# Mandibular Osteotomy for expanded Transoral Robotic Surgery (MOTORS): A Novel Technique

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## Introduction

**Introduction**
Transoral Robotic Surgery (TORS) has revolutionized the treatment of head and neck cancer, specifically for malignant lesions of the oropharyngeal region. Recent studies have shown that this approach is a safe procedure and can provide favorable clinical and functional outcomes with respect to traditional approaches. These investigations have noted several advantages relative to traditional transmandibular approaches which include faster recovery of swallowing and vocal function, decreased need for reconstruction, decreased incidence in aspiration pneumonia and decreased length of hospitalization.[1,2]

Current TORS applications in the head and neck include lesions of the laryngopharyngeal subsites including the base of tongue, tonsillar fossa, palate, posterior pharynx and epiglottis. However, a small minority of patients that present with these lesions may not be TORS candidates due to anatomic constraints related to previous therapy or anatomic factors. Patients with anatomic features such as a retrognathic mandible, macroglossia, and small oral aperture limit the ability to provide an adequate surgical port to introduce the endoscopic arm and two instrument arms. Additionally, patients with a history of adjuvant radiotherapy often have resulting cervical fibrosis and treatment related trismus. Recent literature has demonstrated that salvage surgery with TORS for recurrent oropharynx tumors versus open surgery has superior outcomes with respect to function, morbidity and operative time.[3] Despite transoral surgery being the favored salvage option, some patients are unable to undergo transoral procedures due to limited access. In these patients, the ability to gain appropriate exposure to the lesion often dictates which patients can undergo TORS/TLMS (transoral laser microsurgery), rather than oncologic considerations alone. Sub-optimal exposure leads to increased operative times, greater risk of surgical complications, and the possibility of inadequate surgical resection margins.

We propose a modified TORS approach in which transoral mandibular osteotomies are performed that can greatly improve exposure to oropharyngeal subsites and expand access to the larynx in selected patients. This technique takes advantage of transoral mandibular osteomy to improve surgical access without the increased morbidity of transmandibular or transfacial approaches, which would be required in many patients with inadequate access for TORS. In addition, due to similar anatomic constraints our technique can applied to any transoral surgery requiring increased access such as in the case of TORS or TLMS. This investigation is designed to test the hypothesis that mandibular osteotomies can expand access to the oral cavity, oropharynx, hypopharynx, and supraglottis.

## Methods

Five fresh cadaveric specimens were employed in the study. All measurements were collected in a standard database format (Microsoft Excel: Microsoft Inc. Redmond, WA)

Age, height, weight, sex and maximal incisor opening are depicted in Table 1. Pre-osteotomy measurements were then performed as outlined below. Maximal incisal opening was measured as the inter-incisal distance at maximal mouth opening. Specimens were placed on standard operating room tables and placed in the surgical position with cervical flexion an atlanto-occipital extension; a shoulder roll was not employed. Sutures were passed through the anterior tongue to allow traction of the tongue during placement of the retractor. The Feyh-Kastenbauer (FK) retractor (Gyrus ACMI, Southborough, Massachusetts) was then placed in the standard fashion for TORS. The retractor was then deployed to its maximal opening in the craniocaudal and transverse dimensions with the standard blades and cheek retractors. Measurements were then taken of the distance and the horizontal distance of the FK Retractor aperture opening. After these baseline measurements extraoral digital photographs were taken at a fixed focal length to allow 1:1 reproducibility and comparison after osteotomy.

Spinal Needles were placed to approximate the superior and inferior angles of the surgical approach in the sagittal plane. An operative C-arm (OED Series 9600, General Electric, CT) was then placed at a standardized distance from the operative table and lateral radiographs were taken. The C-arm and operative table were locked into place in order to provide accurate lateral radiographs and prevent magnification error.

Pre- and post intervention pharyngeal volume was approximated using acoustic pharyngometry. In addition to nasal cavity and nasopharyngeal volume assessment, this tool has been used by sleep apnea clinicians to assess the geometry and volume of the oropharyngeal cavity.[4,5] The device emits an acoustic signal and measures the reflection to determine volume.

## References

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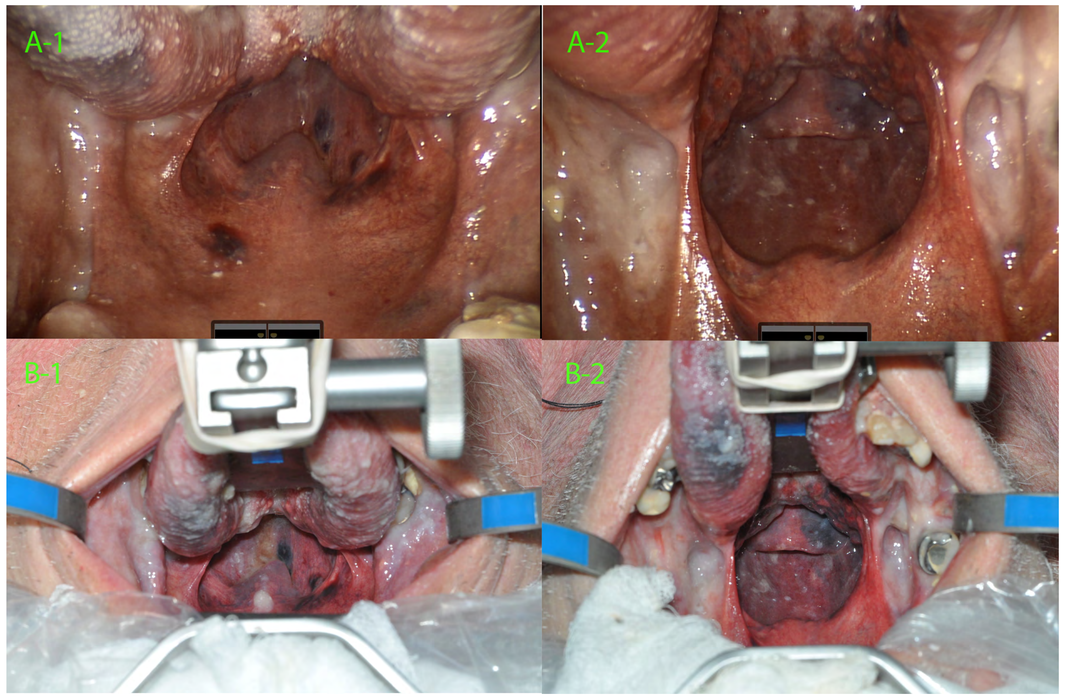


**Figure 1** Representative photographs of subject 4 with a very limited mouth opening. Plate **A-1** captured image using the 0 degree telescope of patient 2 with the retractor in place prior to mandibulotomy, Plate **A-2** is the captured image following mandibulotomy. Plate **B -1** is a image taken using a digital camera prior to mandibulotomy and **B-2** is the picture taken following mandibulotomy.

| Measurements Prior To Osteotomy | | | |
|---|---|---|---|
| Subject | Cranciocaudal(mm) | Transverse (mm) | Pharyngometer Mean |
| 1 | 37 | 75 | 98.7 |
| 2 | 55 | 77 | 122 |
| 3 | 37 | 82 | 105.7 |
| 4 | 33 | 68 | 115.3 |
| 5 | 35 | 70 | 119.3 |
| Mean | 39.4 | 74.4 | 112.2 |
| **Measurements Following Osteotomy** | | | |
| Subject | Craniocaudal (mm) | Transverse (mm) | Pharyngometer Mean |
| 1 | 55 | 84 | 146 |
| 2 | 70 | 70 | 141.6 |
| 3 | 56 | 76 | 126 |
| 4 | 49 | 60 | 127 |
| 5 | 55 | 72 | 129 |
| Mean | 57 | 72.4 | 133.92 |

**Table 1** anatomical measurements before and after osteotomy, pharyngometer measurements before and after osteotomy, calculated mean values.

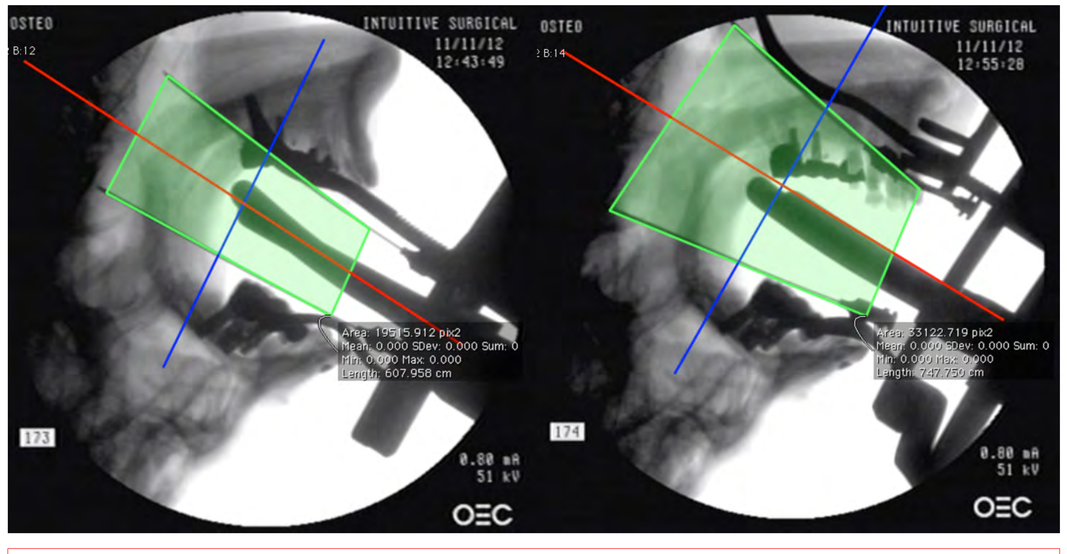


**Figure 2** The representative lateral cephalograms taken prior to midline mandibulotomy with retractor in place and after the mandibulotomy was performed. The green shaded area represents the area between the retractors and the optical working cavity provided by the retraction.

## Surgical Technique

After the baseline measurements were taken the specimens were then sequentially modified by a transoral midline mandibulotomy. No external incisions are used with this technique. A midline mucosal incision was performed and mucoperiosteal dissection exposed the mandibular symphysis sufficiently for osteotomy. Reflection of the lingual mucoperiosteum exposed the lingual surface of the mandible to prevent damage to the lingual tissues and submandibular ducts. Pre-adaptation of titanium plates in an appropriate fixation scheme was performed prior to osteotomy. A reciprocating saw with a thin osteotomy blade was then used to make a midline mandibular osteotomy from the inferior border thru the alveolar segment between the central incisors. See Figure 1. (artist rendition of procedure) After performing the mandibular osteotomy the FK retractor was replaced and maximally deployed as previously stated above. Post-osteotomy measurements were then performed as outlined in the above protocol. (Figure 1-A and Figure 1-B)

## Discussion

This preliminary investigation represents the first application of transoral mandibular osteotomies to increase the exposure for TORS. In patients who would be candidates for TORS from an oncologic standpoint, but have limited surgical access related to anatomical variations or previous therapy, MOTORS offers significant additional surgical access without the additional morbidity of transmandibular/transfacial approaches. Coupling these techniques with TORS surgery may offer an excellent alternative approach to patients who would not otherwise be candidates for TORS. When comparing the visualization with standard TORS approach to the MOTORS technique in cadavers all subjects exhibited a dramatic increase in exposure of the epiglottis, hypopharynx and base of tongue. Midline mandibular osteotomy with separation creates improved access via a two-fold mechanism. Firstly, the bulk of the tongue musculature is retracted into the space created when the mandible is separated. In addition the mandible is allowed to splay laterally about the condylar axis. The result is an expanded optical cavity posteriorly as well as anterior displacement of the base of tongue and epiglottis creating improved surgical access. The lateral radiographs reveal the expansion of the optical working cavity. The additional caudal and anterior retraction of the tongue allows this area to placed “on-stretch” to optimize both visualization of tumor and augment surgical dissection with increased tissue traction.

The feasibility of transoral robotic supraglottic laryngectomy has been assessed by several groups and one center has shown that it can be performed safely with appropriate surgical margins and excellent functional outcomes.[6] However, each group has commented that inadequate transoral exposure as the critical point in performing the procedure. The MOTORS approach reduces this technical challenge by increasing anterior and caudal retraction of the tongue. Displacement of the bulk of the oral tongue into the space created by the midline mandibular osteotomy offers significant increase in the volume of the hypopharyngeal optical cavity and visualization of the base of tongue and hypopharyngeal region. By optimizing the angle of attack and working cavity of the current instrumentation surgical resection at the hypopharynx and larynx would be significantly augmented.

The obvious argument against the MOTORS approach is the added morbidity of the midline mandibulotomy, which is somewhat counterintuitive to a minimally invasive surgical technique such as TORS. It should be noted however that several investigations evaluating transmandibular approaches, which include midline mandibulotomy with a lip splitting incision and floor of mouth division with mylohyoid myotomy have shown that this is a safe, reliable technique associated with few complications mainly related to local wound healing.[7,8] We recommend use of a thin osteotomy blade with the surgical reciprocating saw for the mandibular osteotomy, and a thin osteotome for interdental separation after scoring the outer alveolar cortex. When performed appropriately this will ensure minimal bone loss, decrease incidence of injury to the dentition. In addition, meticulous soft tissue management with appropriate incision designs, which are not coincident to the location of the osteotomy, can minimize complications.

In-vivo, this procedure would add an estimated 30 minutes to the procedure to include the osteotomy and rigid fixation performed using mini-plates or lag screw techniques. Fixation of the mandible with a single titanium plate at the inferior border has been a proven method to repair the osteotomy and does not require intermaxillary or maxillomandibular fixation.[9]