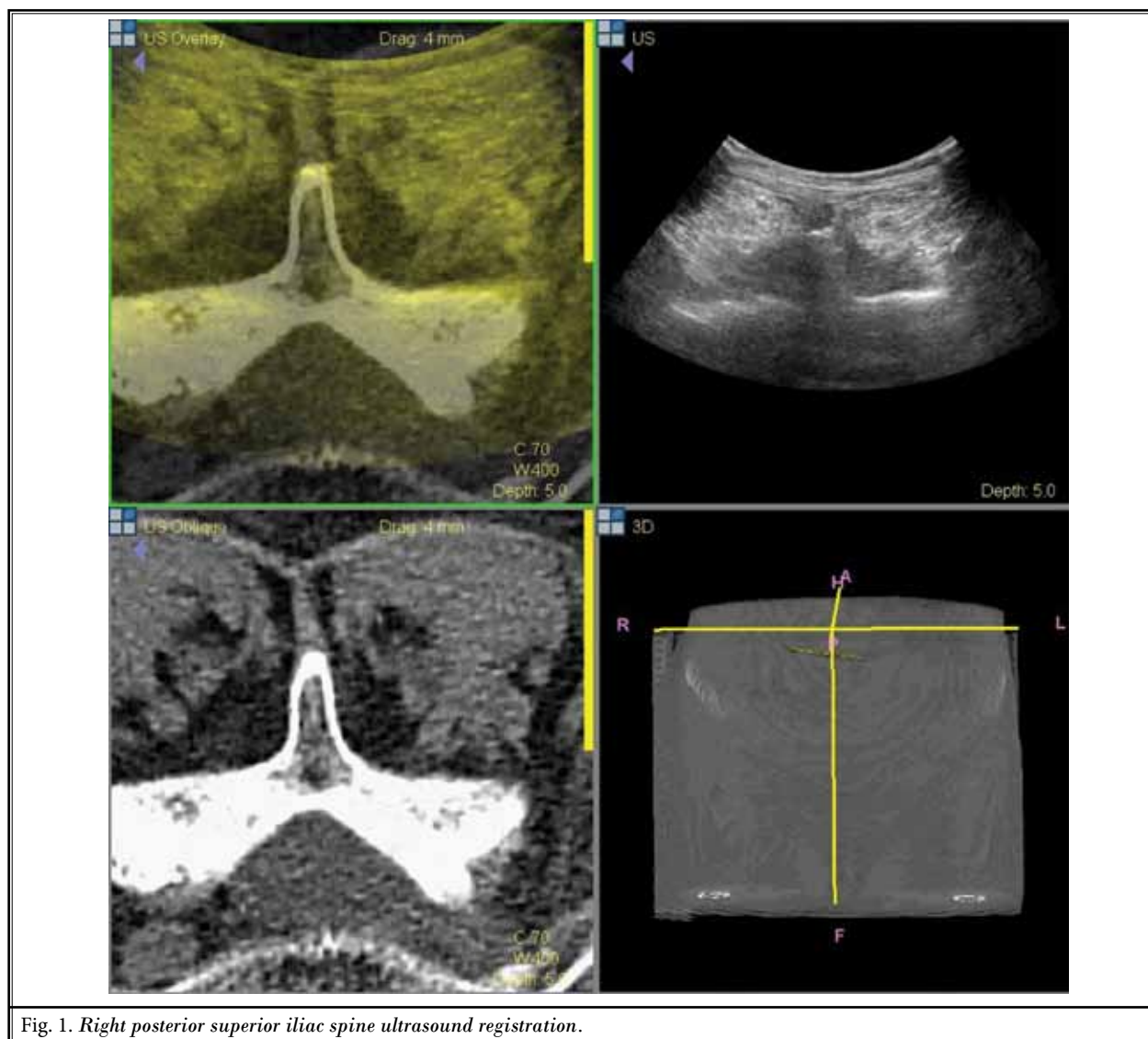


Fig. 1. Right posterior superior iliac spine ultrasound registration.

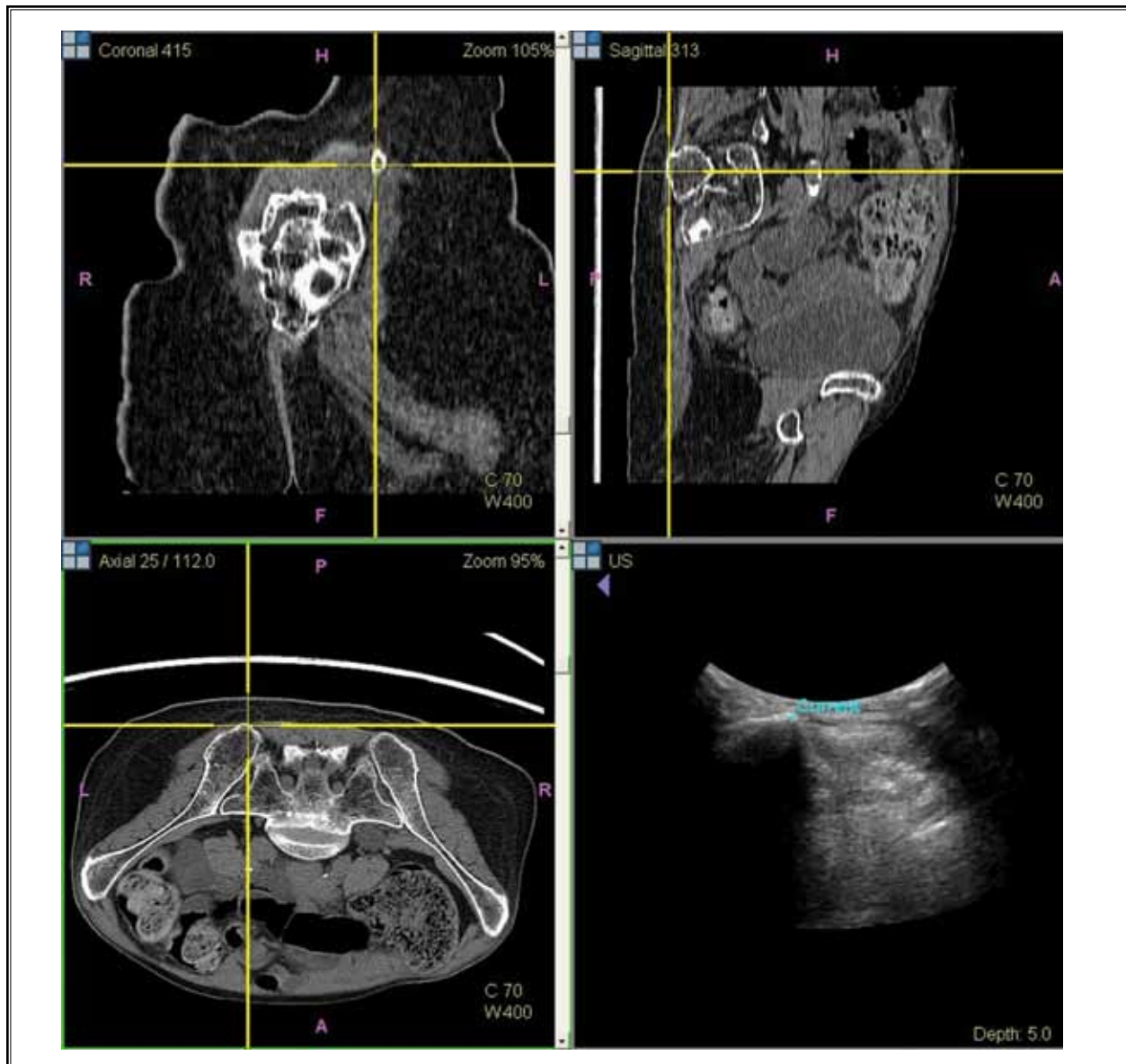


Fig. 2. Left posterior superior iliac spine ultrasound registration.

ultrasound image as well as on the CT or MRI using the navigation system software. This process was repeated until at least 3 points had been registered with the navigation system.

The registration error was computed and displayed by the system. The CT image was then verified with a tracked ultrasound probe and confirmed with an anatomic overlay of the CT and ultrasound image. Two planes were then needed for verification to ensure accurate overlay in 3-dimensions (Fig. 3).

After registration, the navigation system visualized the tracked needle relative to the CT scan in real-time using 2 orthogonal multi-planar reconstructions centered at the tracked needle tip. An additional reconstruction display was centered at that selected target location and provided feedback about the currently selected target location and provided feedback about the current distance and position relative to the target. A fourth display panel showed a targeting circle view that corresponded to needle advancement.

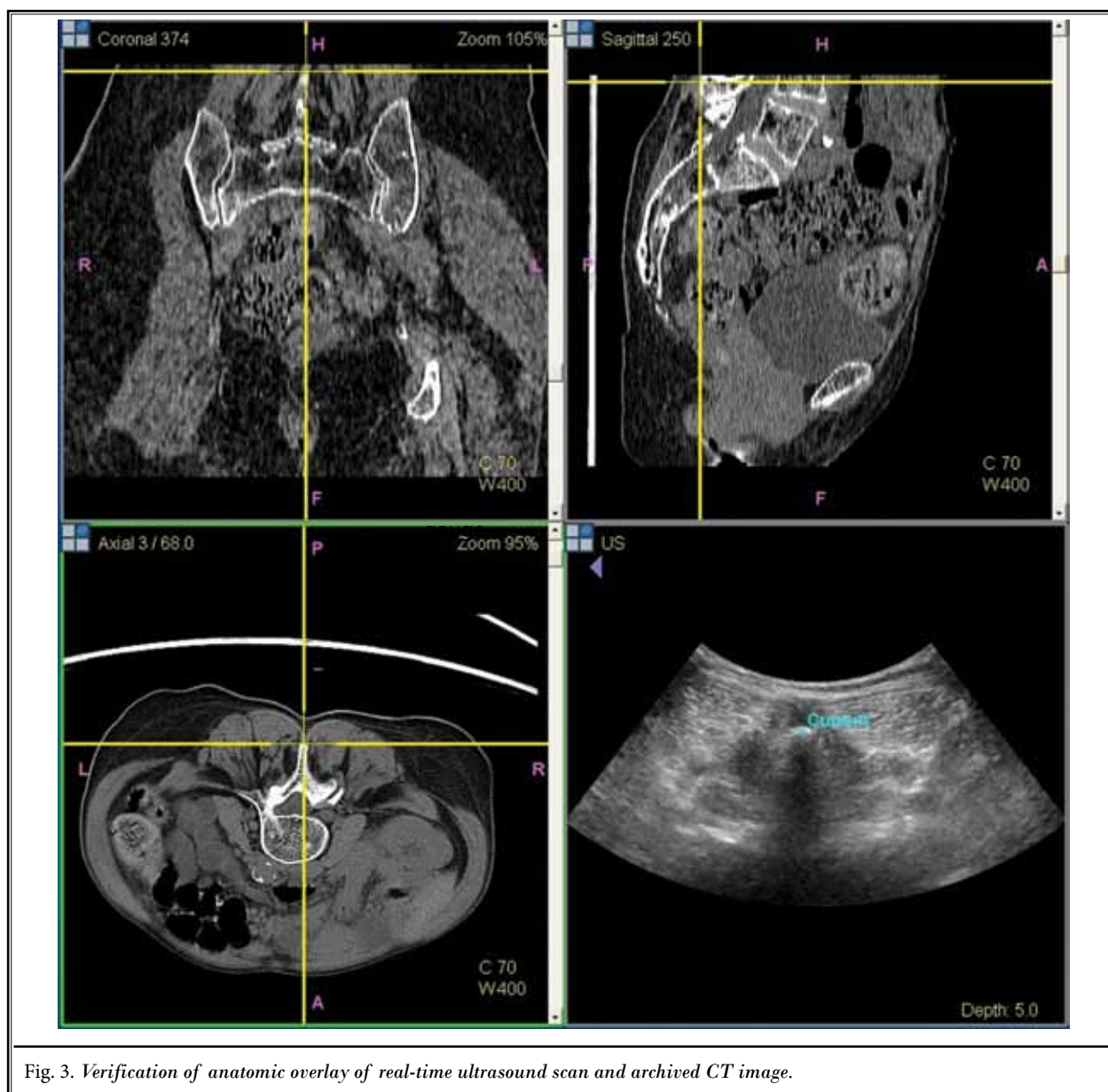


Fig. 3. Verification of anatomic overlay of real-time ultrasound scan and archived CT image.

The piriformis muscle was identified on the downloaded CT scan and the target was manually selected and marked with a "T" (Fig. 4). The skin was prepped with chlorhexidine and then 1% lidocaine was injected into the needle entry point. Needle insertions were guided by the image guidance system using a 19-gauge, 10 cm tracked introducer (5-degree of freedom sensor integrated inside the needle tip) with a 22-gauge stylet.

The intersection of the yellow line on the display screen represents the tip of the stylet. The monitor gave a continuous display of the distance of the needle tip

to the preselected target. A solid yellow line on the display screen identified the needle and a dotted yellow line represented the needle trajectory. The yellow crosshair represented the needle tip advancing to the target, which can be assisted by the red circle targeting function. This feature provides a red circle over the target which decreases in size as the needle approaches the target. When the needle is positioned at the target, the stylet is removed (Fig. 5). The needle position was confirmed with contrast medium by fluoroscopy. The piriformis muscle was injected with a 6 mL injection of

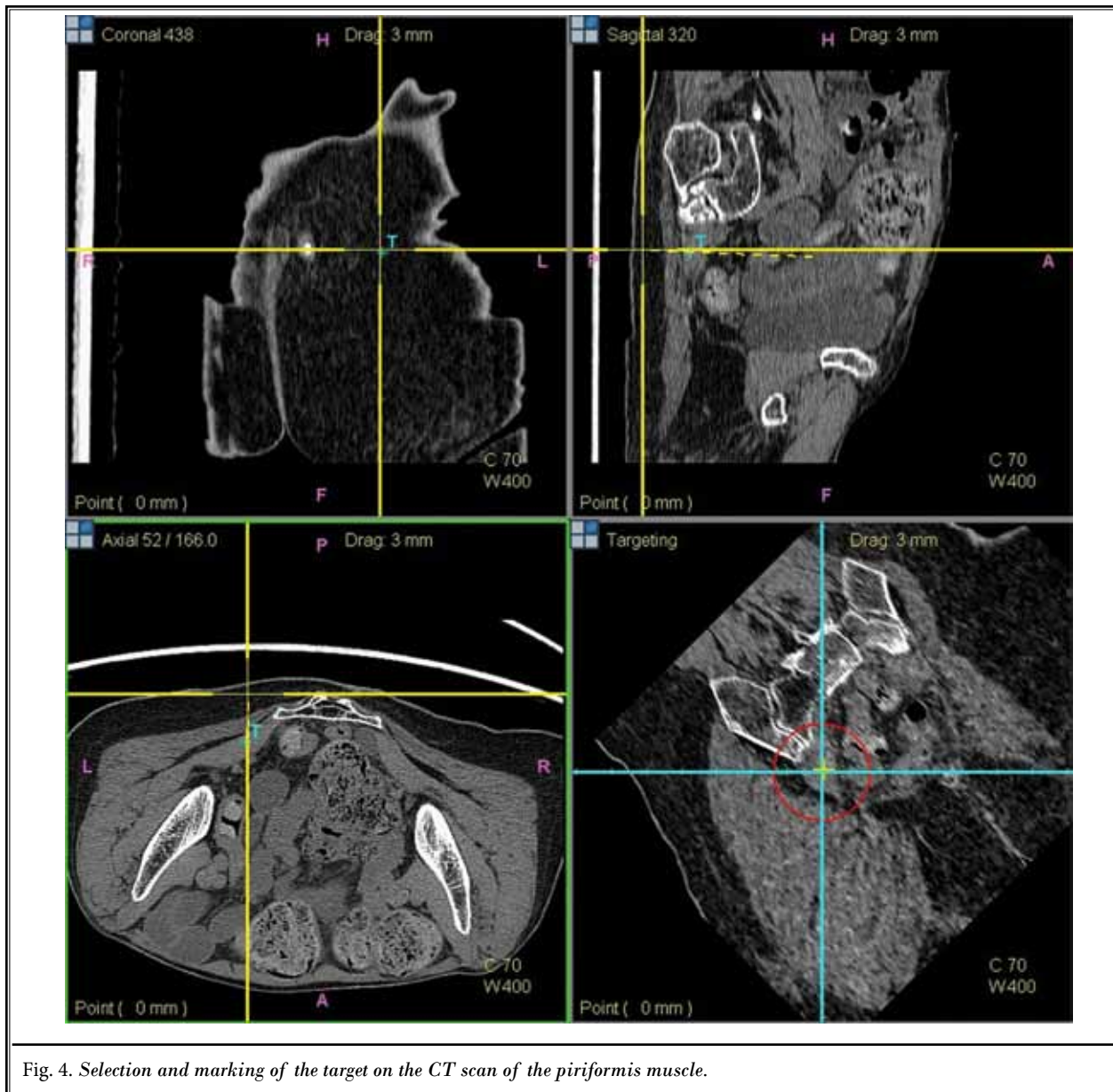


Fig. 4. Selection and marking of the target on the CT scan of the piriformis muscle.

0.25% bupivacaine and 40 mg of triamcinolone.

RESULTS

All 5 enrolled patients completed the study. Accurate needle placement was confirmed by fluoroscopy. Figure 6 shows navigation displays and confirmation scans during a procedure. The mean body mass index of the patients was 26.8 ± 7.57 % (mean \pm standard deviation [SD]).

Procedure Timing

The mean (\pm SD) procedure time for all 5 patients was 19.08 (\pm 4.9) minutes. The procedure time started at the moment the patient entered the room until the time the physician deemed the procedure was complete. Steps during the procedure included covering the field generator with a sterile cover, positioning the field generator, and registration and carrying out the procedure, including verification with fluoroscopy. The mean (\pm SD) time from skin prick to reaching the target in all 5 procedures was 1.84 (\pm 1.54) minutes.

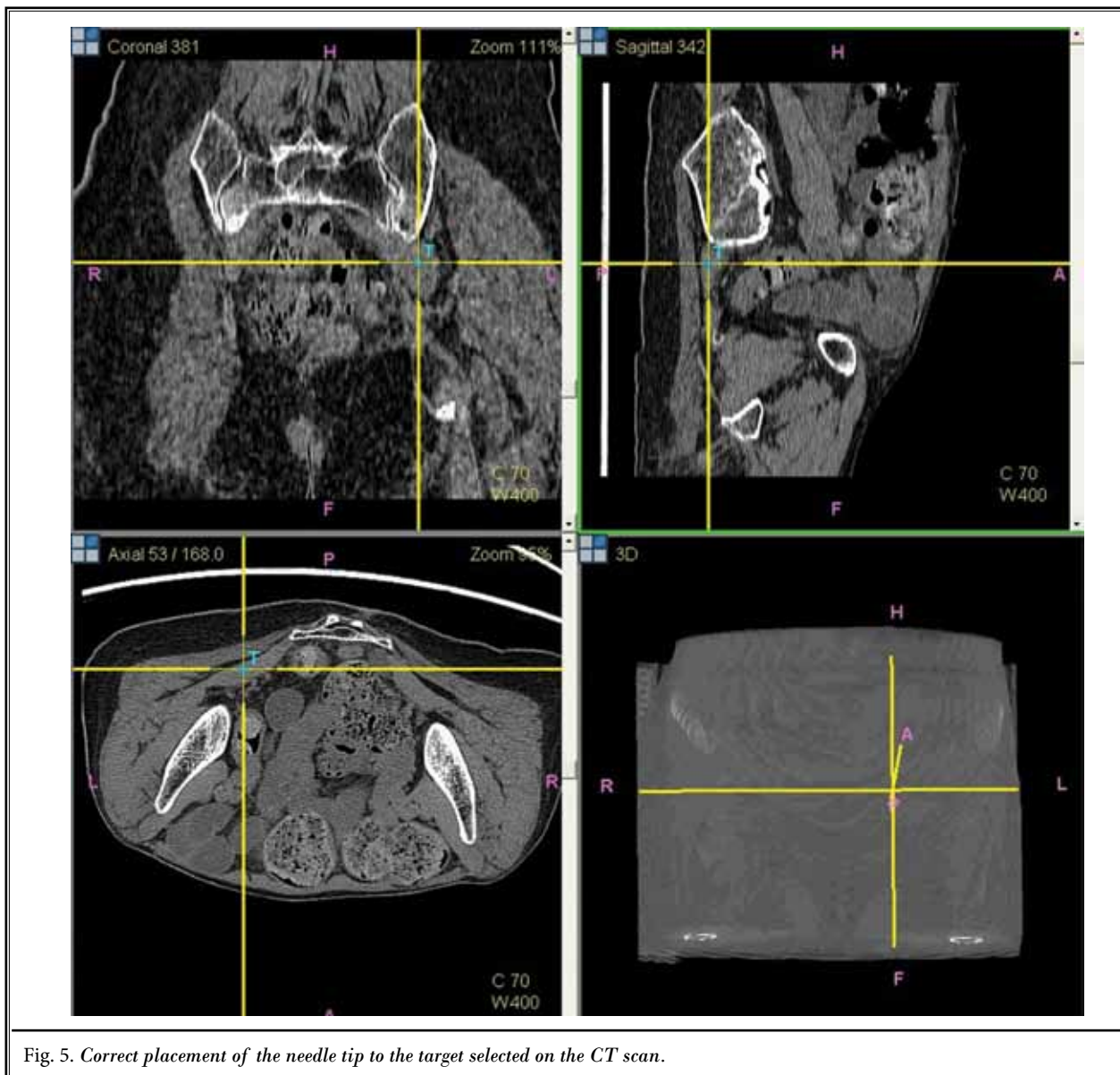


Fig. 5. Correct placement of the needle tip to the target selected on the CT scan.

Registration Error

The mean (\pm SD) registration error was evaluated in all 5 patients and was 4.02 ± 1.63 mm. The registration of 2 of the 5 patients also included a mean manual scan drag of 1.40 ± 1.95 mm to align the modalities. This is a measure of how well the preprocedure images are fused to the live ultrasound images.

Distance to Target

The mean (\pm SD) distance to the marked target displayed on the screen prior to skin prick was 57.42 ± 37.27 mm for all 5 procedures. The mean (\pm SD) dis-

tance to the marked target displayed on the screen at the point when the physician was satisfied with the needle placement and was "at target" was 4.26 ± 3.18 mm.

Needle Passes

The total number of needle passes required to reach the manually defined target was recorded for each case. A "pass" is defined as a deliberate backward motion of the needle followed by a trajectory change and reinsertion. The mean (\pm SD) number of passes was $1.0 \pm .86$. The number of passes required to reach the

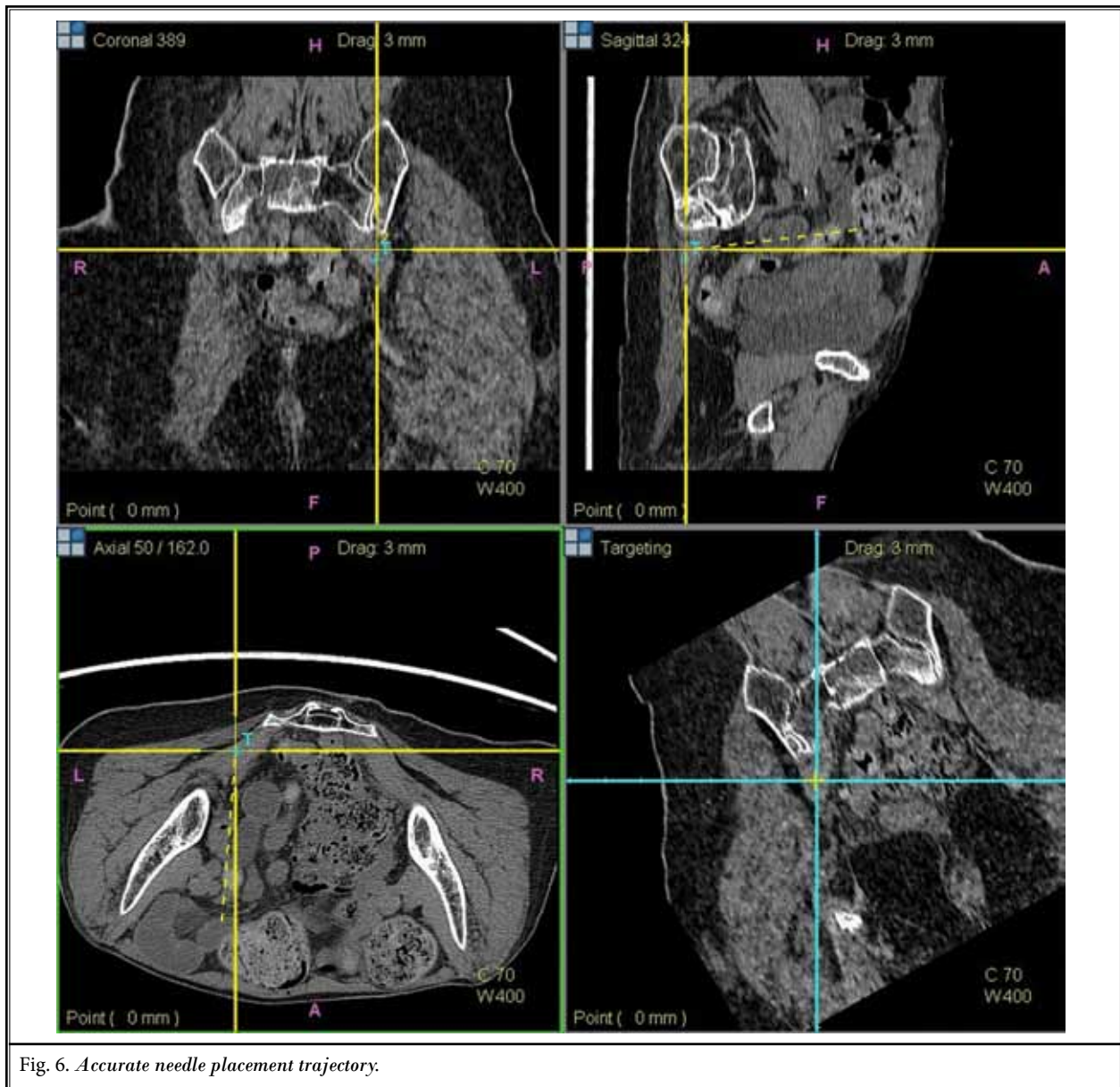


Fig. 6. Accurate needle placement trajectory.

target for each patient decreased as patients were enrolled (from Patient 1 to Patient 5).

Clinical Evaluation

Each procedure was evaluated by the respective physician after its completion to qualitatively assess the utility of the navigation system and associated tools. The information from the questionnaire is displayed and the results are displayed in Table 1. The questionnaire was rated on a nonnumeric sliding scale, indicating their strength of agreement to the questions (i.e.,

strongly disagree to strongly agree). The responses were then converted to numeric values by overlaying a number line between 0 and 10, where 0 corresponded to strongly disagree and 10 corresponded to strongly agree.

The various techniques utilized for piriformis injection have inconsistent success rates. The piriformis muscle is known to have anatomical variations that are easily identified by CT or MRI scans but are not visible with x-ray. Fluoroscopically guided injection exposes the patient and staff to radiation and relies

Table 1. Clinical evaluation scores from questionnaire.

Question	Statement	Score	SD
1	In general, I considered this to be a difficult case	3.82	1.15
2	The navigation system provided useful information	8.08	1.52
3	I was able to plan the procedure more effectively with the navigation system	7.2	2.05
4	The navigation system gave me greater confidence	6.3	2.48
5	The fusion software was useful	7.98	1.98
6	The navigation system reduced procedure time	4.74	3.31
7	The navigation system reduced the number of scans	6.26	3.01
8	The navigation system reduced the amount of contrast required	4.22	2.48
9	The navigation system was user-friendly	7.5	1.47
10	Overall, the navigation system improved patient care	6.84	2.08
11	I can see the need for the navigation system in a variety of cases	6.84	1.88

0 < strongly disagree - strongly agree > 10

on bony landmarks with contrast medium injection for confirmation of accurate needle placement. Real-time ultrasound-guided piriformis injections have been shown to be accurate, but may present a challenge with needle tracking and identification of the muscle in an obese patient. A large number of patients referred to our pain clinic have had prior imaging studies (CT or MRI scans) that can be loaded into the navigation system and used for EM-guided tracking of the needle. The registration of the electromagnetic field allows visualization of a tracked needle to be superimposed on the preprocedure CT scan. The projected needle trajectory allows the physician to preselect the course of the needle prior to insertion. This may be of benefit over fluoroscopy in procedures such as sacroiliac injections where there may be bone shadowing. This pilot study demonstrated that the use of a 3-D image guided navigation system might be a viable alternative for accurate needle guidance for piriformis injection.

Side Effects/Complications

As with any invasive procedure, the concern of complications exists. These patients were informed of the possibilities of an allergic reaction, the risk of direct trauma to the sciatic nerve or portions of the nerve from the needle, and the risk of infections.

The patients did not display any adverse effects or symptoms during their procedures. During postprocedure observation, these 5 patients did not display any side effects or complications. Additionally, no neurological deficits were observed. The patients were instructed to continue to take their medication for relief

of severe pain. Each of the patients was then scheduled for a follow-up visit in 6 weeks.

DISCUSSION

A recent study of piriformis muscle injection performed under ultrasound guidance had a 95% success rate in comparison to fluoroscopically guided injection, which had 30% accuracy (7). At our institution, we use a fluoroscopically guided and contrast medium-controlled technique to inject the piriformis muscle. We use as the target a spot situated 1.5 cm caudad to the inferior border of the sacroiliac joint and 1.5 cm lateral to the edge of the sacrum. The needle is then placed under local anesthesia and sterile technique, and a lateral view is obtained to confirm the placement of the tip of the needle 4 to 5 mm anterior to the ventral aspect of the sacrum. Contrast medium is then used for seeing the distribution of the dye along the fibers of the muscle extending from the lateral edge of the sacrum toward the greater trochanter. Additionally, our institution utilizes ultrasound for piriformis injections.

Here, we present a case study of 5 successful piriformis injections using 3-D computer-assisted electromagnetic needle tracking coupled with ultrasound. PercuNav, a computer-assisted, image-guided diagnostic and interventional navigation system was used successfully when performing these interventional procedures using ultrasound and previously acquired images (CT, MRI scans).

CONCLUSION

This technique allows for electromagnetic instrument tip tracking with real-time 3-D guidance to the

selected target. The enhanced accuracy utilizing ultrasound coupled with 3-D navigation and the decreased risk of radiation exposure to patients, physicians, and staff encourages future usage (8).

AUTHOR CONTRIBUTIONS

All authors contributed as investigators to the study and as authors to the manuscript. All authors discussed the results of the study and made comments on the manuscript. All authors had final approval of the manuscript.

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