Anatomic Imaging of the Soft Palate During Phonation as an Aid in Cleft Palate Presurgical Planning

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Purpose: To establish methodology that will allow presurgical acquisition of anatomic information concerning soft palate configurations during speech articulation in children in the age group of 5 to 10 years who will undergo cleft palate surgery to correct speech deficiencies. Specifically, protocols are described that allow anatomic imaging of the position of the soft palate, or velum, in adults during sustained phonation of the normal English hard vowels and nasal consonants. Enabling the child to close the velopharyngeal port to the nasal pharynx when sounding nasal consonants is the principle surgical aim. The few previous studies, all at 1.5T on adults (1,2,3) suggested that increase in SNR was for this application, desirable. We hypothesize that studies at 3T using a multichannel head coil will provide sufficient sensitivity enhancement relative to 1.5T to make this protocol practical for clinical usage. This study is a precursor to studies on children.

Methods: A series of 7 subjects have been scanned. We found that phonation could be sustained by all but 1 of these subjects for as long as 14 seconds. We therefore evaluated image quality during sustained phonation of 7 seconds in three subjects. Studies were carried out using a 3.0 T GE Long Bore Signa Excite scanner and a GE 8-channel brain array coil assembly with summations of signals from the eight channels for best SNR. Most studies used the sequence known as FSE-XL. Technical parameters were optimized, arriving at the following values: TR = 750 ms; TE = minimum; matrix = 256 × 256; FOV = 18 × 18 cm; slice = 3 mm; NEX = 1; echo-train length = 16; scan time = 14 s. A single sagittal slice was acquired that was very carefully centered. At midline, partial volume blurring was negligible in the anatomy of interest when using a slice with of 3 mm. It was interesting to discover that an optimum in image quality is obtained when using 16 echoes in this turbo sequence. In all subjects, control studies were obtained at rest while breathing through the nose. We discovered that in this condition the velum consistently rests against the tongue. We therefore investigated the possibility that improved anatomic images of the velum could be obtained using longer acquisition times while breathing through the nose. We purposely avoided any mention of swallowing, and found that in all subjects, image acquisition of one minute could easily be obtained with the subject at rest and breathing through the nose. Images in this condition were acquired using the following technical parameters: pulse sequence: FSE-XL; TR = 2000 ms; TE = 102 ms; Acq Matrix = 256 × 256; FOV = 18 × 18 cm; slice = 3 mm; NEX = 2; echo-train length = 16; scan time = 1:08 min.

Results: Sounding of any of the 5 vowels, a, e, i, o, or u, results in closure of the nasopharynx. The velum is pulled up tightly by the levator palatini, and the genu of the velum is in close contact with the posterior wall of the nasopharynx. See Fig. 1a. This is the most important muscular activity involved in this closure, but other planes-of-section revealed the effects of motion of the muscles on the lateral and posterior walls during closure of the velopharyngeal port. This port is open when sounding "n", Fig 1b. An alternative strategy for closure when sounding "a" is shown in Fig. 1c. This closure strategy was observed in only one subject. Figure 1d shows our best anatomic image of the velum obtained while breathing through the nose. Velum positions during phonation of other vowels showed variation within subjects that might be indicative of slight resonances of the nasopharynx, but no trends across subjects that we discerned.

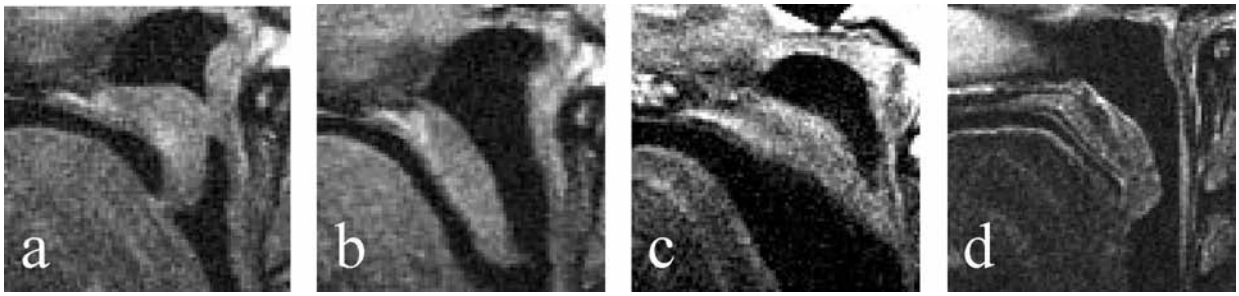

Fig. 1. Soft palate images: a) phonation of “a”, b) phonation of “n”, c) phonation of “a” in an exceptional subject, and d) at rest, nose breathing.

Discussion: We have established from the adult studies described here a baseline of experience of sufficient depth that studies can now begin on children, and protocols for this purpose are in place. The discovery that during nose breathing the velum is stationary and musculature can be seen using sequences as long as one minute may well be the most significant result, from a clinical perspective. It remains to be seen whether or not scarring from previous surgery when the child was an infant can be revealed with sufficient image quality. Inspection of the images suggests that an improved multichannel coil targeting the orofacial cavity would be valuable. Sensitivity of the coil that we used at the level of the velum was the best of three coils available to us, but was clearly lower than the sensitivity at a level only a few cm superior to the velum.

References: 1. Ozgur F, et al. Ann Plast Surg 2000;44(1):8–13. 2. Kane AA, et al. Plast Reconstr Surg 2002;109(2):472–481. 3. Beer AJ, et al. J Magn Reson Imaging 2004;20:791–797.