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Ultrasound: A Key to "Sound" Diagnosis and Healing

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ABSTRACT

Since the first "hyperphonograph" was published in 1947, ultrasonography has gained immense popularity worldwide due to it being non-invasive, inexpensive, painless, portable, and ability to not cause any harmful ionizing radiation in both the patient and operator. Ultrasound is being used in the diagnosis and detection of various oral disorders (both hard and soft tissues). This review provides an overview of the most recent advances of ultrasound imaging in dentistry.

KEYWORDS: Ultrasound, Diagnosis, Temporomandibular Joint Disorders

INTRODUCTION

The term "Medical Imaging" refers to the application of different techniques used by clinicians to view the human body that helps them in diagnosing, monitoring and treating various types of medical conditions.[1] One of such techniques used is the "Ultrasound", which has been in service of humankind for over half a century. The first use of this technique has been attributed to Dr. Karl Theo Dussik (an Austrian neurologist) and his younger brother, Friedrich (radio and mathematical physicist), who applied it as a medical diagnostic tool to image the brain and ventricles. Together, they published their first ultrasound images in 1947, and termed the procedure "hyperphonography" which has gained immense popularity since then.[1]

In modern times, ultrasound (US) is one of the most widely used imaging technologies in the field of medicine as it has the advantages of being portable, is free of radiation risk, and is relatively inexpensive when compared to other imaging modalities(e.g. MRI and CT). In addition, the images produces by US are tomographic (offer a "cross-sectional" view of anatomical structures). In this technique, the images can be assimilated in "real time," which provide instant visual guidance

for many interventional procedures.[3] All diagnostic applications of the ultrasound are centred on the detection and display of acoustic energy that is reflected from interfaces within the human body.[4]

The initial images produced by an ultrasound technique was two dimensional(2-D), but now systems have been developed that are capable of preserving(quantitatively) the amplitude of information which is termed as gray scale ultrasonography.[5] Advances in the last decade have led to combining the advances in ultrasound image quality with recent advances in 3D visualization and establishing the "3D ultrasound", which has demonstrated benefits by better diagnosis of disease as well as providing guidance in procedures involving minimal invasive therapy in patients.[6]

Researchers are searching for more safer and comparable alternative(s) to the present imaging modalities in the field of dentistry due to ever increasing concerns regarding radiation dose and economic limitations of the imaging equipment. In this context, the recent developments in the Ultrasonography equipments enables fine detail visualization of the oral and maxillofacial tissues without the use of ionizing radiation, thus causing little or no harm to the patient. The technology of adapted by an ultrasound is based on the reflection of ultrasound waves (echoes) that are sent towards the area of interest using a piezoelectric transducer (Figure 1.) at the interfaces of tissues that have different acoustic properties leading to visual differences in the

projecting monitor and helps in diagnosis of normal and abnormal organ/tissue structure(s).[7]

Ultrasound finds its use in the field of examination of the bone and superficial soft tissue, abnormalities in major salivary gland or duct stone and salivary gland lesion detection, imaging of the temporomandibular joint, fracture detection, detection of vascular lesions, examination of anomalies in the lymph node and visualization of vessels of the neck including the carotid for detection of atherosclerotic plaques.[8] In addition, ultrasound can also be used to investigate oral cysts and tumors, and perform ultrasound guided core needle biopsies which is recommended as a safe and reliable technique in the diagnosis of cervico-facial structures.[9]

USES OF ULTRASOUND IN DENTISTRY

Ultrasound Guided Fine Needle Aspiration

Visualization of Normal and abnormal structures of oral and maxillofacial can be done using the B-mode of US imaging. An US can easily detect salivary gland disorder and is a useful tool for FNAB (Fine Needle Aspiration Biopsy). FNAB can also be done through other imaging modalities (e.g. CT, MRI). However, among them, Ultrasound is considered to be the least invasive, relatively inexpensive and easy to use technique with a relatively high accuracy.[10]

Alkhafaji et al. in their study of 10 years found that needle aspiration of parotid masses had a sensitivity of 82%, a specificity of 86% with an overall diagnostic accuracy of 84%. The authors also support that ultrasound guided FNAB by reporting that pathological diagnosis of lesions obtained by ultrasound guided FNAB agreed with final histo-pathological diagnosis after surgical resection in about 90% of the cases.[11]

Cervical Lymph Node (LN) Metastasis

It is important to know information about LN staging and localization of metastatic lymph node in patients with head and neck cancer as it decides the choice of therapy. Therefore, imaging plays a very important role in diagnosis of the staging the LN in patient(s) with Oral Cancer. Ultrasound has been found to have diagnostic sensitivity varying from 63% to 97% and specificity varying from 69% to 100% in detection of cervical LN metastasis with the added advantage that it is the only imaging technique that can be used for frequent routine follow-up of these patients.[10]

Carcinoma of Tongue

The prevalence of Carcinoma of tongue is relatively common among 3% of all the malignancies that arise within the oral cavity and hence, it is important to assess extent of carcinoma in order to predict the subsequent Lymph Node metastasis. The intraoral application of ultrasound is thought to be more easy and precise to evaluate the tumor depth as compared to the more commonly used imaging modalities such as CT and MRI in dentistry.[12]

Temporomadibular Joint (TMJ) Disorders

It is believed that imaging studies of the TMJ are expected to provide key information like disk position, joint effusion and bone abnormalities for the evaluation of diseases related to the TMJ.[10] Manfredini D et al. in their review concluded that ultrasound is useful as an alternative imaging technique for monitoring TMJ Disorders. It was reported that diagnostic accuracy of US in detection of disk displacement ranged from 62% to 100%, sensitivity and specificity ranged from 31% to 100% and from 30% to 100%.[13] However, the image interpretation in ultrasound based reports was not standardized because the definition of the disk varied in different studies. Manfredini D et al. theorize that a widened distance between the articular capsule and mandibular condyle in lateral portion of the TMJ might result from the interposition of a displaced disk between the condyles.[13]

ADVANTAGES

1. It is a dynamic and readily available technique.
2. It is particularly useful in the examination of superficial structures.
3. It is widely available and relatively inexpensive.
4. It is a non-invasive technique.
5. It is well tolerated by the patient.
6. It does not interfere with normal function.
7. Artifacts are few.
8. The technique is highly acceptable to most patients.
9. Images are rapidly acquired.
10. Images are simple to store and retrieve.
11. Images obtained are easy to read once the

observer is trained.
12. It can be performed without heavy sedation.3. It has no known cumulative biological effects.
14. It is proven to be reproducible and simple.
15. Equipment(s) is portable.
16. It is easily accessible and painless.
17. It causes less discomfort, is relatively rapid and examination can be performed even at the patient's bedside.
18. Its absolute non ionizing nature.
19. Equipment(s) is relatively cheap.
20. It is convenient to use.
21. Its possibility of real time imaging.
22. It helps to distinguish between solid and cystic lesions.
23. Its ability to detect non calcified pathological entities such as sialoliliths.

DISADVANTAGES

1. The technique is very operator- and equipment dependent.
2. Clinically only the bone surfaces and not the whole cortex or spongiosa can be visualized in intact done due to ultrasound frequencies.
3. It has to be performed by experienced investigators.
4. Images when archived they may be difficult to orientate and to interpret unlike CT and MR scans, which have acquired in standard reproducible scans.
5. The difficulty of picturing the TMJ using ultrasounds depends on the limited accessibility of the deep structures, especially the disc, due to absorption of the sound waves by the lateral portion of the head of the condyle and the zygomatic process of the temporal bone.
6. Ultrasound images are affected by inherent noise accompanying the signal returned to the transducer which makes interperatation of the static images, and sometimes the dynamic ones as well and a nonmoving object will vary in appearance because of this noise.
7. Ultrasonography waves do not visualize bone or pass through air, which acts as an absolute barrier during both emission and reflection.

CONCLUSION

Ultrasonography has revolutionized the world of medical imaging as a diagnostic and therapeutic aid. Though diagnostic ultrasound has been used as a reliable diagnostic tool in the medical field but still not found its place as a routine diagnostic aid in the orofacial region.
It is recognised as one of the most risk-free methods of evaluating any disease in the human. Ultrasound real time imaging has wide application in numerous diagnostic fields.
It has been suggested that it can provide useful information forthe assessment of TMJ disorders. Despite the limitations that it is operator dependent, better standardization is required and normal parameters must be set and it remains potentially useful as an alternative imaging technique for monitoring TMJ disorders particularly for the diagnosis of articular disc displacement and joint effusion.
It has several advantages over conventional radiography namely its non- invasive nature, easy reproducibility, possibility of real time imaging, its ability to detect non calcified pathological entities, relatively rapid and inexpensive technique.

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LEGENDS

Figure 1. Piezoelectric transducer used in an ultrasound