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Ultrasonography in orthodontics: Review article

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ABSTRACT

Recent development of the ultrasonography (US) equipments enables the visualization of fine detail of the surface structure of the face and neck soft tissue. This review article deals with studys which were carried out to determine the thickness of masseter muscle and its relation with various dentofacial pattern. It also include assessment of temporalis muscle and tongue function and movement during swallowing.

Keywords: Ultrasonographic Thickness, Masseter Muscle, Temporalis Muscle.

INTRODUCTION

Ultrasound is widely recognized by the general public for its diagnostic imaging capabilities; however, ultrasound is also inherent in a variety of therapeutic medical procedures that have accrued attention in recent decades. [1]

Ultrasonography is developing rapidly as the mainstream investigatory tool. Ultrasonography (US), as the name implies, utilizes sound waves within the frequency of 2- 18MHz that bounce off the tissue to provide the depth and density of the image conventionally captured on the screen as a real time image.[2] It was developed for medical use in the 1940's with parallel developments across the Atlantic in the USA and Sweden. It has since been widely accepted as the safest investigating tool and is applied widely in obstetrics. [2]

Recent decades have been the development of Computed Tomography, Magnetic Resonance Imaging, Nuclear Medicine and Ultrasonography. These imaging modalities that have revolutionized dental & medical diagnosis. All diagnostic ultrasound applications are based on the detection & display of acoustic energy reflected from interfaces within the body. [3]

Ultrasonography has been used in many studies for static imaging of the oral cavity (eg, for studying tongue morphology and for diagnosis of sialolithiasis, cysts, and tumors). [4] At high levels of exposure, ultrasound waves can damage tissues, in addition to having teratogenic effects, due to heat, and acoustic cavitation. However, within the diagnostic range at low intensities and pressure levels, the probability for heating beyond the normal physiological range, or cavitation in the absence of gas bubbles is very low. [5]

Tongue function during swallowing

According to Balters, the tongue is the centre of reflex activity in the oral cavity and its position must be considered carefully in planning treatment.

He believed that discoordination of tongue's function would lead to abnormal growth and actual deformation. He has pointed out that a posterior displacement of the tongue would lead to class II malocclusion and a low anterior displacement of the tongue would lead to class III malocclusion. [6] Therefore the dental professionals must be able to identify abnormal tongue postures and movements that might have adverse effect on dentofacial growth and treatment. The altered tongue function can lead to increased relapse after orthodontic treatment. [6]

It is paramount for orthodontists to understand the relationship between tongue function and facial morphology. Significant percentage of relapse after orthodontic treatment might be related to orofacial muscle imbalance and abnormal swallowing. [6]

M-mode ultrasonographic technique has been used routinely in echocardiography for quantitative and qualitative evaluation of heart functions. The application of this technique in dentistry was first reported by Japanese researchers in a study of tongue skills. [7]

Ultrasonography has the advantage of allowing visualization of the actual soft tissues of the tongue and floor of the mouth rather than of the bolus, as is visualized in radiography. Measurements also can be made directly and accurately from the ultrasonogram without need for complicated procedures.

Furthermore, because of the lack of biologic effects, ultrasonographic real-time scanning appears promising and should be capable of yielding additional information about the swallowing mechanism.[7]

A noninvasive diagnostic technique, computer-aided B-mode plus M-mode ultrasonography, was used in combination with the CST to assess their tongue movements. The CST is based on four components, which are illustrated in (figure 1). [7]

The use of CST and M-mode ultrasonography has opened a new era for the study of tongue movements. It provides a time-amplitude diagram for a better understanding of the entire tongue dynamics during swallowing. It also gives quantitative and qualitative data for a digital assessment of tongue movement. [7]

Study carried out by Dr vaishnavi et al (2014)[6] concluded that

The individuals with class III skeletal pattern (prognathic mandible) have prolonged duration of tongue movement and greater motion magnitude in the early final phase of swallowing. Though there is a decrease in the motion magnitude and duration of swallowing in the individuals with class II skeletal pattern, the difference between the class II and class I skeletal pattern was not found to be statistically significant. There is no significant difference in the speed of swallowing between the three skeletal patterns. More correlation was found to exist between abnormal tongue function during swallowing and class III skeletal pattern than the class I and class II skeletal patterns. [6]

The use of CST and M-mode ultrasonography has opened a new era for the study of tongue movements. It provides a time-amplitude diagram for a better understanding of the entire tongue dynamics during swallowing. It also gives quantitative and qualitative data for a digital assessment of tongue movement. Hence, wide application of ultrasonography in the field of diagnosis of oral conditions may be no longer unattainable. [7]

Study carried out by peng et al (2004) concluded that

The tongue movements of mature swallowing and tongue-thrust swallowing can be differentiated with ultrasound.

Tongue-thrust swallowing has a prolonged duration in the late transport phase (IIb) compared with mature swallowing. The tongue movement of a tongue-thrust swallower is slower in the late transport phase (IIb) and quicker in the early final phase (IIIa) than in mature swallowers.

The center of the tongue might serve as an ideal representative of the whole tongue and can give the observer a brief view of whole-tongue movement during swallowing.

The cushion scanning technique for ultrasound visualization of tongue thrust, compared with other methods that require opening of the lips, foreign bodies in the mouth, or x-ray radiation, offers a safer and more attractive way to evaluate tongue movement.

Assessment of temporalis and masseter muscle

Wolff's law is an important theory in the field of biodynamics which relates form and function to bone morphology. This law states that, "Every change in the form and function of bone or of their function alone is followed by certain definite changes in their internal architecture, and equally definite alteration in their external conformation, in accordance with mathe laws." Under the principles of Wolff's law a relationship has also been defined between bone shape and muscle function. [8]

Dentofacial morphology is closely related to the attached muscle activity. [9] Muscle thickness may be measured using Magnetic Resonance Imaging (MRI), Computed Tomography, or Ultrasound, but for clinical examinations, ultrasonography is better than MRI and Computerized Tomography because it is a rapid and inexpensive technique, the equipment can be easily handled and transported, and it has no known cumulative biological effects. Ultrasonography is proven to be a reproducible, simple, and inexpensive method for accurately measuring muscle thickness, provided the operator adheres to a strict imaging protocol. [9]

Intensive use of any skeletal muscle may cause changes in the muscle fiber size and composition, which in turn will increase the strength of the muscle and the resistance to fatigue. This is also true of the masticatory muscles. Prolonged high activity of these muscles resulted in increased ultrasonographic thickness of the masseter muscle and increased maximal bite force values. A different level of bilateral activity of the masticatory muscles was recorded in children with unilateral crossbite or lateral forced bite, possibly a functional adaptation of the masticatory system to avoid cuspal interferences. [10]

The main action of temporalis is to elevate the mandible, raising the lower jaw. Elevation of the mandible occurs during the closing of the jaws. If only the posterior part contracts, the muscle moves the lower jaw backward. Moving the lower jaw backward causes retraction of the mandible. Retraction of the jaw often accompanies the closing of the jaws. [8]

The thickness of the temporalis muscle was greatest in horizontal growth pattern, followed by average growth pattern and vertical growth pattern. [8]

Masseter muscle thickness

A line was drawn joining the lateral commissure of the mouth to the intertragic notch of the ear, crossing the masseter muscle. A generous amount of water‑soluble conductive gel was applied evenly on muscle area on the cheeks using a gauze pad. The ultrasound probe was placed on the line with a feather‑like pressure. The angle of the probe was adjusted to produce the strongest echo from the mandibular ramus, which was achieved when the scan plane was perpendicular to its surface. When the teeth were occluding gently with the muscle in a relaxed position and during maximal clenching, with the masseter muscle contracted. The measurements were made directly from the image at the time of scanning (fig 2 and 3). [9]

Study carried out by Ajit K Rohila et al (2012)[9] concluded that

• The masseter muscle thickness varied among three vertical dentofacial patterns, with hypodivergent group having the maximum thickness followed by normodivergent, and was the minimum in hyperdivergent group. The masseter muscle thickness was more in males as compared to females in their respective groups.

• Increase in the thickness of masseter muscle increases the sagittal growth, while limiting the vertical growth of jaws. Masseter muscle thickness had a positive correlation with facial width, maxillary width, symphyseal width, and intermolar width of maxillary first molars. This helps us to conclude that masseter muscle thickness has a positive influence on the transverse growth of the face and symphyseal width.

Study carried out by Stavros Kiliaridis et al (2007)[10] concluded that

The masseter muscle in untreated individuals with unilateral crossbite is thinner in the crossbite side than in the contralateral normal side.

• This was not the case for the individuals some years after successful treatment of this malocclusion, possibly due to elimination of the asymmetric bilateral activity of the masticatory muscles after the crossbite correction.

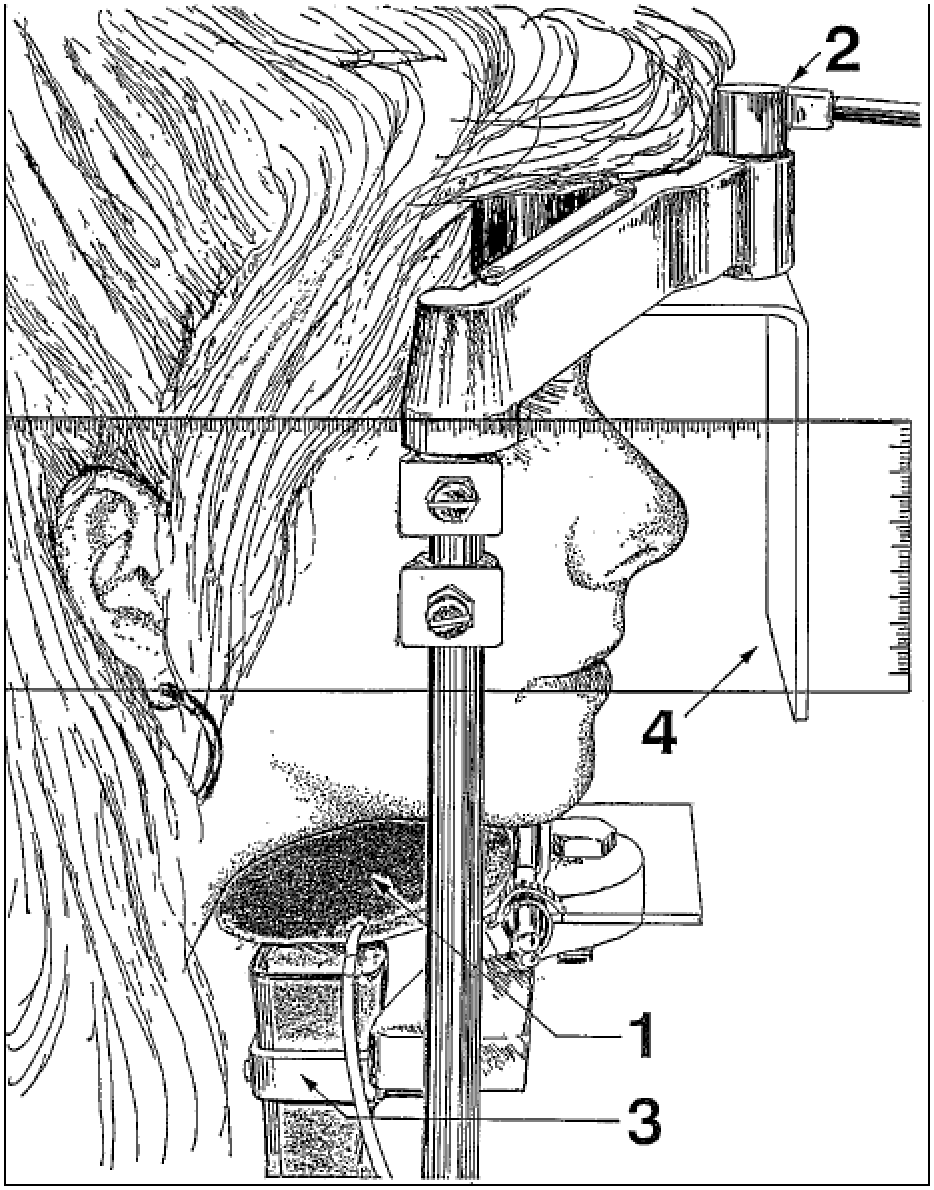

Figure 1: Schematic illustration of the four components of the

CST system used in this study. 1, Cushion; 2, head support; 3, ultrasound transducer holder; 4, head position recording device.[7]

Figure 2: thickness of masseter muscle measured on ultrasonography in relaxed state.[9]

Figure 3: thickness of masseter muscle measured on ultrasonography in contracted site.[9]

Ultrasound imaging of condylar motion[11]

Imaging of the temporomandibular joint in an effort to understand normal and abnormal function continues to be a challenge. The principal methods currently used to image the joint in the sagittal view are x-rays, magnetic resonance imaging, and arthroscopy. The main disadvantage of x-rays is that they provide a static view while exposing the surrounding structures to radiation. With magnetic resonance imaging, the patient's head position is abnormal, which can influence mandibular motion. It is a costly procedure and often requires the patient to travel to a special facility. Arthroscopy involves surgical invasion of the joint with attendant surgical risks as well as the significant likelihood of altering normal function by its presence.

Ultrasound imaging has been recognized for some time as having several important advantages: it does not require special facilities and thus has the potential to become available in an orthodontic office, and it can be used to view the joint in a continuum without invasion, discomfort, alteration of the patient's normal head posture, or interference with condylar motion.

Audio frequencies greater than 1600 Hz (cycles per second) are considered ultrasonic. An ultrasonic sound wave passing through tissue will have a portion of the sound wave reflected on transiting dissimilar tissues. This reflected energy is returned to the ultrasonic emitting device (transducer) where the location of the interface is determined, and an appropriate image is produced representing the interface contours.

In earlier studies, ultrasonic transducers have been placed at various parts of the skin surfaces related to the temporomandibular joint area. This produced nonconventional images of the joint from the frontal, superior, or both aspects. Recently Hirt and Knupfer obtained images images of the temporomandibular joint in the more conventional sagittal plane. These were images of the joints of cadavers. Until now, obtaining conventional (sagittal) images of the temporomandibular joint via sonography has been limited for several reasons. Ultrasound is unable to penetrate the relatively large mass of bone overlying the joint, and the size of the transducer has prevented its strategic placement in order to produce conventional sagittal images.

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