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Review Article

Elastosonography– A revisited novel facet in dentistry

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ABSTRACT

Ultrasound Elastography/Elastosonography is the non-invasive method of qualitative and quantitative evaluation of strain and elastic modulus distribution in soft tissues. One of the main benefits of ultrasonography is that it is a straightforward, less intrusive procedure. A general understanding of the underlying principles could benefit the entire process of data acquisition and interpretation, enhancing the USE reproducibility. The present review will highlight the topographies of the novel method and it is used in dentistry.

1. Introduction

Often, the first imaging modality to look into oral and maxillofacial abnormalities is ultrasound.[1] Variety of diagnostic modalities, such as intraoral and panoramic radiography, ultrasonography (USG), computed tomography (CT), magnetic resonance imaging (MRI), and nuclear medicine techniques like positron emission tomography, can be used to detect the varied disorders that are noticeable in the oral and maxillofacial provinces. When it comes to the non-invasive diagnosis of disorders connected to soft tissues, USG is the most user-friendly of these modalities.[2]

While sonographic signs suggestive of a certain diagnosis can be seen on grayscale and power Doppler USG, there can be notable overlap within diagnostic categories, particularly between benign lesions and some low-grade malignant neoplasms. Using ultrasonic imaging, elastography evaluates the tissue's viscoelastic characteristics to produce both qualitative and quantitative assessments of elasticity values.[3] Elastography, to put it simply, is the study of tissue stiffness and how deviations from this measure indicate pathology in the tissue or organs under examination.[4] For example, a procedure involving fat deposition results in less stiff tissue, but a procedure inducing fibrosis or scar tissue deposition creates more stiff tissue. Because morphological changes typically precede changes in tissue stiffness or elasticity, this approach allows for early disease process diagnosis and tissue characterization.[5]

Ultrasound (US) elastography is an indicative skill that is cost-effective, non-invasive, non-ionizing, real-time, and more patient-acceptable. In situations where tongue opening is little or non-existent, it can be the most useful instrument.[6]

2. History

The earliest known account of bats using sound waves for spatial direction dates back to 1794, when Lazaro Spallanzani made the discovery of echo-location.[7] In the latter part of the 1980s, English researchers were the first to enter the field of ultrasonic elastography; Tristam et al. With little to no success, early attempts were made to

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quantify tissue elasticity and deformability using subjective ultrasound-based techniques such motion quantification and visual evaluation of B- and M-mode pictures.[7] In 1988, University of Rochester researchers made a device that used a modified colour Doppler to measure the movement of tissue. The ensuing innovation came in the late 1990s in the realm of dynamic elastography, where a non-imaging FibroScan instrument was created specifically for the purpose of assessing liver stiffness. The next major advancement in go-ahead elastography was the introduction of shear wave elastography (SWE), which is currently the most used technique and has attracted a lot of interest with the newer imaging modalities. SWE is currently the subject of extensive research. The technique known as "sonoelasticity" imaging produced tissue stiffness-based pictures by utilising Doppler signals. Ophir et al. from the University of Texas Medical School in the United States invented and used the first strain elastography technology that was officially recognised in 1991.[8,9]

3. Basic Working Principle

The elastic characteristics of different tissues can be evaluated via elastography, and the resulting images are compared to both pre- and post-compression states. Different tissues, such as fat, collagen, etc., and the same tissue under different pathologic conditions, such as inflammation and cancer, have different levels of elasticity.[10] Tissue toughness can be visualised by detecting the distortion of the tissue under an applied force, and it usually increases as the disease progresses. Early disease process detection may be possible with the help of the high contrast images that are produced. To ascertain how much displacement each little area of tissue experiences in reaction to the compression the ultrasonic transducer applies, the data are then compared using a cross-correlation technique.[11]

4. Types

The methods used to estimate tissue elasticity and the kinds of information they yield are what differentiate the various forms of elastosonography. Static or quasi-static elastography and dynamic elastography are the two elastography methods now in use.[12]

The basis of strain elastography, a type of static or quasi-static elastography, is the capture of radiofrequency (RF) signals both prior to and during the application of a deforming force by a transducer in the form of mild tissue compression. The pre-compression and post-compression image data sets' RF signals are compared, and there is a correlation between them.[13]

Dynamic elastography can be based on magnetic resonance (MR) or ultrasonography (US). Acoustic radiation force impulse imaging (ARFI), transient elastography (TE), point shear wave elastography (pSWE), and shear wave elastography (SWE) are the several forms of dynamic US elastography.[14] ARFI creates and propagates quick bursts of long focused ultrasound pulses, commonly known as "push pulses," using a conventional transducer. These pulses cause tissue deformation, and radiofrequency echo monitoring is utilised to track the pulses' propagation.[15] In TE, a transducer that resembles a piston is utilised to create a slight thud by the use of a probe fixed to a vibrator. The transducer's edges produce a shear wave, which is monitored using a tissue Doppler with a high pulse reiteration frequency and computed in M-mode to provide quantitative information. Point shear wave, sometimes referred to as quantitative ARFI, creates shear waves that are tracked by Doppler after brief tissue displacement brought about by ARFI.[15,16]

A new technology called shear wave elastography stresses tissues with push pulses and uses ultrafast ultrasound imaging to find the resulting shear waves. Shear wave elastography was used to calculate the elasticity values for various tissues. At some locations along the acoustic axis, tissue displacement and deformation are caused by an acoustic radiation force impulse. RF echo tracking is used to image the generated shear wave over a grid of points, producing a real-time image.[17,18] Real-time tissue elastography (RTE) can be used to quantity the pliability of muscle and soft tissue in real time. RTE has been utilised to assess the masseter muscle's hardness in order to assess stomatognathic function and to assist in the identification of oral cancer. RTE is also helpful for assessing the tongue's movement during swallowing and the movement of soft tissues during function.[15]

As a dynamic technique, magnetic resonance elastography operates on the same fundamental principles as other types of dynamic elastography. In addition to being unsuitable for patients who are unstable due to the lengthy acquisition time, MR elastography is not very useful in iron-overload conditions.[19]

5. Advancements

Ultrasound practice has been revolutionised by technological advancements in electronics and computing, with ever-expanding applications. Greater bandwidths with better spatial and contrast resolution have been made possible by advancements in transducer tools and display designs. Advances in digital signal processing have led to advancements in visual display, archiving, and beam formation.[20] New imaging modalities that take gain of the non-linear behaviour of tissue and microbubble contrast agents have been made possible by technological advancements. Ultrasound's therapeutic and research applications have been significantly expanded by the use of microbubble contrast agents.[10] With the introduction of tissue-specific agents, ultrasound's sensitivity and specificity in identifying and characterising focal liver lesions should be able to compete with CT and MRI. Recently, ultrasound has been used therapeutically, with promising results in the delivery of medications and genes using high intensity focused ultrasound (HIFU) and microbubble aided ultrasound.[21]

6. Elastography in Maxillofacial Region

A useful diagnostic auxiliary for diseases affecting the maxillofacial region is elastography. It is beneficial in the following ways:[5,7]

1. Cervical lymph node assessment: Identifying reactive from malignant nodes.
2. Recognise benign from malignant pathologies.
3. Used to scale muscle stiffness in myofacial pains.
4. Assess localised lesions in the main salivary glands.

7. Advantages[5,7]

1. Improved margin delineation and tissue component definition.
2. Separating benign tumours from malignant ones.
3. Can add more diagnostic data to B mode US pictures.
4. Clinically helpful manual for nodal dissection or percutaneous biopsy.
5. Early recurring cancer detection.

8. Limitations[5–7]

1. The transducer's inability to regulate the degree of tissue compression.
2. Inadequate probe contact over a vast area can result in unsatisfactory strain pictures of big lymph nodes.
3. The movement of the surrounding tissues and arteries may result in artefacts.

9. Discussion

A technique known as elastography has the potential to produce a variety of novel image types known as elastograms. Because of this, all of the characteristics of elastograms differ from the well-known characteristics of sonograms. Elastograms relate to the local stresses, Young's moduli, or Poisson's ratios of the tissue, whereas sonograms provide information on the confined aural backscatter energy as of its constituent parts.[22]

Sonoelastography is the most widely utilised radiology modality, however it is also used in other modalities like as MRI and US. Elastography has been used since the middle of the 1990s to assess the elasticity and stiffness of soft tissues by applying external pressure. Because it is non-invasive and safe, it is a substitute method for biopsy. It is capable of detecting muscle and other bodily tissue stiffness and flexibility.[10,23]

Alam F et al.,[24] assessed the diagnostic efficacy of B-mode sonography and sonographic elastography both separately and in combination for the identification of reactively and metastatically enflamed cervical lymph nodes. For B-mode sonography, the corresponding values were 98%, 59%, and 84%; for elastography, they were 83%, 100% and 89%; and for the combined evaluation, they were 92%, 94% and 93%. The diagnosis of metastatic distended cervical lymph nodes may be further improved by combining very sensitive conventional B-mode sonography with highly selective elastography.

Zengel P et al.,[25] noted that elastography is a simple diagnostic technique with potential to be an important tool for determining the severity of a disease. This is because, it allows patients to have a treatment benefit assessment when there is a significant difference between the MEI ratios of the symptomatic and asymptomatic sides in TMD patients experiencing myofascial pain.

Ariji Y et al.[26] in 2012 examined the characteristics of the masseter muscle inflexibility in temporomandibular disorder (TMD) patients with myofascial pain, as well as the relationship amid the masseter muscle elasticity index (MEI) ratio obtained by sonographic elastography and the toughness measured by a firmness metre in healthy volunteers. Whereas, Shingaki M et al.[27] calculated the clinical value of intraoral strain elastography in establishing a tongue cancer early diagnosis. The findings implied the possibility of using intraoral strain elastography as a substitute non-invasive technique to identify tongue cancer.

Ogura I et al.,[28] sought to assess tongue carcinoma's quantitative strain elastography utilising intraoral ultrasound. The average strain of the typical tissue and tongue cancer in the 50-year-old male were 1.468 and 0.000%, respectively, according to the results. In a 59-year-old male, the typical strain of typical tissue and tongue cancer were 1.007 and 0.000%, respectively. Summary was that intraoral ultrasound-based strain elastography is a potentially useful method for identifying and separating cancer from normal tongue tissues.

Reichel CA et al.,[29] determined that individuals with sialolithiasis, one of the supreme ubiquitous non-malignant illnesses of the salivary glands, can reasonably be followed up on during therapy using acoustic radiation force impulse imaging (ARFI).

Monzoor I et al.,[30] analysed sonoelastography's diagnostic accuracy in patients receiving primary and secondary healthcare in 2018. There were 46 studies on breast masses, lymph nodes, prostate cancer, liver diseases, diseases of the salivary and parotid glands, pancreatic masses, musculoskeletal disorders, and renal diseases. Sonoelastography had an overall sensitivity of 83.14% in diagnosing all of these diseases, and a specificity of 81.41%, specifying high sensitivity and specificity in making diagnosis of various body disorders.

On Contradictory, Bhatia KSS et al.,[21] examined the quality of ultrasound elastography in order to determine the ability to distinguish benign lesions from malignant disease in localised salivary gland masses found during ordinary clinical practice.

Mukul SK et al.,[31] in 2019 carried out a study to see whether ultrasonic elastography could be used to measure clinical presentation objectively in relation to the severity of OSMF clinical condition. There were 27 clinically analysed and staged OSMF subjects in the study sample. The following is the range of summative elastography scores: The three groups, 8–10, 11–14, and ≥15, indicated the corresponding degrees of tissue stiffness, ranging from mildly stiff to severely stiff. In the end, it was determined that ultrasonic elastography appeared to have promising advantages over the subjective clinical approach for OSMF diagnosis and staging.

Sasaki Y et al.,[32] assessed the ability of shear wave elastography to discriminate amid benign and malignant cervical lymph nodes in patients through oral carcinoma and establish that it is a useful method for the objective and quantitative diagnosis of oral carcinoma metastases to the cervical lymph nodes.

Toker C et al.,[33] examined the suitability of shear wave elastography (SWE) for bruxism diagnosis in ten individuals with confirmed bruxism and a control group matched for age and gender. Three circumstances were used to quantify the SWE of the left and right masseter muscles: relaxed jaw, 50% of the perceived maximum bite force, and maximal jaw opening. The authors proved the probability of SWE in bruxism and its impending convenience for monitoring and diagnosis; however, we also point out significant limitations and methodological factors that will need to be taken into account for further research.

Akatsuka K et al.,[34] evaluated 60 paediatric patients, 30 boys and girls each, ages 6 to 11, using ultrasonography to quantity vagaries in tongue hardness during growth. According to the authors, measuring tongue elasticity can be done well with the use of ultrasound SWE and SE.

Generally by the current review, as a diagnostic technique, ultrasonic elastography appears to have some promising advantages over the intuitive clinical way of diagnosis.

10. Conclusion

Elastosonography, which employs a variety of approaches based on the elasticity estimating principles, is a potent non-invasive method for assessing tissue stiffness. We have sufficient evidence for optimism that elastography will advance into a more objective, non-invasive diagnostic instrument in the future, and that it will be highly beneficial.

11. Source of Funding

None

12. Conflict of Interest

None

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