Measurement of Infant Tongue Thickness Using Ultrasound: A Technical Note

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ABSTRACT: Novel uses of ultrasound include obtaining images of intra-oral structures to further research in speech production and feeding. In this technical note we describe a noninvasive, cost-effective, and reliable method for measuring infant tongue muscle thickness. The current pilot study demonstrates high reliability of a trained ultrasonographer to obtain adequate images of the infant tongue and the ability to measure reliably between two anatomic landmarks to determine tongue thickness and investigate a potential relationship between tongue size and tongue force. © 2012 Wiley Periodicals, Inc. J Clin Ultrasound 40:364–367, 2012; Published online in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/jcu.21933

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The introduction of high-resolution technology has enhanced the value of ultrasonography as a diagnostic imaging tool for the assessment of various soft-tissue pathologies.1 The tongue is an ideal organ for US examination, especially at its base, because this area can be imaged directly by applying the transducer on the examinee’s submental skin.2 When the US transducer is held against the skin of the neck beneath the chin and above the larynx, the ultra-high-frequency sound emitted by the piezoelectric crystals travels upward through the tongue and is reflected back to the transducer from the tongue—air interface. The resulting echo patterns are used to reconstruct a two-dimensional image of the tongue surface (in any plane), which can then be viewed or recorded from the machine as a video image for analysis.3 Ultrasound technology has been used successfully to assess adult tongue movement in the oral cavity. Previous studies have documented the use of US for assessing movement of the tongue in the oral cavity,4–11 and for determining surface area of the tongue.2,12 Additionally, Fucile et al, Bosma et al, and Geddes used US to describe early tongue movement in infants.13–15 Taken together, these studies document the increased popularity of ultrasound imaging for examining tongue movement, speech sound development, and speech treatment research.12 What has not yet been reported is the use of US to study possible relationships between tongue size and tongue force in response to muscle disuse. US is a particularly attractive imaging technique for exploring clinical questions related to tongue size because techniques such as MRI and cinefluorography are cost prohibitive and difficult to access.12 Other benefits of US for the measurement of tongue thickness include (1) the opportunity for real-time imaging assessment; (2) the ability to create images in multiple planes; and (3) the fact that US is noninvasive and acceptable for use with more vulnerable populations such as infants. Last, US is comparatively less expensive than other imaging techniques, and it is not associated with risks such as exposure to radiation or magnetic fields.1,2

Therefore, the primary aim of this article is to describe a technique using diagnostic ultrasound as a means of imaging and measuring infant tongue thickness in an effort to estimate tongue size. Additionally, anatomic landmarks that are
visualized using ultrasound are described as a means of adding validity and reliability to the technique. Reliability of this ultrasound technique for measuring infant tongues is also presented.

**MATERIALS AND METHODS**

**Subjects**
This pilot study was initiated following approval from the university institutional review board where the study was carried out. Seven subjects met inclusion criteria and were recruited for the pilot study. A minimum of three tongue measurements were taken for each of the subjects, with the exception of the last subject; only one acceptable measurement was acquired due to fatigue and lack of cooperation so that data were not used in the reliability analysis. Four boys and two girls (including two sets of fraternal twins) remained and US measurements were collected. Demographic data for gestational age, body weight at birth, length at birth, head circumference, age at exam, and body weight at exam were collected on all subjects. Means and standard deviations for the variables of interest are presented in Table 1.

**Diagnostic Ultrasound Technique**
A portable diagnostic ultrasound unit (LOGIQ Book XP; GE Healthcare Products, Milwaukee, WI) was used either bedside in an in-patient hospital setting or in our musculoskeletal laboratory as an outpatient. Images were obtained by a trained pediatric diagnostic radiologist. Following a scheduled feeding, infants were placed supine in their crib or on a plank table with the neck in slight hyperextension to access the submental area under the chin. Warmed ultrasound transducer gel was placed on a linear 12L-RS probe and the probe was positioned transversely (Figure 1). Depth of penetration was set at 4 cm.

The following landmarks were identified to confirm consistent transducer placement for each subject: fascia between the mylohyoid muscle and intrinsic muscles of the tongue and the interface between the soft palate and air in the oral cavity (identified by the hyperechoic line of the soft palate and the hypoechoic air) (Figure 2). Additionally, the image of the tongue was identified as “heart-shaped,” further confirming consistent positioning of the transducer. Multiple images of the six subjects were obtained and stored.

Following acquisition, US images were evaluated for obliqueness and the distance between the aforementioned landmarks was measured using the electronic calipers on the ultrasound machine. Measurements were determined on the image at the time the images were taken. The measurements of the same images were then

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD (n = 6)</th>
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<tbody>
<tr>
<td>Gestational age (weeks)</td>
<td>34.4 ± 2.3</td>
</tr>
<tr>
<td>Body mass at birth (g)</td>
<td>2,198.4 ± 697.4</td>
</tr>
<tr>
<td>Length at birth (cm)</td>
<td>46.7 ± 4.7</td>
</tr>
<tr>
<td>Head circumference (cm)</td>
<td>31.4 ± 3.5</td>
</tr>
<tr>
<td>Age at examination (days)</td>
<td>13.3 ± 6.1</td>
</tr>
<tr>
<td>Body mass at examination (g)</td>
<td>2,318 ± 839</td>
</tr>
</tbody>
</table>

**TABLE 1**
Subject Characteristics and Anthropometric Variables (mean ± SD)

**FIGURE 1.** Positioning of the infant and transducer to obtain the US image of the buccal cavity and tongue.

**FIGURE 2.** Coronal ultrasound image of the buccal cavity with tongue thickness measured. Identified is the fascia between the Mylohyoid muscle and intrinsic muscles of the tongue (A); interface between the soft palate and air in the oral cavity (B); and the tongue (C).
reviewed at a later date and measured a second time using the electronic calipers. This allowed for the generation of two measurements, the first (Trial 1) and the reviewed (Trial 2) to be used to assess the intratrial reliability of this technique.

Statistical Analysis

Means and SD for the three tongue measurements were calculated for each subject. To assess the intratrial reliability of the US measurement, intraclass correlation coefficients (ICC) and the SE of measurements (SEM) were generated across all trials for each subject with a 95% confidence interval. Statistical analysis was performed using Microsoft Excel version 2007 (Microsoft Corp., Redmond, WA).

RESULTS

Individual subject measurements along with the calculated mean ± SD, intratrial ICCs with 95% confidence intervals, and SEM values of tongue size for each subject and trial are presented in Table 2. The ICC analysis for the intratrial reliability demonstrated strong reliability with low SEM values for the mean tongue measurement for each trial.

DISCUSSION

This pilot study presents a noninvasive, cost-effective, and reliable technique for measuring tongue thickness in infants. The current study demonstrates high reliability of a trained ultrasonographer to obtain adequate images of the infant tongue and the ability to measure reliably between two anatomic landmarks to determine tongue thickness. This measurement is being investigated as a possible indicator of the relationship between tongue size and tongue force in at-risk infant populations. Although our ICC values for the intratrial reliability of this US technique are excellent, it should be noted that the sample size for this pilot study is small, resulting in a wide ICC 95% confidence interval. Increasing the number of subjects in subsequent studies will narrow this confidence interval.

A major disadvantage of US is operator dependence and the inherently long learning curve. To take advantage of the strengths of US, the operator of the imaging modality requires technical expertise, high-resolution equipment, attention to detail, and awareness of their own strengths and weaknesses. In the correct hands, US can be a valuable tool. Once experienced, the examiner can perform a quick, targeted examination to address a clinical question or specific area of concern.

The technique described here is not without limitations. First, operator dependence is significant so the operator should have a clear working knowledge of both ultrasound and oral anatomy. This is particularly important when dealing with infants and small children as there can be anatomic differences in these populations, especially at-risk populations. Second, the technique requires a somewhat still patient, which is not always possible with infants. To obtain clear images for measuring, a static image is vital. In the current study, images were obtained after the infant had been fed in an effort to increase the likelihood he or she would be tired and relaxed. Infants in the semi-asleep state allowed the examiner to obtain clearer images because there was less movement of the subject.

CONCLUSION

The technique used in this pilot study may prove useful for other studies focused on infant disorders of the mouth and tongue, as well as feeding and speech disorders in pediatric populations. Although US is highly operator dependent and infants can be a difficult population to study due to their size and lack of cooperation, this noninvasive, reliable, and relatively inexpensive method for evaluating structures of the oral cavity could become the gold standard for performing research in these areas.

REFERENCES


