Ultrasonography, a non-invasive technique in dentistry

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Abstract
Ultrasonography as an imaging technique in dentistry has been broadly analyzed in recent years due to several advantages that it provides. It is a non-invasive, cost effective, portable, and radiation free imaging technique. However, in comparison to other imaging techniques intraoral ultrasonography has been rarely in application. It has recently been drawing more attention due to its advantages. Ultrasonic image is produced by ultrahigh-frequency sound waves. It is used in dentistry for the assessment of the salivary glands and ducts, as well as the floor of the mouth, buccal mucosa, labial mucosa, and palatal mucosa, the tongue, periodontal tissues and periapical lesions. The main aim of this review is to provide an overview of the facilitation of intraoral ultrasonography in dentistry.

Keywords: Ultrasonography, Dentistry, Applications.

Introduction[1-3]
Ultrasonography is based on the application of ultrasound. Ultrasound is "sound at frequencies bigger than twenty kHz'' that is more than the higher perceptible limit of human hearing. The principle and application of ultrasound was first discovered by Jacques and Pierre Curie in 1880. The first data on diagnostic ultrasonography in dentistry was reported in 1963 by Baum et al.

Ultrasonography is employed to look at internal body structures, such as tendons, muscles, joints, vessels, and internal organs.

In ultrasonography the scanners used, generate electrical impulses that are converted into ultra high frequency sound waves by a transducer a device that can convert one form of energy into another. The most vital element of the electrical device could be a skinny crystal or material created from an excellent variety of dipoles organized in a very geometric pattern. Currently the foremost wide used electricity material is Lead Zirconate Titanate (PZT). According to Ultrasonography logic, the lower the frequency, the higher the penetration of tissues but the lower the potential image resolution. Depending on the shape and configuration of the probe, different-shaped fields of view are generated. The sound echoes off the tissue; different tissues reflect varying degrees of sound.

These echoes are recorded and displayed as images to the operator. Since ultrasound is blocked by bone, it can be used only if there is a bony defect over the lesion through which ultrasonic waves can traverse.

Compared to other prominent methods of medical imaging, Ultrasonography has several advantages: it provides images in real time, is portable, inexpensive, radiation free, non-invasive, and unaffected by metal artefacts, such as dental restorations. It also allows identification of the vascularity of lesions via its power Doppler and color Doppler facilities and is capable of differentiating cystic from solid lesions; it is also helpful in differentiating benign from malignant masses. The drawbacks of Ultrasonography include limitations with respect to its field of view, such as patient cooperation and physique, difficulty in imaging structures behind bone and air, and its dependence on a talented operator. Oral and nasal cavities, as well as the pharynx, larynx, and trachea, are nearly completely filled with air, and multiple bone barriers further complicate a Ultrasonography examination.

In addition to its use of conventional radiology techniques, modern dental radiology has recently begun to use advanced imaging techniques, such as computed tomography (CT), magnetic resonance imaging (MRI), radionuclide imaging, and USG. Modern Ultrasonography devices with high-frequency linear probes (7.5–12 MHz) provide high-resolution images in multiple planes in the head and neck regions.

In dentistry, Ultrasonography is generally used in the imaging of maxillofacial fractures, cervical lymphadenopathy, various soft tissue masses, masticatory and neck muscles, temporomandibular joint (TMJ), periapical lesions, and salivary gland diseases. However, most dental radiologists do not know how to utilize ultrasonography in the diagnosis of various kinds of oral diseases, which is very disadvantageous for patients with any of the aforementioned diseases.

At the present time, there are no plans for the manufacturers of ultrasonography devices to produce probes specifically for intraoral usage. High-frequency small-footprint transducers which are produced for various purposes are typically used for intraoral ultrasonography. Therefore, applications using the existing probes may not always permit an ergonomic intraoral approach. It may be difficult for patients and physicians. Before initiating the intraoral ultrasonography examination, the patient must be sprayed with topical 1% lidocaine, and the transducer surface must be covered with ultrasound gel and wrapped with a disposable clingy wrap. When performing an intraoral ultrasound scan, it is advisable start from the buccal mucosa. Starting the procedure this way will cause less discomfort to patients and minimize the gag reflex.

In the examination of oral lesions, transcutaneous ultrasonography is carried out by placing the transducer on an extraoral site. However, it is difficult to obtain high-quality images via this method. Placing the transducer directly on the surface of tumors in the oral cavity, combined with a lower frequency for deeper lesions and a higher frequency for superficial lesions, as used in this technique, allows evaluation of the thickness, echogenicity, and in addition, vascularity of lesions on Doppler application. Accurate measurement of the size and extension of tumors of the tongue, mouth floor, and buccal mucosa can easily be accomplished preoperatively with the help of intraoral ultrasonography.

Intraoral Ultrasound Scanning Procedures in Dentistry[4,5]

Examination of the salivary glands, parenchyma, and ductal systems

Patients are usually not uncomfortable during an examination of the sublingual region with a transducer. To find the sublingual gland, scanning must be started from the orifice of Wharton duct to the floor of the mouth. Inflammatory lesions, cysts, or neoplasm can be clearly detected. To examine Wharton duct, the transducer must be turned a bit inside from the region of sublingual gland. The conventional transcutaneous approach is more limited at visualizing Wharton duct, which, in most cases, is not easily detected if it is depressed when placing the probe. Intraoral USG can visualize the submandibular duct and detect the presence of small calculi. In addition, intraoral ultrasonography enables one to detect even the thickness of stones.

When sialolithiasis of the submandibular gland is suspected, ultrasonography might show whether the stone is located in the glandular parenchyma or in Wharton duct. This distinction is essential in choosing the method of treatment. With respect to sialolithiasis, ultrasonography features include strongly hyperechoic lines or points with distal acoustic shadowing. In symptomatic cases with duct occlusion, dilated excretory ducts are also visible. Some authors claim that sialoliths smaller than 2–3 mm may be overlooked because of the absence of acoustic shadow and that hyperechoic air bubbles mixed with the saliva may sometimes mimic stones. Tiny calculi, especially in the region of the salivary duct opening, are hard to visualize during conventional ultrasonography examination of the neck. However, intraoral ultrasonography can reveal stones within the proximal portion of the submandibular duct.

Examination of the lingual artery and nerve

When we go deep inside along Wharton duct, we can find various vessels on the floor of the mouth. A recent experimental study on pig cadavers demonstrated that ultrasound is well able to visualize the position and status of the lingual nerve. A hockey-stick transducer may be used to image the lingual nerve in relation to the retromolar triangle, the ramus, and the medial aspect of the alveolar bone along the second and third mandibular molars. The prevalence of damage to the nerve as a result of extraction of third molars ranges between 0.6% and 11%. The lingual nerve does not migrate inferiorly, however, because of the alveolar bone resorption in edentulous patients; second molar implants may also cause lingual nerve injuries. It should be noted that ultrasound cannot penetrate the mandibular cortex; its role in preoperative imaging of the relationship between the lower third molars and mandibular canal thus remains obscure.

Examination of the minor salivary glands, buccal mucosa and lips

The minor salivary glands are clearly seen when the transducer is placed near the lip, and the depth and size of any ulceration on the lips can be precisely evaluated. A detailed scan can be conducted along the rest of the oral cavity because the patient feels minimal discomfort. A normal pattern of the buccal mucosa consists of homogenous echoes with a hyperechoic aspect due to the thick cortical bone of the mandible. The buccinator muscles, superficial minor salivary glands, the orifice of Stensen duct, and any soft-tissue lesion on buccal mucosa can also be detected.

Examination of the tongue

Lesions can easily be scanned through the mobile tongue anteriorly and the tongue base posteriorly. High-resolution 7–15 MHz, linear, hockey-stick probes are often used for intraoral ultrasonography tongue evaluations and the probe is placed directly on the surface of the tongue. Patients are able to tolerate a transducer placed at the anterior aspect of the mobile tongue, and they are instructed to protrude the tongue and, while it is gently held with gauze, to keep it as still as possible. The wrapping film is used for hygienic purposes; the gel is placed on the probe and plays an essential role in preventing the accumulation of air between the surface of the probe and the wrapping film. The scan direction is usually parallel to the longitudinal axis of the tongue, and a normal intraoral ultrasonographic pattern of the tongue shows homogenous echoes. The transverse muscle of the tongue is located at a deeper site, and it could be well depicted with hypoechoic lines on intraoral sonography.

Several studies have reported that USG is useful in evaluating the thickness of primary lesions in tongue carcinoma. Transcutaneous USG is now considered inferior to intraoral USG in tongue-tumor examinations. Patients with cervical lymph-node metastasis from oral squamous cell carcinoma have poor prognosis and will generally receive surgical excision of the primary tumor and therapeutic neck dissection. Tumor thickness should be assessed preoperatively in oral carcinoma. A noninvasive and accurate method to detect the lesion and measure tumor thickness before starting therapeutic procedures will be useful.

While examining tongue lesions via intraoral USG, blood flow response during posterior echo strengthening and Doppler USG may indicate infiltration of blood vessels, lymph ducts, or both. The relationship between the ultrasonic images of oral tongue cancer and histopathological features has not been elucidated. Another

drawback to USG is its status as a highly operator-dependent technique. Therefore, some researchers have attempted to develop computer-aided diagnostic systems that can assist inexperienced operators to avoid misdiagnosis.

Intraoral USG could demonstrate sequential change of the primary site of the tongue cancer, and it has also been found useful in detecting recurrent tumors and post treatment changes. It can depict the sequence changes of the tongue after radiotherapy, and it is thus beneficial in the confirmation of clinical findings associated with either radiation ulcers or recurrence.

Examination of the hard/ soft palates

Considered the best initial investigation technique for the evaluation of palatal masses, ultrasonogrphy is also acknowledged to be quite useful in conducting preoperative evaluation in patients with small palatal tumors less than 3 cm in diameter. Ultrasonography imaging of palatal regions leads to measure the thickness of the potential donor site for subepithelial connective tissue graft or to choose a suitable orthodontic anchorage screw.

Intraoral USG is also a useful imaging technique in evaluating the nature of suspicious masses of the palatal minor salivary gland. The ultrasonic, well-delimited margins of the palatal tumors are related to the presence of a histological capsule, and posterior echo enhancement shows defects in the palatal bone. However, intraoral USG of the palate is problematic because of the dome shape. Moreover, it is difficult to perform a full approach with linear probes to in this region, particularly in patients with narrow palates; small-footprint convex probes may be more appropriate. However, their frequency remains too low for use in superficial examinations.

Examination of periodontal tissues

Periodontal ultrasonography is a reliable, non-invasive, and cost-effective method for identifying anatomical elements necessary for obtaining accurate periodontal diagnosis of the examined area. Recent studies have shown the validity and reliability of ultrasonography in the measurement of not only gingival thickness but also of other periodontal structures that cannot be assessed through inspection and palpation. Linear, small-footprint, high frequency (40 MHz) transducers are used for periodontal ultrasonography. On the ultrasound image, the following micrometric level measurements may be performed: gingival sulcus depth, free gingival thickness, width of the periodontal space in the most coronal position, distance between marginal gingiva and alveolar crest, height of the clinical crown, and height of the anatomic crown. Furthermore, with respect to implantology, the bone level and the thickness of soft tissue around implants are measurable by intraoral ultrasonography.

Examination of periapical diseases

Conventional root-canal therapy is the main treatment modality for periapical granuloma, but it has no benefit for periapical cysts because true cysts are less likely to be resolved by conventional root-canal therapy and require surgical intervention. Linear, regular-size, multifrequency ultrasonography probes at an average frequency of 8–11 MHz may be used for this purpose. Possible fenestration and thin anterior bone permits the capture of ultrasonography images in intraosseous jaw lesions. Both transverse and longitudinal scans may be obtained by placing the ultrasound probe intraorally in the buccal sulcus overlying the apical area of the affected tooth. However, intraoral scanning is not possible if the patient's vestibule is too shallow.

The intraoral ultrasonography is limited to the anterior aspects of the jaws, as the presently available probes are not ideal for use in the posterior jaws in areas of thick cortical plates.

Conclusion

Ultrasonography is an innovative and evolving imaging technology with plenty of research continuing to be done in medical field. It is safe, rapid, portable and economic. Further studies towards clinical applications of the ultrasonography in the dento-maxillofacial region are essential in order to obtain information regarding accurate and appropriate clinical usage of the system in dentistry. Intraoral ultrasonography makes it possible to visualize oral cavity structures, such as the sublingual gland and the submandibular duct, lingual artery and nerve, the tongue, lips, tonsils, and soft palate, which are virtually impossible to image via the use of conventional ultrasonography. Thus, intraoral ultrasonography can be used to imaging of oral cavity structures.

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Conflict of interest

None.

References

1. Caglayan F, Bayrakdar IS. The Intraoral Ultrasonography in Dentistry. *Nigerian J Clin Prac* 2018;21(2):125-33.
2. Malhotra S. Journal Club on Ultrasound in Dentistry- A Review. Slideshare.com. April 26, 2016. Available on: https://www.slideshare.net/srvmalhotra1/ultrasound-in-dentistry
3. Wikipedia.org. Ultrasound. Cited on 30th September 2019. Available on: https://en.wikipedia.org/wiki/Ultrasound
4. Yoshida H, Akizuki H, Michi K-I, Krupp S. Intraoral Ultrasonic Scanning as a Diagnostic Aid. Plastic and Reconstructive Surgery. 1988;82(6):1110.
5. Ahuja AT, Ying M, Ho SY, Antonio G, Lee YP, King AD et al. Relationship between masseter muscle size and maxillary morphology. *Eur J Orthod* 2011;33:664-59.
6. Kundra P, Mishra SK, Ramesh A, Ultrasound of airway. *Indian J Anaesth* 2011;55;456-62.
7. Naser-ud-Din S, Thoirs K, Sampson WJ. Ultrasonography, lateral cephalometry and 3D imaging of the human masseter muscle. *Orthod* 2011;14:33-43.

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