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● *Original Contribution*

SONOHISTOLOGY FOR THE COMPUTERIZED DIFFERENTIATION OF PAROTID GLAND TUMORS

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Abstract—A system for the computerized differentiation of parotid gland tumors is proposed. The parotid gland is the largest of the salivary glands. It is found in the subcutaneous tissue of the face, overlying the mandibular ramus and anterior and inferior to the external ear. The classification system is based on a multifeature tissue characterization approach, using fuzzy inference systems as higher-order classifiers. Baseband ultrasonic echo data were acquired during conventional ultrasound imaging examinations using standard ultrasound equipment. Several tissue-describing parameters were calculated within numerous small regions of interest to evaluate spectral and textural tissue properties. The parameters were processed by an adaptive network-based fuzzy inference system, using the results of conventional histology after parotidectomy as the "gold standard." The results of the classification are presented as a numerical score indicating the probability of a certain tumor or alteration for each parotid gland. The score can be presented to the physician during examination of the patient to improve the differentiation between various types of parotid gland tumors. The system was evaluated on n = 23 cases of patients undergoing radical parotidectomy. The receiver operating characteristic curve area is A_{ROC} = 0.95 ± 0.07 when using fourfold cross-validation over cases and differentiating between various benign parotid gland tumors and monomorphic adenoma. (E-mail: Ulrich@Scheipers.org) **© 2005 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Tissue characterization, Tissue typing, Parotid cancer, Parotid gland tumors, Fuzzy logic, Fuzzy inference systems, Cancer diagnostics, Computer-aided diagnostics, Multifeature classification, Parametric imaging.**

INTRODUCTION

The incidence of parotid gland tumors is one of the highest of all incidences of tumors in otorhinolaryngology. In some cases, differentiation between benign and malignant lesions is difficult. At later stages of the disease, some types of benign parotid gland tumors, such as the pleomorphic adenoma, may even become malignant. Therefore, the possibility of early detection, differentiation and excision is important. The initial characterization of the tumor will define the extent of surgical intervention and treatment. The excision of parotid gland tumors is extensive, time-consuming and, therefore, costly because several facial nerves are situated within the extent of the parotid gland; thus, requiring precise surgery to prevent damage to the nerves.

Usually, B-mode medical ultrasound (US) is applied as the main diagnostic modality to differentiate among the various types of parotid gland tumors. However, the results of medical US imaging of the parotid gland are dependent on the skills of the examining physician. Two typical examples of tumors of the parotid gland are shown in Fig. 1. Doppler-based US modes, such as color Doppler and power Doppler, can help differentiate between different types of parotid gland tumors, if used in combination with conventional B-mode US (Izzo et al. 2004; Martinoli et al. 1994; Schade et al. 1998; Schick et al. 1998). However, the lack of distinctive vessel patterns prevents the exclusive application of Doppler modes for the differentiation of tumors of the parotid gland (Schade et al. 1998). The application of US contrast agents can only increase the ability to differentiate between certain types of parotid gland tumors (Steinhart et al. 2003).

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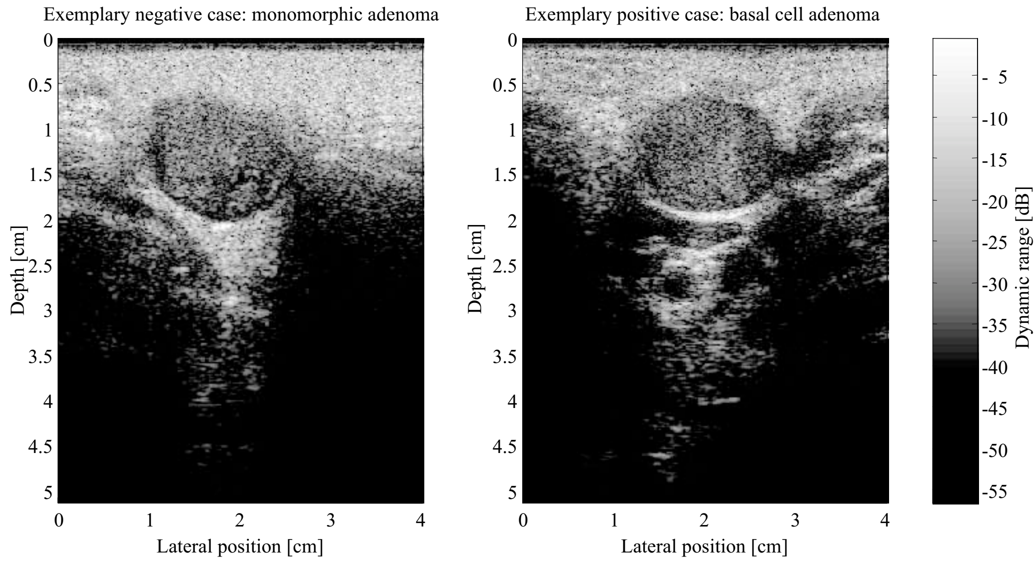

Fig. 1. Exemplary B-mode images of (left) a negative case (monomorphic adenoma) and (right) a positive case (basal cell adenoma). Differentiation between different types of parotid gland tumors and parotid gland alterations requires experienced physicians.

Overall, the current methods of diagnostics of parotid-gland tumors, including medical US and magnetic resonance imaging (Izzo et al. 2004), lack accuracy, especially when it comes to differentiate between benign and malignant forms of alterations. Currently, only the histopathologic examination of tissue specimen can provide the information needed for a definite diagnosis. The application of ultrasonic tissue characterization can add additional information to the currently available methods of diagnosis. In the future, ultrasonic tissue characterization might replace histopathologic examinations.

Methods of ultrasonic tissue characterization have been evaluated on various organs. Representative overview articles on ultrasonic tissue characterization in general have been published by Thijssen (2000) and Delorme and Zuna (2000). Shimizu et al. (1999) compared sonographic and histopathologic findings of parotid gland tumors, providing a baseline for ultrasonic tissue characterization of parotid glands. Texture analysis of parotid glands was formerly performed by Ariji et al. (1996) and Yonetsu et al. (2004).

The ultrasonic tissue characterization system used for the approach described in this work was formerly developed at Ruhr-University Bochum for the early detection of prostate carcinoma (Scheipers et al. 2001, 2002, 2003a, 2003b, 2004). The whole system was adapted for application in diagnostics of parotid glands.

By using US baseband data instead of video data, various tissue-describing parameters that contain sufficient information to classify the underlying tissue with satisfactory accuracy, can be calculated. Often, only the use of US baseband or radiofrequency data can provide the information needed to calculate parameters that characterize biologic tissue in an adequate way.

Because the different parameters used in this approach have a highly nonlinear interdependence, only a nonlinear model is able to combine the parameters and, thus, lead to reliable classification results (Scheipers et al. 2001, 2002, 2003a, 2003b, 2004). Both radial basis neural networks, which are based on symmetrical model functions of typically Gaussian shape, and network-based fuzzy inference systems perform reliably when applied in pattern recognition for ultrasonic tissue characterization (Bishop 1995). In this approach, a network-based fuzzy inference system was used (Zadeh 1973, 1989; Jang 1993; Mendel 1995; Furuhashi 2001). Most classification approaches only work satisfactorily if the underlying parameters are normally distributed. Some parameters used in this approach cannot be assumed to be distributed normally (Lizzi et al. 1997a, 1997b). Under these circumstances, a network-based fuzzy inference system that is quite robust to the distribution of input vectors, still performs sufficiently well (Blackmore 1994).

For successful application of spectral parameters, the compensation of depth-dependent diffraction and attenuation effects was found essential (Oosterveld et al. 1991; Huisman and Thijssen 1996; Lizzi et al. 1997a, 1997b; Schmitz et al. 1994, 1999). For estimation of some texture parameters, the compensation of these effects was found to be less important. However, these