Probing the Radiation-Induced Changes of Extravascular Extracellular Space of Parotid Glands using DCE and DW MRI

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Introduction

Dynamic contrast-enhanced (DCE) MRI and diffusion-weighted (DW) MRI serve as non-invasive tools for clinical diagnoses and treatment evaluation. They both have been applied to investigate the radiation effects on the highly radio-sensitive parotid glands [1, 2]. To the best of our knowledge, the relationship between parotid perfusion and diffusion properties has not been investigated yet. In this study, we attempted to seek for the correlation between parotid perfusion and diffusion before and after radiotherapy.

Material and Methods

Patients

Ten pathologically proven nasopharyngeal carcinoma patients (9 men and 1 woman, age: 48.0 ± 12.6 years), who did not have any parotid gland lesion, were recruited in this study. They were all treated with intensity modulated radiation therapy (IMRT), and the radiation dose delivered to each gland was 28.6±4.1 Gy. These patients underwent MR examinations both before (pre-RT) and after radiation therapy (post-RT), at an interval of 50.1±16.3 days. Since the parotid glands at each side received different radiation doses, each gland was regarded as an individual sample (i.e., totally 20 glands).

Image acquisition

All MR images were acquired at a 1.5T scanner (GE Healthcare, Signa HDx, USA). DW images were acquired using a diffusion-weighted EPI sequence. Besides b0 images, diffusion gradients were applied in all 3 directions with b-value=1000 $mm^{-2}s$ for ADC measurement. The DW image resolution was 0.94x0.94 mm^2, and 18 slices with a 5-mm slice thickness were used. On the other hand, a fat-saturated fast spin-echo sequence was adapted for DCE MR images using TE/TR = 12.3/400 msec. The temporal resolution was 12.3 sec, and in total 20 dynamic phases were recorded with a spatial resolution of 0.55x0.55x6 mm^3. Six slices were acquired at each time frame. Gd-DTPA (0.1mmol/kg) was manually injected within 3 seconds.

Data Processing and Statistical Analysis

Apparent diffusion coefficient (ADC) was calculated with the b0 and b1000 images. Meanwhile following previously reported procedure [3], peak enhancement (PE), time-to-peak (TTP), and wash-in slope (SLP) were calculated from the DCE time-series. To compare both modalities, Pearson's correlation test was applied on perfusion parameters as well as the ADC values. A *p*-value less than 0.005 was regarded as having statistical significance.

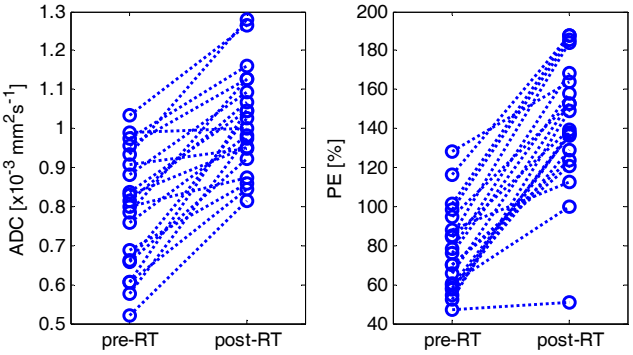

Fig. 1 (a) the ADC and (b) the PE trends before and after RT. Increases in ADC values and PE could be clearly observed in all glands. The blue dotted lines connect each pair of parotid glands before and after RT.

Results

The post-RT parotid glands had higher ADC values and PE in all cases, respectively (Fig. 1). The results were consistent with previous observations [1, 2]. There were significant linear trends between the ADC values and PE in both pre-RT and post-RT groups with R^2 of 0.454 ($P < 0.005$) and 0.405 ($P < 0.005$), respectively (Fig. 2). The post-RT group had a higher slope (16.35×10^2 $mm^{-2}s$) than the pre-RT group (9.81×10^2 $mm^{-2}s$). As for other perfusion parameters, no statistically significant correlation was found.

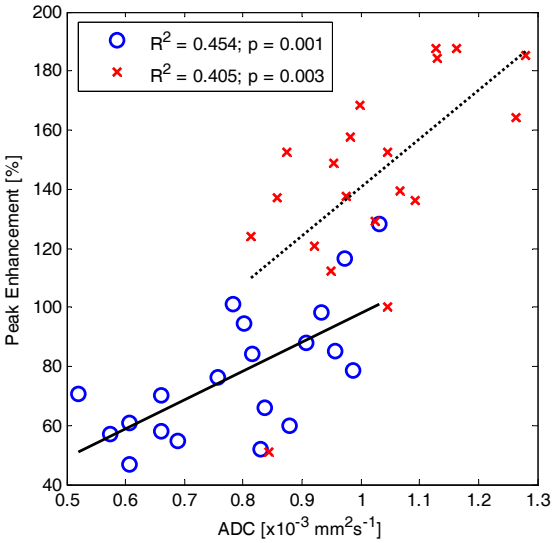

Fig. 2. The correlation test on peak enhancement and ADC values. Blue circles and red crosses denote the pre-RT samples and the post-RT samples, respectively. The corresponding linear regression lines of each group are drawn in black solid line and black dotted line.

Discussion and Conclusion

Since the contrast agent could not enter the acinar cells of parotid gland, PE is chiefly determined by the fraction of extravascular extracellular space (EES). Also, an increase of PE is suggestive of an increase of EES fraction. On the other hand, ADC value represents the diffusibility of water proton. And, an increase of ADC value reflects an increase of diffusibility. It is well known that the radiotherapy causes loss of parotid acinar cells, which implies an increase of EES and decrease of intracellular space of parotid gland after radiotherapy. Our results show a considerable correlation between PE and ADC values not only in the pre-RT group but also in the post-RT group. Accordingly, our results might also suggest that the EES plays a more important role than the intracellular space in determining the ADC values of parotid gland. Nevertheless, further investigation with larger population and histological correlation shall be performed to verify this point of view.

Reference

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