Temporal Evolution of the Irradiated Parotid Glands: Volume and ADC value

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Introduction

Patients who have nasopharyngeal carcinoma (NPC) and are treated by radiation therapy (RT) often encounter impaired function and reduced volume of the parotid glands. In vitro studies have suggested that the parotid acinar and ductal cells might have the capability of regeneration after radiation treatment [1, 2]. MR images are capable of delineating the structural and physiological changes of the irradiated parotid glands non-invasively [3, 4]. To the best of our knowledge, the potential regenerative process of the parotid glands has not been investigated in vivo yet. In this preliminary study, we aimed to investigate the temporal evolution of the structural and physiological features of the irradiated parotid glands in NPC patients.

Material and Methods

Patients

Eleven NPC patients (9 men and 2 women, age: 47.4 ± 12.1 years) without any physiological abnormality in their parotid glands were recruited in this study. They were all treated with intensity modulated radiation therapy (IMRT), and the radiation dose delivered to each gland was 30.1 ± 4.0 Gy (mean ± SD). All patients underwent the first MR examination prior to the radiotherapy for the cancer evaluation and three post-RT follow-ups. The time interval between the end of the radiation therapy and the MR examinations are defined as the Radiation-MR Interval (RMI). According to the following RMI criteria, MR data were classified into four 4 stages in this study: 1) stage 0 represented MR examinations acquired before RT, 2) stage 1 as those with RMIs less than 100 days, 3) stage 2 as those with RMIs between 101 days and 1 year, and 4) stage 3 as those with RMIs larger than 1 year. Since each parotid gland experienced different level of irradiation, each gland would be regarded as an individual sample (i.e., totally 22 glands).

Image acquisition

All MR images were acquired at a 1.5T scanner (GE Healthcare, Signa HDx, US) with an 8-channel head and neck coil. For the purpose of parotid gland volume measurement, a fast spin-echo sequence (echo train length = 22, TE/TR = 80/3150 msec) was adopted for T2-weighted images. The acquisition matrix size was 512x512, providing an in-plane resolution of 0.49x0.49 mm^2, and the slice thickness was 5 mm with a 1-mm inter-slice gap. Diffusion-weighted images, on the other hand, were acquired using a diffusion weighted EPI sequence. The image resolution was 0.94x0.94 mm^2, and 36 slices with 5-mm slice thickness were used to cover the entire head and neck region. The b-value was set to be 1000 $mm^{-2}s$ for the ADC measurement.

Data analysis

For parotid gland segmentation, regions of interest (ROIs) were manually contoured, and the parotid gland volume could then be calculated by multiplying the number of voxels within the ROIs with the voxel volume. Apparent diffusion coefficient (ADC) was calculated from the DW images. For the statistical analysis, two-sample T-test was utilized for the comparison of the measured parameters at each stage to the stage 0. A *p*-value less than 0.001 was considered as statistically significant.

Results

RMIs for stage 1, 2 and 3 were 51.2 ± 15.9 days, 240.3 ± 54.6 days, and 489.3 ± 99.2 days, respectively. The morphological evolution of the parotid glands was demonstrated in Fig. 1. The parotid glands showed a 33.7 ±12.2% volume loss at stage 1. Volumetric analysis disclosed a trend of significant initial loss (stage 1) and gradual restoring of parotid gland volume (stage 2 and 3) (Fig. 2; top). Analysis of parotid diffusivity showed a reciprocal trend, i.e. significant initial increase (stage 1) and gradual decrease of parotid ADC values (stage 2 and 3) (Fig. 2; bottom).

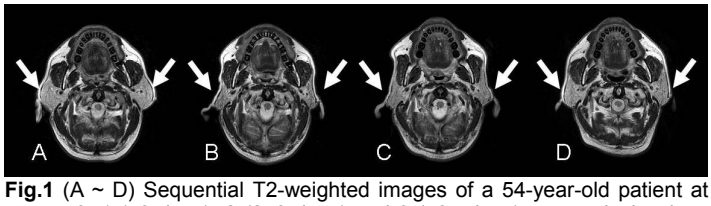

Fig.1 (A ~ D) Sequential T2-weighted images of a 54-year-old patient at stages 0, 1 (53 days), 2 (270 days) and 3 (435 days), respectively, show initial shrinkage (B) and gradual regain (C, D) of the parotid glands (arrows).

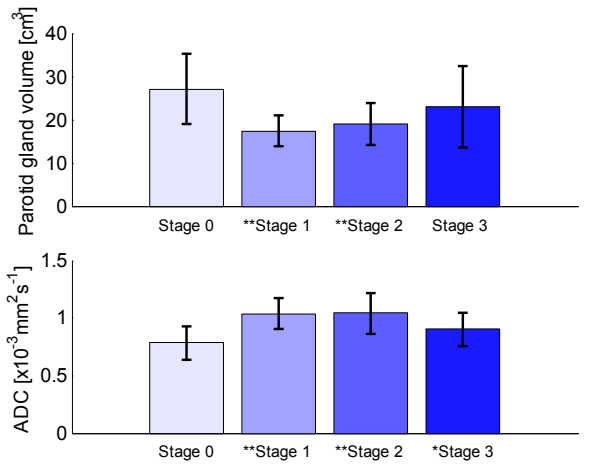

Fig. 2 Temporal evolution of volume (top) and ADC values (bottom) of the parotid glands. (*p<0.05, **p < 0.0005)

Discussion

Our study successfully reveals the temporal evolution of structural and physiological changes of the irradiated parotid glands using MR images. The volume loss and increased ADC values at stage 1 are likely attributed to the acinar loss as observed by prior researches [3 - 5]. Our results further provide evidences supporting that the irradiated parotid glands may undergo a regenerative process, reflected indirectly by the gradual increased volume and decreased ADC values, as early as stage 2, while a radiation dose as low as 30.1 ± 4.0 Gy is delivered by parotid-sparing technique.

Reference

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