INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD ISSN: 2455-0620 Volume - 6, Issue - 10, Oct – 2020
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value: 86.87 Impact Factor: 6.719
Received Date: 30/09/2020 Acceptance Date: 15/10/2020 Publication Date: 31/10/2020

Ultrasonography: Maxillofacial Applications: A Review

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Abstract: *The story of the application of ultrasound (US) in imaging goes back a long way in history. It has been deemed useful in various situations and has evolved over time to a more sophisticated and precise modality. Some of the advances are in the form of newer and more useful equipment increasing its pertinence in dentistry and medicine. Currently, it is being used in various head and neck pathologies owing to its non-invasive nature and has gained wider acceptance in maxillofacial imaging. This paper reviews about the areas such as its history, basic principles, advances in the equipment and wide array of applications in head and neck pathologies and also weigh its merits and demerits in specific areas.*

Key Words: *Ultrasonography (USG), Maxillofacial.*

1. INTRODUCTION:

After the discovery of X-rays by William Roentgen discovered in 1895, the head & neck region began to be explored in the area of radiology widely. Dental radiology has played critical diagnostic role in dentistry with expanding areas in imaging modalities. Recently there have been the development of Computed Tomography, Nuclear Medicine, Magnetic Resonance Imaging Cone beam Computed Tomography and Ultrasonography. These imaging modalities that have revolutionized dental & medical diagnosis[1]

Ultrasonography (USG) imaging modality have gained importance in human medicine due to its notable features like non-invasive, non-ionizing, rapid and painless techniques.[2]

Due to its remarkable features ultrasound has been widely used by different medical specialties for diagnosis and therapeutic procedures.[3] .All diagnostic ultrasound applications are based on the detection & display of acoustic energy reflected from interfaces within the body.[4]

Technically Ultrasonography is based on sound waves that acquires images in real time and without the use of ionizing radiation. This phenomenon recognize as sound is the result of periodic changes in the pressure of air against the eardrum. The periodicity of these changes lies anywhere between 1500 and 20,000Hz.[5]By definition, ultrasound has a periodicity greater than the audible range. Diagnostic USG (sonography), ultrasound, uses vibratory frequencies in the range of 1 to 20MHz.

The ultrasound signal transmitted into a patient is diminished by absorption, reflection, refraction and diffusion. As there is high in frequency of sound waves there will be higher image resolution but the less the penetration of the sound through soft tissues. Fraction of the beam that is reflected to the transducer depends on the acoustic impedance of the tissues, which is a product of its density (and thus the velocity of sound through it) and the beam's angle of incidence. The has tissue has a characteristic internal echo pattern due to its acoustic impedance

Tissues that do not produce signals, such as fluid-filled cysts, are said to be anechoic and appear black. Tissues that produce a weak signal are hypo echoic, whereas tissues that produce intense signals such as ligament, skin, or needles or catheters are hyper echoic and appear bright[6.]

Diagnostic Ultrasonography has various modes namely A-mode, B-mode, M-mode and D-mode. A-mode or amplitude mode is not used frequently. It is of historical use and rarely used only in ophthalmology now a days. B-mode or brightness mode is important in diagnostic US. It produces different scale of grey on the basis of different echogenicity of reflected waves. M-mode or motion mode is extremely valuable for accurate valuation of rapid movements. It has excellent temporal resolution. D-mode or Doppler mode is based on the Doppler Effect i.e. change

in frequency (Doppler shift) caused by reciprocal movement of sound generator and observer.[7]US, as an imaging modality, has been extremely explored in recent years due to several advantages it provides.[1]

2. Uses in Maxillofacial Region:

The value of ultrasonography is very well understood in inflammatory soft tissue conditions. It is an effective diagnostic tool to confirm abscess in the superficial facial spaces and is highly diagnostic in detecting the stage of infection.[8]

Many obstructive, inflammatory and tumour like lesions can be detected and differentiated by ultrasound. It can differentiate between cystic swellings, abscesses, benign and malignant lesions. Many researchers have also advised use of US in diagnosis of intra-osseous lesions.

Clinical applications of US in dentistry are mainly in diagnosis of disorders of major salivary glands, diseases of facial musculature and superficial soft tissues. As high resolution US was developed it also became useful in imaging early tongue carcinomas, periapical lesions & temporo-mandibular disorders (TMD). A more recent addition to use of US in dentistry is diagnosis of cervical lymph node metastasis due to development of US-elastography.[9]US can also be useful in guiding the exact site of biopsy of intra-osseous lesions of law, if necessary.[10]

Salivary gland calculus: The first use of ultrasound to identify and locate a parotid calculus was reported by Pickrell in 1978. Transcutaneous extra-oral ultrasound was introduced as a simple and safe imaging technique for the detection of calculi in the salivary glands (Fig.1). It was found to be as effective as sialography in identifying calculi of 2 mm in diameter. Contemporary innovative small high frequency ultrasound probes allow access to the ducts both in the submandibular and parotid glands *via* an intraoral approach.[11]

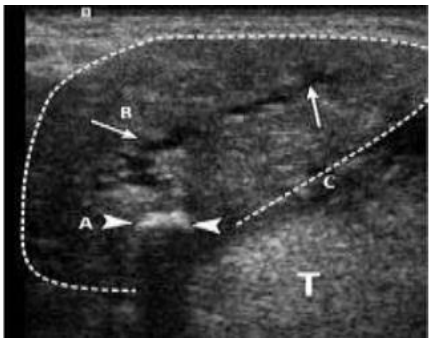

FIG 1 USG image of a submandibular gland showing the sialolith as hyperechoic (arrows)above the stone the gland duct is dilated which is hypoechoic (arrows B) in the inflamed parenchyma Of submandibular gland which appears hypoechoic and inhomogenous (dotted line C)[12]

Internal Derangement of TMJ: The TMJ region consists of diverse structures that reflect sound waves differently. Bone tissue, on the head of the condyle and the articular eminence, is generally hypoechoic and appears black, while the margin of the bone is hyperechoic and appears white in USG images. Connective tissue, represented by the joint capsule and the retrodiscal tissue; muscular tissue, represented by the lateral pterygoid and masseter muscles, are isoechoic and appear heterogeneously grey in ultrasonography images as can be seen in (FIG 2)

However the surface of the joint capsule, as well as the surface of the muscles, highly reflects the sound waves generating a hyperechoic (white) line. Empty space and water such as the superior and inferior joint spaces, are hypoechoic and appear black in ultrasonography images, however, these anatomic cavities are near due to the opposing surfaces are in contact, and they are usually not detectable unless effusion is present. Joint effusion can be detected indirectly by measuring the distance between the two articular surfaces/ capsular width.[13,14]

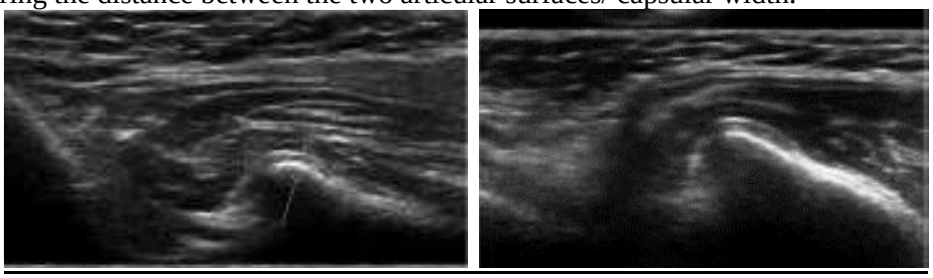

FIG 2.1 **FIG 2.2**

FIG 2

2.1. Closed Mouth: The mandibular condylar head and glenoid fossa are hyperechoic curved lines and the articular disc (arrows) is present between both with displacement of disc anteriorly over madibular condyle.
2.2. Open mouth: The articular disc (arrows) is displaced anteriorly is seen as hypoechoic band over head of mandibular condyle

Maxillofacial fractures: Nasal bone, frontal bone and zygomatic arch fractures have 100% accuracy in the ultrasound diagnosis.[15]A Mohammadi *et al* compared ultrasound and conventional radiography in the diagnosis of nasal bone fractures[16]

Also sonography shows trauma of the cartilaginous part of the nose more accurately than conventional radiography. In 1990 Hiromichi Akizuki *et al* used USG intra operatively to evaluate zygomatic arch fracture reduction[17]. He had concluded that USG can be used as an ideal imaging tool to evaluate fracture reduction and can also avoid over correction. (FIG 3 Fig 4)

FIG 3

FIG 4

Soft Tissue Lesions like Masseteric
Hypertrophy: Masseteric hypertrophy usually presents as a relatively firm, painless, pre-auricular swelling, but may cause considerable diagnostic difficulty. On Ultrasonography examination thickness of the masseter muscle at rest and at maximum clenching position can be recorded.[18]

Cervical lymphadenopathy: The lymph node staging plays a major role in head and neck cancer patients. The N-staging and the localization of the lymph node which are metastasize are mandatory for the choice of therapy. However, clinical examinations are not specific and they do have poor results. Therefore, radiology plays a key role in staging of the lymph nodes in patients with oral cancer.
On USG, lymph nodes are in general depicted as low echogenic oval or round structures. An echogenic hilum, containing vessels and fat, is seen as a central area of higher echogenicity.[19] (Fig 5)

FIG 5: USG image showing typical malignant node enlarged, roughly rounded, hypoechoic and inhomogeneous, with no visible hilum

Carotid artery calcifications: Cerebrovascular accidents (CVA) are the third most leading cause of death globally. Atherosclerotic disease known to causes one and half strokes at the carotid bifurcation. USG can diagnose carotid calcifications in which location, number, size, shape, borders of calcifications along with condition of artery, thickness of intima media complex hemodynamic alterations, flow velocity & spectral patterns can be assessed.[20]

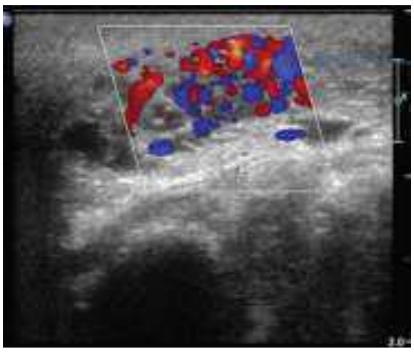

FIG 6 Colour Doppler USG showing intense Vascularity and presence of both arterial and venous flow

Infections of maxillo facial region: USG is a valuable diagnostic as well as therapeutic help in the management of superficial fascial space infections. Usually clinical diagnosis is not able to differentiate between cellulitis and abscess; in such cases USG provides precise imaging of the superficial structures of head and neck region, delimited medially by a bony skeleton. Compared to clinical examination, ultrasound imaging is much superior in defining the exact location of abscess because of its real time processing.
USG cannot differentiate an abscess from surrounding blood vessels, but due to advancement and combination of colour Doppler ultrasonography with grey scale has solved this problem. The target of colour Doppler imaging is the moving blood cells within the blood vessel. The vessels of the inflammatory tissue which has a higher blood volume due to increased permeability of the vessel wall are depicted as a color flow signal. Blood flowing towards the US transducer is displayed as red and which is moving away from the transducer appears as blue. In contrast the retained pus which does not contain flowing blood cells is delineated as no colour flow signal. This property of Doppler ultrasonography allows it to differentiate blood vessels from static regions of images.[21]

USG in Oral Submucous Fibrosis (OSMF): Oral Submucous Fibrosis (OSMF) is a precancerous condition and predominantly seen amongst betel quid chewers in south Asian countries. It demonstrates the number, length, thickness of the fibrotic bands and pattern of overall vascularity in the affected area. OSMF showing increased hyperechoic areas (Fig. 7) representing fibrous bands or diffuse fibrosis with normal/decreased vascularity and peak systolic velocity. USG is a valuable modality for evaluating fibrosis and vascularity status during & post treatment period thereby helps to monitor the efficacy of the treatment instituted. USG monitoring during treatment helps to alter and assess the efficacy of treatment schedule instituted. In some OSMF cases, it evaluates feeble fibrotic bands in clinically appearing normal buccal mucosa. USG helps monitoring the progress or otherwise of the lesion.[22]

Fig 7 USG Image of the right buccal mucosa, Showing the hyper echoic oral mucosal lining (white Arrow), the hypoechoic fibrous bands above which is the buccinators muscle

Periapical assessment: The use of USG in the differential diagnosis of periapical lesions was introduced by Cotti et al. in 2002[23] and 2003[24]. They defined cystic lesion as a hypoechoic well-contoured cavity filled with fluids with no evidence of internal vascularity on power Doppler imaging, and granuloma as a hyperechoic or mixed hyper- and hypoechoic areas with a rich vascular supply on power Doppler imaging. Gundappa et al reported that USG demonstrated a high diagnostic accuracy in the differentiation of periapical granulomas and radicular cysts with a side-by-side comparison between USG and hisopathology.[25]

USG-Guided Fine Needle Aspiration: For Guided-FNAB various imaging modalities such as USG, CT, MRI may be used to complete the procedure without disturbing important blood vessels and other structures. Of these modalities USG is least invasive, relatively inexpensive and easy to use technique. In addition, accuracy of USG-guided FNAB

has been relatively high. USG guided needle aspiration is a safe and effective procedure & can be used as reliable alternative to surgical incision and drainage of fascial space infection cases.[26]

3. Advantages:

- Absence of ionizing radiation.
- Portability
- Possibility of dynamic and repeated examinations.
- Fast & comfortable.
- Economic.

4. Limitations:

- USG waves can damage tissues at high exposure levels.
- Teratogenic effects, due to heat, and acoustic cavitation. However, within the diagnostic range at low intensities and pressure levels, occurrence of heating beyond the normal physiological range has very low probability.
- Metallic implants, dental fillings and restorations may cause blurring of the image due to artefacts generated by the metal.
- Poor hard tissue details.

5. Conclusion:

Ultrasonography is an innovative and evolving imaging technology in medical & dental field. Ultrasonography imaging as a diagnostic tool stands as a non-invasive, cost effective, readily available and repeatable technique. It is relatively easy to use. And also the use of Colour and power Doppler ultrasound imaging allows detecting blood flow within or around the lesion.

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