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Effects of biodegradable hydrogel spacer injection on contralateral submandibular gland sparing in radiotherapy for head and neck cancers

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A B S T R A C T

Xerostomia is the most common late toxicity after head and neck radiation. We demonstrate injection of a hydrogel spacer anteriorly displacing the submandibular gland. This procedure enables reduced dose to the displaced submandibular gland in cadaveric models of oropharynx cancer treated with IMRT, with potential implications in reducing xerostomia risk.

With the increasing role of radiotherapy for head and neck cancer (HNC) and the high rates of tumor control and long-term survival [1], a keen focus on reducing the late toxicity of radiotherapy is crucial given the influence of side effects on quality of life, morbidity, and even mortality [2]. Radiation-induced xerostomia is the most common late side effect of radiotherapy for HNC and has an impact on speech, taste, sleep, swallowing function, and dental caries [3,4].

The parotid and submandibular glands are the most important glands in saliva formation, contributing 60–65% and 30% of salivary output, respectively [5]. Submandibular glands contribute to up to 90% of unstimulated salivary output [6,7]. Dose–response relationships and the effects of irradiated parotid [8,9] and submandibular gland [10] volumes on function have been previously described. For the submandibular glands, restricting the mean dose in one submandibular gland to less than 39 Gy improved salivary flow and correlated with less xerostomia [11,12]. Mean doses to the parotid below 24 Gy also resulted in substantial preservation of salivary flow [8].

Hydrogel injection for spacing organs at risk from the radiation target to increase the deliverable dose or decrease toxicity of radiation therapy has been evaluated most extensively in the treatment of prostate cancer [13], with some experience in gynecologic cancers as well [14]. This study assessed the feasibility of injecting a similar synthetic hydrogel spacer posterior and medial to the submandibular gland in a cadaveric model in order to anteriorly displace the gland. Comparing pre- and post-injection simulations and planning for oropharynx cancer, we hypothesized that this would enable a reduction in radiation dose to the contralateral submandibular gland.

Methods and materials

Using an approved protocol, four refrigerated, unfixed, unfrozen, cadaveric specimens were obtained within the first 3 postmortem days. Prior to injection of the hydrogel, computed tomography (CT) simulation (Philips Brilliance Big Bore CT, 3 mm slice thickness, 120 kVp, 200 mA, 60 cm field of view) was performed with the cadaver specimen placed supine with a customized aquaplast mask, neck extended, and shoulders down.

Ultrasound (US) imaging and guidance were performed using a GE LOGIQ E9 with ML6-15 MHz and 9 L MHz transducers, along with biopsy needle guide attachments allowing needle placement angles of 44.6°/53.3°/64.6° or 27.6°/33°/27.6° for the respective transducers. Scanning was performed in transverse plane. The transducer was oriented with the needle guide either lateral or medial to the gland, and the angle was chosen to guide the needle

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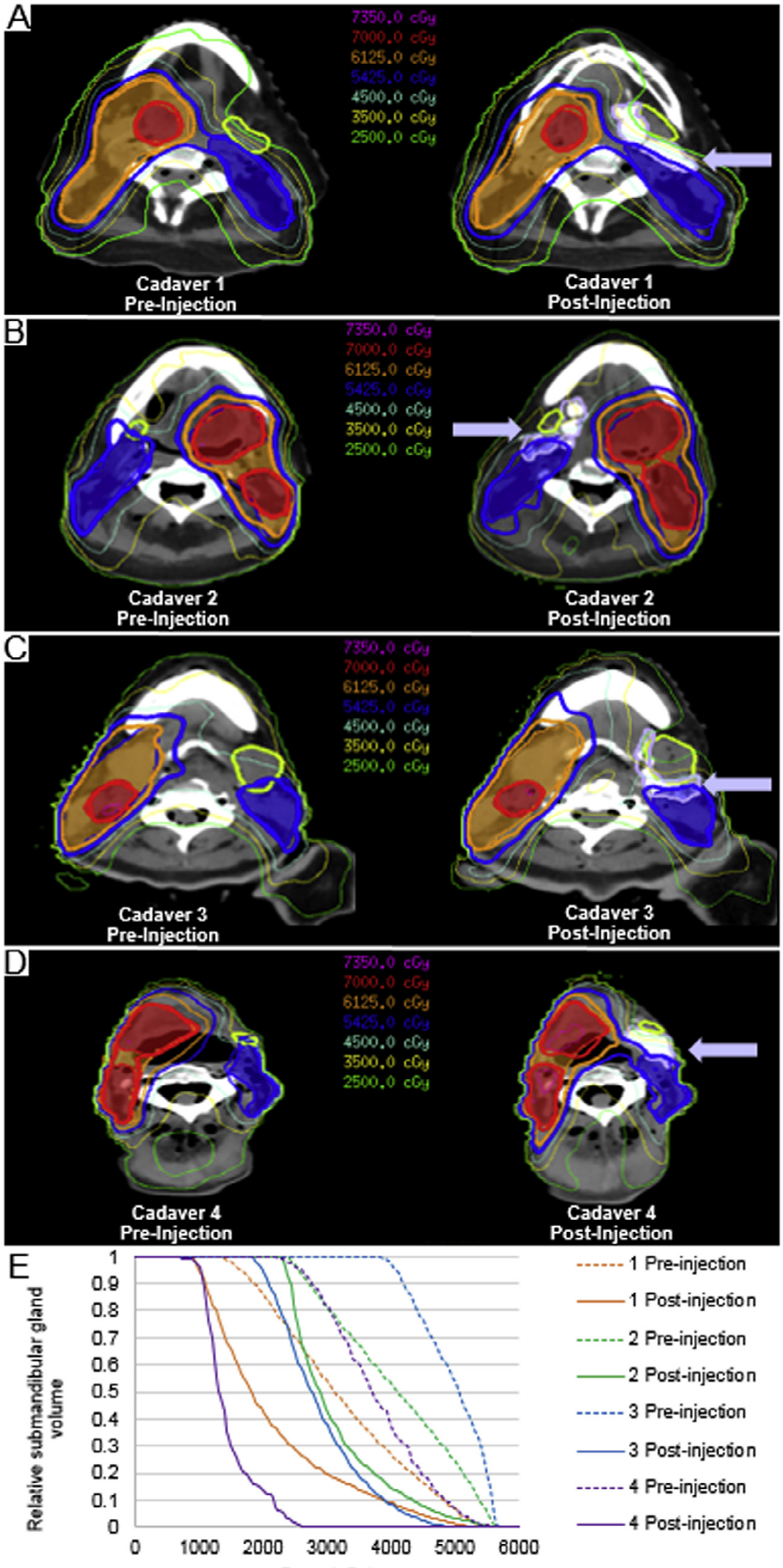

Fig. 1. Matched pre- and post-injection treatment plans simulating T2N2b base of tongue squamous cell carcinoma and resulting dose–volume histogram of contralateral submandibular gland dose. Pre- and post-injection treatment plans for cadaveric specimens 1–4 (a-d) anterior displacement of the submandibular gland of interest (purple arrow) due to injection of hydrogel spacer (purple contour). A dose–volume histogram shows consistent and reproducible reduction in dose to the contralateral submandibular gland on post-injection radiotherapy plans compared to baseline pre-injection radiotherapy plans. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

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