

## Measuring the change in mechanical properties of upper airway soft tissues in obstructive sleep apnea using magnetic resonance elastography

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### Introduction

Obstructive sleep apnoea (OSA) is a respiratory disorder characterized by the repetitive collapse of the upper airway during sleep. It affects ~ 7 % of the population and is a major risk factor for fatigue related accidents and cardiovascular disease. The pathophysiological mechanisms of OSA are unclear and the change in mechanical properties of soft tissues and tongue muscles surrounding the upper airway may contribute to collapsibility. Magnetic resonance elastography can be used to probe the mechanical properties of the tongue in deep regions not easily measured by other techniques. Our recent study showed that the average mechanical property of the tongue measure using MRE corresponded very well with those measured using other techniques [1]. The aim of this study is to measure the mechanical properties of the upper airway muscles in patients with obstructive sleep apnoea using MRE. We hypothesized that there will be regional softening of soft tissues in OSA patients compared to healthy control subjects. These first results support this hypothesis.

### Methods

Five diagnosed severe OSA patients and five healthy normal subjects were recruited for this study. Subjects lay supine on the scanner bed with a custom-moulded MRE mouth guard and were requested to keep still and rest their tongue on the hard palate close to the upper teeth during the scans. Sagittal scans were performed on a 3T MR scanner (Achieva 1.2; Philips Medical Systems, Best, The Netherlands). Shear waves were propagated through the tongue with a MR-compatible mechanical transducer consisting of two coaxial coils [2]. The transducer (Figure 1) was mounted on a transmit-receive neurovascular coil and coupled to the maxilla and mandible via a bite bar inserted into an individually moulded polymer mouth guard. The coaxial coils on the transducer were driven by a pulse generator triggered by the MR spectrometer. The associated magnetic field created by the coils is coupled with the magnetic field of the MR scanner to produce a torque and thus oscillation of the coils. The frequency of the oscillation was set at 80 Hz based on preliminary experiments and typical imaging parameters were  $TR/TE$  550/60 ms, scan resolution  $64 \times 64$  pixels, FOV 200 mm, and slice thickness 2 mm. Measurements consisted of 7 slice images leading to a total acquisition time for each dataset of ~ 11 mins for each subject. In addition to the MRE dataset, a T<sub>2</sub>-weighted anatomical scan with identical geometry at higher resolution was collected to identify tongue and soft palate anatomy (Fig 2). The techniques for the scan sequence and reconstruction methods have been described in more detail previously [3,4].

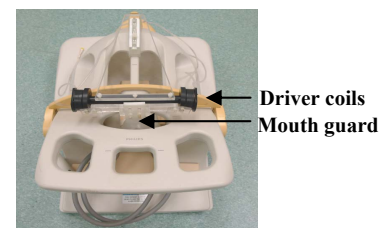


Figure 1

### Results

Results of the in-vivo viscoelastic properties of the tongue and soft palate for the subjects are presented in Table 1 and Figure 2 shows the data of a typical OSA and normal subject. A paired t-test was used to compare the storage modulus ( $G'$ ) and loss modulus ( $G''$ ) of the tongue and soft palate in the two groups of subjects. Results showed that the storage and loss moduli of the tongue are significantly lower in OSA patients ( $p < 0.05$ ). However, the mechanical properties (storage and loss moduli) of the soft palate are not significantly different ( $p > 0.05$ ) between healthy volunteers and patients.

	Normal	OSA	
Tongue, $G'$	$2.72 \pm 0.40$	$1.47 \pm 0.97$	$p < 0.05$
$G''$	$1.03 \pm 0.14$	$0.54 \pm 0.31$	$p < 0.05$
Soft palate, $G'$	$2.12 \pm 0.91$	$1.59 \pm 0.92$	$p > 0.05$
$G''$	$0.15 \pm 0.48$	$0.49 \pm 0.29$	$p > 0.05$

Table 1. Shear moduli for tongue and soft palate in normal subjects and OSA patients

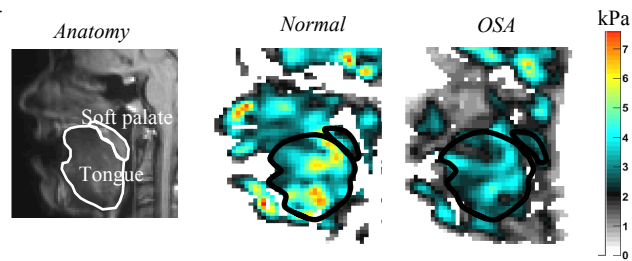


Figure 2. Sagittal T2W image of upper airway, showing tongue and soft palate (left). Storage modulus ( $G'$ ) map for normal volunteer (middle) and OSA patient (right)

### Discussion

These results suggest that the tongue in patients with OSA is softer compared to healthy control subjects. While the reasons for this are not definitively known, this may be the result of higher fat content in the muscles [5]. As the mechanical properties of the soft palate in both groups of subjects are not significantly different, this suggests that a change in soft palate tissue properties does not play a major role in OSA. The results suggest a softer tongue may contribute to increased upper airway collapsibility in OSA, and this may underpin changes in respiratory related motion of the tongue in OSA patients [6], providing new insight into the mechanisms of OSA. The technique may provide useful information for diagnosis of OSA, and has potential to elucidate the role of mechanical factors in different patient phenotypic groups. Future studies will determine how mechanical changes relate to age, obesity, disease severity and progression.

### References

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