Accurate Classification of Parotid Tumors Based on Histogram Analysis of ADC-maps

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Target Audience: Radiologists, physicists and surgeons with an interest in DW imaging of head and neck cancers

Purpose:

Parotid tumors account for about 3% of the head and neck cancers[1]. Due to their large histological variety and vicinity to the facial nerves, pre-operative diagnosis and differentiation of benign and malignant parotid tumors, is one of the major challenges among radiologists. This is essentially important as accurate diagnosis of benign parotid tumors can prevent the patients from undergoing unnecessary surgery, which may incur high risks, costs, and morbidity[2]. In this context, MR imaging has shown to play a key role which could enable accurate diagnosis of the tumor grade. Diffusion weighted imaging (DWI) and the computed mean apparent diffusion coefficient (ADC) map have shown to be sensitive techniques for detecting biophysical variations and providing noninvasive physiological biomarkers for lesion characterization [3]. Generally, in previous studies, mean ADC have been calculated to discriminate between benign and malignant tumors[2]. In this retrospective study, we seek to investigate the diagnostic value of several quantitative ADC-map parameters, including commonly used measures (mean, median, max, and min) as well as histogram-based features. Furthermore, an automated classifier is exploited to find and introduce the best quantitative markers for distinguishing benign and malignant parotid tumors.

Materials and Methods:

Data Acquisition: Eighteen patients with parotid tumors (11 benign and 7 malignant as identified with histological assessment) underwent DW-MR imaging on a 3T MR scanner (Siemens MAGNETOM Tim TRIO) using a head coil with the following specifications: TE/TR = 93/7500 ms, slice thickness = 3.6 mm, FOV = 170×200 mm^2, matrix size = 102×160, number of slices = 25, b-values = 50, 1000 mm^2/s. ADC-maps were created from DW images on the system workstation. Data Quantification: The perimeter of the whole solid component of the tumor, as the region-of-interest (ROI) was delineated manually by an expert radiologist in head-and-neck oncology imaging. Several commonly-used quantitative parameters, including mean-, max-, min-, and median-ADC, were then calculated on the selected ROIs. Moreover, first-order histogram analysis was applied on the ROIs to derive the following features: (1) histogram standard deviation, representing average contrast, (2) normalized variance, as a measure of smoothness, (3) skewness, denoting the third moment, (4) energy, as a measure of uniformity or homogeneity, and (5) entropy, a statistical measure of irregularities of ADC-values within the ROI. Differences in the 9 parameters between benign and malignant tumors were tested using Mann-Whitney t-test. A level of P-value less than 0.05 was regarded as statistically significant. Classification: For evaluating the capability of each extracted feature in differentiating benign and malignant parotid tumors, a linear discriminant analysis (LDA) classifier was applied.

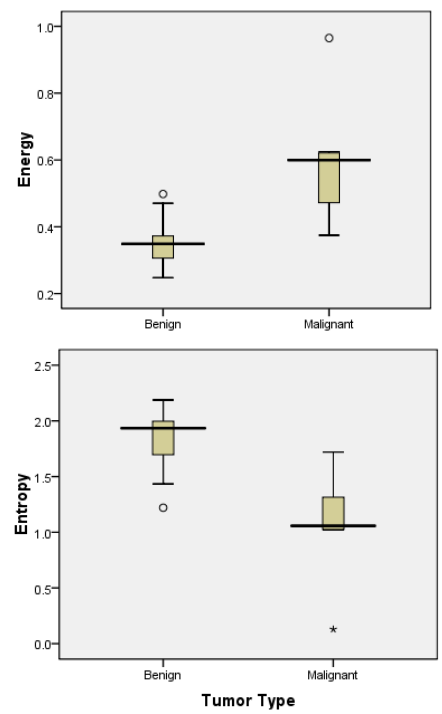

Figure. Box-and-whisker plots of energy and entropy histogram features with the highest accuracies in distinction of benign and malignant parotid tumors.

Results: Statistical analysis revealed that significant differences among benign and malignant groups could be observed with all parameters except for min-ADC and skewness (Table). To further compare the capability of parameters in distinction of the two patient groups, box-and-whisker plots of each parameter were explored. Among all features, energy and specifically entropy demonstrated the highest separation between the tumor types (**Figure**). Using LDA, the sensitivity and specificity of each extracted parameter in classifying benign and malignant parotid tumors were computed (**Table**). It is apparent from the table that energy and min-ADC are the most specific features (100%) and entropy, standard deviation and normalized variance are the most sensitive parameters. Entropy measure indicates the highest accuracy (about 89%) among all other features for differentiating benign and malignant parotid tumors.

Discussion and Conclusion:

In this work, we strived to explore several quantitative ADC measures to select the most accurate feature as a potential predictive biomarker of parotid tumor type. In this regard, to reveal the physiological behavior of the tumor beyond simple quantitative parameters, histogram analysis was carried out on the whole-tumor region. The results showed that energy was the most specific parameter; i.e. this measure of uniformity is capable to detect the homogeneous nature of benign lesions and differentiate them from malignant tumors. However, this parameter overestimates the benignity. On the other hand, entropy, standard deviation and normalized variance induce the highest sensitivity; this behavior is mainly due to the irregular pattern of malignant lesions, which cause higher entropy, higher contrast (difference in ADC levels) and less smoothness. Entropy also shows very high specificity (~91%), suggesting that this feature could be used as a powerful and accurate discriminator of benign and malignant parotid tumors (this is also evident from the box-and-whisker plots of entropy measure). In conclusion, histogram analysis can provide sensitive and specific features for distinguishing benign and malignant parotid tumors. Specifically, entropy measure was found to be the most accurate indicator for predicting the progression of parotid tumors.

	P-value	Sensitivity (%)	Specificity (%)	Accuracy (%)
Mean-ADC	0.026	71.4	81.8	77. 8
Max-ADC	0.026	71.4	90.9	83.3
Median-ADC	0.021	71.4	81.8	77.8
Min-ADC	0.751	0.0	100.0	61.1
Standard Deviation	0.002	85.7	81.8	83.3
Normalized Variance	0.002	85.7	81.8	83.3
Skewness	0.135	14.3	72.7	50.0

Table: The calculations of p-value, sensitivity and specificity of each ADC-derived features in discriminating benign and malignant parotid tumors.

References:

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