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Original Article

An observational study of ultrasound to confirm cervical spine segmental positional rotation

Theodore B. Flaum, DO [a, *], Frances M. Rusnack, OMS III [a], Arfa Mirza, OMS IV [a], Theresa E. Apoznanski, DO [a], Aida Munarova, DO [a], Joseph P. Mazzie, DO [b, c], Michael J. Terzella, DO [a], Sheldon C. Yao, DO [a]

[a] *New York Institute of Technology, College of Osteopathic Medicine, Northern Boulevard, PO Box 8000, Old Westbury, NY, 11568, USA*
[b] *Winthrop University Hospital, Department of Radiology, Winthrop University Hospital, Division of Musculoskeletal and Interventional Radiology, 259 1st St, Mineola, NY 11501, USA*
[c] *Stony Brook University School of Medicine, 101 Nicolls Road, Stony Brook, NY, 11794, USA*

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A B S T R A C T

Objectives: Various studies demonstrate the significance of ultrasound use in undergraduate medical education. Palpatory assessment and diagnosis of the body is fundamental to osteopathic medical education and may be improved by ultrasonographic imaging. A previous study determined that ultrasound is a reliable instrument to assess lumbar spine somatic dysfunctions, yet the use of ultrasound to assess those of the cervical spine has not yet been established. This study investigated the use of ultrasound as an instrument to assess cervical spine vertebral rotation as a component of somatic dysfunctions and to establish the validity of cervical segmental rotatory motion testing.
Methods: In this observational study, two physicians independently confirmed the diagnosis of the most prominent cervical rotational asymmetry. Ultrasound measurements of the left and right articular pillars were obtained by a separate, blinded musculoskeletal radiologist and then compared to palpatory findings. Results: Nineteen of the 41 palpatory findings agreed with ultrasound findings. Results demonstrate no significant difference in rotation of the articular pillars in cases where ultrasound agreed with palpatory findings and in cases where ultrasound did not agree with palpatory findings ($p=.099$).
Conclusions: Our results demonstrate that ultrasound was not an appropriate tool to assess cervical spine segmental rotation compared to palpatory findings. Further studies need to be conducted to improve the assessment of the cervical spine utilizing ultrasound. Differences in cervical spine anatomy and biomechanics as compared to those of the lumbar spine may account for the discrepancy compared to prior studies.

1. Introduction

Ultrasound (US) is a noninvasive and radiation-free imaging modality that is used in patient diagnosis, clinical procedures, and medical student education [1–3]. Many medical schools are incorporating basic US training into core curricula [1,2,4]. While US is used most often to assist with teaching anatomy, physiology, pathology, and clinical diagnosis, osteopathic medical schools have extended US use to further explore osteopathic concepts of musculoskeletal biomechanics, somatic dysfunctions, and manipulative medicine techniques [1,5].

A somatic dysfunction (SD) is defined as an "impaired or altered function of related components of the somatic (body framework) system … " or a change in the normal functioning of a joint [6]. Areas of impaired function are diagnosed using the criteria of detecting tissue texture changes, asymmetry, restriction of motion, and tenderness [7]. For example, a single vertebra in the cervical spine may be rotated and sidebent to one side relative to the adjacent vertebrae [8]. Static findings found by physicians are further evaluated through segmental rotatory motion testing, also known in osteopathic medicine as rotoscoliosis motion testing [8]. These findings are combined to allow differentiation between

* Corresponding author. Department of Osteopathic Manipulative Medicine, New York Institute of Technology, College of Osteopathic Medicine, Northern Boulevard, PO Box 8000, Old Westbury, NY, 11568, USA.
E-mail address: tflaum@nyit.edu (T.B. Flaum).

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positional findings and morphological variation. Osteopathic medical student training emphasizes the use of palpation to identify the rotational component of SDs in the spine.

Previous studies have proposed the use of US to evaluate anatomical landmark asymmetry in order to objectively confirm medical students' palpatory assessment of SDs [9]. However, few studies have explored the content validity of cervical segmental rotatory motion testing, defined as the extent to which a procedure adequately and comprehensively measures what it claims to be evaluating [10,11]. Objective localization of SDs is necessary for standardization and reproducibility, which are crucial to osteopathic research, medical student training and patient treatment. Therefore, US's ability to confirm cervical spine segmental rotation would help to establish segmental rotatory motion testing as evidence-based medicine [12].

Our study propagates the idea put forward by Najm et al. that objective methods need to be established to determine the validity of spinal palpatory assessment [11]. A study by Shaw et al. used US to analyze the validity of palpation to locate a lumbar spine SD and to provide imaging of the effect of osteopathic treatment on that dysfunction [9]. In this study, US imaging of the lumbar spine provided reliable measurements that allowed objective identification of transverse process rotation [9]. Furthermore, physician and US findings demonstrated a concordance of 1.0 confirming palpatory assessment as a reliable method for diagnosis of the lumbar spine [9].

The use of US as a reliable instrument for objective confirmation of cervical spine findings remains elusive. Despite evidence that suggests US use in osteopathic medical education improved anatomical understanding of other body regions, such as the heart, abdomen, and upper and lower extremities, there has been limited educational gain after US examination of the neck [13]. This suggests a greater need for understanding cervical diagnosis and the role of US [13]. A study by van Eerd et al. recognized the difficulty of accurate identification of cervical spine landmarks and the current need for validated US images for all levels of the cervical spine [14]. In response, this study constructed an anatomical model of the cervical spine using cadaver vertebrae and beeswax [14]. US imaging of the model landmarks were verified using laser beams and applied to the development of an in vivo US protocol on 4 human subjects [14]. While this model and protocol may be used to detect and count cervical vertebrae, research remains lacking for accurate evaluation of cervical spine rotation [14].

With the increasing use of US in osteopathic medical education and the need to establish content validity and inter-examiner reliability, we sought to investigate the effectiveness of US as a standardization tool for confirming vertebral rotation of the cervical spine. We hypothesize that physician rotational findings will agree with US measurements.

2. Materials and methods

This study was developed as part of a larger randomized controlled trial that was approved by the Institutional Review Board (BHS-988) and registered with ClinicalTrails.gov (NCT02249858). The larger randomized controlled trial evaluated articular pillar depth of cervical spine SDs before and after performing a high-velocity, low-amplitude osteopathic technique to the dysfunctional segment. Osteopathic physicians diagnosed the cervical spine SDs and ultrasonographic imaging was obtained pre and post treatment for comparison. For the present study, STROBE statement for reporting observational studies was applied.

2.1. Subjects

Forty-one medical students were recruited through post-laboratory announcements and faculty emails. After physicians fully explained the study to each subject, written informed consent and demographic information of age, sex, race, height and weight were obtained. Inclusion criteria included asymptomatic, healthy subjects. Exclusion criteria included acute cervical pain, radiculopathy, ligamentous laxity, prior back surgery and history of seizure or stroke.

2.2. Clinicians

Licensed, board-certified osteopathic physicians performed the palpatory assessments. As full-time osteopathic manipulative medicine faculty, the physicians performing the assessments had a mean 18 years (range 13–24 years) of experience in clinical diagnosis and treatment. US imaging was completed by an osteopathic radiologist board certified in musculoskeletal radiology with 8 years of experience.

2.3. Procedure

2.3.1. Cervical diagnosis

Two physicians independently assessed each subject for a single vertebral rotation between levels C2-C7 using segmental rotatory motion testing. Segmental rotatory motion testing is a standardized method for osteopathic evaluation of the cervical spine. It is performed with the subject lying supine and the physician cupping the subject's head posteriorly. Starting at the level C2, slight anterior pressure is alternatingly applied to the left and right articular pillars. This procedure is continued at each vertebral segment from C2 to C7 and the physician notes the relative restrictions and freedoms of rotational motion [8]. A consensus was reached between the physicians for each subject's key rotation by comparing C2 to C7 primary findings of motion restriction and asymmetry, along with secondary findings of tissue texture changes and tenderness. The agreed upon key cervical spine segmental positional rotation was recorded. The physician palpated the key segment and while maintaining contact with the posterior articular pillars, drew a 1-inch horizontal line at the level bilaterally. The subject then walked to a second room for imaging.

2.3.2. Ultrasound imaging

Images and measurements were obtained using the SonoSite M-MSK Ultrasound System with a SonoSite M-Turbo HFL50x transducer (21919 30th Drive SE Bothell, WA 98021 USA). With the subject prone, the radiologist, blinded to the rotational diagnosis, obtained US imaging at the level of the marked segment. The radiologist obtained a single measurement of the tissue depths from the most superficial layer of the skin to the most posterior aspect of the articular pillar of the vertebral segment by uniformly floating the US probe over the marked segment (Fig. 1). This technique used sufficient US gel and avoided any downward force on the transducer.

2.4. Data analysis

Statistical analyses were performed using IBM SPSS software (version 22; IBM Corporation, Armonk, New York). US finding of a cervical spine rotation was defined as having one articular pillar more posterior than the other, indicating that it was rotated relative to midline. The posterior articular pillar was determined from the US image as the side with the shortest tissue depth measurement. An independent sample *t*-test was conducted to compare the