Histogram Analysis Parameters Apparent Diffusion Coefficient for Distinguishing High and Low-Grade Meningiomas: A Multicenter Study ⊕ CrossMark

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Abstract

Low grade meningiomas have better prognosis than high grade meningiomas. The aim of this study was to measure apparent diffusion coefficient (ADC) histogram analysis parameters in different meningiomas in a large multicenter sample and to analyze the possibility of several parameters for predicting tumor grade and proliferation potential. Overall, 148 meningiomas from 7 institutions were evaluated in this retrospective study. Grade 1 lesions were diagnosed in 101 (68.2%) cases, grade 2 in 41 (27.7%) patients, and grade 3 in 6 (4.1%) patients. All tumors were investigated by MRI (1.5 T scanner) by using diffusion weighted imaging (b values of 0 and 1000 s/mm^2). For every lesion, the following parameters were calculated: mean ADC, maximum ADC, minimum ADC, median ADC, mode ADC, ADC percentiles P10, P25, P75, P90, kurtosis, skewness, and entropy. The comparison of ADC values was performed by Mann–Whitney-U test. Correlation between different ADC parameters and KI 67 was calculated by Spearman's rank correlation coefficient. Grade 2/3 meningiomas showed statistically significant lower ADC histogram analysis parameters in comparison to grade 1 tumors, especially ADC median. A threshold value of 0.82 for ADC median to predict tumor grade was estimated (sensitivity = 82.2%, specificity = 63.8%, accuracy = 76.4%, positive and negative predictive values were 83% and 62.5%, respectively). All ADC parameters except maximum ADC showed weak significant correlations with KI 67, especially ADC P25 ($P = -.340$, $P = .0001$).

Translational Oncology (2018) 11, 1074–1079

Introduction

Meningioma is the most frequent intracranial tumor in adults with a prevalence of 13–26% of all intracranial neoplasms and an annual incidence of 6 per 100 000 population [1]. According to the world health organization (WHO), there are three subgroups of meningiomas: low grade tumors (grade 1), moderately differentiated lesions (grade 2), and high grade or malignant tumors (grade 3) [1]. Most

frequently (about 90%), WHO grade 1 tumors occur, whereas WHO grade 2 are in 5–7%, and anaplastic variants (WHO grade 3) represent 1–3% [1].

Magnetic resonance imaging (MRI) plays an important role in diagnosis of meningioma and in surgical planning and/or evaluation of postoperative status. Besides diagnostic role, MRI, especially diffusion weighted imaging (DWI) can also characterize meningiomas and predict their behavior. For example, some previous reports suggested that a quantified parameter of DWI, namely apparent diffusion coefficient (ADC) can differentiate low grade from high grade meningiomas [2–5]. It has been shown that grade 1 lesions had higher ADC values in comparison to grade 2 and/or 3 tumors [2–5]. Furthermore, also a threshold ADC value was proposed for distinguishing grade 1 and 2/3 tumors with a sensitivity of 72.9%, specificity of 73.1%, positive and negative predictive values of 54.1% and 86.1%, respectively [5].
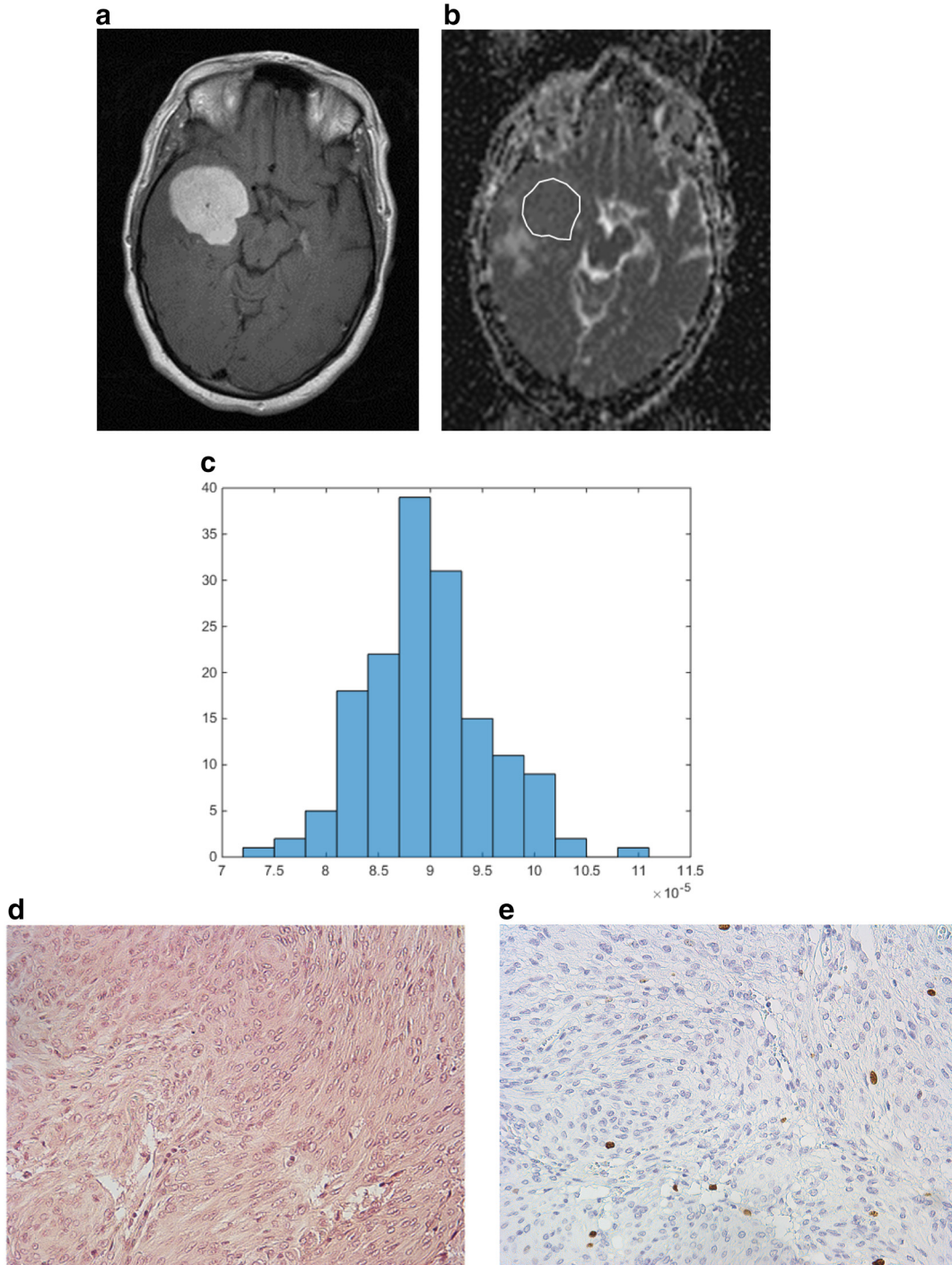

Figure 1. ADC histogram analysis parameters of a grade 1 meningioma. a. T1 weighted image after intravenous administration of contrast medium showing a right temporal meningioma. b. ADC map of the tumor with a ROI. c. ADC histogram. The histogram analysis parameters ($\times 10^{-3}$ mm^2 s^{-1}) are as follows: $ADC_{min} = 0.74$, $ADC_{mean} = 0.89$, $ADC_{max} = 1.09$, P10 = 0.83, P25 = 0.86, P75 = 0.93, P90 = 0.98, median = 0.9, mode = 0.9, kurtosis = 3.25, skewness = 0.24, and entropy = 2.97. d. Histopathological investigation after tumor resection: meningothelial meningioma (hematoxilin&eosin staining). e. KI 67 index of the tumor is 5% (MIB staining).