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Ultrasound in dentistry

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Abstract
Modern computed tomography, cone-beam computed tomography, magnetic resonance imaging, nuclear medicine, ultrasonography (USG), xeroradiography, and arthrography are only a few of the advanced diagnostic imaging modalities used in oral and maxillofacial radiology.
Since its inception, USG has been employed in the realm of medicine for both diagnostic and therapeutic purposes in order to identify lesions. Using sound waves instead of ionising radiation, USG is a method that acquires images in real time. Compared to hard-tissue lesions, soft-tissue lesions are easier to diagnose with USG. In this article, the uses of ultrasonic imaging in dentistry are reviewed.

Keywords: ultrasound, USG, radiology, diagnostic, CT

Introduction
The diagnosis, detection, and discovery of lesions in the oral and maxillofacial region depend heavily on a variety of imaging modalities. The development of procedures like magnetic resonance imaging (MRI), computed tomography (CT), and ultrasonography (USG) has revolutionised the area of imaging and lessened treatment uncertainty.
USG outperforms other imaging modalities due to benefits such the use of safe nonionizing radiation, wide availability, simplicity, low cost, and the absence of artefacts caused by metallic restorations. Real-time imaging is a USG capability that allows echoes to be processed at a fast enough rate to enable the perception of motion. Ultrasound scanning using very high frequency pulsed ultrasound beams is known as USG. From two- to three-dimensional visualisation in the assessment and identification of diseases, USG has observed several changes.
The use of contrast medium over the years in USG has helped radiologists or clinicians in the assessment of blood flow and its echogenecity more accurately [2]. Ultrasound imaging has a promising future as a hard- and soft-tissue diagnostic tool in all dental specialties [3, 4].

History
Jacques and Pierre Curie discovered high-frequency sound waves in the late 1800s when they exposed specific crystals to an alternating current at their resonance frequency [5].
In the year 1926, Paul Langevin was the first to report the biological effects of ultrasound after observing the violent and fatal reaction of fish to strong ultrasound fields. Initially, majority of researchers concentrated their research more on the diagnostic purpose of ultrasound rather than on its therapeutic application
However, the therapeutic application of USG was discovered in the late 1940s. Osteoradionecrosis, chronic osteomyelitis, and a number of other infectious diseases were all treated using USG [5]. Multiple researchers discovered that USG can promote callus development in healed bone the following year, in 1952.
The structural integrity of the bone that is mending is not compromised by USG [6]. The use of USG in dentistry has been the subject of additional research. It was discovered in 1955 that USG may remove plaque and calculus from human teeth. It can also be used to treat temporomandibular joint issues (TMJ) [7].
With time, more studies took place on USG and its mechanism of action. As clinicians came to know about its physiological and biological effects on tissues, the role of USG in bone repair began to attract more attention in the 1980s.
Numerous studies on the potential therapeutic effects of USG on maxillofacial bones were published in the 1990s [8]. Over the years, it has been discovered that USG plays a role in enhancing the likelihood of successful implantation, diagnosing precancerous lesions and disorders, maxillofacial swellings, lymph node metastases, and other problems [9-11].

Applications of Ultrasound in Dentistry
The prevalence of disorders affecting the oral and maxillofacial areas is rising daily, along with the use of imaging techniques. Disease diagnosis has never been easier than it is today because to daily improvements in imaging modalities. In order to diagnose diseases in the oral and maxillofacial region, one such modality that should be used is USG. USG has its own benefits, but it also has its own drawbacks.

Ultrasonic echography has been used as a diagnostic aid with an advantage that it can be used to examine deeper areas as well as superficial regions [16-18].

Salivary Gland Disorders

Identifying the nature of salivary gland's swelling as benign or malignant is difficult clinically and to rule out any confusion, various imaging modalities are used. Ultrasound is the first imaging modality of choice for salivary gland swellings. The normal echogenicity of all major salivary glands is generally homogeneous and varies from very bright to only slightly hyperechoic in comparison to adjacent muscles which appear as hyperechoic band.

USG helps in differentiating solid and cystic masses. USG in salivary gland diseases has one characteristic feature of diagnosing parenchymal structure. USG helps in diagnosing acute inflammation [19] chronic inflammation, [20] sialolithiasis, sialosis, and Sjögren syndrome Pleomorphic adenomas are usually hypoechoic, have well-defined and sharp borders with lobulization of contour and posterior acoustic enhancement that may contain calcifications [21]. Warthin's tumors are generally ovoid, hypoechoic mass [22].

USG is a diagnostic tool for characterizing salivary gland tumor. Nowadays, technical advances in many imaging centers have made USG the investigation of choice for major salivary gland diseases. USG findings of various salivary gland diseases are unique to each and every disease, thus making USG a valuable diagnostic tool.

Oral Sub Mucosal Fibrosis

USG helps in demonstrating the number, length, and thickness of the fibrotic bands and pattern of overall vascularity in the affected area. USG also helps in the diagnosis of feeble fibrotic bands in clinically normal buccal mucosa. The mucosa overlying the band has less flow velocity compared to the mucosa in between the bands where vascularity was found to be normal.

Oral submucous fibrosis (OSMF) shows increased hyperechoic areas representing fibrous bands or diffuse fibrosis with normal/ decreased vascularity and peak systolic velocity.

Neck and Cervical Lymph Nodes

Assessment of neck lymph nodes is essential in patients with head-and-neck cancers for predicting prognosis and selecting the appropriate treatment. Normal lymph nodes appear ultrasonographically as somewhat flattened hypoechogenic structures [24] USG can differentiate benign lymph nodes from malignant lymph nodes in patients of oral cancer.

Malignant lymph nodes appear hypoechoic in comparison to neighboring strap muscles with sharp margins. In malignancy, irregular margins or blurred margins usually indicate frank invasive contour extracapsular and extranodal spread with the absence of hilum [25].

USG can also be used to diagnose systemic diseases such as tuberculosis, eosinophilic granuloma, histiocytic necrotizing lymphadenitis, sinus histiocytosis, lymphoma, lung cancer and thyroid cancer metastases, and syphilis by lymph node examination. The major roles of USG are to check for nodal metastasis, check the size of lymph nodes, and assess the regional extent of disease. Sensitivity of USG in assessing cervical lymphadenopathy is 96.8% compared to clinical examination. Specificity of USG is 93% when combined with fine-needle aspiration cytology, i.e. 93% [26]. Like any other noninvasive technique, USG has its own limitations such as changes in the internal architecture of the deeper lymph nodes cannot be recognized.

TMJ Disorder

Imaging of TMJ may be necessary to supplement information obtained from clinical examination, particularly when an osseous abnormality or infection is suspected. USG is not a preferred imaging modality for TMJ but still can be used as one of the modalities along with MRI, CT scan, cone-beam CT, and arthrography [27].

A thorough understanding of TMJ anatomy and morphology of TMJ is essential so that a normal variant is not mistaken for an abnormality. The TMJ regions are unique because they constitute two separate joints anatomically; they function together as a single unit as the mandibular components are part of one bone.

On USG examination, articular eminence and mandibular condyle are generally hypoechoic, whereas the margin of the bone is hyperechoic in USG images. However, the surface of the joint capsule, as well as the surface of the muscles, appears hyperechoic, whereas the articular disc appears hyperechoic, hypoechoic, or isoechoic due to different structural, morphological, and positional abnormalities in the patients examined [28].

USG can be used as a diagnostic instrument in the study of TMJ disc displacement and TMJ effusion. USG has proved to be accurate in the detection of joints with effusion and to study clinically painful joints [29].

Inflammatory Swelling

Inflammatory lesions are the most common pathologic condition of the jaws. Inflammatory lesions constitute an important aspect of oral and maxillofacial pathology. The physical examination of jaw swellings lacks the diagnostic accuracy; hence, various investigations have been introduced to evaluate jaw swellings, with USG being one of the recent tools. USG echogenecity of swellings varies from hyperechoic (brighter), isoechoic (equal), hypoechoic (darker), anechoic (no internal signals), to mixed signals.

Most benign neoplasms have clear boundaries and irregular shapes and are hypoechoic. Cysts such as radicular cyst show hypoechoic to totally anechoic lesions; odontogenic keratocyst shows hypoechoic lesions; and dentigerous cyst shows anechoic to focal hyperechogenecity [30].

Muscular Pathology

Ultrasound imaging can be an adjunct to evaluate and diagnose diseases involving facial muscles. Constant change in the parts of USG, making it more diagnostically accurate, will thus help in evaluating deeper muscle pathology too. USG helps in the diagnosis of inflammation of muscle with unknown etiology. It further helps in even describing the dimensions of the lesion. USG also helps in the diagnosis of muscle hypertrophy in patients where all other etiological factors have been ruled out, which leads to muscle hypertrophy, thus helping in reaching to a diagnosis of idiopathic muscle hypertrophy

Apthous Ulcers

Recurrent aphthous stomatitis (RAS) is a common disease which shows multiple recurrent small, round, or ovoid ulcers with circumscribed margins. Clinically, they manifest as minor, major, or herpetiform type of RAS.

They are either single or multiple in number with no tissue tags from ruptured vesicles. They are less commonly seen on heavily keratinized palate or gingiva. Low-intensity ultrasound is most often used for canker sores therapy. USG has a nonthermal effect on tissues. USG acts either by increasing angiogenesis or by inducing granulation tissue formation or altering the oral microflora. Numerous studies have been conducted to show the efficacy of USG on RAS. In a study conducted by Brice on 35 students, it was found that low-intensity ultrasound appears to have a modest beneficial effect on RAS.

Other Fields of Dentistry

Ultrasound imaging can be used in the field of endodontics too. It can improve root canal access, monitoring postsurgical healing of periapical lesions of endodontic origin. To access this, a study was conducted by Tikku *et al*. to evaluate the role of USG in the diagnosis of periapical lesion of endodontic origin in maxilla and mandible. A total of thirty patient were evaluated for periapical lesions to diagnose whether the lesion is cystic or solid in nature. Periapical surgery was done, and the specimen was sent for histopathological examinations. Report of histopathology correlated with USG findings. Results showed that USG can have a role in detecting periapical lesions [33].

Periodontal USG helps in measuring periodontal depth and in the assessment of periodontal health [34]. Color Doppler in sonography has helped in the diagnosis of oral vascular malformations and vascular tumors.

USG can be used in various aspect of dentistry such as in the detection of either foreign bodies or muscular pathology or fracture or periapical lesions. USG can also be used in promoting healing; sterilization and management of superficial fascial space infections etc. Hence, the use of ultrasound imaging is immense in the field of dentistry with advantages and disadvantages too

Future Perspective

Apart from diagnostic process, USG also enhances rapid healing process of various injuries. With time, USG has also undergone lots of advances such as three-dimensional imaging to allow multiplanar reformatting, surface renderings, and color Doppler sonography for the evaluation of blood flow. With the advancement in transducers, USG has resulted in more precision.

Most of the researches done nowadays on USG show its diagnostic capability such as diagnosis of inflammatory swellings of maxillofacial and periapical regions. The future of USG in dental field is bright, but proper training of students and radiologists should be imparted in the evaluation of various lesions. Various clinical researches are required with good sample size to check for the efficacy of USG in the maxillofacial region.

Advantages

- It is a dynamic and readily available technique
- It is a noninvasive technique
- It is particularly useful in the examination of superficial structures
- It is widely available and relatively inexpensive
- It is well tolerated by the patient Equipment are portable Artifacts are few
- It can be performed without heavy sedation It has no known cumulative biological effects
- It does not interfere with normal function
- It is proven to be reproducible and simple
- It is easily accessible and painless Images obtained are easy to read once the observer is trained
- It is of absolute nonionizing nature
- It causes a less discomfort and is relatively rapid, and its examination can be performed even at the patient's bedside
- It has the possibility of real-time imaging

Disadvantages

- The technique is very operator- and equipment-dependent

- Clinically, only the bony surfaces and not the whole cortex or spongiosa can be visualized in intact done due to ultrasound frequencies
- 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
- Images when archived may be difficult to orientate and interpret unlike CT and MR scans, which have acquired in standard reproducible scans
- USG waves do not visualize bone or pass through air, which act as an absolute barrier during both emission and reflection
- Ultrasound images are affected by inherent noise accompanying the signal returned to the transducer which makes interpretation difficult
- It has to be performed by experienced investigators

Conclusion

After serving medical field for many years, the role of USG in dental field is a matter of great research, thus helping humankind in knowing its infinite potential in various diseases affecting oral and maxillofacial regions. As a diagnostic and therapeutic tool, USG stands as a noninvasive, widely available, affordable, and repeatable technique. USG technique is extremely operator dependent.

The addition of color and power Doppler ultrasound imaging has increased the efficacy of USG. The finding of USG report should be clinically correlated to increase the efficacy of USG

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