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Mabel Qi He LEOW
Singapore General Hospital

Shu Li CUI
Singapore General Hospital

Mohammad Taufik Bin MOHAMED SHAH
Singapore General Hospital

Taige CAO
National Skin Centre, Singapore

Shian Chao TAY
Singapore General Hospital

See next page for additional authors

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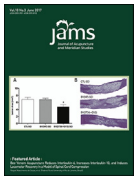

CASE REPORT

Ultrasonography in Acupuncture—Uses in Education and Research

Mabel Qi He Leow [1,*], Shu Li Cui [2], Mohammad Taufik Bin Mohamed Shah [3], Taige Cao [4,5], Shian Chao Tay [1,6], Peter Kay Chai Tay [7], Chin Chin Ooi [3]

[1] *Biomechanics Laboratory, Singapore General Hospital, Singapore*
[2] *Pain Management Centre, Acupuncture Services, Singapore General Hospital, Singapore*
[3] *Department of Diagnostic Radiology, Singapore General Hospital, Singapore*
[4] *Medical Department, National Skin Centre, Singapore*
[5] *Singapore College of Traditional Chinese Medicine, Singapore*
[6] *Department of Hand Surgery, Singapore General Hospital, Singapore*
[7] *School of Social Sciences, Singapore Management University, Singapore*

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Abstract
This study aims to explore the potential use of ultrasound in locating the second posterior sacral foramen acupuncture point, quantifying depth of insertion and describing surrounding anatomical structures. We performed acupuncture needle insertion on a study team member. There were four steps in our experiment. First, the acupuncturist located the acupuncture point by palpation. Second, we used an ultrasound machine to visualize the structures surrounding the location of the acupuncture point and measure the depth required for needle insertion. Third, the acupuncturist inserted the acupuncture needle into the acupuncture point at an angle of 30°. Fourth, we performed another ultrasound scan to ensure that the needle was in the desired location. Results suggested that ultrasound could be used to locate the acupuncture point and estimate the depth of needle insertion. The needle was inserted to a depth of 4.0 cm to reach the surface of the sacral foramen. Based on Pythagoras theorem, taking a needle insertion angle of 30° and a needle insertion depth of 4.0 cm, the estimated perpendicular depth is 1.8 cm. An ultrasound scan corroborated the depth of 1.85 cm. The use of an ultrasound-guided technique for needle insertion in acupuncture practice could help standardize the treatment. Clinicians and students would be able to visualize and measure the depth of the sacral foramen

* Corresponding author. Biomechanics Laboratory, Singapore General Hospital, Academia, Level 1, 20 College Road, 169856, Singapore.
E-mail: mabelleowqihe@yahoo.com (M.Q.H. Leow).

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acupuncture point, to guide the depth of needle insertion. This methodological guide could also be used to create a standard treatment protocol for research. A similar mathematical guide could also be created for other acupuncture points in future.

1. Introduction

In acupuncture treatment, sufficient needling depth is required to ensure adequate degree of somatosensory stimulation for treatment efficacy [1], yet safe needling depth is a concern [2,3]. However, needling is based on blind insertion. Hence, acupuncturists face two challenges in delivering needle insertion: location and depth of needle insertion.

Location of an acupuncture point is based on palpation, and deep acupuncture points could be difficult to palpate. Reaching the desired needle depth is mainly based on the patient's self-report of having felt dullness, tightness, soreness, tingling, aching, or electrical sensation either around the needle or traveling up or down the affected meridian, also known as the *de qi* sensation. The sole reliance on *de qi* to justify treatment efficacy is insufficient due to patients' subjectivity and the manipulation of the needle, which could produce a "fishing" sensation being misinterpreted as *de qi*. Such a sensation could also be stimulated by other factors such as anxiety during treatment.

Although standard guides have been developed to provide ranges for depth of needle insertion, the ranges can differ by a significant percentage. For example, in the acupuncture point at the second sacral foramen BL 32, the recommended depth of needle insertion ranges from 1 cun to 1.5 cun [4], representing a difference of up to 1.5 times. In addition, in acupuncture points that require deep insertion such as those in the sacral foramen, ensuring sufficient depth has been a challenge [5].

In Western medicine, ultrasound has been used to assist in clinical procedures such as biopsy [6] and peripheral nerve blocks [7]. In acupuncture, ultrasound can be a useful tool to create a scientific method of quantifying acupuncture depth and the location of anatomical structures. A review of the literature revealed that only two studies have explored the potential use of ultrasound in acupuncture [8,9]. Konofagou and Langevin [8] used ultrasound to assess the magnitude of soft-tissue displacement from the movement of needle (needle manipulation and rotation). In our previous study on a cadaveric hand, we could see the position of the needle as an echogenic spot in relation to muscle and bone [9]. Ultrasound has also been used to measure the physiological changes in blood vessel size, blood flow velocity and volume, and muscle strain before and after acupuncture needle insertion [10].

Besides ultrasound, computer tomography (CT) and magnetic resonance imaging (MRI) of human bodies have also been used to study the tradition Chinese meridian [11,12]. CT and MRI have been found to be useful for reconstructing the body fasciology and studying in relationship with the meridians [11]. A pattern of line-like structures that appear similar in form and distribution to the meridians has been observed [12]. Although MRI and CT are other cross-sectional imaging modalities that can potentially be used to guide needle insertion, these modalities have their limitations. MRI is a costly modality and not widely available. The ionizing radiation involved in a CT scan is a concern. Ultrasound is nonionizing, cost effective, and widely available and can provide real-time images. Hence, ultrasound is a better alternative modality to MRI or CT scans in locating the anatomical structure. In the present study, we aimed to explore the potential use of ultrasound in quantifying depth of insertion and surrounding anatomical structures, using a case example of an acupuncture point at the second posterior sacral foramen.

2. Materials and methods

2.1. Acupuncture needle insertion

We performed the acupuncture needle insertion on a study team member. The team member signed an institutional informed consent form about knowing the procedure involved in acupuncture, and the possible risks and complications. The acupuncture was performed by a certified acupuncturist. The acupuncture point used in this study was BL 32 (Ci Liao), located at the second sacral foramen. The sacral foramen has three acupoints—BL 31, BL 32, and BL 33. However, we have empirically chosen BL 32 as it is the middle point, and we were able to confirm the point by referencing it to BL 31 and BL 33. The participant was laid prone. A sterile technique was used—the site of needle insertion was cleansed using alcohol swab prior to needle insertion. The needle was directed superiorly at a 30° angle, using a 0.30×50 mm^2 disposable stainless-steel acupuncture needle. The needle was inserted at a 30° angle to enable visualization of the needle tip on ultrasound. This is a limitation of ultrasound. In addition, after visualizing the sacral foramen, an angle of 30° was used to best reach the opening due to the pelvic tilt of the participant.

2.2. Ultrasound scan

Ultrasound scans were conducted using a Philips iu22 system (Philips Healthcare, Bothell, WA, USA) with a 12—5 MHz linear probe at the Department of Diagnostic Radiology. A board-certified sonographer performed the scans. Aquasonic 100 was used as the coupling gel.

2.3. Experimental steps

There were four steps in our experiment.

First, the acupuncturist identified the acupuncture point (BL 32) that corresponds to the level of the posterior second sacral foramen. This was done by identifying the posterior superior iliac spine by palpation, followed by locating the BL 32 point that lies medial and inferior to it. The point was then marked using a skin marker.

Second, we used the ultrasound machine to visualize the structures surrounding the location of the acupuncture point and measure the depth required for needle insertion. An ultrasound scan was performed on bilateral sacral foramen to ensure that the depth was similar for both sides. The probe was placed a 90° angle to visualize the posterior sacral foramen. Any anatomical variations or anomalies were also recorded.

Third, the acupuncturist inserted the acupuncture needle into the acupuncture point. The acupuncturist stopped further insertion on feeling that the needle has reached the sacral foramen.

Fourth, we performed another ultrasound scan to ensure that the needle was in the desired location. The tip of the needle is located real time by asking the acupuncturist to move the needle using the lifting—thrusting technique, and visualizing an echogenic spot on the ultrasound image. This was correlated with the participant's self-report of the *de qi*. The ultrasound probe was placed approximately 3.5 cm distal from the location of needle insertion.

3. Results

3.1. Anatomical structures

Ultrasound was able to clearly visualize the structures at the level of the BL 32 acupuncture point. From superficial to deep, the skin, gluteus maximus muscle (Gmax), hyperechoic short posterior sacroiliac ligament, hypoechoic second posterior sacral foramen, and posterior shadowing caused by the sacrum were identified (Fig. 1). There was no anatomical variant. In our study participant, the distances from the skin to the superficial part of the second posterior sacral foramen on each side were measured at 2.1 cm.

3.2. Location of acupuncture point

After inserting the needle to a depth of 3.5 cm, our study participant verbalized feeling a dull tingling sensation and pain, which correlated with the first *de qi* sensation. The participant experienced an increased sensation as the needle was further inserted to 4.0 cm, to reach the surface of the sacral foramen.

On ultrasound scan, the tip of the needle was located within the gluteus maximus muscle, near the surface of the sacral foramen. Doppler function showed that it was in proximity to the exiting branch of the superior lateral sacral artery.

Based on Pythagoras theorem, taking a needle insertion angle of 30° and a needle insertion depth of 4.0 cm, the estimated perpendicular depth is 1.8 cm. An ultrasound scan corroborated the depth of 1.85 cm. The diagrammatic description is shown in Fig. 2.

4. Discussion

Our study showed that ultrasound can be a useful bedside tool to ascertain that the palpated location is at the desired acupuncture point and estimated depth of needle insertion, using a case example of the second posterior sacral foramen. Although we specifically used BL 32 in this study, the principles could be translated to all the acupuncture points at other sacral foramina. The mathematical calculations used in our study were found to correlate with theory. The depth of needle insertion in our study was

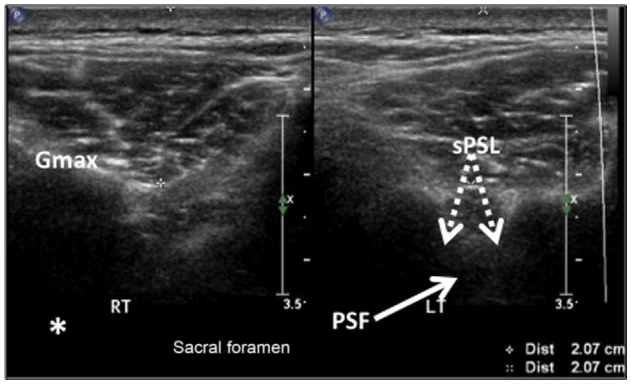

Figure 1 Location of acupuncture needle insertion. Transverse dual-view ultrasound image of bilateral BL 32 acupuncture points demonstrating sonographic anatomy at the level of bilateral second PSF. Calipers measure linear distances from skin to second PSF on each side. The hypoechoic left second posterior sacral foramen (white solid arrow), echogenic left sPSL (dotted white arrows), right gluteal maximus (Gmax), and right bony sacrum (*) are indicated. PSF = posterior sacral foramina; RT = right; sPSL = short posterior sacroiliac ligament.

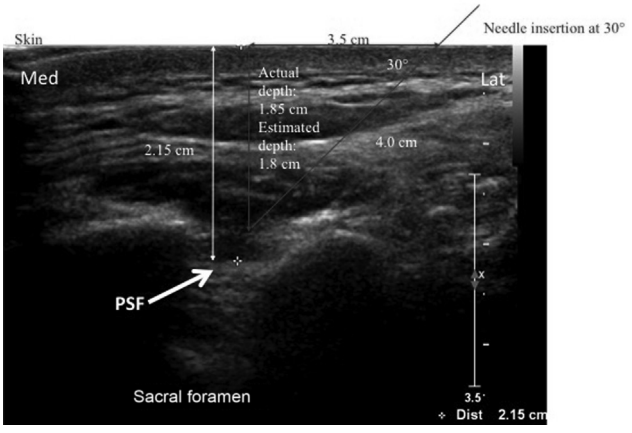

Figure 2 Transverse view of the ultrasound image demonstrating sonographic anatomy at the level of left second PSF (white solid arrow). Calipers measure linear distances from skin to second PSF. Laterality is labeled at the top of the image: Lat and Med. Pythagoras theory—needle insertion angle of 30° and depth of 4.0 cm. Estimated depth of sacral foramen is 1.8 cm, actual depth is 1.85 cm. Lat = lateral; Med = medial; PSF = posterior sacral foramina.

4.0 cm, which was within the recommended range of 3.3—5 cm for the BL 32 acupuncture point. In order to visualize the entire needle length during injection, the needle was angled at about 30° to the skin and inserted some distance from the BL 32 point. The mathematical calculations, for example, using the Pythagoras theory in our case, could serve as a guide for clinical practice and education. In research, it could be used to estimate the depth of needle insertion and standardize treatment protocols for studies on acupuncture at the sacral foramen. Currently, administration of acupuncture treatment is based purely on the experience of the acupuncturist, and subjective self-reports of patients having the *de qi* sensation. The use of an ultrasound-guided technique and objective mathematical calculations can optimize needle tip positioning and potentially improve patient outcome.

For novice acupuncturists, palpation of the acupuncture points and ensuring sufficient needling depth could be a challenge. The literature has reported that acupuncture points at the sacral foramen have superior therapeutic effects on the urinary, digestive, and reproductive systems [5], and reduce pelvic pain in pregnant women [13]. Although these acupuncture points were found to be effective in treating several ailments, these acupuncture points are seldom utilized because of difficulties in locating them due to their depth [5], which is magnified in obese patients. In obese patients, the depth of needle insertion could be insufficient as the needle has to transverse deeper layers of subcutaneous fats and gluteus maximus muscle to reach the posterior sacral foramen, which is beyond the depth recommended in the textbooks. With the aid of ultrasound, these points could be located, increasing their use.

In addition to the location of an acupuncture point, ultrasound can be used to visualize adjacent vascular structures and nonpalpable masses. Although acupuncture is known as a low-risk procedure and no such occurrences have been documented in the literature, use of ultrasound can serve as a potential safety precaution.

Our study also found that the first *de qi* sensation could be achieved even before the needle reached the sacral foramen in the gluteus maximus muscle. Second *de qi* sensation is achieved when the needle is inserted deeper, reaching the posterior sacral foramen as seen on ultrasound. Future studies can be conducted in a larger sample to ascertain the maximum distance from the sacral foramen before achieving *de qi*. This will also enable us to create a scientific method for quantifying the treatment effectiveness of acupuncture through the location of anatomical landmarks on ultrasound images.

5. Conclusion

The use of an ultrasound-guided technique for needle insertion in acupuncture practice could help standardize the treatment. Clinicians and students would be able to visualize and measure the depth of the sacral foramen acupuncture point, to guide the depth of needle insertion. This methodological guide can also be used to create a standard treatment protocol for research. A similar mathematical guide can also be created for other acupuncture points in future.

Disclosure statement

The authors declare that they have no conflicts of interest and no financial interests related to the material of this manuscript.

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