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ULTRASONOGRAPHIC (USG) IMAGING IN OROFACIAL DISEASES– A REVIEW

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ABSTRACT:

Diagnostic ultrasound has become a radiology subspecialty. Ultrasonography(USG) is a procedure in which high-energy sound waves are bounced off internal tissues or organs and make echoes, which are picked up by the transducer and converted into an electrical signal and then into a real-time black, white and grey visual echo picture, which is displayed on a computer screen. The principles, various indications, advantages, disadvantages and advanced applications of ultrasonography in relation to maxillofacial region are enlightened in this review article.

KEYWORDS: Ultrasonography, Echoes, Sonogram, Imaging.

INTRODUCTION

History

Historically, ultrasound was developed in World Wars I and II and was used to locate submarines. In 1950, sonar equipment became available in medicine. The initial work in ultrasonography in medicine was done by Wild and Howry in the United States in 1952.

In Japan, the Medical Ultrasound Research Center was founded at the Jutendo University School of Medicine in Tokyo in 1965. There has been constant research and new developments in this field[1].

Introduction

Diagnostic ultrasound(US), has become a radiology subspecialty. By this technique we are able to locate and measure interfaces between different organs and tissues and to cut cross-sectionally through different structures. In contrast to other examinations which give direct information, ultrasound enables us to outline the lesion directly and to investigate its relationship with neighboring structures. The major feature that is unique to ultrasound is the ability to recognize and verify deep body organs and lesions having similar density on conventional x-ray studies[2].

With the application of modern electronic equipment and rapid reporting data retrieval systems, sonography is no longer merely a research project, but an important tool for diagnosis and care of the patient[1].

By definition, according to the National cancer institute - A procedure in which high-energy sound waves are bounced off internal tissues or organs and make echoes. The echo patterns are shown on the screen of an ultrasound machine, forming a picture of body tissues called a sonogram. Diagnostic ultrasonography (sonography), the clinical application of ultrasound uses vibratory frequencies in the range of 1 to 20 MHz[3].

Principle of Ultrasound

Scanners used for sonography generate electrical impulses that are converted into ultra-high frequency sound waves by a transducer, a device that can convert one form of energy into another- in this case, electrical energy into sonic energy[1].

The most important component of the transducer is a thin piezoelectric crystal or material made up of a great number of dipoles arranged in a geometric pattern. A dipole may be thought of as a distorted molecule that appears to have a positive charge on one end and a negative charge on the other. Currently, the most widely used piezoelectric material is lead zirconate titanate (PZT)[3].

The electrical impulse generated by the scanner causes the dipoles in the crystal to realign themselves with the electrical field and thus suddenly change the crystal's thickness. This abrupt change begins a series of vibrations that produce the sound waves that are transmitted into the tissues being examined[3,4].

The Ultrasound machine (**Fig.1**)

Several machines are available. But, basically the ultrasound machine has a pulse generator, transducer and an oscilloscope[1].

As the ultrasonic beam passes through or interacts with tissues of different acoustic impedance, it is attenuated by a combination of absorption, reflection, refraction, and diffusion. Sonic waves that are reflected back (echoed) toward the transducer cause a change in the thickness of the piezoelectric crystal, which in turn produces an electrical signal that is amplified, processed, and ultimately displayed as an image on a monitor. In this system the transducer serves as both a transmitter and a receiver[3].

Diagnostic Imaging by ultrasound

The high frequency ultrasound beam is directed into the body from a transducer placed in contact with the skin. Jelly is placed between the transducer and the skin to avoid an air interface. As the ultrasound travels through the body, some of it is reflected back by tissue interfaces to produce *echoes*, which are picked up by the same transducer and converted into an electrical signal and then into a real-time black, white and grey visual *echo picture*, which is displayed on a computer screen[4].
Current techniques permit echoes to be processed at a sufficiently rapid rate to allow perception of motion; this is referred to as *real-time imaging*[3].

Display Modes

The detected echoes may be represented in four ways: A-mode, B-mode, M-mode and B-scan mode and color Doppler mode[1].

A-mode: The oscilloscope displays the electrically converted echo pattern as a vertical deflection. The number, shape, location and amplitude of the echo spikes furnish detailed information of the structure examined[1].

B-mode: Echoes appear as dots of light, whose brightness varies with the intensity of the reflected waves and appears on the oscilloscope. The dots of the recording oscilloscope are registered in linear traces[1].

M-mode or Motion-mode: The motion of the pulsatile structure can be recorded by moving the B-mode tracing across the oscilloscope at pre-selected speeds. Actually, the amplitude of echo can be changed to dots and the dots of moving organs on B-mode are swept across the oscilloscope in a vertical direction and the motion demonstrated in the horizontal direction can be registered by time exposure photography[1].

B-scan mode: This technique permits cross sectional study of the body and is produced by moving the transducer across the area of interest[1].

Color Doppler will depict an anatomic view of vessels and show the mean velocity and direction of blood flow in the region of interest by color-encoding the gray-scale image[5]. Power Doppler is more sensitive to slow-flow than is standard color Doppler[5].

Doppler effect: a change in the frequency of sound reflected from a moving source - allows the detection of arterial and/or venous blood flow. As can be seen, the computer adds the appropriate colour like red or blue, to the vascular structures in the visual echo picture image, making differentiation between structures straight forward[4](**Fig.2**).

Interpretation of Diagnostic Ultrasound

The ultrasound image is also a sectional image or *tomograph*, but it represents a topographical map of the depth of tissue interfaces, just like a sonar picture of the seabed. The thickness of the section is determined by the width of the ultrasound beam. Areas of different density in the black/white echo picture are described as *hypoechoic* (dark) or *hyperechoic* (light)[4] and *anechoic* images[4,7].

A mass is hypoechoic if it has a intensity lower than that of the adjacent tissue. Hyperechoic is used for masses of higher intensity and isoechoic is used for masses with intensity similar to the adjacent tissue. The appearance of hypoechoic masses is darker where as the hyperechoic masses appear rather bright, and the isoechoic ones have a similar appearance. A calcified mass appears hyperechoic and a clear fluid or blood appears anechoic[6].

The internal echoes may be either *homogeneous* or *heterogeneous*.

'Homogeneous' refers to an even echo pattern or reflections that are relative and uniform in composition. If the mass is uniformly hypoechoic or hyperechoic, then it is described as a homogeneous mass[7,8].

'Heterogeneous' refers to an uneven echo pattern or reflections of varying echodensities. If a mass lesion contains hyperechoic and hypoechoic areas, it would be described as a heterogeneous mass[7,8].

The ultrasound wave must be able to travel through the tissue to return to the transducer. If it is absorbed by the tissue, no images will result[4]. Since air, bone and other

Fig.1 Ultrasound Machine

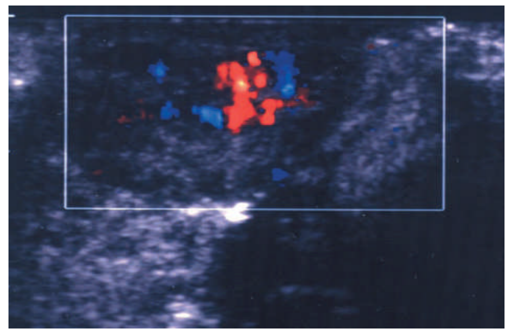

Fig.2 Doppler Effect

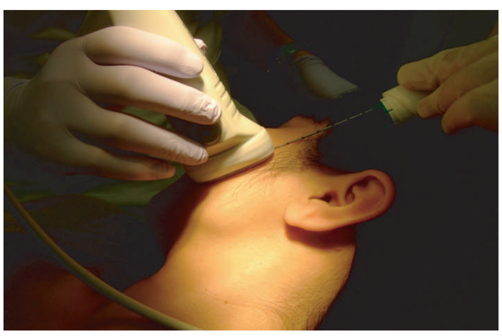

Fig.3 USG guided FNAB of Salivary Gland

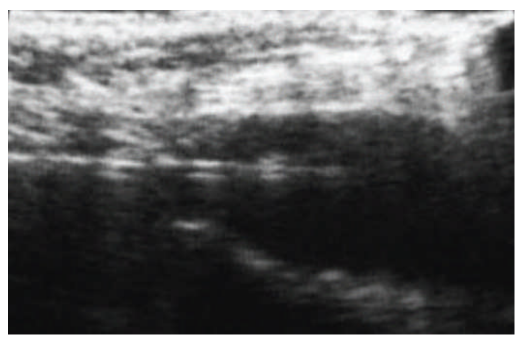

Fig.4 - US Guided Needle in the Mass

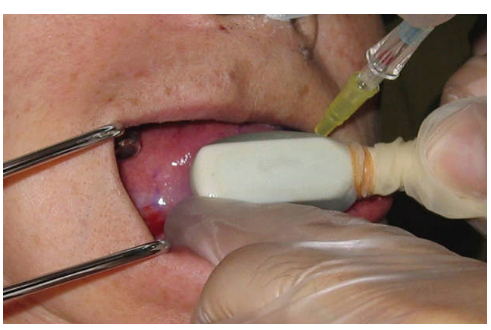

Fig.5 FNAB of Tongue

Fig.6 Intra oral Probe

calcified materials absorb nearly all the low frequency ultrasound beam its diagnostic use is limited. However, the newer high frequency machines enable penetration of more superficial structures to provide high resolution images[4].

USG can be a valuable aid to oral and maxillofacial and head and neck surgeons, if the following situations exist: 1) MRI is not available; 2) MRI results are not definitive, as in cases with fixed metallic restorations in the oral cavity causing artifacts in the obtained MR image; 3) the patients are suffering from claustrophobia; and/or 4) the patient is young with excessive movement during the image acquisition and need general anesthesia; then USG could be used as an alternative[9].

Advantages ***[4]***

- Sound waves are NOT ionizing radiation.
- There are no known harmful effects on any tissues at the energies and doses currently used in diagnostic ultrasound.
- Images show good differentiation between different soft tissues and are very sensitive for detecting focal disease in the salivary glands.
- Technique is widely available and relatively inexpensive.

Disadvantages[4]

- Ultrasound has limited use in the head and neck region because sound waves are absorbed by bone. Its use is therefore restricted to the superficial structures.
- Technique is operator dependent.
- Images can be difficult to interpret for inexperienced operators.
- Real-time imaging means that the radiologist must be present during the investigation.

Main indications and Applications for ultrasound in the head and neck

- Evaluation of swellings of the neck, particularly those involving the thyroid, cervical lymph nodes or the major salivary glands — ultrasound is now regarded as the investigation of choice for detecting solid and cystic soft tissue masses and ductal calculi and tongue related diseases[4,9,10,14].
- Therapeutically, in conjunction with the newly developed sialolithotripter, to break up salivary calculi into approximately 2-mm fragments which can then pass out of the ductal system so avoiding major surgery[4].
- Assessment of the ventricular system in babies by imaging through the open fontanelles[4].
- In diagnosis of superficial fascial space infections and in demonstrating the stages of infections[9].
- Ultrasound imaging is used in the assessment of periradicular lesions of endodontic origin and diagnosis of intraosseous lesions of the jaws[11].
- Doppler US is used in assessment of blood flow in the carotids and carotid body tumours, hemangiomas and other vascular malformations[12].
- Dynamic High Resolution USG being non-invasive can provide valuable information about internal derangement of the temporomandibular joint disorders[13].
- Ultrasound in Fine-Needle Aspiration Biopsy(FNAB) - US probe directly contacts the skin over the target examination areas at various angles, (**Fig.4**) can readily detect and diagnose salivary gland and lymph node - related diseases hence is a very useful tool for FNA biopsy.[15]
- US has been used in the diagnosis of primary lesions of the tongu**e-** to accurately estimate tumor size or thickness and to define adequate resection margins with tumor extension and deep infiltration[16] (**Fig.5**).
- Doppler US evaluates the vascular pattern of nodes and helps to identify the malignant and metastatic lymph nodes.[15,16] Normal lymph nodes have extensive vascularity originating in the hilus and branching radially towards the periphery. Conversely, the metastatic lymph nodes have peripheral vasculature that runs along the periphery of nodes and no vasculature around the hilus.[16]

CONCLUSION

Ultrasonography is a valuable tool and should be preferentially selected for the differential diagnosis of swellings of orofacial region, salivary gland, lymph node-related diseases and TMJ disorders. Further investigation is needed to standardize the methods of USG for diagnosing various kinds of diseases in the oral and maxillofacial regions.

Ultrasonography has revolutionized the world of medical imaging as a diagnostic and therapeutic aid, but it has still not found its place as a routine diagnostic aid in the orofacial region. The clinical application of USG in the oral and maxillofacial regions should be advocated in various publications.

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