ULTRASONOGRAPHY AND COLOR DOPPLER ULTRASONOGRAPHY IN DENTISTRY: A REVIEW AND UPDATE

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Real-time ultrasound imaging, also called real-time echotomography or echography has been widely used diagnostic technique in many fields of medicine. The imaging system in echographic examination is based on the reflection of ultrasound waves (US) called 'echos'. The US oscillating at the same frequency are generated, as a result of the piezoelectric effect, by a synthetic crystal and are directed towards the area of interest via an ultrasonic probe. The different biological tissues of the body possess different mechanical and acoustic properties. When the US encounters the interface between two tissues with different acoustic properties, they undergo the phenomena of reflection and refraction. The echo is the part of the US that is reflected back to the crystal. The intensity of the echoes depends on the difference in acoustic properties between two adjacent tissue compartments: the greater the difference, the greater the amount of reflected ultrasound energy, and the higher the echo intensity. Echoes are then transformed into electrical energy and into light signals in a computer inside the machine. The movement of the ultrasonic probe produces the US images seen on the monitor over the part of interest in the body. Since each movement gives one image of the tissue and there are an average of 30 images per second, the exam will appear in the monitor as moving images. The interpretation of the gray values of the images is based on the comparison with those of normal tissues.

The color and power Doppler is based on the red blood cell's Rayleigh's scattering effect and on the Doppler effect. When applied to the echographic examination, it allows representing the presence and direction of the blood flow (Doppler), under the format of color spots superimposed to the images of blood vessels (color), and the intensity of the Doppler signal with its modifications in real time (power)

The intravenous injections of substances (contrast mediums) will increase the echogenicity of the blood and will render the echo-power-Doppler exam more sensible by creating a major difference of acoustic impedance in the area of interest. Ultrasound imaging is considered to be a safe technique, but the energy of US waves is absorbed in the form of heat from the biologic tissues that need to be controlled. This potentially adverse effect of the system depends on the time of application of the sound energy; therefore, one seeks to limit the number and the repetitions of the exams. In any case the risk is much lower than the risk associated with radiographic investigations.

Ultrasound imaging seems to be a better compromise in that is not as expensive as CT and MRI or dangerous in terms of radiation risk as CT. If conducted with a limited number of examinations it does not entail biologic adverse effects. Clinically it may be useful for dimensional assessment of the pathologic areas and for the specific evaluation of fluid versus solid content of the lesions. The other strengths of ultrasound are that it images muscle, soft tissue, and bone surfaces very well and is particularly useful for delineating the interfaces between solid and fluid-filled spaces. It renders "live" images, where the operator can dynamically select the most useful section for diagnosing and documenting changes, often enabling rapid diagnoses.. It has no known long-term side effects and rarely causes any discomfort to the patient. Equipment is widely available and comparatively flexible. Small, easily carried scanners are available; examinations can be performed at the bedside. It is relatively inexpensive compared to other modes of investigation (e.g. computed X-ray tomography, DEXA or magnetic resonance imaging). Spatial resolution is better in high frequency ultrasound transducers than it is in most other imaging modalities. The images obtained are easy to read once the observer is trained. They are also simple to store and retrieve. By obtaining a real time image, a working diagnosis could be made without delay and may prevent unnecessary exposure of the patient to ionizing radiation.

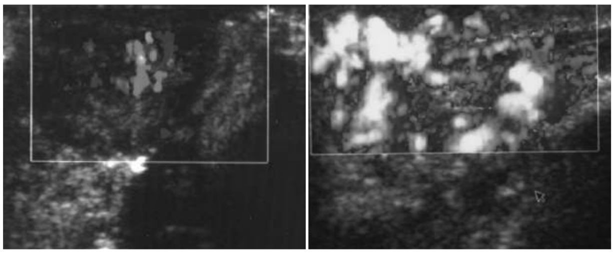
This technique has few limitations as well. Sonographic devices have trouble penetrating bone. For example, sonography of the adult brain is very limited. Sonography performs very poorly when there is a gas between the transducer and the organ of interest, due to the extreme differences in acoustic impedance. For example, overlying gas in the gastrointestinal tract often makes ultrasound scanning of the pancreas difficult, and lung imaging is not possible (apart from demarcating pleural effusionsEven in the absence of bone or air, the depth penetration of ultrasound is limited, making it difficult to image structures deep in the body, especially in obese patients. The method is operator-dependent. A high level of skill and experience is needed to acquire good-quality images and make accurate diagnoses. There is no scout image as there is with CT and MR. Once an image has been acquired there is no exact way to tell which part of the body was imaged.

USES IN DENTISTRY

Ultrasonography has been successfully attempted in the diagnosis and treatment planning of various oral lesions and conditions.

HEAD AND NECK VASCULAR ANAMOLIES

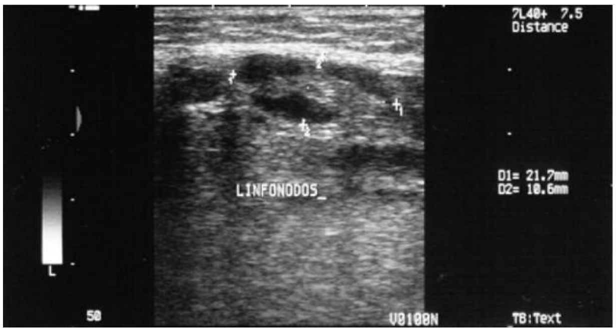
Doppler US is a widely available, non-invasive and relatively inexpensive technique which can be used to characterize the flow of head and neck vascular anomalies and thus differentiate hemangiomas from other vascular malformations.



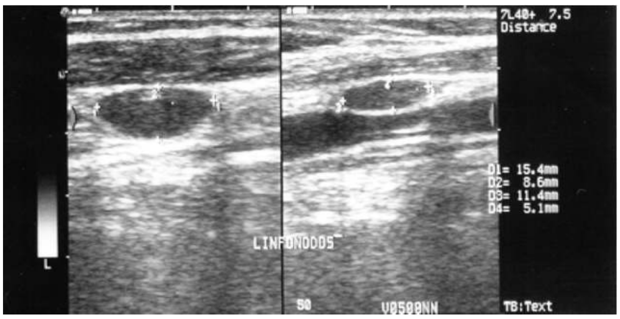
Two examples of highly vascular lesions. (A) Numerous vessels are visible within an hemangioma of the tongue in Colour Doppler mode. (B) Low-flow Power Doppler visualisation of a high- density vascular lesion in the supracilliary region, which was a hemangioma in proliferative phase

NODAL STATUS

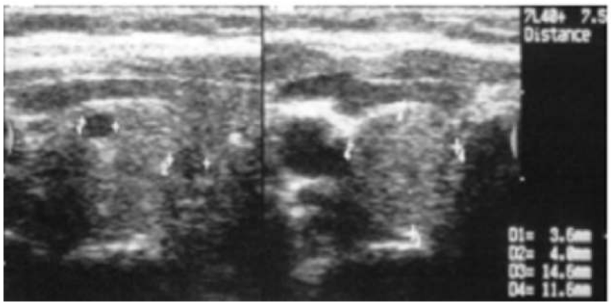
Basic ultrasonographic characteristics (shape, echogenicity, echogenic hilum, calcifications, and cystic necrosis) help in the differentiation of metastatic and nonmetastatic lymph nodes in patients with carcinoma.



Normal lymph nodes



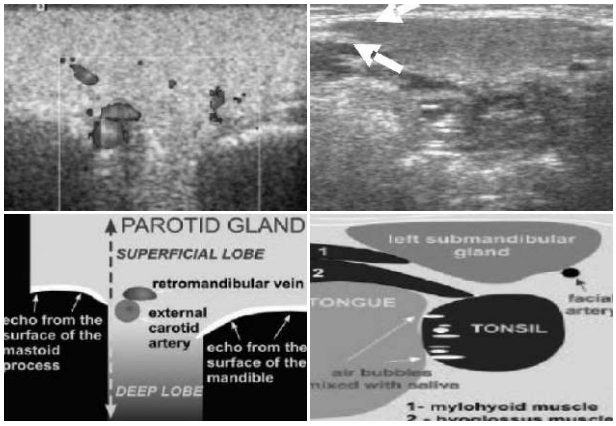
Sonogram showing a round, hypoechoic metastatic node (left). Note the absence of an echogenic hilum.



Sonogram of a hyperechoic metastatic node with intranodal cystic necrosis (left).

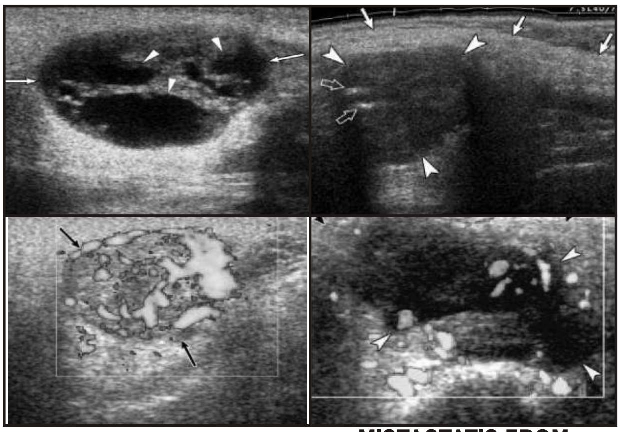
SALIVARY GLAND PATHOLOGIES

Ultrasonography is indespensible to diagnose inflammatory and neoplastic diseases of salivary glands.



PAROTID GLAND SUBMANDIBULAR GLAND

Ultrasonography of normal glands

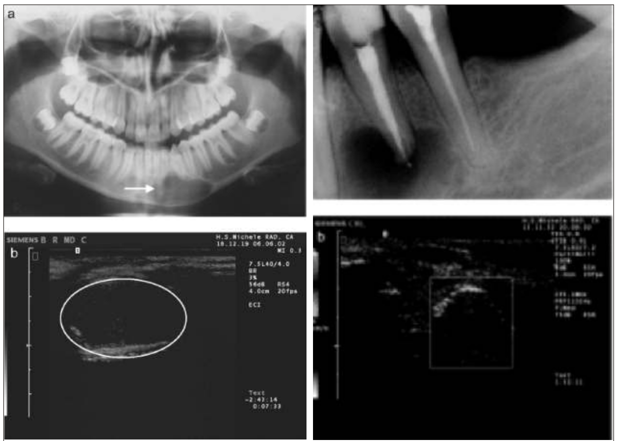


WARTHIN'S TUMOR MISTASTATIS FROM MALIGNANT MELANOMA

Ultrasonography of tumors

PERIAPICAL LESIONS

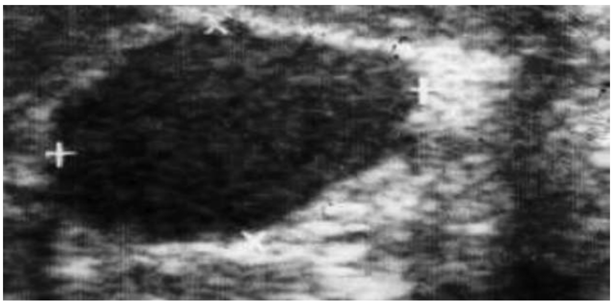
The application of echographic examination to the study of endodontic disease has been attempted with success. The technique is easy to perform and may show the presence, exact size, shape, content and vascular supply of endodontic lesions in the bone. Alveolar bone appears as a total reflecting surface (white) if healthy; the contours of the roots of the teeth are even whiter, this tissue is then considered hyperechoic. A fluid-filled cavity in the bone appears as a hypo-reflecting surface (dark) to different degrees, depending of the cleanliness of the fluid (hypoechoic): a simple serous filled cavity has no reflection (anechoic or transonic). Solid lesions in the bone have a 'mixed echogenic appearance', which means their echos are reflected with various intensities (light grayish). If the bone is irregular or resorbed in proximity of the lesion, this can be seen as an inhomogeneous echo; if the bony contour limiting a lesion is reinforced, then it is very bright. Major anatomic landmarks, such as the mandibular canal, mental canal, and maxillary sinus, are clearly distinguished and mostly transonic. At the color power Doppler, the vascularization within the lesion and around it can be seen; the details of it are enhanced by the use of contrast mediums



Periapical cyst confirmed by Ultrasound | **Periapical granuloma confirmed by Ultrasound**

INTRAOSSEOUS JAW LESIONS

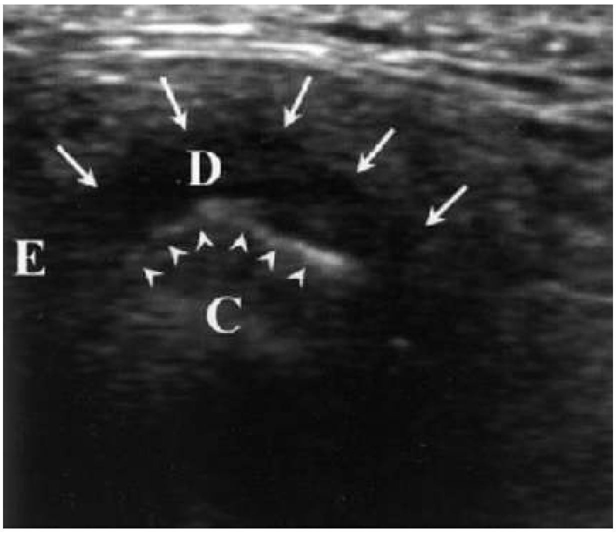
Ultrasonography can provide accurate information on the content of the intraosseous lesions of the jaws before any surgical procedure. It can classify jaw lesions as cystic, semi solid and solid. Doppler studies evaluate the blood flow and can help to differentiate between cysts and tumors.



Ultrasound of odontogenic cyst

TEMPOROMANDIBULAR JOINT

US remains potentially useful as an alternative imaging technique for monitoring TMJ disorders, particularly the presence of intrarticular effusion. A systematic search in the National Library of Medicine's Database was performed to identify all peer-reviewed papers in the English literature that assessed the accuracy of US with respect to magnetic resonance (MR), computerized tomography (CT), clinical assessment or autopsy specimens for the diagnosis of TMJ disk displacement, effusion and osteoarthrosis. The combined search words “ultrasonography” and “temporomandibular joint”, “temporomandibular disorders”, “effusion”, “disk displacement”, “condyle”, yielded 20 papers. Most studies (N=17) focused on detecting disk displacement, with less emphasis on assessing joint effusion (N=6) and osteoarthrosis (N=7). US accuracy was 54-100% for diagnosing disk displacement, 72-95% for joint effusion and 56-93% for osteoarthrosis.



Ultrasound of TMJ

MASSETRIC MUSCLE HYPERTROPHY

Ultrasonography has been found to be a reliable and accurate method for study of the thickness of the masseter muscle. One study was aimed to evaluate ultrasonography as a method for measuring masseter muscle thickness, to quantitate the normal range of the ultrasonically measured thickness of the masseter in adults, and to test whether the variation in the thickness of the muscle is related to the variation in the facial morphology in different individuals. In 40 healthy, fully-dentate young adults, 20 men and 20 women, the masseter thickness was measured bilaterally by a real-time ultrasound imaging technique. The measurements were performed under both relaxed conditions and with maximal clenching. Standardized facial photos of the subjects were taken so that their facial morphology could be determined. The measurement error of the thickness of the masseter was found to be small, not exceeding 0.49 mm. Under relaxed conditions, the mean thickness (± S.D.) of the muscle in men was 9.7 (± 1.5) mm, and under contracted conditions, 15.1 (± 1.9) mm. In women, the respective measurements were 8.7 (± 1.6) mm and 13.0 (± 1.8) mm. The thickness of the masseter muscle was found to be related to the facial morphology, mainly in women, but not in men; the women with a thin masseter had a proportionally longer face.. There was a large variation in the thickness of the muscle between individuals, and the thickness of the masseter was related to facial morphology in women. This study proved US as an efficient diagfnostic aid in cases of massetric hypertophy.

THE FUTURE OF ULTRASOUND

As with other computer technology, ultrasound machines will most likely get faster and have more memory for storing data. Transducer probes may get smaller, and more insertable probes will be developed to get better images of internal organs. Most likely, 3D ultrasound will be more highly developed and become more popular. The entire ultrasound machine will probably get smaller, perhaps even hand-held for use in the field (e.g. paramedics, battlefield triage). One exciting new area of research is the development of ultrasound imaging combined with heads-up/virtual reality-type displays that will allow a doctor to "see" inside you as he/she is performing a minimally invasive or non-invasive procedure such as amniocentesis or biopsy.

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