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INTRODUCTION
Velopharyngeal insufficiency (VPI) is the failure of the soft palate to meet the posterior pharyngeal wall during speech and swallowing. This insufficiency can result in nasal speech sounds and nasal regurgitation during eating. Intrar oral bolus pressure is created by sealing the nasopharynx during the oropharyngeal phase of swallowing. VPI is failure of complete velopharyngeal closure, resulting in a decreased intrar oral bolus pressure and consequently bolus stasis.1

Oropharyngeal carcinoma treatment includes primary radiation or chemoradiation therapy; open or transoral surgery; and more recently, transoral robotic surgery.2–4 These treatments can result in an acquired VPI.5 Large oropharyngeal defects require surgical or prosthetic augmentation with obturators,5,6 including rotational flaps and free flap reconstruction.7 Smaller defects are generally left untreated.2

Injection pharyngoplasty is a well-described procedure for VPI in the pediatric population.8–11 This has been used as a primary treatment for mild cases or as an adjuvant procedure following cleft palate repair or sphincter pharyngoplasty.12 Injection pharyngoplasty displaces the posterior pharyngeal wall anteriorly to provide a contact point for the soft palate and allow adequate velopharyngeal closure.8 There are only a few reported cases of injection pharyngoplasty use in adults.13–15 However, to our knowledge there are no reports of injection pharyngoplasty performed in an office setting. This retrospective case series describes the procedure of in-office injection pharyngoplasty and its use in the treatment of acquired VPI after treatment of oropharyngeal carcinoma.

METHODS
Patient Selection
This study was approved by the University of Southern California Institutional Review Board. A retrospective chart review was performed to identify patients from September 2015 to November 2017 with VPI acquired post–head and neck treatment who underwent in-office injection pharyngoplasty. Diagnosis of VPI was determined by symptoms of nasal regurgitation during swallowing, hypernasal speech, or evidence of VPI on nasolaryngoscopy. Patients with large oropharyngeal defects requiring prosthesis or flap reconstruction were excluded from the study.

Procedural Technique
Written informed consent was obtained; and the risks, benefits, and alternatives of the procedure were discussed in detail. The method of in-office injection pharyngoplasty has not been previously described. Briefly, the patient is administered 4% topical lidocaine with oxymetazoline into the right or left nares. A 1-second dose of topical Cetacaine spray (Cetylite Industries, Pennsauken, NJ) is administered to the posterior pharyngeal wall. A distal chip flexible laryngoscope is placed in the inferior meatus of the nose to visualize the posterior nasopharyngeal wall. The micronized allograft (Cymetra) (Allergan, Madison, NJ) is prepared according to the manufacturer’s specifications. A 1.5-inch 23-gauge needle is used. The patient is asked to gently say “ah,” and the needle is placed through the mouth and directed to posterior pharyngeal wall. Under visualization, the material is injected into the posterior pharyngeal wall at the level of Passavant’s ridge. Areas are slightly over injected in anticipation of absorption (Figs. 1–3). The patient is retested to ensure complete closure, and additional areas are injected as needed. Patients initially return at 1 month to evaluate success of procedure and then as needed when the injection effectiveness has worn off. The procedure can be repeated as necessary with additional augmentation using longer-acting materials such as calcium hydroxyapatite.

RESULTS
We describe four patients undergoing six in-office injection pharyngoplasties (Table I). The mean age was
64 (standard deviation [SD] ± 10.2) years old. Tonsil was the primary cancer site in all patients (100%); one patient also had base of tongue involvement. Three (75%) patients underwent surgery, including a radical tonsillectomy followed by radiation therapy, whereas the remaining one (25%) patient received primary chemoradiation. The mean time from completion of cancer treatment to injection augmentation was 19 months (3–60 months). Average follow-up time was 11 months (4–20 months).

All patients completed pre- and postinjection EAT-10 Eat Assessment Tool questionnaire. The mean score prior to the procedure was 29 (SD 4.08) (Table I). The postprocedural EAT-10 mean score was 14.5 (SD 5.3). This was a statistically significant improvement ($P < 0.002$). Three (75%) patients also received swallow therapy as part of their treatment. Perceptual evaluation demonstrated improved nasal speech in all patients. All patients tolerated the procedure well, and there were no complications.

DISCUSSION

The three-dimensional valving mechanism of the velopharyngeal valve is based on the fully coordinated function of the muscles contributing to its action. Its competency is essential for normal speech and nonphonetic activities such as swallowing. The seal of the nasopharynx aids in increasing intraoral bolus pressure. This bolus pressure in part contributes to bolus propulsion from the oropharyngeal into the hypopharynx. When there is a VPI, there is a defect in the valving mechanism of the velopharynx resulting in air escape and insufficient intraoral bolus pressure. This can contribute to symptoms of dysphagia and nasal regurgitation during swallowing.

Augmentation of the posterior pharyngeal wall for VPI as a primary or adjuvant intervention was first described using paraffin in 1904. Teflon was then used for augmentation but was abandoned because of concerns of granuloma formation. Lypka et al. has the largest series on posterior pharyngeal wall augmentation. They investigated posterior wall augmentation using silicone and Gore-Tex implants in 111 pediatric patients over a 40-year period. Seventy-three percent of their patients achieved near-normal speech. Excluding the patients lost to follow-up, improvement was seen in nearly all patients (98%).

Injection augmentation is simpler than implants, and new materials including acellular micronized dermis and calcium hydroxyapatite have been described. Given
that the majority of the work on injection pharyngoplasty has been in the pediatric population, in-office posterior pharyngeal wall augmentation has not been introduced.

To our knowledge, this is the first report of in-office injection augmentation of the posterior pharynx. In the last 15 years, there has been a widely adopted practice of in-office injection laryngoplasty for glottic insufficiency.\textsuperscript{21} Injection pharyngoplasty for VPI uses the same materials as vocal fold injections and is readily available in an otorhinolaryngologist’s office. During this procedure, the patient’s velopharyngeal closure is tested, and additional material is injected as needed. This real-time feedback allows for appropriate location and volume of injection. There are several reports in the literature of injection pharyngoplasty for stress VPI in wind musicians.\textsuperscript{13–15} To our knowledge, this is the first description of pharyngeal injection augmentation being used for postoropharyngeal carcinoma treatment. This is not an appropriate treatment for those patients with larger defects for which a local rotational flap, free flap, or obturator would be necessary. Posterior wall augmentation has been shown to be most effective for patients with good palatal movement and velopharyngeal gaps of up to 5 mm.\textsuperscript{20} In-office posterior pharyngeal augmentation is a procedure that can be used for those patients with mild defects and VPI symptoms.

Swallowing function postprocedure was evaluated with a patient-reported outcome measurement tool, the EAT-10. Using this questionnaire, there was statistically significant improvement in swallowing from ($P < 0.002$). It is important to note that 75\% (3 of 4) of the patients had previously received radiation therapy, which likely contributed to swallowing dysfunction. Improved speech resonance was noted on perceptual assessment in all patients. This improvement, however, was not quantified and based on patient and nonblinded clinician assessment.

### CONCLUSION

There are several limitations to this study. Nasometric measures were not recorded pre- or postprocedure. The perceptual assessment of hypernasality was assessed by a nonblinded treating physician with no qualitative measures. Dysphagia symptoms were measured using patient reports outcomes objective, and a postprocedure modified barium swallow evaluation was only obtained in two patients.

The case series suggests that in-office injection pharyngoplasty is safe and well tolerated. It is effective improving dysphagia symptoms in select patients with acquired VPI after oropharyngeal carcinoma treatment. Further longitudinal studies, with a larger series of patients, that examine the safety, efficacy, and patient selection are warranted to better understand the possible use of in-office posterior pharyngeal wall injection symptomatic VPI.

### BIBLIOGRAPHY


