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REVIEW ARTICLE

DENTAL ULTRASOUND- A REDEFINED MODALITY AS DIAGNOSTIC AND THERAPEUTIC AID: REVIEW

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Abstract

Background:Dentistry is about appropriate diagnosis and effective management. Diagnosis and management can be done through various ways. The most important diagnostic aid in dental evaluation include imaging through X-rays, cone beam computed tomography, ultrasound and magnetic resonance imaging.

Purpose: Evaluate the diagnostic significance of ultrasound in dentistry and oral and maxillofacial surgery

MetodsUpon doing an search across PubMed, Scopus, Web of Science, Cochrane Library, and Google Schola 62, published were found. 38 of the chosen articles met the requirements for a analysis when inclusion and exclusion were applied

Results: Ultrasound is a form of real time imaging technique which acts as therapeutic as well as diagnostic aid in dental and medical field. Conventional radiography has certain disadvantages such as cost, radiation etc.These drawbacks of convetional radiography can overcomed by ultrasounds in dentistry. Also, to shift from radiating to non-radiating imaging and repeated imaging have demanded for ultrasonography in dental filed.The main advantages of ultrasound include non-ionizing radiation, portability possibility of repeated examinations and is economical.

Though therapeutic ultrasound in dentistry is still in infancy, its use in treating myofascial pain dysfunction syndrome,temporomandibular joint disorders, sialolitotripsy, descaling, endodontic procedures, ultrasonic cleaning of dentures and in periodontal regeneration techniques are being employed. Standardization of intensities, frequencies, time period of ultrasounds should be standardized to ensure maximum beneficial effects.

Conclusion: Use of ultrasound in dentistry is gradually increasing and will gain even more space if proper research is encouraged. Clinicians should be aware of the advantages of ultrasound in dentistry which include non-invasive, non-ionizing, painless, accurate, patient friendly, which makes it easy as well as interesting. To improve and increase the utilization of ultrasound in dentistry, further studies should be conducted with the goal of achieving better diagnostic and therapeutic aids.

Keywords: ultrasound in dentistry, diagnostic myofascial pain dysfunction syndrome,temporomandibular joint disorders, sialolitotripsy, descaling, endodontic procedures

Introduction

Imaging techniques play crucial role in the field of dentistry. Though conventional radiography can diagnose most of the conditions and is dentist's first diagnostic aid, it sometimes does not provide convincing evidence on dimensions, extent or limits, content of lesions and also cannot distinguish different types of lesions.[1] These drawbacks of conventional radiography can be overcomed by ultrasounds in dentistry. Also, to shift from radiating to non-radiating imaging and repeated imaging have demanded for ultrasonography in dental field.[2] Ultrasonography (US) was introduced in 1950's to medical field to improve diagnosis later its usage has been studied in dentistry.[3] Lefkowitz in 1953 reported on the early introduction and use of ultrasound in dental feild. Baum and associates in 1963 demonstrated the internal workings of teeth using a 15 MHz transducer.[4] It is a non-ionizing, non-invasive, economical and painless comforting the patient or patient freindly. It can also provide real-time image which is quick, reproducible. It can be easily tolerated by patient and can display both hard and soft tissue. It can be safe diagnostic aid in pregnant and lactating women due to its non-ionizing radiation.[5]

A high frequency sound waves of 2 to 20 MHz is used by ultrasound to produce images of both hard and soft structures inside the body. Ultrasound in dentistry used the frequencies between 3 MHz and 12 MHz.[6]

Principle of ultrasonography

A transducer transmits sound waves into the body. These sound waves travel through tissue interfaces which have different acoustic properties and produce echoes. Images of these echoes are identified and displayed[7] Hyperechoic refers to an interface or tissue area that exhibits a significant amount of ultrasonic reflection, whereas hypoechoic or transonic refers to an area that exhibits a lower echo intensity than the surrounding tissues. An area that lacks echoes' reflection is called anechoic, and it usually occurs in homogenous liquids. Transducers are available in different shapes which can be used to produce different images for small parts, vascular, and obstetric applications.[8]

Two modes are generally used in dentistry i.e., Amplitude mode (A-mode) and brightness (B mode) modes. Plotting the radiofrequency (RF) data results in the most basic display mode, known as A-mode ultrasonography, which was widely employed in the early US.[9] It creates a one-dimensional image with the echo time displayed horizontally and the echo amplitude displayed vertically using a single crystal. This mode is used for measuring gingival thickness. As of right now, US machines produce regular images on screen in B-mode. These ultrasound images can be created by tracking the journey of a transducer i.e., ultrasound probe, receiving RF-echo signals from each probe position, and employing grayscale on a monitor to obtain a light spot by converting electrical energy.[10] The B-mode produces one or more two-dimensional (2D) images that enable the observation and spatial measurement of the positions and dimensions of hard and soft tissues as well as foreign entities like implants and grafts.[11]

Application of ultrasound in dentistry

Ultrasonography can be either diagnostic or therapeutic in dentistry.

In diagnostic ultrasonography, high frequency sound waves are transmitted into the body. In dentomaxillo facial structures, ultrasound can help in recognition of head and neck abnormalities such as inflammatory soft tissue conditions along with superficial tissue disorders. It can also be an alternative diagnostic aid for detecting temporomandibular disorders.[12]

Any pathologies in major salivary glands such as sublingual and submandibular salivary glands can be detected using ultrasound. Echo-dens spots with a characteristic acoustic shadow can be seen in cases of sialolithiasis of parotid gland.[13]

The vessel resistance, velocity of blood flow and the surrounding morphology can be evaluated by color Doppler US. Cervical lymph node metastasis can also be detected using US. Cervico-facial masses can be detected by US guided core needle biopsy which is a safe and reliable technique. Potential fracture lines of injured bone or visualization of mid facial injuries before and after closed reduction can be observed.[14]

In endodontics, US will help in diagnosing peri apical lesions and also can differentiate cystic and non-cystic lesions. In addition, it can evaluate the vascular supply, size, and content and offer a preliminary diagnosis that might distinguish between granulomas and cysts. Enamel thickness can be measured using high-frequency transducer of 25 MHz and 35 MHz.[15] It can also help in detecting enamel, dentinal fractures and cracks. It also helps in detecting carious lesions of tooth surfaces.[16] Culjat et al. conducted ultrasound with a frequency of 10 MHz on maxillary third molar and could report underlying dentino-enamel junction.[17] In periodontics, non-invasive and non-ionizing radiation technique can help the clinician to evaluate hard and soft tissue healing after periodontal surgery.[18] It can detect periodontal bony defects.[19] An analysis of the application of ultrasonography in dentistry was carried out by Ghorayeb et al. The review demonstrates that owing of the complicated

architecture and modest impedance mismatch, US detection of periodontal ligament is still challenging.[20]

Gingival thickness can be measured using ultrasound. On 33 patients, Müller and Kononen conducted a clinical study to measure gingival thickness with the help of ultrasound. They found out that ultrasound was useful tool for measuring gingival thickness. In implantology, prior to implant placement, ultrasound can be used for initial clinical assessment and treatment planning. Soft tissue thickness during flapless implant placement can be determined by US. US can locate submerged implants during subsequent healing period and can avoid unnecessary surgical exposure of gingiva during prosthodontic placement.[21]

Therapeutic ultrasound uses lower intensities to reduce muscle spasm, to increase blood flow, and accelerate soft tissue and bone healing. It can also help in accelerating wound repair and in extracorporeal lithotripsy.[22]Let us discuss the most important therapeutic uses of ultrasound.

Ultrasonic therapy for temporomandibular joint Dysfunction

Ultrasound usage in temporomandibular dysfunctions (TMJ) as well as muscle spasms is very common and effective. By generating deep heat at the joints and lengthening the extra capsular soft tissue, ultrasound aids in the treatment of joint contracture. It also lessens tendinitis, non-acute pain, and muscular spasms. It also makes the tendons easier to stretch soft tissue by reducing collagen's viscosity, which in turn lessens the firing of type II muscle spindles and facilitating the breakage of calcium deposits in bursitis.[22] Clinicians usually use it as an adjunctive therapy rather than alone. A study done by few authors on large group of patients showed than US was very effective when used as an adjunct to other methods of management such as heat application, acupuncture, occlusal splints.[23] According to Esposito et al.'s conclusion, ultrasonography is most successful in relieving muscle-related symptoms and less successful at easing disc-related symptoms.[24]

Ultrasonic therapy in myofascial pain: Ultrasound in myofascial pain helps in increasing vasodilatation and decreasing inflammation. It also accelerates lymph flow, and stimulates metabolism subsequently decreasing pain. [25]A study done by Esposito and colleagues on 28 patients with MPDS who were treated initially with occlusal splints showed positive results with ultrasound therapy. They used pulsed ultrasound for a duration of 3 to 5 minutes at a frequency of 1 MHz, a pulse repetition rate of 120 Hz, and an intensity of 0.75 to 2 W/cm2 for patients who did not respond to occlusal splint therapy for 6-8 weeks. Ultrasonography is most helpful at decreasing muscular pain but cannot be recommended for disk-related pain.[26]

Healing of full thickness excised lesions using ultrasound non-ionizing radiation:

Ultrasound therapy is used to promote faster healing through angiogenesis and reduce pain by modifying scar tissue production. A study done by Young et al has shown that US therapy played a very important role in decreasing inflammation and accelerating early proliferative stages of repair.[27]

Ultrasound guided lithotripsy of salivary calculi:

Extracorporeal shock wave sialo lithotripsy can be done using integrated B mode ultrasound targeting device in treatment of calculi of salivary glands.[12] A study was done on 54 successive patients who underwent lithotripsy for the sialolithiasis of the parotid and submandibular gland. This study concluded that the device used in this study was very effective in treating parotid gland calculi than sub mandibular calculi. Here, integrated B mode sonography aided in targeting the caucus precisely.[28]

Ultrasound in periodontics:

*Ultrasonic descaling:*Ultrasound in dentistry were mainly used to remove plaque and calculus from the tooth surfaces using an ultrasonic descaler. The frequency recommended for removal of calculus deposits is usually between 25-42 kHz and help in reducing the mechanical effort required by the clinician. Other advantages include ease of operation, reduction in treatment time and level of discomfort to patient.[29]

The ultrasonic vibrations are generated by a piezoelectric transducer or a magnetostrictive within the handpiece. A cooling water flow is incorporated into both designs, passing through the handpiece and onto the oscillating tip. The cooling water helps by lowering frictional heating at the tooth/tip junction. Clinical studies showed that ultrasonic scalers removed effectively in smaller fragments and saved time. It also removed surface layer of necrotic cementum from periodontal disease teeth. Studies also showed larger reduction in tissue inflammation and stimulated increased rate of collagen production.[20]

Detection of sub-ginvival calculus: Ultrasound based device was developed by Meissner *et al to* automatically detect subgingival calculus in clinics.[30]

Ultrasonic magneto strictive units can help in removal of endotoxins and can also help in root detoxification.

In endotoxin removal and root detoxification: Moreover, ultrasounds are used for periodontal

pocket epithelial lining debridement.[31]

*Ultrasounds as microultrsonics:*The diameter of the tips of microultrasonic instruments ranges from 0.2 to 0.6 mm. With active working sides on all instrument surfaces and the ability to move at ultrasonic speeds (25000 to over 40000 cycles per second), these can provide ultrasonically activated lavage in the working field.[32]

Therapeutic use of ultrasound in Endodontics:

Root canals of non-vital teeth are prepared and cleaned using Ultrasonic vibrations. A small file is attached near the end of the main driver and is placed at an angle of 60°-90° to oscillate in main longitudinal axis. These instruments are essentially a direct adaption of the ultrasonic descaler, where a stiff metal rod is pushed to oscillate in its longitudinal mode. As a result, a transverse wave is created along the length of the file throughout the procedure, and the oscillating file is then inserted into the tooth's root canal to remove contaminated organic and inorganic material by abrading the walls.[33] Acoustic micro streaming fields are developed within the canal when an antiseptic solution is added to the ultrasonic cleaner. The adapted ultrasonic descaler is also used for condensation of amalgam restoration as well as restoration contouring and elimination of interproximal ledges. By breaking the cement seal, ultrasonic descaler can be used to extract broken metal posts from teeth. By causing dentinal tubule occlusion, ultrasound therapy promotes dentin development and repair. This ensures in potentially reducing dentin hypersensitivity.[34]

Therapeutic application of ultrasound in oral and maxillofacial surgery:

Ultrasounds were used in surgical extraction of teeth and for removing apical portion of root. The main advantage of ultrasonic in surgeries is that there is good visibility by controlling hemorrhage. There are no adverse reactions to ultrasound and healing appears uneventful with minimal patient discomfort.[12]

Application of ultrasound in orthodontics:

Ultrasound in orthodontics is used to remove cemented orthodontic brackets, interdental contacts between teeth, and superficial decalcification of enamel.[20]

Ultrasound therapy in bone healing and osteointegration

Bone fractures were better healed when therapeutic low intensity pulsed ultrasound was used. It facilitated hard tissue regeneration and early healing. Animal studies done on rats showed 25.8% increase in bone size of fractured femurs when treated with ultrasound.[35]

Ultrasonic cleaning bath

Ultrasound cleaning baths operate at 18-100 kHz and help in removing debris from instruments prior to sterilization. They also remove calculus and satins from dentures and also disinfect rubber base impressions to casting. The principle behind ultrasonic cleaning include cavitational activity and acoustic microstreaming.[36]

Therapeutic Low-Intensity Pulsed Ultrasound (LIPUS):

It has been demonstrated that LIPUS promotes PDL cell differentiation in cementoblast-like cells and chondrocyte proliferation in collagen scaffolds. Furthermore, it has been documented that LIPUS therapy leads to markedly enhanced cellular proliferation in human GFs, increased collagen synthesis, and osteogenic differentiation. Following flap surgery, LIPUS also improves periodontal healing. Furthermore, it has been shown that with LIPUS, in a span of 28 days, PDL cells in tissue culture produce more alkaline phosphatase (ALP).[37,38]

Table 1: The below table shows the usage of ultrasound in various fields of dentistry

ULTRASOUND IN FIELD OF DENTISTRY	USE
Oral and maxillofacial surgery	For evaluation of TMJ disorders, salivary gland disorders, head and neck abnormalities, cervical lymph node metastasis and potential fracture lines of injured bones. To treat muscle spasms, maxillary third molar extractions, hemorrhage control. It can also help in accelerating wound repair (both soft and hard tissue) and in extracorporeal lithotripsy.
Endodontics	To detect enamel, dentinal fractures and cracks, carious lesions on tooth surfaces. It helps in disinfection of root canals.
Periodontics	To evaluate hard and soft tissue healing after periodontal surgery. It can detect periodontal bony defects. To detect sub gingival calculus To perform ultrasonic scaling. As microultrasonics. Can be used for root detoxification.
Prosthodontics and implantology	For cleaning of dentures using ultrasonic cleaning method. For initial clinical assessment and treatment planning in and during implant placement. To evaluate gingival thickness and to locate implants in submerged implants.
Orthodontics	To remove cemented orthodontic brackets, interdental contacts between teeth, and superficial decalcification of enamel.

Limitations of ultrasound:

The major limitations of ultrasound in examination is it does not have hard tissue penetration, therefore cannot detect bony changes. This examination also differs from maxilla to mandible. The other disadvantages include no spatial registration and low user acceptance.

Conclusion:

Use of ultrasound in dentistry is gradually increasing and will gain even more space if proper research is encouraged. Clinicians should be aware of the

advantages of ultrasound in dentistry which include non-invasive, non-ionizing, painless, accurate, patient friendly, which makes it easy as well as interesting. In dentistry, ultrasound can provide early detection of carious lesions, differentiation of cystic and non-cystic lesions, enamel cracks and fractures etc. Therapeutically ultrasound is used in temporomandibular diseases, myofascial pain, endodontic teeth, periodontally weakened teeth and in orthodontics. To improve and increase the utilization of ultrasound in dentistry, further studies should be conducted with the goal of achieving better diagnostic and therapeutic aids.

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Declaration of competing interest

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Data Availability

All data generated or analysed during this study are included in this article.

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