Rapid frame-rate MR acquisitions to reveal mechanisms of circular breathing and sound production in the Australian Aboriginal didgeridoo

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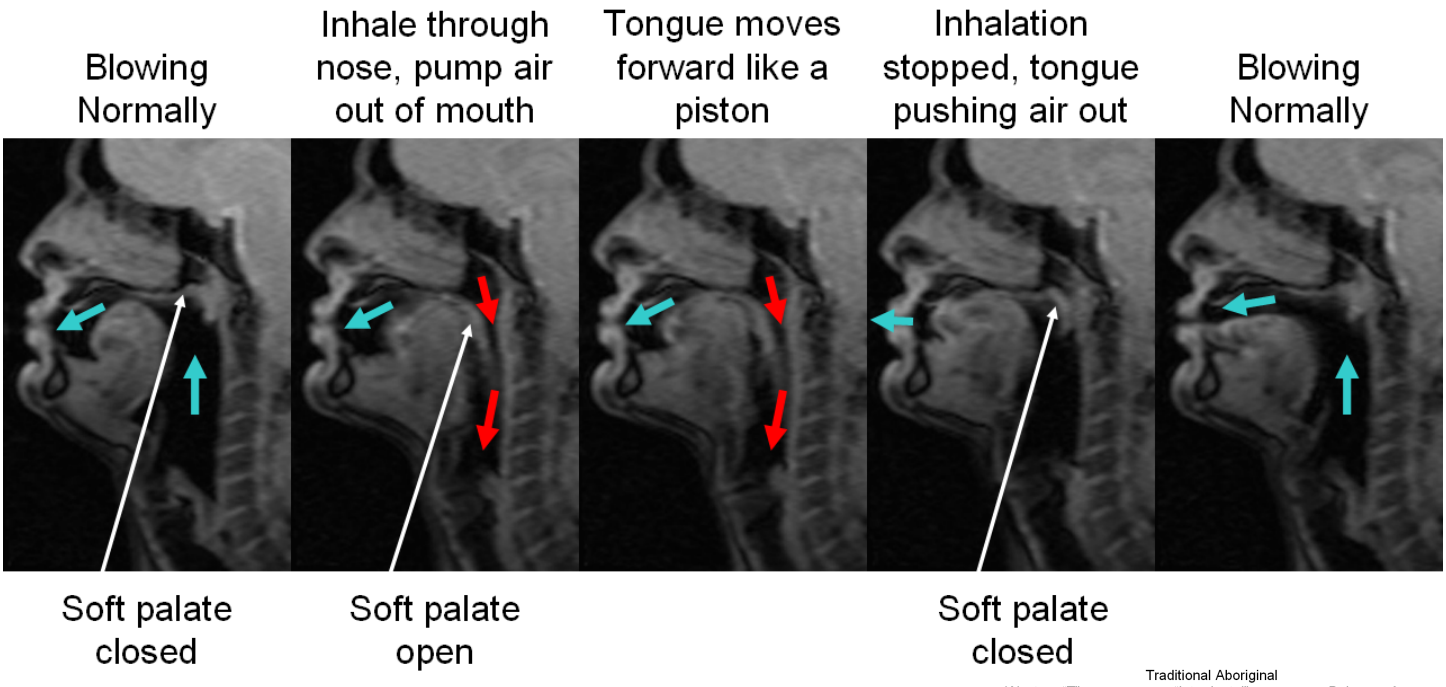
Introduction: It can be difficult to visualize or communicate the internal configurations of the mouth, tongue and throat that are involved in the proper performance of a musical wind instrument. The Australian Aboriginal didgeridoo requires a number of techniques which are unusual in Western music, such as circular breathing, the use of an interdental tonguing technique and modifications of the vocal tract which cause a formant-like filtering effect in the sound of the instrument analogous to various vowel sounds in speech. Even when a player has mastered these techniques it can be difficult to communicate them to aspiring players. X-Ray fluoroscopy has been used to examine the configuration of the tongue when playing the trumpet, but there are risks associated with the ionizing radiation used. MRI has been used to examine the articulation of speech [1] and the vocal tract configuration of opera singers. Through the use of a modified didgeridoo that can be played while the subject is lying supine, and a high frame rate FLASH acquisition, we have created MRI movies which clearly show the mechanics involved in playing the didgeridoo.

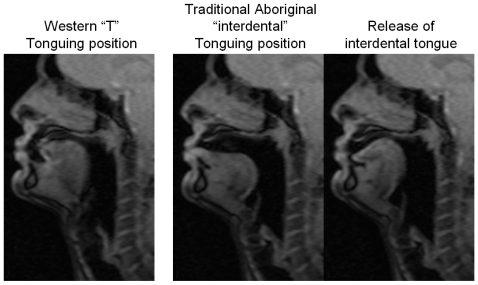
Methods: A didgeridoo was constructed consisting of a G10 fiberglass tube 105cm long and 3.2cm in diameter, connected to a section of flexible corrugated plastic tubing which was bent through 90 degrees (Figure 1). The subject was placed in a Siemens 12 channel Matrix head coil and 4 channel neck coil (Siemens Healthcare, Erlangen, Germany). By rotating the head slightly it was possible to bring the modified digeridoo up to the mouth where it could be played as normal. A high frame rate FLASH acquisition was acquired in a sagittal plane with TR/TE/Flip = 120mS/1.1/5deg, BW = 965. Slice = 10mm, Matrix = 80 x 192, field of view = 250 x 300mm, 50% partial Fourier and GRAPPA acceleration factor 2. All scans were obtained on a 3 Tesla Siemens Tim Trio scanner (Siemens Healthcare, Erlangen, Germany).

Figure 1: The subject holding the modified didgeridoo to his mouth while in the coils on the patient bed

Results: The mechanics of circular breathing are clearly revealed in the MR images in figure 2. When blowing into the instrument as you would a normal Western wind instrument, the soft palate is closed against the back of the throat so that air pressure from the lungs is delivered through the mouth to the instrument (frame 1). In order to circular breathe, the soft palate must be opened, and the tongue pressed up against it to trap a volume of air over the tongue, and perhaps also in the cheeks (frame 2). The tongue moves forward like a piston to force air out of the mouth into the instrument to sustain the sound while air is being inhaled through the nose (frames 3 and 4). The cycle is complete when the soft palate is closed again and air from the lungs is supplied once more to the instrument (frame 5).



The MR images also illustrate the tongue position used in the traditional Aboriginal tonguing technique whereby the tongue is thrust forward between the teeth and allowed to vibrate against the lower lip. After a brief interval the tongue is retracted, creating a distinct pulse in the sound.



Conclusions: High frame rate FLASH MR of the vocal tract while playing the didgeridoo can reveal the mechanics behind circular breathing and sound production and may serve as an aid to aspiring players

[1] Narayanan S, J Acoust Soc Am 1995;98:1325-1347