Ultrasound as diagnostic and therapeutic aid-A boon in the field of dentistry: A brief review

Madhukar Nayaka Chandrabanda[1,*], Sujata Byahatti[2], Renuka Ammanagi[3]

[1]Post Graduate Student, [2]Reader, [3]Professor & HOD, Maratha Mandal Nathaji Rao G Halgekar Institute of Dental Science & Research Center, Belagavi-590010

***Corresponding Author:**
Email: madhukar.nayak1@gmail.com

Abstract

In emerging dentistry imaging techiques plays as an important and crucial role in superficial soft tissue and hard tissue pathologies. Advanced imaging techniques such as ultrasound imaging, Magnetic Resonance Imaging, Computed tomography, Nuclear Medicine and in which Ultrasound and MRI imaging are the only imaging technique, which does not cause radiation hazards to the patients. In the world of medical imaging as a diagnostic and therapeutic aid in the orofacial region . Hence this following article reveals in detail about applications of ultrasound role in the maxillofacial region.

Keywords: Ultrasound Imaging, Frequency, Diagnostic, Therapeutic

Introduction

X-rays were discovered by William Roentgen in the year 1895, which began to explore the head and neck region in ways which was never been possible before the existence and development of radiology. Dental radiology has long play an significant with diagnostic role in dentistry.[1] Imaging technique play a extremely vital role in the diagnosis of head and neck pathologies. Contrast radiographic techniques such as like Computed Tomography, Magnetic Resonance Imaging (MRI), Nuclear Medicine , Sialography, and Angiography can be used but these techniques are invasive and carry certain morbidity, and these equipment are not universally available and are expensive. Ultrasound has emerged as a recent imaging modality being non-ionizing, non-invasive and cost effective.[(2)]

Diagnostic Ultrasound is now established as the first choice imaging modality for soft tissue pathology of the head and neck,. It is a non invasive non-ionizing radiation that uses a very high frequency (7.5 – 20 MHz) pulsed ultrasound beam to produce high resolution images of more superficial structures.[(3)]

It is a stethoscope of the radiologist to look into the intriguing pathological conditions and provide useful information for better patient care. Ultrasound imaging has a wide application in the diagnostic field of Oral Medicine.[(4)]

Ultrasound Machine and Parts

A high resolution US machine is ideally desirable, but not essential. A linear 7.5-10 MHz probe with a relatively small 'foot print', i.e. a small contact area, is optimal. Higher frequency probes, i.e. 10 MHz and above, allow superior resolution for superficial structures but there is lack of depth penetration. Low frequency probes, i.e. 5 MHz are useful in appreciation of the deeper anatomy such as deep lobe of parotid gland. Color flow facilities are now standard on most machines; and while preferable they are not necessarily essential. Power flow is desirable for assessing flow patterns, for example in lymph nodes.

One essential piece of equipment is high quality, adjustable mobile table, which can be easily positioned so that the patient's neck is in level with the US monitor and within operators scanning range. When carrying out biopsy techniques the operator must be positioned so that the monitor can be viewed comfortably without undue stretching or twisting. The probe, needle, monitor and patient should be in acute field of view for optimal performance.[5]

The transducer probe is the part of the machine that produces the sound waves and receives the echoes. It consists of one or more crystals in a plastic housing. A high frequency potential difference is applied across the crystals causing them to change shape very rapidly – this is the piezoelectric effect, hence the crystals are called piezoelectric (PZ) crystals. This generates the necessary high frequency sound waves. The sound waves are then focused by an acoustic lens. When sound waves bounce back to the probe they cause the crystals to change shape and this generates a potential difference which can be measured. This signal is then processed to form the ultrasound image. Because the same piezoelectric crystals are used for sending and receiving the ultrasound pulses they have to operate in a switched or pulsed mode. This means that they emit a quick sound pulse, rest and then listen for the echo. This switching between transmitting and receiving modes happens many thousands of times a second.

- **The transducer pulse controls** allow the ultrasonographer operating the machine to alter the frequency and length of the ultrasound pulses to suit any given conditions.
- **The central processing unit (CPU)** is a computer. It sends the electrical signals to the transducer probe and receives signals back from it. The CPU

carries out all of the data processing necessary to create the final image.

- **The display** is usually a high definition computer monitor. Ultrasound images are displayed using a grey scale. High amplitude echoes are received from areas where there is a high acoustic mismatch and these are displayed as light grey or white pixels. Echoes received from areas where there is a small acoustic mismatch are displayed as dark grey. Black pixels represent a lack of echoes.
- **The keyboard and cursor** allow the ultrasonographer to add notes to the images as they are displayed.
- **Disc storage** allows scans to be stored digitally and kept with a patient's medical records.
- **A printer** is usually attached to the machine so that hard copies of images can be printed off as required.(5)

Various types of commercial available ultra sound machine in market: There cost may ranges from 1.5-10 lakhs depends on frequency they have used

1. Aeroscan CD 40 Color Doppler Ultrasound Machine
2. Ab Opthalmo Scanner
3. Sonoscape Ultrasound Series Equipment
4. Digital Ultrasound System
5. Portable Usg Machine
6. Ultra Sound Colour Doppler System
7. EDAN DUS3 Model Ultrasound Scanner With Convex Probe
8. Sonoscape

Principle

The basic principle behind Ultrasound and Doppler imaging are based upon the scattering of sound energy by interfaces which are formed of materials with different properties where in interactions were been governed by acoustic physics. The sound waves which are used as diagnostic ultrasound have a frequency over 20000 cycles per second (20 kHz), where as the human audible range is up to 20 kHz. Sound waves are propagated through a medium by the vibration of molecules (longitudinal waves). Within the wave, regular pressure variations occur with alternating areas of compression, which correspond to areas of high pressure and high amplitude.(5)

A-mode

In this form of ultrasound the echoes be present as peaks the same as the space between the different structures can be measured. This pattern be not frequently displayed although the parallel information be use to build two-dimensional in B-mode image.(6)

B-mode

In this form of image show every part of the tissue traversed by the use of the ultrasound scan. The images are two dimensional the same as B-mode images or B-mode sections. If multiple B-mode images seen in rapid sequence, they converted into real- time images.(6)

Real- time

In this form of image mode display motion by means of showing the images measurement of the body below the transducer while it is individual scanned. The images vary with each one movement of the transducer or else any part of the body is moving(for a case, a moving fetus or pulsating artery) The movement be revealed on the screen in genuine time as it occurs. In most real time units, it is posssible to "freeze" the displayed image, should be constant so that it can be studied and measured if necessary.(6)

M-mode

This is a different way of displaying motion. The result is a wavy line. This mode is commonly used for cardiac ultrasound .(6)

Diagnostic ultrasound applications be based on the principle of detection & display of acoustic energy reflected from interfaces in the body.(7)

Indications of Ultrasound as a Diagnostic AID**(3,8)**

Diagnostic ultrasound – the intensities used are typically 5 to 500 mW/cm2 which has wide range of applications are listed below

1. Ultrasound is the investigation of choice for detecting solid and cystic soft tissue masses. Hence it is used for evaluation of swellings of the head and neck, for example Swellings in orofacial region, , Periapical lesions, Salivary glands disorders, Lymph nodes – benign/malignant. Ultrasound has high sensitivity (98%) and specificity (95%) when combined with fine-needle aspiration cytology (FNAC). It has a higher sensitivity than palpation in detection of cervical nodes (96.8% and 73.3%, respectively). With the use of power Doppler sonography, the vascular pattern of lymph nodes can be evaluated, and blood flow velocity and vascular resistance can be measured with spectral Doppler ultrasound.(9,10)
2. Used for determination of periodontal bone morphology also measurement of alveolar bone topography, intraosseous lesions, midfacial fracture, fractures of mandibular condyle and ramus . Sonographic fracture diagnosis have report to be successful in midfacial regions like orbit, zygomatic arch and nasal bone. Studies have been reported where ultrasonography was used to confirm the position of fragments during the surgical reduction of zygomatic arch fracture.(11,12)
3. Used during the imaging of TMJ discs in the diagnosis of internal disc derangement's, assessment of masticatory muscles within temporomandibular dysfunction. It can be use to examine the joint within a continuum without invasion, anxiety, variation of the patient's standard head position, or obstruction by condylar motion. As a consequence, US have be recently introduce in the study of the TMJs, by high-quality images for the detection of both disc displacement also intrarticular effusion.(13,14)

4. Detection of salivary gland and duct calculi, Submandibular gland injection of botulinum toxin for hypersalivation in cerebral palsy , Basket retrieval of salivary stones : Ultrasound can accurately localize whether the calculus is intraglandular or within the main salivary duct. This affects patient management, particularly for submandibular calculi. For intraglandular calculi, the gland may have to be removed whereas for main salivary duct calculi, exploration of the duct with stone removal is often successful. Complications of calculi, including sialocele and abscess, can be easily identified with ultrasound.[15]
5. Evaluation of the relationship of vascular structures and vascularity of masses by the addition of color flow Doppler imaging.
6. Evaluation of blood flow within the carotids and carotid body tumors.
7. Evaluation of the ventricular system in babies via imaging through the open frontanelles.
8. Ultrasound guided fine needle aspiration cytology and biopsy.
9. Used to detect foreign bodies.
10. By the combined use of Doppler it can be used in the diagnosis of vascular lesions of head and neck region like Congenital vascular lesions of head and neck hemangioma and lymphangioma.

Advantages[3]

1. Sound waves are not ionizing radiation.
2. Technique is easilly available and relatively inexpensive.
3. It does not require special facilities and thus has the potential of becoming available in a dental office under the supervision of the radiologists.[3]
4. It is a non invasive method without any discomfort to the patient.
5. Recently use energies and doses in diagnostic ultrasound be no harmful effects on any tissues of the body.
6. Images explain high-quality differentiation between the normal and pathological soft tissues also be very sensitive for detecting focal disease in salivary glands.

Disadvantages[3]

1. Ultrasound have restricted use in head and neck region as sound waves are absorbed by bone. Therefore its use is restricted to superficial structures.
2. Technique be hand skill dependent.
3. Images can be not easy to interpret for inexperienced operators.
4. Real time imaging means the radiologist must be present during the investigation[3]

Indications of Ultrasoundas a Therapeutic AID[8]

Therapeutic ultrasound – The first application of ultrasound in medicine was for therapy as reported by Pohlman in 1939.

Used intensities of 1 to 3 W/cm2 and it includes –

Therapeutically, in combination with the recently developed sialolithotripter, to removal of salivary calculi into approximately 2-mm fragments which can follow through via the ductal system.

1. Myofascial pain . During this condition ultrasound will decrease inflammation, increase vasodilatation with waste amputation, accelerate lymph flow, along with stimulates metabolism. Pain relief be theorize to be associated to wash of pain mediators via increased blood flow, change in nerve conduction, or alteration within cell membrane permeability to decrease inflammation.[16]
2. Temporomandibular joint dysfunction.[17]
3. Ultrasound guide lithotripsy of salivary calculi with an electromagnetic lithotripter.[18]
4. Bone healing and osteointegration: Therapeutic low intensity pulsed ultrasound have be made known to accelerate bone fracture healing indicating with the purpose of ultrasound can be used as a tool to facilitate hard tissue regeneration.[19]
5. Oral Cancer : A method which selectively affects malignant cells without causing any damage to the surrounding normal tissue is safe; ultrasound could certainly be considered a treatment of choice for at least certain malignant diseases.[20]
6. Helps in healing of full thickness excised skin lesion. A study conducted by young shows that US therapy can be considered as useful in both accelerate the inflammatory and also early proliferative stages of repair.[21]
7. Ultrasonic descaling and Modifications of the ultrasonic descaling.

Other applications-

1. Endodontics
2. Surgical applications
3. Ultrasonic cleaning baths

Conclusion

Over the past two decades, rapid strides in ultrasound technology and in particular development of high resolution ultrasound have led to a greater role for ultrasound in the evaluation of the head and neck pathologies. The majority treatments involving the use of diagnostic as well as therapeutic ultrasound be based upon individual view as well as experience, and that there is a need for more restricted experiments to be done to explore the scientific claim that ultrasound does indeed accelerate healing. The ongoing advance within this field may possibly assure exciting development in the upcoming days.

As it is relatively inexpensive, noninvasive method where in non ionizing radiation has been used which makes it as readily available and provides both static and dynamic images. Hence, the use of ultrasound will continue to increase and definately has better scope in the future.

Refrences

1. Sharma S, Rasila D, Singh M, Mohan M. Ultrasound as a diagnostic boon in Dentistry a review. Inter J Sci Study.2014 May;2:70-6.
2. Pogrel Anthony M. The use of ultrasonography as a diagnostic tool for superficial space infections. J. Oral Maxillofac. Surg., 1998;56:1132-1135.
3. Eric Whaites. Essentials of dental radiography and radiology. (3rd edition) Elsevier publications.237-239.
4. Anil Ahuja and Rhodri Evans. Practical head and neck ultrasound. (1st edition) Greenwhich medical media limited, 2000.
5. Key stage physics lesson4 ultrasoud4.5.
6. Sharma S, Rasila D, Singh M, Mohan M. Ultrasound as a diagnostic boon in Dentistry a review. Inter J Sci Study. 2014 May;2:70-6.
7. Manual of diagnostic ultrasound :B.Beryer: acoustic coupling agents page no 45
8. Carol M. Rumack, Stephanie R. Wilson, J. William Charboneau, Diagnostic ultrasound. volume 1; edition 3rd.
9. Sharma S, Rasila D, Singh M, Mohan M. Ultrasound as a diagnostic boon in Dentistry a review. Inter J Sci Study.2014 May;2:70-6.
10. Knappe M, Louw M, Gregor RT. Ultrasonography-guided fine-needle aspiration for the assessment of cervical metastases. Archives of Otolaryngology–Head & Neck Surgery. 2000 Sep 1;126(9):1091-6
11. Takes RP, Knegt P, Manni JJ, Meeuwis CA, Marres HA, Spoelstra HA, De Boer MF, Bruaset I, Van Oostayen JA, Laméris JS, Kruyt RH. Regional metastasis in head and neck squamous cell carcinoma: revised value of US with US-guided FNAB. Radiology. 1996 Mar;198(3):819-23.
12. Friedrich RE, Heiland M, Bartel-Friedrich S. Potentials of ultrasound in the diagnosis of midfacial fractures. Clinical oral investigations. 2003 Dec 1;7(4):226-9.
13. Friedrich RE, Plambeck K, Bartel-Friedrich S, Giese M, Schmelzle R. Limitations of B-scan ultrasound for diagnosing fractures of the mandibular condyle and ramus. Clinical oral investigations. 2001 Mar 25;5(1):11-6.
14. Pereira LJ, Gaviao MB, Bonjardim LR, Castelo PM. Ultrasound and tomographic evaluation of temporomandibular joints in adolescents with and without signs and symptoms of temporomandibular disorders: a pilot study. Dentomaxillofacial radiology. 2007 Oct;36(7):402-8.
15. Stefanoff V, Hausamen JE, van den Berghe P. Ultrasound imaging of the TMJ disc in asymptomatic volunteers: Preliminary report. Journal of Cranio-Maxillofacial Surgery. 1992 Dec 1;20(8):337-40.
16. Rubaltelli L, Sponga T, Candiani F, Pittarello F, Andretta M. Infantile recurrent sialectatic parotitis: the role of sonography and sialography in diagnosis and follow-up. The British journal of radiology.1987Dec;60(720):1211-4
17. Esposito CJ, Veal SJ, Farman AG. Alleviation of myofascial pain with ultrasonic therapy. The Journal of prosthetic dentistry. 1984 Jan 1;51(1):106-8.
18. .Gray RJ, Quayle AA, Hall CA, Schofield MA. Physiotherapy in the treatment of temporomandibular joint disorders: a comparative study of four treatment methods. British Dental Journal.1994Apr;176(7):257-61.
19. Eggers G, Chilla R. Ultrasound guided lithotripsy of salivary calculi using an electromagnetic lithotriptor. International journal of oral and maxillofacial surgery.2005Dec31;34(8):890-4.
20. Rawool NM, Goldberg BB, Forsberg F, Winder AA, Hume E. Power Doppler assessment of vascular changes during fracture treatment with low- intensity ultrasound. Journal of Ultrasound in Medicine. 2003 Feb 1;22(2):145-53.
21. Schortinghuis J, Bronckers AL, Gravendeel J, Stegenga B, Raghoebar GM. The effect of ultrasound on osteogenesis in the vertically distracted edentulous mandible. A double-blind trial. International journal of oral and maxillofacial surgery. 2008 Nov 30;37(11):1014-21.
22. Young SR, Dyson M. Effect of therapeutic ultrasound on the healing of full-thickness excised skin lesions. Ultrasonics.1990 May 31;28(3):175-80.