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REVIEW ARTICLE

Elastography: A New Dimension in Oral and Maxillofacial Imaging

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ABSTRACT

Elastography or elasticity imaging is a new non-invasive imaging modality that involves tissue stiffness assessment based on hardness (elasticity) of normal or pathological tissues. The principle being that tissue compression produces strain within the tissue leading to tissue displacement due to which tissue hardness can be estimated. This tissue elasticity resulting from compression is displayed as an image called elastogram. This technique can be particularly useful in preoperative assessment of pathological tissues which are generally harder than normal surrounding tissues. Hence, the purpose of this article is to highlight this technique and its various applications in oral and maxillofacial region.

Keywords: Elasticity imaging, Elastography, Elastogram, Ultrasonography.

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INTRODUCTION

As we are aware many illnesses are often associated with a change in tissue elastic properties. Hence, practitioners often use palpation to 'feel' the presence of disease. This emphasizes the purpose behind the development of various biomedical imaging modalities that contrast soft-tissue elasticity.[1] Elastography is one such tool which was introduced as an ultrasound based imaging modality by Ophir et al in 1991. It is a non-invasive imaging modality that is used to assess tissue hardness. It has a diagnostic specificity of about 93% and sensitivity up to 90%.[2]

Ophir described it as a method for quantitative imaging of strain and elastic modulus distributions in soft tissues. Changes in the tissue elasticity is generally correlated with pathological phenomena. In many cases, the small size of a pathological lesion and/or its location deep in the body preclude its detection and evaluation. Moreover, the lesion may or may not possess acoustic backscatter properties which would make it detectable by ultrasound.[3] Hence, they may appear normal in conventional ultrasound examinations. Elastography can prove to be a boon in the diagnosis of such lesions.

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PRINCIPLE/MECHANICS

The equipment consists of an ultrasound machine and probe (Fig. 1). When the transducer is compressed over the region of interest, a strain is produced within the tissue based on tissue elasticity. The strain produced is lower in harder tissues when compared to softer tissues (Fig. 2).[4] The term harder tissue is implied for pathological tissue since a tumor or suspicious cancerous growth is normally 5 to 28 times stiffer than normal soft tissue background.[2] The echo patterns that are generated before and after compression are processed. This results in an image called an 'Elastogram'.[4] The mechanics of elastography has been summarized in Figure 3.

Elastograms are mainly of two types: Grayscale and Color. In case of grayscale elastograms, the hard tissues (Malignant) appear darker whereas the softer tissues appear bright. In case of color elastograms, the image appears as red, yellow, green and blue based on the increasing order of hardness (Fig. 4). In certain machine configurations the color sequence order is exactly reversed.[4]

Fig. 1: Elastography data acquisition system

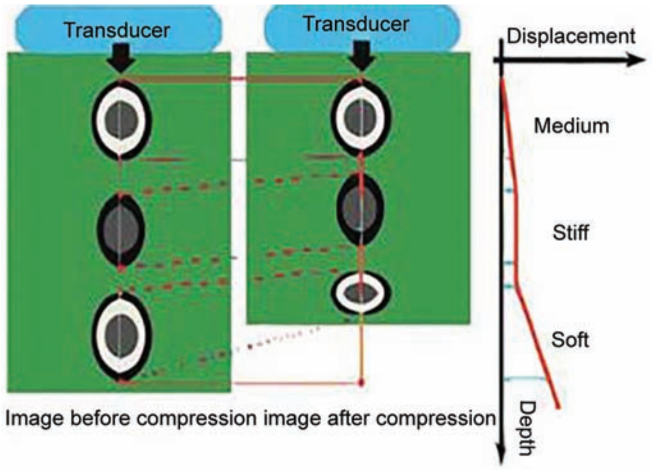

Fig. 2: Displacement due to compression varies according to tissue stiffness. Displacement in soft tissue is high, whereas stiff tissue show no or very little displacement

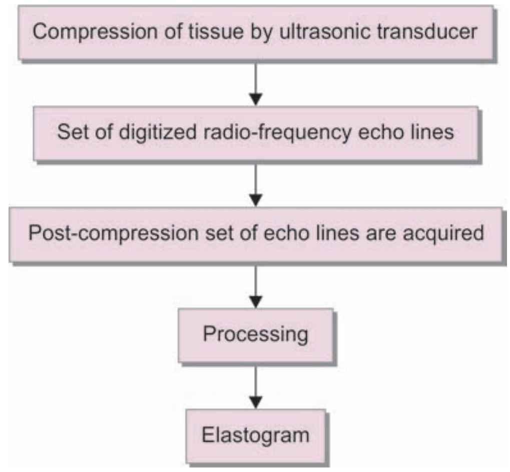

Fig. 3: Mechanics of elastography

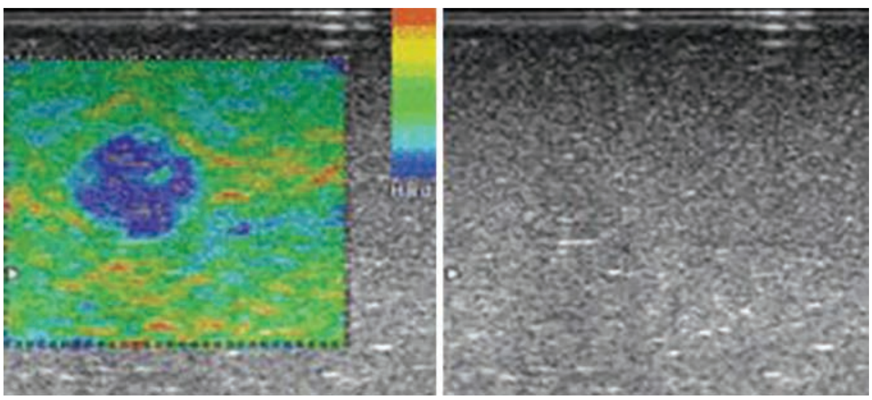

Fig. 4: Displacement is encoded in different colors: 'Hard' tissue as blue and 'soft' tissue as red, thereby showing a well-defined hard structure. Conventional ultrasound image of the same is homogeneous and shows only light shadowing dorsal to undefined structure

INDICATIONS

Assessment of cervical lymph nodes: A study was conducted to evaluate the accuracy of sonoelastography for differentiating benign and metastatic cervical lymph nodes in patients suspected of having thyroid or hypopharyngeal cancer. Histologic nodal findings were used as the reference standard for comparison. They found that most benign nodes had the same brightness as surrounding anatomic structures and were, therefore, not clearly visible on ultrasound elastograms. In contrast, most metastatic lymph nodes appeared darker on ultrasound elastograms. Also, margin delineation was better on elastograms, as the margins of metastatic lymph nodes were more regular and distinct than those of benign lymph nodes.[5]

Another study evaluated the diagnostic performance of sonographic elastography and B-mode sonography of enlarged cervical lymph nodes and found that elastography significantly improved the performance of sonography in the diagnosis of enlarged metastatic cervical lymph nodes.[6]

Assessment of salivary glands: It is used to assess focal lesions of major salivary glands. It can be used in the preoperative noninvasive differentiation of malignant and benign tumors. A study was conducted to assess the helpfulness of sonoelastography in the evaluation of parotid tumors, the diagnostic specificity was found to be 97%.[7]

Elastography can also aid to differentiate between cystic lesions and solid lesions. A study revealed that the presence of cystic areas made the evaluation of the elasticity of solid areas difficult by producing the typical color stratification pattern. However, this artifact could be useful in identifying small fluid areas, not apparent in ultrasonography and distinguishing between a deeply hypoechogenic solid mass and a cyst.[8]

Evaluation of thyroid nodules: Two studies conducted on thyroid gland tumor diagnosis by ultrasound elastography suggested a high potential in predicting malignancy in thyroid nodules with the sensitivity of about 80 to 97% and specificity achieving 100%.[9,10]

Assessing soft tissue neck masses and vascular malformations: A study was done on the use of endoscopic ultrasound (EUS) for the examination of common soft tissue neck masses, the nature of which was confirmed with biopsy or further imaging. It showed that lipomata and venous/lymphatic vascular malformations and thyroglossal cysts were predominantly soft, which was attributed to their fat/liquid content, and neurogenic tumors and dermoid/sebaceous cysts were stiffer, whereas abscesses displayed various levels of stiffness ranging from soft to intermediate, presumably due to various liquid and solid components. Although there was considerable overlap in EUS scores, the authors suggest the potential role of EUS in cases of equivocal B-mode findings, for guiding aspiration or biopsy in abscesses or mixed solid/cystic lesions.[11]

To assess oral malignancies: Tumor thickness in tongue carcinomas.

Evaluation of muscle elasticity and thickness: Masseter muscle stiffness was studied in cases of TMJ disorders and sternocleidomastoid muscle in cases of torticollis.[12,13]

Two studies have examined the stiffness of normal masseter and ocular muscles showing differences in the elasticity of the masseter muscles between sexes as well as differences in elasticity of periocular rectus medialis and lateralis muscles in various gaze positions.[14,15] Although the appearance of normal muscle was not studied in detail, images in their study showed normal relaxed muscle as an inhomogeneous mosaic of intermediate or increased stiffness (green/yellow or blue color, respectively) with scattered softer and harder areas especially at the periphery near boundaries. However, it was not understood what the color variation depended upon, and whether the color patterns were reproducible between different muscles and different individuals. Most of the data available so far about diseased muscle involve degenerative and neuromuscular disease.

A study on inflammatory myositis using strain EUS showed changes in elasticity of the affected muscles, either as increased stiffness due to fibrosis, or as reduced stiffness, secondary to fatty infiltration. A correlation was found between quantitative strain EUS parameters and elevated serum markers, concluding that EUS may be helpful in the diagnosis, staging and monitoring of inflammatory myopathies.[16]

Therapeutic uses: A study was conducted to analyze the use of sonographic elastography of the masseter muscles for optimizing massage pressure in healthy volunteers and patients with temporomandibular joint dysfunction.[15]

CONTRAINDICATIONS

- It is contraindicated in partially cystic lesions as they are associated with artefacts. The image appears as a mosaic of all levels of stiffness
- Small lesions that are deeply seated within the body.

ADVANTAGES

- Easy to use
- Non invasive
- Well tolerated by patients
- Less time consuming
- Inexpensive
- Reduces the number of unnecessary biopsies.

DISADVANTAGES

- Not widely available in clinics and hospital setups.
- One cannot control the extent of tissue compression by the ultrasound transducer. To overcome this investigators have introduced acoustic radiation force impulse (ARFI) imaging. It uses radiation impulses to induce localized displacement of tissues and then monitors the dynamic response of tissues to the induced displacement. Another thing that can be done is to install visual compression indicators on the monitor screens to help the operator to adjust the compression force.[4]
- Some images of large areas are suboptimal as probe contact over large lesions may not be adequate.
- Lesions adjacent to major vessels are associated with artefacts because the pulsations result in mistracking of echoes.

VARIOUS MODES OF ELASTOGRAPHY

Various methods for elastography include ARFI imaging, sonoelastography and magnetic resonance (MR) elastography, the latter two of which work by monitoring low-frequency (typically, <1 kHz) elastic waves inside the tissue. In comparison to ultrasonic and MR techniques, optical detection techniques have the potential to be lower cost and provide real-time imaging over a larger tissue surface area. In particular, coherent optical techniques, such as optical coherence elastography (OCE), detect nanometer tissue displacements and thus have the potential to provide improved sensitivity and resolution.[1]

CONCLUSION

Even though ultrasound elastography has been advocated in a wide range of lesions, many researchers still believe the potential role of elastography is unclear and unsuitable. But it can be a very valuable aid to bring about a completely new dimension in the current standards of diagnosis of lesions wherein one cannot directly palpate the underlying lesion. This in turn will improve the prognosis of a lot of cases, thereby improving the patient's standard of living. It is still an emerging method and with further studies and progress, one can believe that elastography deserves a chance to be considered an important diagnostic tool.

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