The relative risk to the femoral nerve as a function of patient positioning: potential implications for trigger point dry needling of the iliacus muscle

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ABSTRACT

Objectives: Prudent dry needling techniques are commonly practiced with the intent to avoid large neurovascular structures, thereby minimizing potential excessive bleeding and neural injury. Patient position is one factor thought to affect the size of the safe zone during dry needling of some muscles. This study aimed to compare the size of the needle safe zone of the iliacus muscle during two different patient positions using ultrasound imaging.

Methods: The distance from the anterior inferior iliac spine (AIIS) to the posterior pole of the femoral nerve was measured in 25 healthy participants (11 male, 14 female, mean age = 40) in both supine and sidelying positions using a Chison Eco1 musculoskeletal ultrasound unit. The average distance was calculated for each position and a two-tailed, paired t-test ($\alpha < 0.05$) was used to examine the difference between positions.

Results: The mean distance from the AIIS to the posterior pole of the femoral nerve was statistically greater with participants in the sidelying position (mean[SD] = 35.7 [6.2] mm) than in the supine position (mean[SD] = 32.1 [7.3] mm, $p < .001$).

Discussion: Although more study is needed, these results suggest that patient positioning is one of several potential variables that should be considered in the optimization of patient safety/relative risk when performing trigger point dry needling.

Level of Evidence: Level 4 (Pre-Post Test)

KEYWORDS

Trigger point; dry needle; patient position; risk; safety; iliacus

Introduction

Dry needling is described as, ‘a procedure in which a solid filament needle is inserted into the skin to stimulate underlying myofascial trigger points, muscular, and connective tissues for the management of neuromuscular pain, impaired muscle performance, and movement dysfunction [1]’. Trigger point dry needling (TrPDN) refers to a subset of dry needling techniques in which a single solid monofilament is inserted into muscular trigger points (but also may include periosteum and other connective tissues) in order to improve or restore function [2]. TrPDN interventions are becoming more common in clinical practice. In the previous 8 years there has been an increase in variability of proposed patient positions and needle direction used with TrPDN techniques.

Currently, there is a paucity of literature regarding the relative safety, risk and effectiveness of these alternative techniques, particularly with respect to patient

position. Specific to needle placement, several cadaveric validation studies exist examining success rates of reaching target tissue (lateral pterygoid and lumbar multifidus, respectively) [3,4]. Caution must be taken in generalizing these results to patient populations as it is theoretically possible to both reach the targeted tissue and to also, unintentionally, dry needle unintended structures resulting in possible serious adverse events observed only *in vivo*. More recent research on accuracy of needle placement conducted *in vivo* and confirmed by musculoskeletal ultrasound (MSKUS) confirms success in reaching target tissue (in this case the cervical multifidus) [5]. However, the researchers did not examine the impact of patient positioning.

Regarding risk, pneumothorax is a well-recognized and well-publicized, but statistically rare adverse event, related to acupuncture or TrPDN over the thorax [6–10]. Additionally, several case reports describe significant adverse events resulting from inadvertent contact with vascular structures [11–13] or peripheral nerves [14,15]

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as a result of acupuncture interventions. Only one case report to date has attributed a peripheral nerve related injury to TrPDN performed by a physical therapist [16].

Literature exists describing changes in position, volume, and shape of internal organs as a function of subject positioning [17–22]. Currently there are not studies examining how movement of internal structures, including organs or neurovascular structures toward or away from the needle zone, impacts the relative safety of one TrPDN technique compared to another. Fortunately, models exist within the physician literature verifying needle placement during trigger point injections. These models can be used to inform the present research study. De Andres and Palmisani described a technique verifying needle placement during injections of the iliopsoas and quadratus lumborum [23,24] using fluoroscopy. This technique has practical limitations in applicability for physical therapist researchers and clinicians in terms of expense, patient irradiation, and limited ability to administer fluoroscopy. Verification of needle placement with trigger point injections via MSKUS has been described [25,26] and as previously noted, can be applied to needle placement verification and safety studies using dry needling. MSKUS significantly reduces the cost of the procedure while eliminating the radiation exposure to the patient [27].

Specific to this study, there is variation among providers regarding perceived preferred patient positioning. The supine technique is described as follows: the clinician stands at the ipsilateral side of patient with patient's thigh resting in hip flexion, external rotation, and abduction, on clinician's bent knee; and then the clinician inserts the monofilament needle lateral to the neurovascular bundle, directing the needle either posteriorly toward the lesser trochanter or alternatively toward the iliac fossa just medial and anterior to the anterior superior iliac spine (ASIS) [28].

An alternative approach describes the position as follows: the patient is positioned in sidelying with the target muscle superior and the clinician standing behind the patient. With the fingers of the non-needling hands wrapped or 'hooked' around the iliac crest, the monofilament needle is inserted approximately 5 mm from the bone into the external oblique and directed toward the concavity of the anterior ilium [29,30].

This approach hypothesizes that like internal organs [17–22] and vascular structures fall away from the needle zone and toward the treatment table as a function of gravity. As such, a lower relative risk of patient injury is presumed. This hypothesis is reasonable but it lacks evidence. These different techniques suggest a lack of consensus among practitioners. In addition, there is currently no research guiding optimal patient positioning when needling the iliopsoas muscle [28–32].

The term 'safe needle zone' is used in clinical practice to describe a specific anatomical area to which the practitioner must strictly adhere in order to avoid or

minimize the risk of patient injury. This term is most commonly used to describe safe dry needling of the thoracic multifidus in an effort to avoid a patient pneumothorax [33]. It may also be used to describe specific anatomic areas that must be adhered to avoid patient injury to the femoral nerve (when dry needling the iliopsoas or iliopsoas muscles), or femoral vein (when dry needling the pectineus). Note: The iliopsoas was the theoretical focus of this study because neither iliopsoas nor pectineus are taught using a semi-sidelying patient position. The iliopsoas however, may be treated with the patient in either the supine or semi-sidelying position.

Despite an extremely low risk of serious injury from acupuncture [8–15] or dry needling [6,16], every effort should be made to improve upon the safety of existing techniques or when developing new/alternative techniques. Specifically, when needling the iliopsoas muscle, it is unknown whether soft tissue and neurovascular structures change position in response to patient position resulting in changes in the dimensions of the region ascribed to the safe needle zone. Since dry needling of the iliopsoas muscle is performed just medial to the anterior ilium, a greater ASIS to femoral nerve distance would suppose a larger safe needle zone and would therefore reasonably suggest a safer positioning for TrPDN of the iliopsoas muscle. Because the ASIS to femoral nerve distance is too large to be imaged by MSKUS in a single image, the anterior inferior iliac spine (AIIS) to femoral nerve distance was used as a comparable alternative.

Literature does exist describing high accuracy of distance measurements obtained under ultrasound in both phantom models (e.g. 99.5% of measurements accurate within $\pm 4\%$) [34,35,36], as well as distances between other anatomic structures (e.g. inter-rectus distance) in human subjects [37]. However, to the authors' knowledge, this is the first investigation of this novel measurement of the AIIS to the femoral nerve distance. The purpose of this study was to use MSKUS imaging to compare the size of the AIIS to femoral nerve distance as an indicator of potential risk of injury to the neurovascular bundle between two different patient positions while performing a TrPDN technique to the iliopsoas muscle using ultrasound imaging [28–32]. The authors' primary hypothesis was, unlike the movement of abdominal contents, the movement of the neurovascular structures of the upper leg (supported by fascia), would be negligible as a function of subject position.

Methods

Participants

A total of 25 healthy volunteers were recruited. All participants were either clinicians (physical therapists, physical therapist assistants), allied-health students, or administrative support personnel from within Atrium Health (formerly Carolinas HealthCare System) in

Charlotte, North Carolina, USA. Participants were excluded if they were actively in pain, had a history of hernia repair surgery involving mesh, or were unable to lie in supine or on their left side. Body mass index (BMI) was not considered, but it was noted post hoc that most subjects were physically fit healthcare professionals. It is not known whether a more diverse subject sample would have affected results. The study protocol was approved by the Atrium Health (formerly Carolinas HealthCare System) Institutional Review Board (#12-16-05E) for human subject research.

Examiner

All participant screening and ultrasound imaging measurements were obtained by a single investigator who had completed training and was certified in both TrPDN and MSKUS imaging. This investigator is also a physical therapist with more than 20 years of clinical experience who has used TrPDN for more than 5 years in clinical practice to treat the iliacus muscle.

Procedures

This single-group, cross-sectional design involved an initial measurement in supine (Figure 1). Next, the subject was repositioned side-lying for the second measurement (Figure 2). Both of these assessments were performed in the same data collection session. The subject was not dry needled at any point during the study. After providing informed consent, participants were screened for exclusion criteria and

provided demographic information (gender and age). The subjects verbally confirmed they had not had prior hernia repair surgery involving mesh nor did they have pain in the region being imaged.

Supine MSKUS Imaging (Figure 1)

All images were obtained over a single data-collection session lasting approximately 15–20 min using a Chison Eco1 (Universal Diagnostic Solutions, San Diego, CA, USA) and a L7M-A linear transducer producing B-Mode greyscale images. In an effort to both maximize the MSKUS viewing area and standardize the hip flexion position across subjects, all subjects were placed in supine with their lower extremities unsupported and flat on the table.

Secondary to differences in patient morphology, the boney landmark of the AIIS was first visualized under MKSUS using one of two methods (either a superior approach or an inferior approach). Neither the novel image produced for this study nor either of the two image production approaches (e.g. superior or inferior) are part of any traditional hip MSKUS imaging protocol [37]. They were however, reviewed and determined valid by the MSKUS content experts involved with this study and further validated by independent physician content experts.

In the superior approach, the transducer probe was placed horizontally with the reference end of the transducer at the boney landmark of the right ASIS. The transducer probe was then repositioned by sliding the probe inferiorly and, with small changes in angle by moving the tail of the transducer vertically (e.g. fanning) and horizontally from end to end (e.g. heel-toe), the image of the AIIS was optimized. In the inferior

Figure 1. Supine MSKUS imaging position and transducer placement. (Inferior approach to final probe placement shown).

Note that the reference end of the ultrasound transducer is positioned laterally on the AIIS, with the non-reference end placed medially over the femoral nerve.

Figure 2. Sidelying MSKUS imaging position and transducer placement.

With the transducer firmly held on subject, the image was maintained while re-positioning patient into a sidelying position.

approach, the rectus femoris was identified and the transducer probe translated superior until the AIIS came into view. The AIIS image was optimized via subtle fanning and heel-toe adjustments of the transducer probe. With the AIIS as the reference boney landmark, the transducer was translated medially to scan past the femoral nerve until both the pulsating circle of the femoral artery and the adjacent femoral nerve both appeared on the right side of the screen in cross-sectional short axis view (Figure 3). Finally, the distance between AIIS and posterior angle of the triangular femoral nerve was measured using the imaging system's measurement tool (Figure 4). The color doppler function was not used in the course of this study because the ChiSon Eco1 (an affordable entry-level unit currently more likely to be found in clinical practice) does not include this feature. For the sake of reader clarity, an image produced with a more sophisticated imaging device that can produce a color Doppler image (GE Voluson i) is provided (available to the authors only after the data collection phase of the study).

Sidelying MSKUS Imaging (Figure 2)

Following the supine measurement, and while firmly maintaining the transducer position on the subject with the resultant previous image maintained, the subject was then carefully repositioned in sidelying with their lower extremities maintained in the same position relative to the trunk. As was the case when imaging in the supine position, the subject's hips were placed in neutral an effort to both maximize MSKUS viewing area and standardize hip flexion position across subjects. The transducer was once again fanned and heel-toed so as to visualize both the AIIS and most posterior aspect of the femoral nerve. Again, the distance was measured using the imaging system's measurement tool. In an attempt to standardize the imaging procedure between subjects, a strictly sidelying position was used in contrast to the

semi-sidelying position more commonly used by clinicians when dry needling the iliacus.

Data analysis

All data were collected and analyzed with IBM SPSS Version 22 software (Chicago, IL, USA). Descriptive statistics (mean, standard deviation, and range) were performed on the demographic characteristics of the sample (Table 1). The Shapiro-Wilk test for normality of the sample distribution was used (Table 2). A two-tailed paired t-test was used to compare the distance from the AIIS to the posterior pole of the femoral nerve between supine and sidelying positions using alpha of 0.05 to denote statistical significance. (Table 3)

Results

All of the data that was gathered was used without exclusion. All of the subjects agreed to participate and no one was excluded from the study participation for any reason. There were 14 female and 11 male subjects with ages ranging from 23–57 years of age (Table 1). The average distance from the AIIS to the posterior pole of the femoral nerve (Table 3) was statistically greater when the subjects were measured in the sidelying position (mean[SD] = 35.7 [6.2] mm) versus in supine position (mean[SD] = 32.7 [7.3] mm) mean difference [95% CI] = 3.6 [1.5, 1.6] mm). However, the distance from the AIIS to the posterior pole of the femoral nerve was larger in 5 of the 25 participants during supine position than compared to the sidelying position.

Discussion

The purpose of this study was to compare changes in distance from the AIIS to the neurovascular bundle in

Figure 3. Artist rendering of anatomical landmarks for study measurement (incircle lower left). Note the study measurement from AIIS to the posterior (deepest) aspect of the triangular femoral nerve.

healthy, non-painful adult subjects when positioned in supine and sidelying positions respectively. Our results suggest the average distance from the AIIS to the femoral nerve was 3.6 mm greater in the sidelying position than in the supine position for this population. Interestingly, 20% ($n = 5$) of the subjects had distances that measured larger in the supine position. Of note, one individual had exactly the same measurement in supine as in sidelying. It is not known what specific factors may account for this variance. The authors suggest future study with a larger number of subjects to explore covariates ranging from age, gender, BMI, pelvic morphology, sacroiliac joint mobility, global hypermobility, and/or ethnicity, with consideration of intrabdominal pressures which have been shown to

influence abdominal organ position related to intraabdominal surgery or respiration [38].

While rare [6,7,16], the potential seriousness of adverse events related to TrPDN demands that clinical professionals using the technique leverage their clinical reasoning to optimize patient safety. In such cases it is necessary that the clinician fully understand and incorporate relative risk into the clinical reasoning process. As an example Hannah et al. (2016) described an alternative technique to the gold standard inferior-medial method of dry needling the lumbar multifidus muscle taught by the originators of the technique [4]. In this augmented technique, the needle is directed in a strictly posterior to anterior direction to land on the lamina. Although the authors hit lamina on 8 out of 8 cadavers, Hannah and colleagues did

Figure 4. MSKUS short-axis/cross-sectional image of AIIIS to posterior pole of the triangular-shaped femoral nerve.

Table 1. Descriptives (N = 25, no missing data).

	Age (years)	Side lying (mm)	Supine (mm)
Mean	39.8	35.7	32.2
Standard deviation	11.8	6.20	7.36
Range	38	25.1	30.1
Minimum	23	23.5	17.4
Maximum	61	48.6	47.5

Table 2. Test of Normality (Shapiro-Wilk).

	W	P
Sidelying	0.979	0.874
Supine	0.973	0.727

Significant results suggest a deviation from normality. JASP (version 9.4.3., University of Amsterdam) used to perform the Shapiro-Wilk test.

not consider relative clinical risk as compared to the gold-standard technique. Specifically, the rationale for the inferior-medial approach is more than simply landing upon the lamina, but also to decrease the risk of slipping between two adjacent vertebrae and causing iatrogenic epidural hematoma. This risk is more than theoretical and not profession specific. It has been documented in both a 2010 case report describing the rare event of an epidural hematoma causing paralysis in a 58 year old female resulting from dry needling of spinal musculature by her

family physician [39], as well as a more recent case report describing paralysis of a 64-year-old man resulting from acupuncture of a deep point within the paraspinal musculature [40]. This is not to say that technique augmentation in terms of needle direction or patient position is never appropriate. Unique patient characteristics may in fact demand it. The augmented approach described by Hannah, et al. has, in fact, been taught by a variety of TrPDN continuing education providers as an acceptable augmentation when performing TrPDN in patients with lumbar laminectomy and fusion at a superior level. It is not, however, considered equivocal by the authors of this article to the traditional technique in terms of relative risk in lieu of any mitigating factors.

No in vivo literature exists regarding accuracy of advancing a dry needle to intended target tissue. Studies involving cadaveric preparations describe success rates of reaching target structures [3–5], but not error rate in terms of distance, of reaching a specific point within said target tissue. Evidence exists in the interventional radiology literature suggesting that joint injections can be performed with reasonable accuracy/specificity without imaging guidance [41], but that accuracy improves to within 2 mm when the needle injection is performed under imaging guidance with robotic assist [42–44].

Table 3. Paired Samples T-Test.

							95% Confidence Interval		
		Statistic	df	p	Mean difference	SE difference	Lower	Upper	
Side lying	Supine	Student's t	3.60	24.0	0.001	3.58	0.995	1.52	5.63

Studies have shown benefit of ultrasound guided injection over accuracy of landmark guided ultrasound injection in terms of needle placement, but again in terms of distance from reaching a specific point within said target tissue [45]. Regardless, access to computerized robotic guidance, fluoroscopy, computerized topography, or even MSKUS is not yet commonplace in most settings where dry needling takes place. Clinicians must therefore utilize alternative strategies to maximize patient safety during TrPDN. Theoretically, a greater AIIS to femoral nerve distance would suggest a larger ASIS to femoral nerve safe needle zone and would therefore denote a relatively safer positioning for dry needling of the iliacus muscle. Relative to the supine position, the semi-sidelying approach resulted in a greater needle zone and can therefore, be argued to imply a slightly lower relative risk of dry needling unintended structures than the supine technique.

Limitations

In an effort to standardize subject positioning, the side lying position used in this study is a slight modification from 20 to 40 degree 'semi-sidelying' position used in the clinic. Statistical and clinical significance of this modification is unknown. In addition, the true needle zone is slightly more superior and from the ASIS to the femoral nerve than the AIIS to femoral nerve measurement used. Recall that this choice was made on the part of the authors' in an effort to avoid summation of measurements across multiple images (thereby introducing a potentially significant source of measurement error). The acoustic footprint of the L7M-A MSKUS linear transducer probe, ASIS to femoral nerve cannot consistently capture the distance in a single image. It is not known what effect, if any, a direct measurement of ASIS to femoral nerve would have had, but the opportunity for future research exists in using more versatile imaging modalities. For standardization purposes, only the right side of subjects was measured in this study. It is unknown whether limb dominance and potential differences in tissue girth side to side would have altered the results had the measurements been compared side to side or performed on the left. In addition, other smaller nerve structures such as the ilioinguinal and/or lateral femoral cutaneous nerves were not identified. Consequently, as the iliacus muscle was the focus of this study, no conclusion can be reached regarding possible changes in location or clinical implications of patient positioning when needling other muscles of the upper leg. The possibility of visceral pathology upon visceral mobility and resultant effect, upon AIIS to femoral nerve distance was not considered. Finally, although no subject required positioning modification on the basis of BMI, it was not a metric considered for this study. No inferences can be made regarding the impact of BMI upon absolute AIIS to

femoral nerve distance in supine or sidelying, nor the relative change in positionally mediated distances.

Conclusion

Although it is beyond the scope of this article to define the exact distance of a safe needle zone or threshold for safety, the authors' aim of this study is to build a case for utilizing patient positioning as a component of relative safety when performing TrPDN. Furthermore, in certain clinical scenarios, patient positioning may suggest a safer positioning strategy as opposed to merely 'preferred' positioning. This study demonstrated a statistically significant wider safe needle zone between AIIS and femoral nerve with the patient placed in a sidelying versus a supine position. Clinicians should consider patient positioning as one of several variables that may impact patient safety when performing TrPDN. Absent any mitigating factor (ranging from patient inability to lie on the contralateral shoulder or hip, to clinician comfort/confidence in performing the technique with patient in one position versus the other) clinicians should consider the semi-sidelying position for TrPDN of the iliacus as a potential safety strategy to avoid an adverse event to the femoral nerve.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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