MRI-Guided Midline Laser Glossectomy in Porcine Models: Evaluation of Safety and Efficacy for Reducing Tongue Base Volume

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Introduction & Purpose: Reducing tongue base volume has been shown to improve clinical outcomes in patients with hypopharyngeal obstructive sleep apnea (OSA) due to macroglossia [1]. Surgical and minimally invasive ablative therapies using radiofrequency and laser have been practiced [2]. Ablations are currently performed blindly, without any image guidance, via a transoral approach. We have previously described a technique for percutaneous MR-guided RFA of the tongue base [3] and have demonstrated its feasibility and safety in producing small controlled ablation zones under direct visualization of the neurovascular bundles and tongue mucosa. The aims of the current work are to build upon our earlier success and (1) examine the utility of this technique to safely create large, therapeutic-type laser ablations (LTA) within the tongue base and to (2) explore the efficacy of such single-session treatment in reducing tongue base thickness over extended follow-up durations.

Methods: 4 farm pigs were subjected to tongue base laser ablations. Laser fiber placement and monitoring of lesion formation were performed entirely within a 1.5T open-configuration interventional MR system (Magnetom Espree, Siemens, Germany). A cooled 2-cm diffusion tip Nd:YAG laser fiber (radius=1.5 mm) (Photomedex, PA, USA) was percutaneously advanced into the tongue base aiming at the midline plane between the lingual arteries and was stopped short of the surface mucosa via IMRI guidance. A new tri-orthogonal plane true-FISP sequence was used throughout the guidance phase (TR/TE/NSA/FA: 2589/5.4/1/60°) [4]. Laser ablation was then applied for 6 min at 19W. Online monitoring of the evolving ablation zone was achieved via continuous tri-orthogonal True-FISP imaging. Immediate post-ablation scans consisted of T2-WI, STIR, CE T1-WI, and True-FISP. Follow-up MR scanning was performed at 2 weeks, 1 month, and 2.5 months using the same sequences and imaging parameters. Animals were sacrificed after the 2.5-month time point; their tongues were then harvested for histopathological correlation.

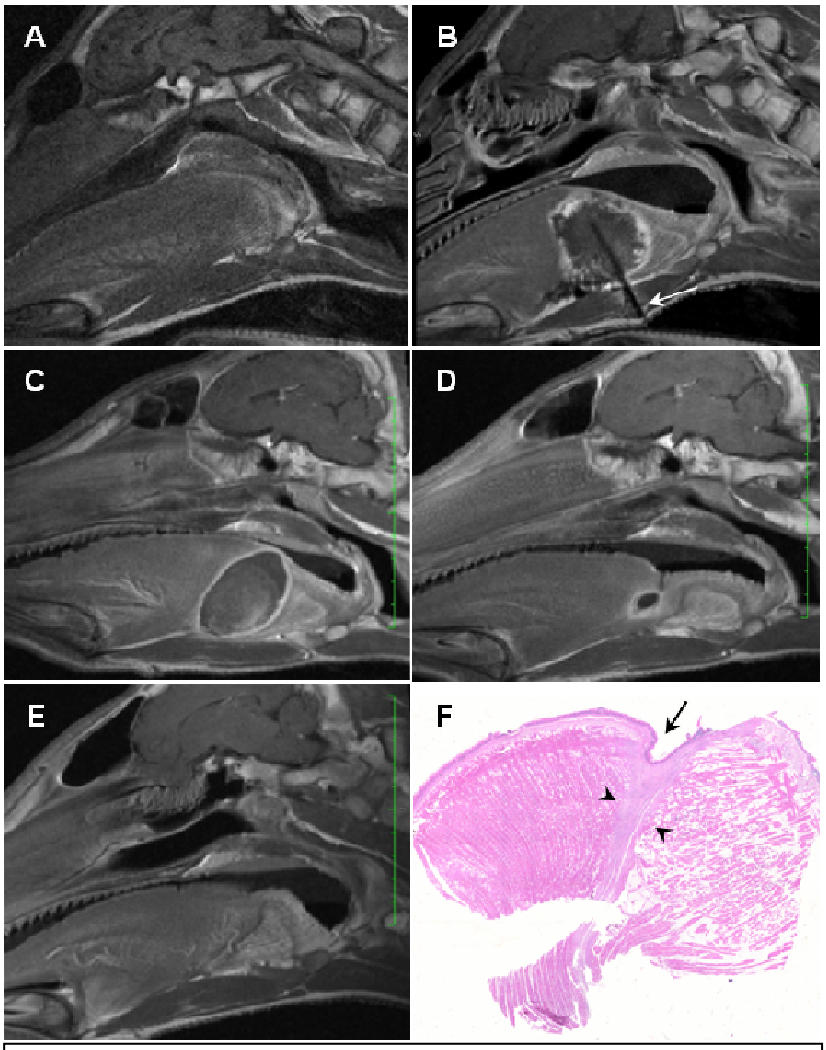

Figure 1: SET1-weighted sagittal images (TR/TE/NSA/TA =539/12/2/4:38min) acquired without gadolinium prior to (a), and with gadolinium immediately after (b), 2 weeks (c), 1 month (d), and 2.5 months (e) after laser ablation. The immediate post-ablation scan (b) demonstrates percutaneously introduced laser fiber (arrow) centered within a large ablation zone occupying the entire tongue base. The central hypointense zone represents the necrotic area, surrounded by enhancing rim of tissue reaction. Follow-up scans (c-e) demonstrate the significant temporal involution of the ablation zone. (f) Sagittal histology section through the tongue at the end of 2.5-month-follow-up shows a dense fibrous tract (arrowheads) replacing the laser ablation zone and retracting the intact surface mucosa (arrow).

Results: MR-guided placement of laser fibers into the desired portion of the tongue was achieved in all procedures without peri-procedural complications. Immediate and follow-up MR scans and subsequently histological analysis demonstrated intact lingual arteries and nerves in all animals. Procedures were well tolerated by all animals. All animals resumed eating upon recovery from anesthesia. No animal required analgesia after the procedure. The mean±SD lesion volume was 21.9±4.2cm^3 on day 0 and 1.96±1.3.2cm^3 (10.0±8.3% of original) on the 2.5-month follow-up scans. Tongue base thickness decreased an average of 0.6±0.5cm (~15%) in thickness at two weeks, and 0.5±0.3cm (~15%) at 2.5 months.

Conclusions: This is the first work demonstrating the safety and efficacy of 1.5T interventional MRI-guided and monitored percutaneous LTA of the tongue base. It builds on our previously described technique of RFA of the tongue base under low-field MRI guidance and further refines both the guidance and the monitoring phases of the procedure. Large, therapeutic-type laser ablations were safely created within the tongue base while monitoring the evolving ablation zone with real-time MRI. The reduction in tongue base thickness herein shown on long-term follow-up of single ablation sessions constitutes promising basis for treatment of patients with hypopharyngeal OSA syndrome due to macroglossia.

References: [1] Mickelson SA & Rosenthal L. Laryngoscope. 107:614-9 (1997) [2] Powell NB, et al. Otolaryngol Head Neck Surg.120:656-64(1999) [3] Nour SG, et al. Radiology. 230:359-68 (2004) [4] Derakhshan JJ, et al. Proc ISMRM 15: 487 (2007)