Volume Shrinkage, Perfusion and Diffusion Alterations of Irradiated Parotid Glands

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Introduction

Human parotid gland was proven as a highly radio-sensitive organ, and is usually found injured on nasopharyngeal carcinoma (NPC) patients treated with radiation therapy (RT). In this study, we monitored the temporal behavior of irradiated parotid glands with two common non-invasive MR techniques: dynamic contrast-enhanced (DCE) and diffusion-weighted (DW) MRI. Moreover, the parotid gland volume was measured for further analyses and investigations.

Material and Methods

Patients

Eleven NPC patients (9 men and 2 women, age: 47.4±2.1 years) without any physiological abnormality in their parotid glands were recruited in this study (total 22 glands). They were all treated with intensity modulated radiation therapy (IMRT), and the radiation dose delivered to each gland was 28.6±4.1 Gy. All patients underwent the first MR examination prior to the RT (marked as pre-RT) for diagnoses and one follow-up (marked as post-RT) according to their medical treatment plan. The time interval between the end of RT and the follow-up MR examination was 51.2±15.9 days.

Image acquisition

All MR images were acquired with an 8-channel head and neck coil at a 1.5T scanner (GE Healthcare, Signa HDx, US). For the DCE MR procedure, a fat-saturated fast spin-echo sequence was adopted with TE/TR = 12.63/400 msec. The temporal resolution was 12.3 s and 20 dynamic phases were measured. Gd-DTPA (0.1 mmol/kg) was manually injected within 3 seconds. Diffusion-weighted images, on the other hand, were acquired using a diffusion weighted EPI sequence. The b-value was 1000 $mm^{-2}s$ and the diffusion gradients were applied in all 3 directions for the ADC calculation. As for the parotid gland volume measurement, a fast spin-echo sequence (echo train length = 22, TE/TR = 80/3150 msec) was adopted. The in-plane resolution was 0.49x0.49 mm^2, and the slice thickness was 5 mm. 32 slices were used so that the whole parotid gland coverage was guaranteed.

Data analysis

Peak enhancement (PE), time-to-peak (TTP), and wash-in slope (SLP) were extracted from the parotid gland DCE time curves, following a previous reported procedure [1]. Meanwhile, apparent diffusion coefficient (ADC) was calculated directly from the DW MR images. As for the parotid gland volume measurement, regions of interest were manually contoured for each parotid gland. Volume reduction ratio was defined as the percentage volume change relative to the pre-RT gland volume. Those parotid glands whose volume reduction ratio exceeding -30% were marked as severe shrinkage (SS), and the rest were included in the mild shrinkage (MS) group. Paired T-test was used within each group for the RT-related difference, and two-sample T-test was adopted to compare the parametrical differences among SS and MS groups. A *p*-value less than 0.01 was seen to have statistical significance.

Results

Thirteen parotid glands were labeled as severe shrinkage, and the rest nine as mild shrinkage. After the radiotherapy, all parotid glands experienced shrinkage ranging from 12.4% to as severe as 53.1% of the original volume. Compared with pre-RT results (fig.1), significant increases in ADC value as well as in PE were found in both groups after RT, which is consistent with previous relevant studies [2-4]. However, only the MS group showed significant difference in the wash-in slope. On the other hand in the intergroup analyses, only the pre-RT TTPs and the pre-RT slopes of these two groups exhibited significant differences (fig. 2).

Discussion and Conclusion

Different patterns of the wash-in slopes were observed between the SS and MS groups. This finding suggests that the vascular permeability might interact with the environmental factors (i.e., radiation in our study), so that the outcome of volume shrinkage are different. Moreover, whether the initial wash-in slope could help to predict subsequent volume shrinkage after RT may be of clinical interest and deserves further investigations. The underneath connection between the physiological factors and the RT-related effects may not be fully disclosed with this preliminary findings at current stage. However, further efforts to clarify the connecting mechanism may help clinical diagnosis as well as the treatment planning for NPC.

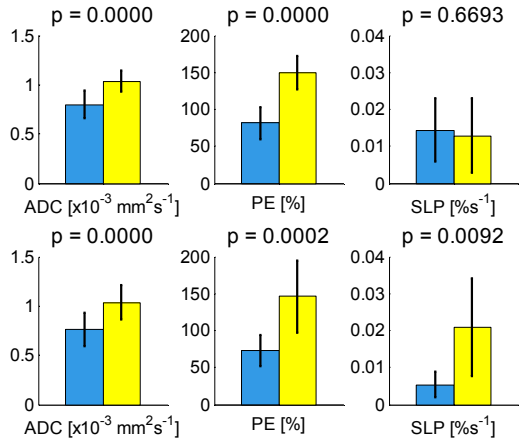

Fig. 1 Intragroup comparisons of SS (top) and MS (bottom). Blue and yellow bars represent pre-RT and post-RT values, respectively.

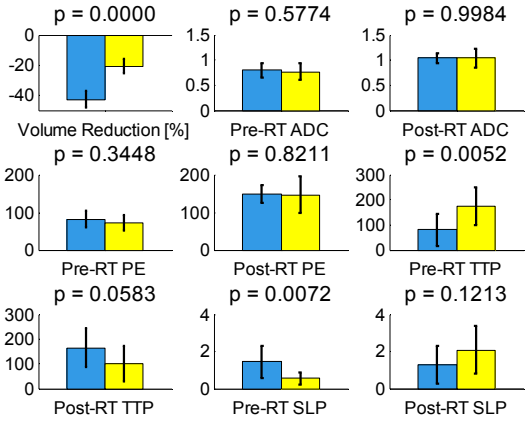

Fig. 2 T-test results of SS (blue bars) and MS (yellow bars) group comparison. (Units: ADC: x10^{-3} mm^2s^{-1}, PE: %, TTP: s, and SLP: $\%s^{-1}$.)

Reference

[1] Cheng, CC., et al, Proc. ISMRM (18) 2010, No. 2415.
[2] Juan, CJ., et al., Eur Radiol, 2009.
[3] Dirix, P., et al., Int J Radiat Oncol Biol Phys, 2008.
[4] Teshima K, et al. Jpn J Clin Oncol 2010