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Original Article

Development of an ultrasound-imaging procedure and acquisition of ultrasound images of acupuncture points for safety and accuracy of needle insertion

Sungha Kim[a], *Sanghun Lee*[a], *Won-Bae Ha*[b], *Jung-Han Lee*[b], *Hyun-Jong Jung*[c], *Hong-Min Chu*[d], *Seung-Bum Yang*[e], *Sunmi Choi*[a], *Mi Ju Son*[a], *Jae Hyo Kim*[d,*], *Youngju Jeon*[a,*]

[a] *Research & Development, Korea Institute of Oriental Medicine, Daejeon, Korea*
[b] *Department of Rehabilitation Medicine of Korean Medicine, College of Korean Medicine, Wonkwang University, Iksan, Korea*
[c] *Department of Diagnostics, College of Korean Medicine, Wonkwang University, Iksan, Korea*
[d] *Department of Meridian & Acupoint, College of Korean Medicine, Wonkwang University, Iksan, Korea*
[e] *Department of Medical Non-Commissioned Officer, Wonkwang Health Science, Iksan, Korea*

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ABSTRACT

Background: Acupuncture is a relatively safe, commonly used “alternative” medical treatment for various symptoms. However, adverse effects can occur, including trauma, pneumothorax, and central-nervous-system injury. Our objective was to develop a reliable and practical procedure for ultrasound imaging of acupuncture points to improve safety during needling, and to acquire ultrasound images of several (44) acupuncture points, especially those in high-risk areas, according to an in-house standard operating procedure.

Methods: We created the standard operating procedure for ultrasound imaging for acupuncture, and collected ultrasound images of acupuncture points in clinical trials.

Results: Ultrasound images for 44 acupuncture points considered as high-risk points were collected from 85 healthy people who were classified by body-mass index, and high-quality, clear representative images of all 44 points were obtained.

Conclusion: These baseline images could be helpful for understanding the anatomy under the skin at acupuncture points, which would allow for an enhanced safety and more accurate needling.

* *Corresponding authors*. Department of Meridian & Acupoint, College of Korean Medicine, Wonkwang University, 460, Iksan-daero, Iksan 54538, South Korea; Research & Development, Korea Institute of Oriental Medicine, 1672 Yuseong-daero, Yuseong-gu, Daejeon 34054, South Korea.

E-mail addresses: medicdog@wku.ac.kr (J.H. Kim), jyj92@kiom.re.kr (Y. Jeon).

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1. Introduction

Acupuncture is a relatively safe, commonly used "alternative" medical treatment for various symptoms. However, there are locations where the needle is next to vulnerable structures, such as internal organs, nerves, and pleural membranes[1]; needling at these locations can induce adverse effects, including trauma, hemorrhage, pneumothorax, and central-nervous-system injury.[2–5]

Preventing these side effects is a key concern while performing acupuncture. For dry needling or injection, similar to acupuncture, ultrasound guidance has been used for preventing soft-tissue injury.[6] To address this concern, there is a growing interest in visualization of the anatomy under the skin at acupuncture points. A survey for Korean medicine doctors (KMDs) found that more than 12% of doctors believe there is a need for visualization of acupuncture points.[7]

Previous studies have used magnetic resonance imaging[8–12] and computed tomography[2,9,13,14] imaging to identify safe depths or angles when needling. However, these imaging modalities are expensive, and in the case of computed tomography, radiographic exposure is required. Ultrasound has been regarded as a safe and convenient method,[15,16] and is suitable for analyzing acupuncture points on the limbs[2] and for live monitoring during the acupuncture procedure.

Ultrasound has been used in several studies to analyze acupuncture points. The primary analyses in these studies included measures of insertion depth or distance from the needle tip to the tissue, including nerve and facet joints, and confirmation of the needle tip for guidance purposes.[1,17–20] However, these have been limited to only a few acupuncture points and to only one cross section. Furthermore, the criterion of a standard operating procedure (SOP), including the angle of probe, to detect specific acupuncture points using ultrasound was not considered in these studies. Therefore, the present study was conducted to develop a reliable and practical procedure for ultrasound imaging of acupuncture points, and to acquire ultrasound images of several (44) acupuncture points, especially those in high-risk areas, according to an in-house SOP.

2. Methods

The workflow is described specifically in Fig. 1. It contained the following specific steps: (1) development of an SOP; (2) clinical trials; and (3) determination of representative images.

2.1. SOP development

The SOP was developed with experts in diagnostics (The Society of Korean Medicine Diagnostics and The Korean Medical Visceral Shape for Sonography Institution), clinical science (Korea Pharmacopuncture Institute, Korean Acupuncture and Moxibustion Medicine Society, and The Society of Korean Medicine Rehabilitation), and basic medical sciences (Society for Meridian and Acupoint, Korea Standards Research Institute, and Korean Medicine Standards Center at the Korea Institute of Oriental Medicine) based on the books *Acupuncture Anatomy: Regional Micro-Anatomy and Systemic Acupuncture Networks*,[21] *Details of Meridians & Acupoints: A Guidebook for College Students*,[22] *WHO Standard Acupuncture Point Locations in the Western Pacific Region*,[23] and the *Acupuncture Acupoints Book of General: Code of Chinese Acupuncture Points Research*.[24] The experts specified the requirements for SOP, and collectively decided which acupuncture points should be chosen for ultrasound imaging. Guidelines for the direction of the probe when imaging via ultrasound were also developed.

2.2. Clinical trials

One-arm clinical trials were conducted to acquire ultrasound images of 44 (in total) acupuncture points. The trials were approved by the Ethics Committee of the Wonkwang University Hospital (WKIRB-201510-BM-001 and WKIRB-201606-SB-033). All volunteers provided written informed consent prior to the study participation. The participants were recruited at Wonkwang University Hospital, first from October 2015 through February 2016, and then from June through December 2016. In all, 85 healthy participants [males ($N = 40$) and females ($N = 45$); body-mass index (BMI in kg/m^2) < 18.5 ($N = 14$), BMI ≥ 18.5 and <25 ($N = 48$), BMI ≥ 25 ($N = 24$)] were recruited; the ages were between 19 and 39 years.

A participant was included if (1) his/her age was between 19 and 39 years old; and (2) he/she agreed to participate and

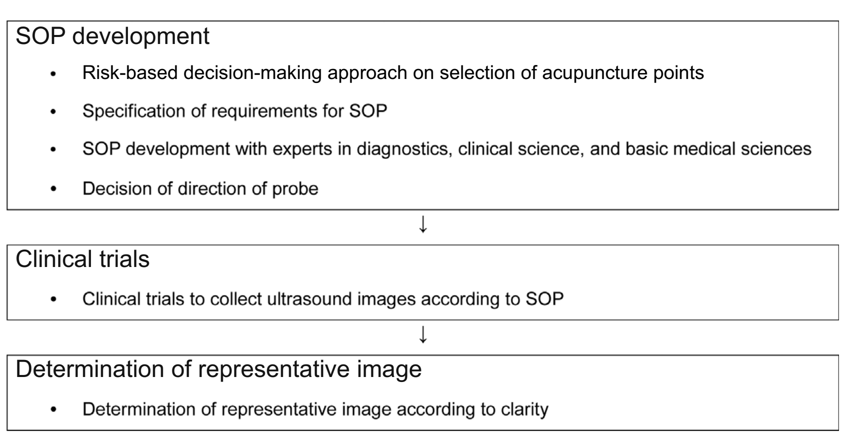

Fig. 1 – Overview of the study process. SOP, standard operating procedure.

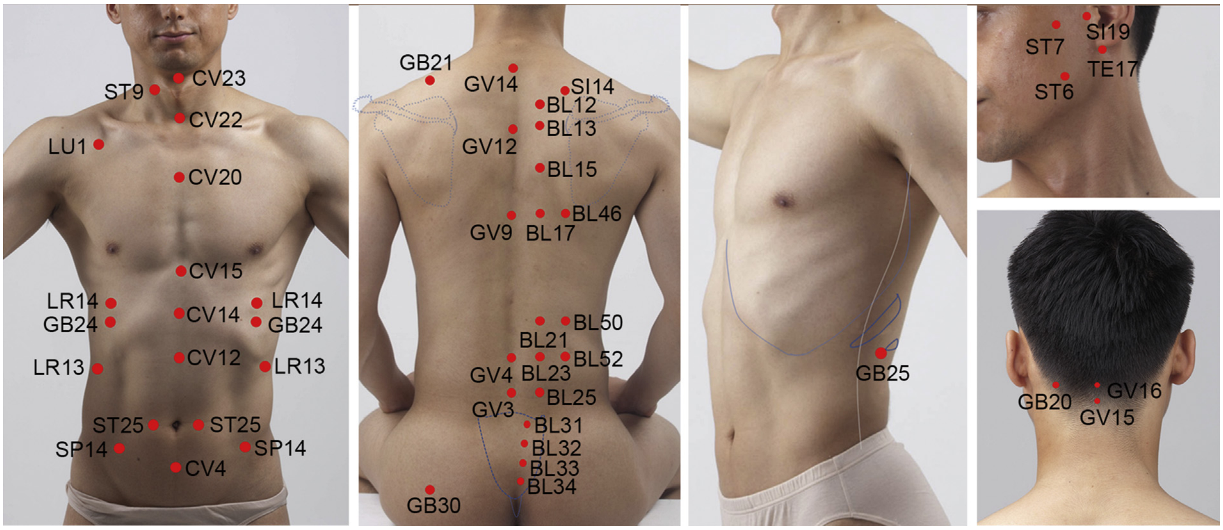

Fig. 2 – Acupuncture points selected for ultrasound imaging.

provide informed consent after listening to a clear explanation of the clinical-study purposes and characteristics. A participant was excluded if he/she met the following criteria: (1) pregnancy or nursing (women); (2) history of liver, kidney, nervous-system, immune-system, respiratory-system, endocrine-system, blood-tumor, or cardiovascular disease, or mental illness; (3) history of surgery or skin disease at the sites of ultrasound imaging; and (4) abnormal shadows, such as tumors at the site of ultrasound imaging.

We measured the weight (BSM330; InBody, Seoul, South Korea), BMI (using a body composition analyzer, InBody570; InBody, Seoul, South Korea), neck circumference, shoulder width, waistline, width between the two anterior superior iliac spines, length from the xiphisternal joint to the pubic symphysis, and width from the second finger to the fifth finger on the right hand; we also measured the thickness of the subcutaneous fat at the left triceps brachii muscle, thigh, infra-scapular region (only for the second recruitment), and iliac crest (skinfold caliper; Jinsan Medical, Seoul, South Korea). We took images for 85 acupuncture points using ultrasound (SonoAce R7 system; Samsung Medison, Seoul, South Korea) and transducers (C2-6IC Curved Array Transducer or L5-13IS Linear Array Transducer; Samsung Medison, Seoul, South Korea). Before the images were acquired, calibration was performed using a US Phantom (ATS 539 Multipurpose Phantom; ATS Laboratories, Bridgeport, CT, USA).[25]

2.3. *Determination of representative images*

Upon reviewing the collected images, four KMDs determined the optimal representative images according to image clarity. One representative image per BMI group and acupuncture point was selected.

3. Results

The expert team decided which acupuncture points should be chosen for ultrasound imaging herein. High-risk areas were prioritized, including the trunk area, in which organs can be damaged; and the neck area, in which blood vessels or nerves may be damaged, with potentially severe consequences. Furthermore, no previous studies have been conducted for observation of acupuncture points located in the neck and trunk. As a result, 44 acupuncture points were finally agreed upon; these are presented in Table 1 and Fig. 2.

Ultrasound is an operator-dependent technique,[26] and so to create more consistent results, the experts specified the requirements of the SOP and developed the SOP for ultrasound imaging of the 44 acupuncture points based on reference books (Table 2). The items of the SOP include the position of the participants, horizontal location (*x* axis), vertical location (*y* axis), depth (*z* axis), and tip and type of probe. In addition, they created guidelines for the direction of the probe during ultrasound imaging. The guidelines chosen were specified as (1) *x* axis, transverse plane according to anatomical position, perpendicular to the surface; and (2) *y* axis, axial according to anatomical position, perpendicular to the surface. Additionally, they proposed a method of placing the probe at a

Table 1 – Acupuncture points selected for ultrasound imaging in the two clinical trials

Region	Acupuncture points
Chest	LU1*, CV20, CV14, CV15, LR14‡, GB24‡, LR13‡, GB25†
Abdomen	CV12, ST25‡, SP14‡, CV4
Neck	CV23, ST9*, CV22
Face and neck	ST6*, ST7*, SI19*, TE17*, GV15, GV16, GB20*, GV14
Shoulder and back	GB21*, SI14*, BL12*, GV12, BL13*, BL15*, GV9, BL17*, BL46*, BL21*, BL50*
Waist and hip	GV4, BL23‡, BL52*, GV3, BL25*, BL31*, BL32*, BL33*, BL34*, GB30*

† Right side.
* Left side.
‡ Both.

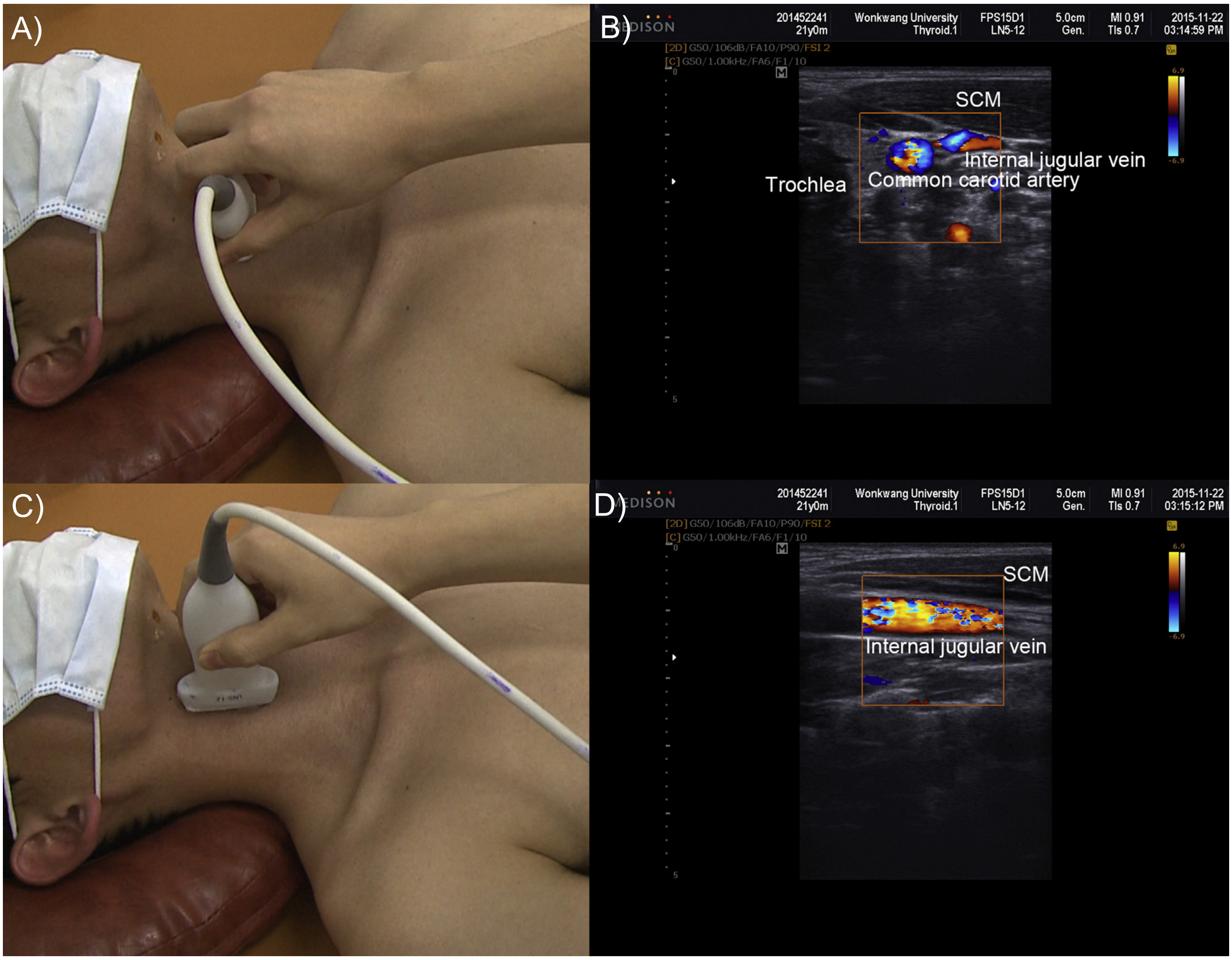

Fig. 3 – Examples of collecting ultrasound images for the acupuncture point ST9. (A) and (B) The probe direction is in the transverse plane according to anatomical position, and perpendicular to the surface. (C) and (D) The probe direction is in the axial plane according to anatomical position, and perpendicular to the surface. SCM: Sterno-Cleido-Mastoid muscle.

Table 2 – Example of the proposed standard operating procedure for ultrasound imaging of acupuncture points

Acupuncture point	ST9
Position	Fit the patient's head angle to the Frankfurt plane.
Horizontal location (x axis)	Where the common carotid artery pulses, in front of the sternocleidomastoid muscle, moving sideways parallel to the base of the jawbone, starting at the top of the laryngeal prominence of the thyroid cartilage
Height location (y axis)	The intersection of the horizontal line passing through the top of the laryngeal prominence of the thyroid cartilage, and the vertical line passing through the jawbone angle parallel to the longitudinal axis of the neck bone
Depth location (z axis)	Vertical line passing through the space between the lower part of the sternocleidomastoid muscle and the common carotid artery
Imaging	Take the ultrasound image of the space between the lower part of the sternocleidomastoid muscle and the common carotid artery, thyroid, and shield cartilage
Tip	(1) Move the patient's head angle to the Frankfurt plane, to make sure that the muscles are in a natural and relaxed state. (2) Draw a vertical line parallel to the longitudinal axis of the neck at the jawbone angle. (3) Draw a line from the laryngeal bulge to this vertical line. (4) Take an ultrasound image at the intersection of these two straight lines.
Type of probe	Linear type

particular target position, and included an optimal imaging technique.

A total of 85 healthy volunteers (age range: 17–31 years; median: 20.21 years) participated in the study (Table 3). The BMI, thickness of the subcutaneous fat, and other factors relevant to body size regarding the distance from the skin surface to the internal organs were measured.[2] Based on the developed SOP, ultrasound images for the 44 chosen acupunc-

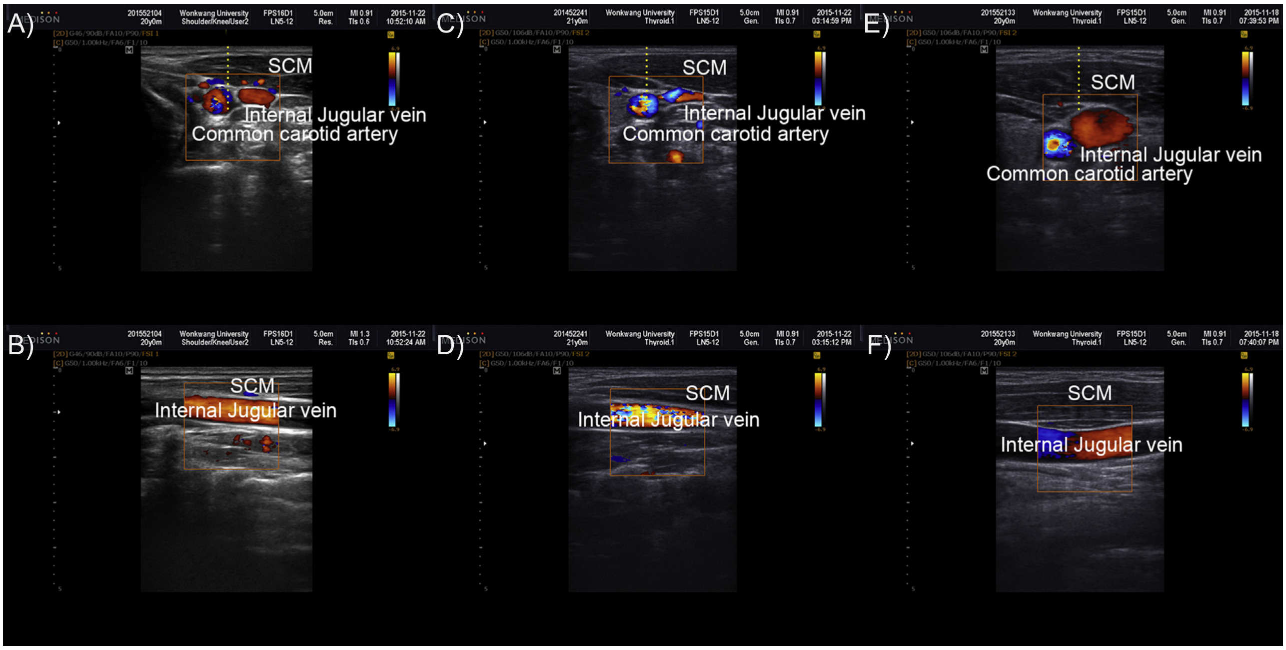

Fig. 4 – Examples of representative ultrasound images for the acupuncture points CV12, ST9, and LU1. The yellow dotted line indicates an acupuncture point. (A), (C), and (E) The probe direction is in the transverse plane according to anatomical position, and perpendicular to the surface.
(B), (D), and (F) The probe direction is in the axial plane according to anatomical position, and perpendicular to the surface. (A) and (B) BMI < 18.5 kg/m^2. (C) and (D) BMI ≥ 18.5 and <25 kg/m^2. (E) and (F) BMI ≥ 25 kg/m^2. SCM: Sterno-Cleido-Mastoid muscle.
BMI, body-mass index.

Table 3 – Characteristics of the study population

	Men	Women	Total
Sample	40	45	85
BMI (kg/m^2)			
<18.5	7	7	14
≥18.5 & <25	21	27	48
≥25	12	11	24
Neck circumference (mm)	369.35 ± 47.88	314.67 ± 31.76	340.40 ± 48.44
Shoulder width (mm)	438.10 ± 46.13	382.13 ± 26.27	408.47 ± 46.25
Waistline (mm)	825.43 ± 136.27	753.42 ± 120.42	787.31 ± 132.38
Width between ASIS (mm)	265.00 ± 35.25	273.40 ± 35.96	269.45 ± 35.67
Length from the sternum end to the pubic symphysis (mm)	374.25 ± 72.20	352.96 ± 40.50	362.98 ± 58.25
Width from the second finger to the fifth finger (mm)	81.33 ± 12.87	76.02 ± 5.00	78.52 ± 9.85
Thickness of the subcutaneous fat (mm)			
Triceps brachii muscle	9.03 ± 8.02*	12.31 ± 6.24*	7.45 ± 3.46*
Iliac crest	14.872 ± 8.97	15.42 ± 6.61	15.14 ± 7.77
Thigh	8.88 ± 10.91*	13.31 ± 10.95*	6.31 ± 0.43*
Infra-scapular region	9.93 ± 6.31*	11.71 ± 4.79*	9.60 ± 0.57*

*Measured only for the second recruitment.
ASIS, anterior superior iliac spine; BMI, body-mass index.

ture points were collected (Table 1, Fig. 3). The representative images, classified by BMI and clarity were determined by four KMDs (Fig. 4).

4. Discussion

Previous studies using ultrasound in acupuncture were designed to define safe depths for needling. However, the calculated depths were inconsistent because of differences in the participant groups and measurement methods.[2] Here, we measured many factors, including neck circumference, shoulder width, waistline, width between anterior superior iliac spines, and thickness of the subcutaneous fat, in order to establish reference factors, while taking into account the body size and BMI. In addition, the subcutaneous structures along the direction of insertion could be different, and so we took images both along and perpendicular to the meridians. The visualization of acupuncture points allowed us to identify the anatomical details of the skin, tissue, fascia and muscle.[27] Such imaging techniques would be helpful for the protection of vulnerable structures, like internal organs, nerves, and blood vessels.

A previous study[1] showed that ultrasound could identify nerve penetration with an acupuncture needle. Our future studies would include the goal of developing an ultrasound guide system for acupuncture that would include ultrasound images of the acupuncture points as reference materials incorporated in any future device. Clinically, this device would allow practitioners to minimize side effects by avoiding blood vessels, nerves, and/or organs in high-risk areas. Such a device could assist practitioners in precisely placing acupuncture needles in anatomically challenging areas, and may facilitate the development of the acupuncturist's skills.[26] In basic research, it would allow monitoring of the extent of the tissue affected by the stimulus of the needle, and limit the amount of manipulation that could obscure results.[27,28]

This study has some limitations. First, the sample size is too small to be a true reference. A significantly bigger sample size is needed for reference imaging. Nevertheless, this study is significant in that it grouped participants by BMI and identified representative images for each BMI group. Second, conditions, including whether to eat, the vertical force pressing the probe, and the standards for the representative image, were not set or controlled. Notably, the depth of the acupuncture points is influenced by the pressure applied during the examination.[19] However, this study was not oriented toward defining the depth, but rather toward analyzing the anatomy under the acupuncture points. Finally, detailed conditions should also be confirmed and validated in future studies.

In conclusion, we have acquired ultrasound images for 44 acupuncture points considered to have a high risk of causing side effects from 85 healthy people classified by BMI following an SOP. The images will aid the understanding of the anatomy under the skin of acupuncture points, and potentially minimize adverse effects by improving the safety and accuracy in needling.

Conflicts of interest

All contributing authors declare no conflicts of interest.

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