# Ultrasonography in Orthodontics : A Review


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## Introduction

Diagnostic sonography (ultrasonography) is an ultrasound based diagnostic imaging technique used for visualizing subcutaneous body structures including tendons, muscles, joints, vessels and internal organs for possible pathology or lesions.

Sonography (ultrasonography) is widely used in medicine. It is possible to perform both diagnosis and therapeutic procedures, using ultrasound to guide interventional procedures (for instance biopsies or drainage of fluid collections.

Sonography is effective for imaging soft tissues of the body. Superficial structures such as muscles, tendons, testes, breast, thyroid and parathyroid glands, and the neonatal brain are imaged at a higher frequency (718 MHz). Deeper structures such as liver and kidney are imaged at a lower frequency 16 MHz.

In Orthodontics, Ultrasonography plays an adjunctive role as it is used for various purposes like:

1. Diagnosis of infantile and mature swallowing
2. Ultrasound Imaging of Condylar Motion
3. Diagnosing a malocclusion/ facial asymmetry using ultrasonography
4. Diagnosis of zygomatic arch fractures
5. Determining the masticatory muscle mass depending on the facial form

## I. Comparison of tongue functions between mature and tonguethrust swallowing

Tongue functions during swallowing are of interest to many orthodontists. In normal deglutition, the tip of the tongue rests on the lingual part of the dentoalveolar area, the contraction of the perioral muscles is minimal during deglutition, the teeth are in momentary contact during swallowing, and there is neither a tongue thrust nor a constant forward posture.

Several methods for evaluation of tongue movements, such as radiocinematography, electromyography, and electromagnetic articulography have been used in previous studies. However, these techniques are now considered unsuitable for clinical use because of their various disadvantages, such as prolonged chair time and the receiver coils and wires attached to the tongue that might affect the swallowing, or they are ethically questionable because of x-ray exposure. Some noninvasive techniques for the study of tongue sensory function have been reported.

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). Dynamic ultrasound investigation of tongue movement through submental scanning has been described by many researchers. A major obstacle of these previous dynamic ultrasound studies was that they used direct transducer-skin coupling scanning to observe tongue movements, this causes various artifacts resulting in inaccurate measurements of tongue movements. A cushion scanning method provides a solution to these problems. With a cushion scanning system that consists of a cushion device, a head support, a probe holder, and a head position recording device, the tongue dynamic can be correctly recorded and measured.[1]

### Dentofacial morphology and tongue function during swallowing

Tongue movement cannot be sufficiently examined because of the difficulty in accessing the tongue in the oral cavity. In the past, examination of the tongue's motor function was restricted to pure clinical observation. To date, various methods have been used to evaluate tongue movements, such as electropalatography, cineradiography, computerized tomography, magnetic resonance imaging, electromagnetic articulography, and ultrasonography.

Electropalatography and electromagenetic articulography are not suitable for examining normal tongue function because it is difficult for subjects to swallow normally with receiver coils and wires attached to their palates or tongues. X-ray cinematography and computerized tomography have the disadvantage of radiation exposure. Magnetic resonance imaging is not suitable for examining swallowing movements because of its high cost and long acquisition time. Ultrasonography has the advantages of being noninvasive, rapid, easily repeatable, and relatively inexpensive. Shawker et al first used B-mode sonography to investigate tongue movements during swallowing. Peng et al used M-mode ultrasonography for quantitative and qualitative evaluation of tongue functions. On the basis of M-mode images, the swallowing phase was reinterpreted and divided into 5 phases (I, shovel phase; IIa, early transport phase ; IIb, late transport port phase IIIa, ealrly final phase; IIIb, late final phase) according to each turn point between 2 different directions of tongue movement. The cushion scanning technique (CST) was used to overcome the problems including movement of the ultrasound transducer during swallowing and compression of the sub mental region that caused abnormal swallowing patterns.

Therefore, noninvasive real-time B+M-mode ultrasonography with CST has become the state-of-the-art tool to study tongue morphology and observe tongue functions such as swallowing and speech.

### Ultrasonographic measurement of tongue during swallowing

Previous US studies on tongue functions were limited by the possibilities of artifacts caused by movement of the submental area during function. Consequently, tongue movements were mis-interpreted. A dynamic tongue imaging technique, the cushion-scanning technique, measured to overcome this problem rates. Swallowing was investigated and divided into five phases using CST-aided M-mode ultra sonograms. In this study, C-S-T in combination with the B-mode and M-mode US was applied to investigate and measure the tongue movement during swallowing in 55 persons. The average duration range of motion and speed of swallowing were found to be 2.435, 24.06mm and 10.34mn/s respectively. The computer-aided B-mode plus M-mode ultrasonography in combination with the cushion-scanning technique is a valuable root for study of tongue function.[2]

## II. Ultrasound imaging of condylar motion

Imaging of the temperomandibular 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 temperomandibular joint area. This produced nonconventional images of the joint from the frontal, superior, or both aspects. Recently Hirt and Knupfer obtained images of the temperomandibular joint in the more conventional sagittal plane. These were images of the joints of cadavers. Until now, obtaining conventional (sagittal) images of the temperomandibular 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.[3-7]

### Ultrasonic motion capture

This system allows for recording of mandibular movements in real time, recording and display of 3D movements is digital form. Following, the parameters of functional analysis, in addition to the settings of a fully adjustable articulator (hinge axis [HA], condylar inclination [CI] and immediate side shifts [ISS] are calculated and issued in a graphic report. The system is based upon the transmission time measurement of ultrasound impulses with highly sensitive sensors located on a head frame secured to the patient head. The ultrasonic emitter array is bonded to the labial side of the mandibular teeth using a jig customized with cold cure acrylic. The mandibular component is sufficiently light weight that it does not interfere with mandibular motions. Reference points are entered via a sensor per and permits re-registration between recording sessions. The manufacturer performance specifications are measurement resolution of 0.01mm and measurement rate of 100 measurements per second.

### III. Diagnosing a malocclusion/ facial asymmetry using ultrasonography

Bilateral difference in the activity level of the masticatory muscles may work as an asymmetric training stimulation, resulting in differences in the thickness of these muscles. Real time scanner with a linear array transducer is used. Orient the transducer perpendicularly to the ramus. Scan the masseter obliquely that will increase the thickness of the muscle.[7]

### IV. Diagnosis of zygomatic arch fractures

Ultrasound has traditionally been used in orbital and ocular diagnosis, but its role in maxillofacial trauma is less widely recognized. The use of ultrasound in the diagnosis and management of facial trauma has been reported previously.

McCann et al used ultrasound with 85% accuracy in diagnosing fractures of the zygomatico-orbital complex (ZMC). According to Friedrich et al, application of ultrasound is most useful for visualization of the zygomatic arch and the anterior wall of the frontal sinus.

An Aloka 3500 (Tokyo, Japan) ultrasound system with a 7.5MHz small linear transducer should be used. The patient's head is turned to the opposite side while he or she is examined in the supine position. After application of sterile gel, the probe is situated over the fractured arch transversely and its whole length is evaluated. Any interruption in the continuity of the radiopaque line of the arch contour, including displacement or depression, is considered to be a fracture. The same procedure will be carried out for the opposite arch. Gross swelling and tenderness over the fracture can make the procedure uncomfortable for the patient and can also make scanning of the bony outlines difficult, decreasing the accuracy of the process. The time span between the injury and sonography is important in alleviation of symptoms.[8,9]

### V. Determining the masticatory muscle mass depending on the facial form

The effects of muscle thickness on bone morphology can be explained by a theory which is recognized in the field of biodynamics as Wolff's law (Dibbets, 1992).

This law points out that the internal structure and the shape of the bone is closely related to function, and defi nes a relationship between bone shape and muscle function (Wolff, 1870). In order to describe facial morphology, the structure of the facial muscles should be investigated thoroughly to determine the pattern of interaction of the skeleton and muscles. The association between masseter muscle thickness and vertical craniofacial morphology seems to be a negative relationship but, in contrast, the association between masseter muscle thickness and craniofacial width appears to be positive. Masseter muscle thickness has been measured by various imaging techniques including ultrasound scanning, computerized tomography (CT) and magnetic resonance imaging (MRI). CT was used by Weijs and Hillen (1984) to measure masticatory muscle thickness in adults.

A water-based gel is applied to the probe before the imaging procedure. During imaging, the transducer is held perpendicular to the surface of the skin and special care is taken to avoid excessive pressure. The measurement site is at the thickest part of the masseter, close to the level of the occlusal plane, approximately in the middle of the mediolateral distance of the ramus. The imaging and measurements should be performed bilaterally with the subjects in a supine position under two different conditions: when the teeth are occluding gently with the muscle in a relaxed position and during maximal clenching, with the masseter muscle contracted. The levator labii superioris muscle is examined bilaterally between the alar cartilage of the nose and the pupil of the eye, and the measurements are made at the thickest part with the muscle relaxed.

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