

# Morphometric analysis of swallowing mechanics after surgery for Obstructive Sleep Apnea (OSA)

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## ABSTRACT

**Outcome Objectives:** To apply a new method of analyzing swallowing biomechanics on postoperative OSA patients using parameters of the modified barium swallow (MBS) imaging.

**Methods:** This novel biometric analysis involved two patients following uvulopalatopharyngoplasty, relocation pharyngoplasty and base of tongue resection for OSA. Postoperative MBS indicated mild swallowing impairment in both patients. Coordinates mapping 10 anatomical landmarks were collected from every frame of the oropharyngeal swallow using ImageJ software. A canonical variate analysis was performed using MorphoJ software with data pooled by subject (S1, S2) and swallowing phase (OP=oral phase, PP=pharyngeal phase). The Mahalobonis distances (D) of the pooled means from each group were defined. Eigenvectors of shape change in these patients were compared to previously published subjects (non-surgical) to document changes in swallowing mechanics.

**Results:** Significant differences in shape change were found for all values: OP vs. PP of S1(D=9.2, p<.0001) and S2 (D=10.7, p<.0001); OP of S1 vs. S2 (D=45.4, p<.0001); PP of S1 vs S2 (D=39.2, p<.0001). Eigenvectors indicated reduced pharyngeal shortening and reduced tongue base retraction compared to published data of normal subjects.

**Conclusion:** Tongue base retraction and reduced pharyngeal shortening was noted in this small cohort of patients. These observations are consistent with the postoperative goal of necessary tightening in these areas to avoid collapse. Future controlled studies should be performed to determine whether these changes in swallowing mechanics are specific to surgical interventions or the underlying morphology of OSA patients. This method could potentially be utilized to quantify the effectiveness of sleep surgical techniques.

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## INTRODUCTION

Obstructive sleep apnea (OSA) is a condition that affects 4% of men and 2% of women worldwide. Many patients undergo surgery to improve their symptoms and/or decrease their use of continuous positive airway pressure (CPAP). The aim of these procedures is to tighten the areas that collapse during sleep. Currently, there is a wide range of reported data on the effectiveness of these surgeries. Studies have shown that 50% of OSA patients have baseline swallowing dysfunction. A meta analysis of uvulopalatopharyngoplasty (UP3) patients showed 31% had postoperative swallowing dysfunction. To date, there have been no studies looking at the difference of swallowing mechanics after sleep surgery or a metric to evaluate physiologic effectiveness of the surgery. These are difficult endpoints to evaluate because the head and neck region is very complex. Swallowing involves hard and soft tissues, has large and fast movements, there are large forces involved and many contact points. Morphometric analysis has been developed to quantify swallowing and give a metric to compare subjects. This novel new analysis technique could be applied to OSA patients to quantify swallowing changes. By comparing OSA patients swallowing we will be able to determine what changes take place in the oral cavity after surgery and how it affects patients swallowing outcomes.

## METHODS

This novel biometric analysis involved two patients following uvulopalatopharyngoplasty, relocation pharyngoplasty and base of tongue resection for OSA. Postoperative modified barium swallow study was performed. Coordinates mapping 10 anatomical landmarks were collected from every frame of the oropharyngeal swallow using ImageJ software. The first five coordinates track the relative position of three skeletal levers: the vertebrae, mandible and cranial base. The next four coordinates mark features of the hyolaryngeal complex including the hyoid, anterior larynx, posterior larynx and upper esophageal sphincter. These coordinates approximate muscle attachments of the proposed two-sling mechanism (suprahyoid and long pharyngeal muscles). The final coordinate is the base of tongue.

A canonical variate analysis was performed using MorphoJ software with data pooled by subject (S1, S2) and swallowing phase (OP=oral phase, PP=pharyngeal phase). The Mahalobonis distances (D) of the pooled means from each group were defined. Eigenvectors of shape change in these patients were compared to previously published subjects (non-surgical) to document changes in swallowing mechanics.

## RESULTS

Significant differences in shape change were found for all values: OP vs. PP of S1(D=9.2, p<.0001) and S2 (D=10.7, p<.0001); OP of S1 vs S2 (D=45.4, p<.0001); PP of S1 vs. S2 (D=39.2, p<.0001). The OSA patients had normal hyolaryngeal excursion, but reduced pharyngeal shortening and reduced tongue base retraction compared to published data of normal subjects. Penetration aspiration scores were 2, which indicated that the bolus penetrated the larynx but was ejected.

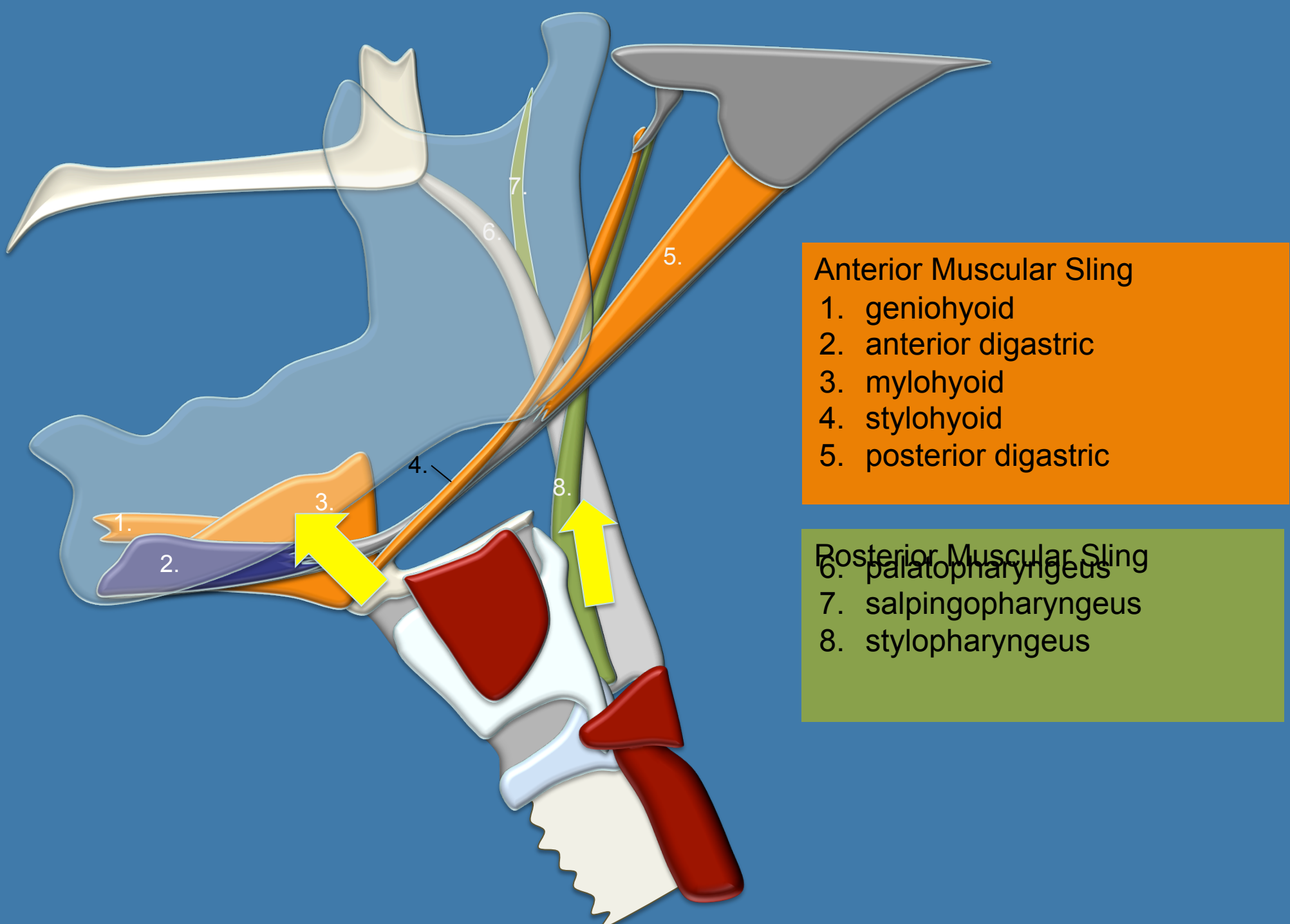


Figure 1: Hyolaryngeal complex

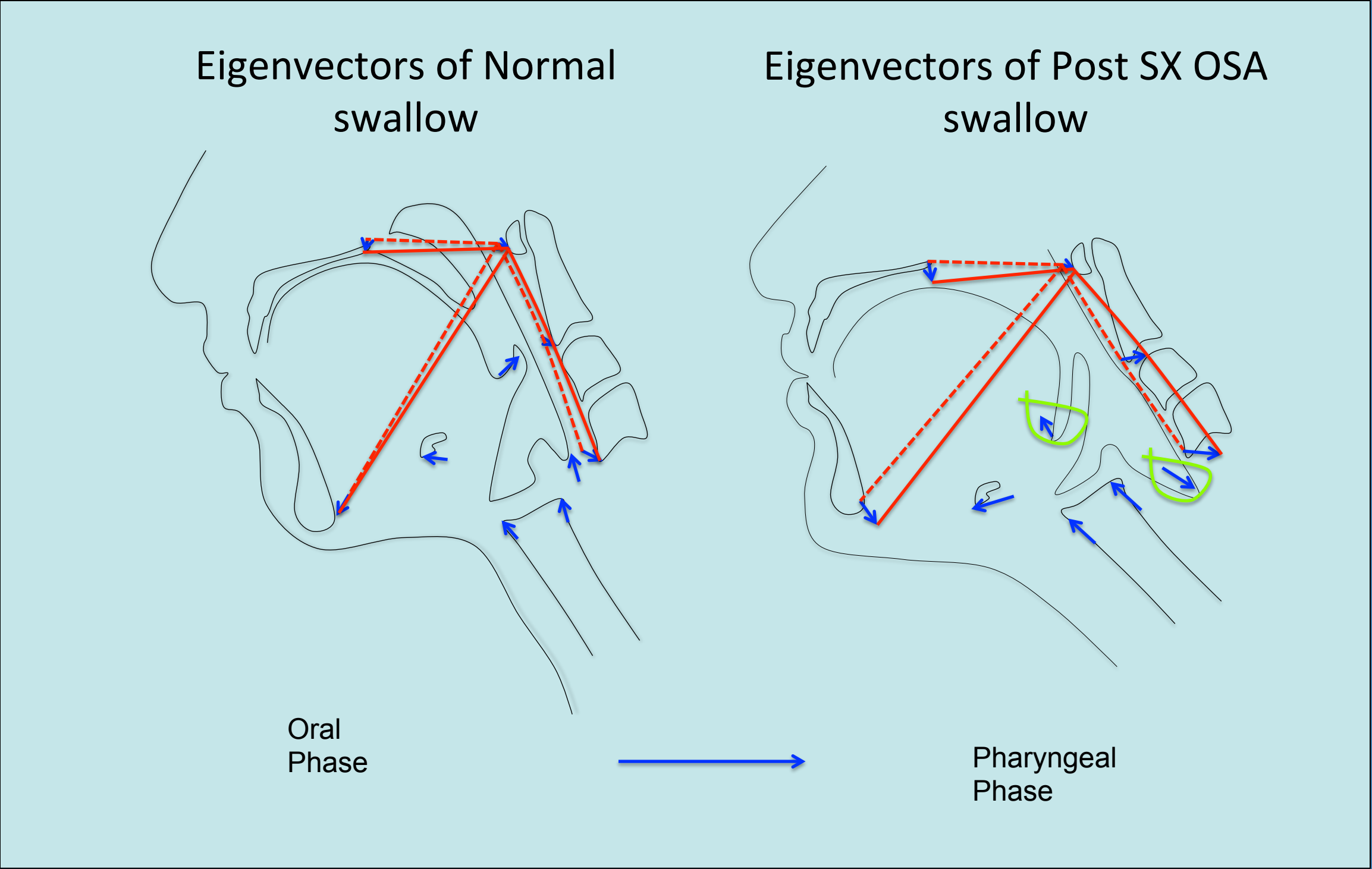


Figure 2: Morphometric vectors of normal subjects vs. postsurgical OSA patients

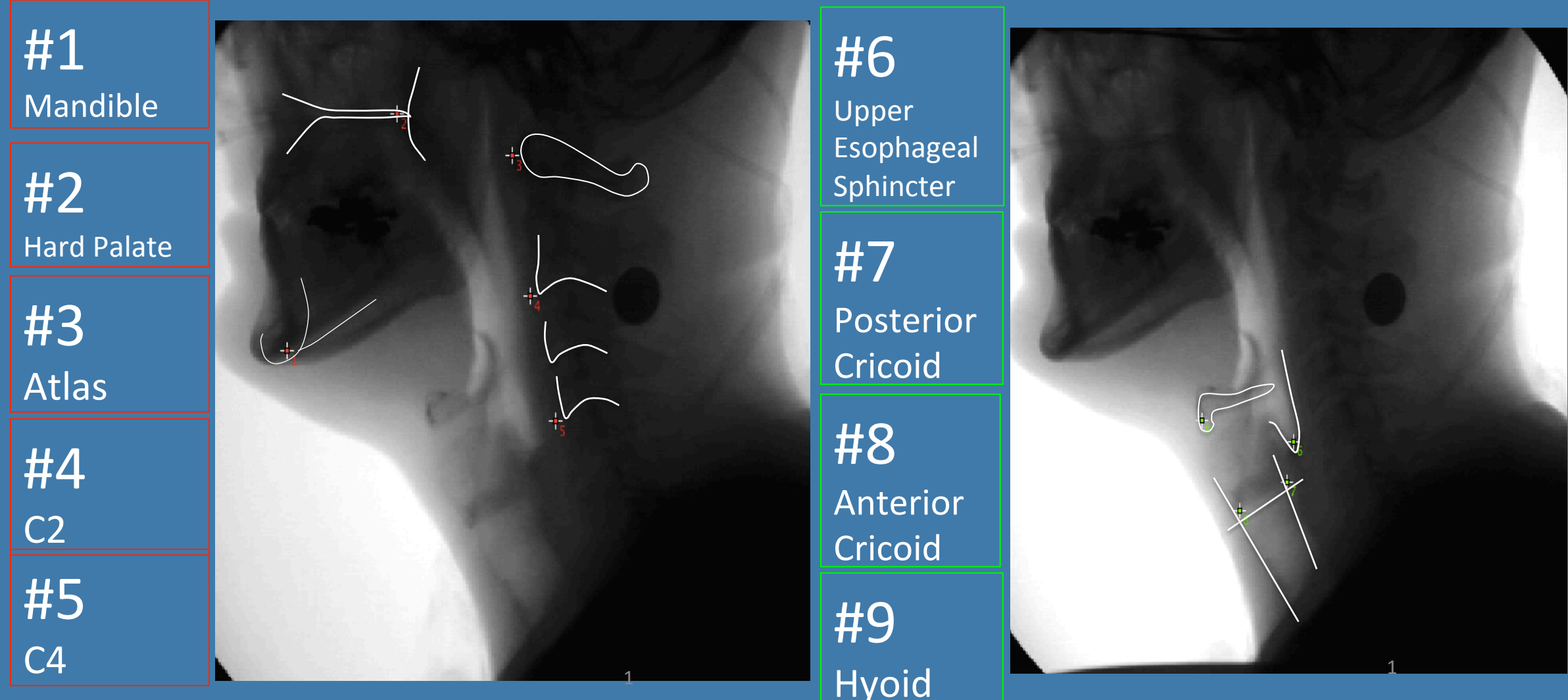


Figure 3: Coordinates on MBSS

## DISCUSSION

This study shows the application of this novel analysis method to answer the important questions of post operative swallowing changes and the post operative changes in tissue dynamics. Findings in this small cohort are consistent with the postoperative goal of necessary tightening to avoid soft tissue collapse after surgery. In future studies, we will expand our patient population and obtain MBSS at both preoperative and postoperative time periods. With both sets of data we will be able to determine if these observed changes are due to surgical intervention or is it the underlying morphology of OSA patients. Also, it may help develop a metric to measure effectiveness of OSA surgery. We hope to use this information for further understanding of patient swallowing outcomes, use for patient counseling and help customize speech therapy. Additionally, this analysis method could be applied to other head and neck procedures, as well as post radiation patients.

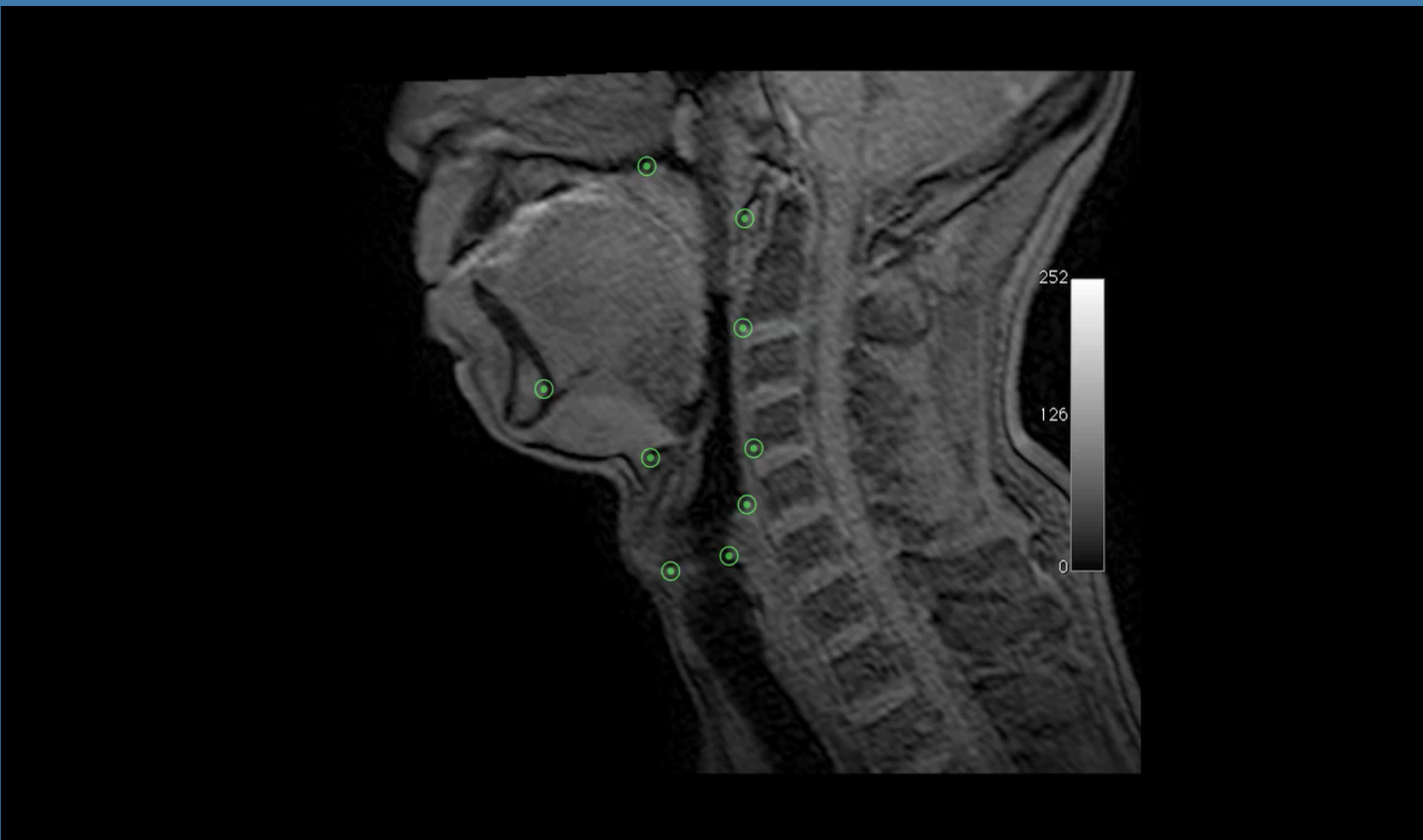


Figure 4: Coordinates on MRI

## CONCLUSIONS

Tongue base retraction and reduced pharyngeal shortening was noted in this small cohort of patients. These observations are consistent with the postoperative goal of necessary tightening in these areas to avoid collapse. Future controlled studies should be performed to determine whether these changes in swallowing mechanics are specific to surgical interventions or the underlying morphology of OSA patients. This method could potentially be utilized to quantify the effectiveness of sleep surgical techniques.

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