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Review Article

Application of ultrasonography in dentistry

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Summary Recent development of the ultrasonography (US) equipments enables the visualization of fine detail of the surface structure of the face and neck soft tissue. In this article, some studies referring to the clinical usefulness of the US in dentistry in the diagnosis of lymph node metastases, tongue carcinomas, periapical lesions and temporomandibular joint disorders are reviewed. For the early detection of lymph node metastases, follow-up US is recommended at an interval of no more than 1 month if a "wait-and-see" policy is adopted. US-elastography has a potential to be a promising method offering complementary information to conventional US. In order to determine the appropriate treatment planning of tongue carcinoma (including the prediction of subsequent lymph node metastases), intraoral US should be routinely used as one of the standard technique for the evaluation of the depth of tumor invasion. In the diagnosis of periapical lesions, US can provide useful information about the extent of the lesions and the location of the tooth root apices once the surface cortical bone around the lesion is eroded. Moreover, US is reported to be useful as an alternative imaging technique for visualization of disk position, joint effusion and bone abnormalities for the evaluation of temporomandibular joint disorders.

Contents

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Introduction

Clinical application of ultrasonography (US) in dentistry has been limited to the major salivary gland, cervical lymph nodes, facial musculature, and surface soft tissues of the face and the neck. However, in recent years with the development of the high-resolution ultrasound equipments, attempts have been performed in imaging the early tongue carcinomas, periapical lesions and temporomandibular joint disorders (TMD). Additionally, newly developed US-elastography has been introduced in the diagnosis of lymph node metastases. In this article, some studies referring to the clinical usefulness of the US on lymph node metastases, tongue carcinomas, periapical lesions and TMD are reviewed.

Cervical lymph node metastases

The lymph node staging plays an important role in patients with head and neck cancer. The N-staging and the localization of metastatic lymph nodes are mandatory for the choice of therapy. However, clinical examinations are unspecific and do not yield to satisfactory results. Therefore, radiology plays an important role in staging the lymph nodes in patients with oral cancer. As diagnostic methods, US, computed tomography (CT) and magnetic resonance imaging (MRI) are used. Furthermore, positron emission tomography (PET) can be performed. Diagnostic reliability of these modalities seems to vary in various reports in the literature. In US, sensitivity varies between 63% and 97% and specificity between 69% and 100% [1].

In US examination, a linear transducer with a high frequency around 10 MHz or more should be used. B-mode is used for the delineation of the shape and internal structure of the lymph nodes. Transverse and longitudinal planes are obtained in standard investigation. On US, lymph nodes are in general depicted as low echogenic oval or round structures. An echogenic hilum, containing vessels and fat, is seen as a central area of higher echogeneity. Doppler sonography is performed for investigation of vessel structures and vascularity. The value of Doppler US criteria (avascular pattern, scattered pattern, peripheral vascularity) as an adjunct to differentiate between benign and metastatic lymph nodes has been reported [2]. Advantages of US over other imaging techniques are its price and low patient burden. Furthermore, US is the only available imaging technique that can be used for frequent routine follow-up.

Of the estimated 800 lymph nodes in the human body, 300 lymph nodes are situated in the neck [2]. Presently, most clinicians use the classification into six levels as adapted by the American Academy of Otolaryngology or the 1991 American Academy of Otolaryngology Head and Neck Surgery (AAO-HNS) guidelines [3], because the majority of patients with head and neck malignancies presently undergo sectional imaging prior to treatment planning.

The transverse diameter of lymph nodes varies according to the different region. In the level 2 (superior internal jugular nodes), the minimal axial diameter is found out to be 7—8 mm in reactive lymph nodes and in other levels it is found out to be 6 mm [4]. In oval-shaped lymph nodes a hyperechoic linear structure is seen going into the lymph node. This is the fatty hilum which contains the vessels supporting the lymph nodes [5]. In benign lymph nodes in a longitudinal section, these vessels are seen as a linear structure which is dividing regularly [6].

In general, none of the currently available imaging techniques are able to depict small tumor deposits inside lymph nodes. The characteristics of metastatic lymph nodes that can be depicted are increased size, a rounder shape, and heterogeneity caused by tumor necrosis, keratinization, or cystic degeneration inside the tumor. Nodal shape is used by several authors. In general, a round shape is considered more suspicious than an oval or flat shape. Grouping of lymph nodes is used as a criterion by several authors as well. Whereas necrosis or cystic degenerations are very reliable criteria for lymph node metastases, those are unfortunately not visible in every metastatic lymph node [7]. As the size of lymph nodes varies according to the level in the neck and because small metastatic deposits inside lymph do not always cause enlargement of a lymph node, it is very difficult to define the optimal size criteria. The size criteria in the literature may vary between 5 and 30 mm. The minimal axial diameter is a better criterion than the maximal axial diameter or the longitudinal diameter [2].

Friedman et al. [8] found that the axial cut of point should be about 10 mm, but other groups found out that this diameter of 10 mm is not relevant as even smaller lymph nodes may be changed by neoplastic infiltration. Because the incidence of exclusively micrometastases in clinically N0 necks with occult metastases is 25%, we should realize that no imaging technique can ever reach a sensitivity over 75% [2]. If the risk of occult metastasis is below 20%, the clinician may refrain from a neck dissection and adapt a wait-and-see policy with careful follow-up to detect a neck metastasis as early as possible. As a risk of 20% of occult metastases is considered acceptable to observe the neck, the sensitivity of any imaging technique should be at least around 50% for non-palpable neck disease so as to detect half of the occult metastases [2].

In a proposal of the criterion of metastatic lymph nodes with a minimal axial diameter of 10 mm or less, a higher or lower density area than surrounding lymphoid tissue caused by central necrosis of metastatic tumor could be shown (Fig. 1A and B). Cystic degeneration is interpreted as a focal hypo/anechoic area and tumor keratinization as a focal hyperechoic area not in continuity with the hilum [9]. Time-course careful observation of the individual lymph nodes might show the increase in size, rounder in shape and more heterogeneous internal echo and the follow-up US is recommended at an interval of no more than 1 month [10] (Fig. 1C and D).

US-elastography is a newly developed imaging technique for the evaluation of tissue elasticity by measuring the degree of tissue's deformation in response to the application of an external force [11,12]. Elasticity is one of the differentiating criteria for metastatic lymph nodes and reactive ones in accordance with the hypothesis that solid tumor cells differ in their consistency from adjacent normal tissue [13] (Fig. 1E and F). Diagnostic use of tissue elastography in breast cancer, thyroid tumor, and lymph node enlargement in head and neck cancers has been reported. In our study in patients with oral cancer, US-elastography showed sensitivity of 92%, specificity of 86%, and overall accuracy of 88% on a lymph node basis by using the categorization of US-elastography