Routine and Advanced Diffusion Imaging Modules of the Salivary Glands

Ahmed Abdel Khalek Abdel Razek, MD

KEYWORDS

• Diffusion • MR imaging • Salivary • Parotid • Benign • Malignant • Recurrence • Radiotherapy

KEY POINTS

- Routine diffusion MR imaging can be incorporated into routine contrast MR imaging of salivary glands.
- Advanced diffusion imaging modules of salivary glands include diffusion tensor imaging, diffusion kurtosis imaging, and intravoxel incoherent motion MR imaging.
- Routine and advanced diffusion imaging modules help in differentiation of benign from malignant salivary gland tumors.
- Advanced diffusion imaging modules can detect radiation and radioiodine–induced sialadenitis.
- Routine and advanced diffusion imaging modules have a role in early diagnosis and staging of Sjögren syndrome.

INTRODUCTION

Over the past decade, there has been increasing interest in the use of diffusion-weighted imaging of the salivary glands. Routine diffusion-weighted MR imaging module can measure the mobility of water molecules diffusing in tissue, which is impacted by biophysical characteristics, such as cell density, membrane integrity, and microstructure.[1–4] Advanced diffusion imaging modules include additional sampling and analysis frameworks that represent other features, such as structural anisotropy (diffusion tensor imaging [DTI]), microvascularity (intravoxel incoherent motion [IVIM]), and microstructural complexity (diffusion kurtosis imaging [DKI]).[4–7] Routine and advanced diffusion imaging modules are noninvasive procedures without radiation exposure or administration of contrast medium. The examination has a short time and can be combined with routine MR imaging with multiparametric analysis of the salivary glands.[3–6]

TECHNIQUES

The routine diffusion imaging model of the salivary gland is a monoexponential form that may be either echo planar or non–echo planar imaging. The advanced diffusion imaging modules include DTI, DKI, and IVIM modules.

Monoexponential

A routine diffusion MR imaging module of the salivary glands is performed as a single-shot echo planar technique due to short acquisition time. Echo planar diffusion is commonly used in salivary glands imaging. Single-shot and multishot echo planar sequences differ in the number of repetition times used for filling the k-space, with the former using 1 repetition alone to fill the k-space and the latter using many repetitions.[2,8] The single-shot technique, although shorter in acquisition time, suffers from greater susceptibility effects, geometric distortion, and reduced spatial

Department of Diagnostic Radiology, Mansoura University, Elgomheryia Street, Mansoura 35512, Egypt
E-mail address: arazek@mans.edu.eg

Neuroimag Clin N Am 28 (2018) 245–254
https://doi.org/10.1016/j.nic.2018.01.010

resolution, which all are improved with the multishot technique. Non–echo planar diffusion can provide further improvement in image quality with lesser susceptibility artifacts and higher spatial resolution but take longer time and have lower signal-to-noise ratio, which necessitates multiple averages.[2,9]

Biexponential Intravoxel Incoherent Motion (Microvascularity)

The IVIM imaging is a technique with the potential for simultaneously assessing both tissue perfusion and diffusion by using a single diffusion-weighted imaging with a different number of *b* values. The signal decay at low b values is primarily attributed to perfusion, whereas data obtained at high *b* values are mainly dominated by diffusion. The IVIM parameters are perfusion fraction (f), pure diffusion coefficient (D), pseudodiffusion coefficient (D*), and apparent diffusion coefficient (ADC). The D value represents true diffusion and D* value represents pseudodiffusion in microcirculation.[6,10]

Diffusion Kurtosis Imaging (Intravoxel Heterogeneity)

DKI quantifies nongaussianity (kurtosis) of the water displacement distribution, which is measurable in a quadratic order expansion of the signal b-value dependence. Metrics from DKI reflect excess kurtosis of tissues, representing its deviation from gaussian diffusion behavior. The water diffusion probability distribution function can be referred to as nongaussian because of the presence of barriers (eg, cell membrane) and compartments (eg, intracellular and extracellular spaces) in many biological tissues. So the nongaussian distribution may be a true condition in tissue, and a diffusion kurtosis model is established to provide a complete characterization of water diffusion. The mean diffusional (MD) kurtosis is significantly higher in malignant tumors compared with benign lesions.[6,11]

Diffusion Tensor Imaging (Anisotropy)

DTI extends routine diffusion imaging module to characterize the orientational variability of the diffusion process, allowing assessment of diffusion directionality or anisotropy.[12,13] DTI requires the acquisition of a greater number of diffusion gradient directions, 6 or more, and expresses the diffusion coefficient as a function of direction in the form of a tensor. The calculated DTI tensor parameters include the MD or ADC and associated anisotropy indices expressing variability between the eigenvalues, such as the normalized index of fractional anisotropy (FA).[6,12]

Diffusion Tensor Tractography

Diffusion tensor tractography is the postprocessing imaging analysis after reconstructing the nerve fibers, allowing displaying the nerve or white matter fascicle. At DTI, there is a decrease in FA of the facial nerve that contacts or infiltrated with the salivary gland tumors. Diffusion tensor tractography can localize the position of the main trunk of the facial nerve and its major branches in relation to salivary gland tumors. The results best at higher 3T scanner. These data are important to avoid facial nerve injury during surgery.[1,14]

IMAGE ANALYSIS

Image analysis of diffusion imaging modules can be performed by visual assessment and region of interest analysis. Advanced image analysis, including histogram analysis, texture analysis, and machine learning, has recently been introduced and still is in research.

Visual Assessment

Qualitative evaluation is performed by means of visual assessment of the signal intensity on images acquired at high *b* values and their corresponding ADC maps. Malignancy shows high signal intensity on a high *b*-value image and low signal intensity on the corresponding ADC map, whereas most benign tumors commonly appear as areas of low signal intensity on high *b*-value images with high signal intensity on corresponding ADC maps.[2]

Region of Interest Analysis

The region of interest analysis is the most common method for quantification of ADC. Simple methods of acquiring a mean ADC include the drawing of multiple small regions of interest on 1 or several sections or a single large region of interest on 1 section or calculation of ADC from the entire lesion. Regions that are frankly necrotic should be excluded from the ADC calculation. The standard region of interest summary statistics is mean or median.[2–4]

Histogram Analysis

Histogram analysis is reflect the intensity distribution of a volume of interest but not the spatial distribution of the intensities on pixel distribution. It is commonly referred to as first-order statistics. ADC histogram features, including ADC, mean