Anatomically Directed Mandibular Osteotomy in Obstructive Sleep Apnea

Joshua S. Park, MD[1]; Christopher Lee, BS[1]; Jason M. Rogers, DDS;[1] Ho-Hyun Sun, MS[2]; Jared C. Inman, MD[1]
[1]Loma Linda University Health System, [2]Western University of Health Sciences

Abstract

Objective: To provide precise measurements that enhance knowledge of mandibular anatomy and to introduce a modified osteotomy for genial advancement surgery in obstructive sleep apnea (OSA) patients.

Study Design: Cone-beam computed tomography (CBCT) analysis.

Methods: CBCT measurements of positions of mental foramina, canines, lateral incisors, central incisors, and genial tubercles in 33 individuals.

Results: Mean horizontal distances from midline to mental foramen and the roots of the canine, lateral incisor, and central incisor were 22.11 ± 1.92 mm, 13.56 ± 3.01 mm, 6.19 ± 1.58 mm, and 2.04 ± 0.87 mm, respectively. Mean vertical distances from the inferior border of the mandible were 15.15 ± 1.77 mm, 17.11 ± 3.28 mm, 20.48 ± 3.10 mm, and 21.81 ± 3.49 mm, respectively. The superiormost aspect of the genial tubercle was 15.63 ± 2.75 mm from the inferior mandible. The angle of the best fit line was 18.14 ± 8.44 degrees on the right and 17.65 ± 7.60 degrees on the left. A parallel osteotomy placed 5 mm below this line would violate 8.7% of teeth and mental foramina, while capturing the entire genial tubercle in 22/33 (66.7%) individuals.

Conclusion: Our proposed osteotomy design achieves a safe, effective, and aesthetically pleasing surgical result for patients with OSA. Preoperative CBCT measurements may aid the design of an individualized osteotomy that maximizes capture of the mandibular musculature and protection of nearby structures.

Introduction

Surgical advancement of the mandible has proven to decrease the severity of obstructive sleep apnea (OSA)[1]. Several osteotomies, including rectangle,[2] circular,[3] and mortised[4] designs, have been proposed. Most genial advancement procedures target only the genioglossus, which originates from the superior genial tubercle of the mandible. However, advancement of two other anteriorly attached mandibular muscles, the geniohyoid and digastric, may provide additional benefit to OSA patients. We present a modified osteotomy design based on the anatomic structures and relationships of the anterior mandible, which include the genial tubercle, mental foramen, and central incisor, lateral incisor, and canine tooth roots.

Methods and Materials

Cone-beam computed tomography (CBCT) of 33 individuals was used in order to obtain the following bilateral measurements: mental foramen (MF) to the inferior border of the mandible (IBM), MF to mandibular midline, canine tooth root (C) to IBM, C to midline, lateral incisor tooth root (LI) to IBM, LI to midline, central incisor tooth root (CI) to IBM, CI to midline, and superior- and inferiormost aspects of the genial tubercle to IBM. These data points were used to determine the slope, which was used to calculate the angle of incline via the inverse tangent. Best fit lines were used to calculate the y-intercept. Parallel lines placed 2.5, 5, 7.5, and 10 mm below the best fit line were created to imitate potential osteotomy placement.

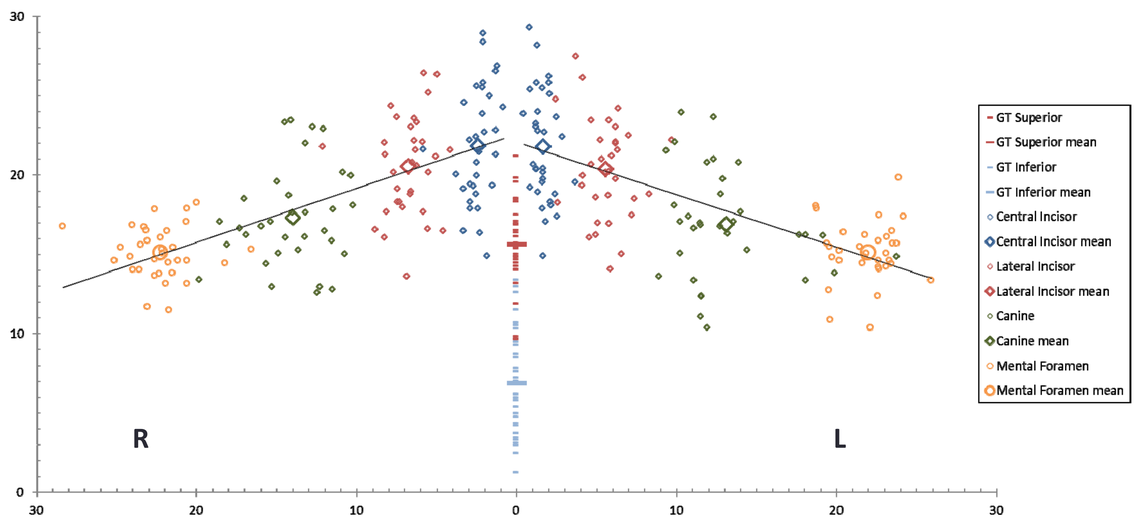

Figure 1. Scatterplot of data points with line of best fit.

Results

Combined (both left and right) mean distances from IBM to MF, C, LI, and CI were 15.15 ± 1.77 mm, 17.11 ± 3.28 mm, 20.48 ± 3.10 mm, and 21.81 ± 3.49 mm, respectively. Combined distances from the mandibular midline to MF, C, LI, and CI were 22.11 ± 1.92 mm, 13.56 ± 3.01 mm, 6.19 ± 1.58 mm, and 2.04 ± 0.87 mm, respectively. Individual data points are presented in **Figure 1**. The mean slope from all data points on the right (MF-C-LI-CI) was 0.34 ± 0.17, compared to 0.32 ± 0.15 on the left (p= 0.614). This yielded an angle of inclination of 18.14 ± 8.44 degrees on the right, and 17.65 ± 7.60 degrees on the left (p= 0.805). The y-intercept of the right MF-C-LI-CI line, representing the midline, was 22.60 ± 3.81 mm, compared to 22.30 ± 3.61 mm on the left (p= 0.744). Parallel lines placed 2.5, 5, 7.5, and 10 mm below the best fit line of the mean revealed the location of tooth roots, MF, and genial tubercle in relation to each proposed osteotomy (**Table 1**).

Osteotomy Location (mm)	> 5 mm	3-5 mm	1-3 mm	< 1 mm	GT_I captured	GT_S captured
2.5	54 (20.5%)	55 (20.8%)	74 (28.0%)	81 (30.7%)	33 (100%)	30 (90.9%)
5	134 (50.8%)	48 (18.2%)	59 (22.3%)	23 (8.7%)	33 (100%)	22 (66.7%)
7.5	216 (81.8%)	30 (11.4%)	13 (4.9%)	5 (1.9%)	33 (100%)	7 (21.2%)
10	252 (95.5%)	9 (3.4%)	3 (1.1%)	0 (0%)	30 (90.9%)	2 (6.1%)

Table 1. Tooth root and mental foramen location in relation to each potential osteotomy location (2.5, 5, 7.5, 10 mm below mean). Abbreviations: GT_I, genial tubercle inferior; GT_S, genial tubercle superior

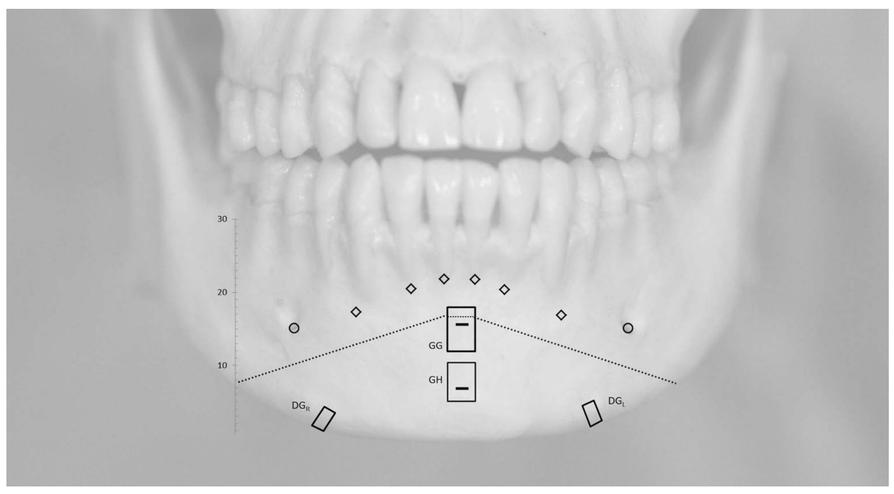

Figure 2. Proposed osteotomy design. Abbreviations: GG, genioglossus; GH, geniohyoid; DG_L, left digastric; DG_R, right digastric. The two horizontal lines at midline represent mean superior and inferior genial tubercle.

Discussion

The geniohyoid and anterior belly of the digastric have not garnered as much interest in sleep surgery literature and clinical practice as the genioglossus even though they also attach to the anterior mandible. Literature and our unpublished cadaveric research indicate that advancing these muscles may benefit OSA patients.[5,6] Therefore, our osteotomy design, shown in **Figure 2**, extends to the inferior border of the mandible to capture the genioglossus and geniohyoid medially and angles outward in order to include the digastric attachment. Previous studies suggest that the mandibular osteotomy be at least 5 mm from both the mental foramen and tooth roots.[7,8] However, our study indicates that it is often not possible to leave > 5 mm distance inferior to tooth roots while capturing the entire genial tubercle.

The angle of the best fit line for our data was about 18 degrees on each side. However, this is not a universal recommendation for these patients. A greater angle will potentially put more tooth roots at risk but aid in capture of the genial tubercle. Likewise, an osteotomy placed lower will protect more structures but be less likely to capture the superiormost aspect of the genial tubercle. Therefore, thorough preoperative evaluation with CBCT may help design the safest and most effective osteotomy for individual patients.

Conclusions

This study provides precise anatomic measurements and introduces an anatomically directed, safe, and effective osteotomy design that achieves the benefits of an aesthetically pleasing monobloc genioglossal advancement and geniohyoid and digastric muscle suspensions for patients with OSA.

Contact

Joshua S. Park, MD
Loma Linda University Medical Center
Email: jospark@llu.edu
Phone: (909) 558-8558

References

1. Riley RW, Powell NB, Guilleminault C. Obstructive sleep apnea syndrome: a review of 306 consecutively treated surgical patients. Otolaryngol Head Neck Surg 1993; 108: 117-125.
2. Powell NB, Riley RW, Guilleminault C. Maxillofacial surgical techniques for hypopharyngeal obstruction in osbstructive sleep apnea. Op Tech Otolaryngol Head Neck Surg 1991; 2:112-118.
3. Mintz SM, Ettinger AC, Geist JR, Geist RY. A modified geniotomy technique for obstructive sleep apnea syndrome. J Oral Maxillofac Surg 1995; 53:1226-1228.
4. Silverstein K, Costello BJ, Giannakpoulos H, Hendler B. Genioglossus muscle attachments: an anatomic analysis and the implications for genioglossus advancement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000; 90:686-688.
5. Den Herder C, van Tinteren H, de Vries N. Hyoidthyroidpexia: a surgical treatment for sleep apnea syndrome. Laryngoscope 2005; 115:740-745.
6. Song SA, Wei JM, Buttram J, et al. Hyoid surgery alone for obstructive sleep apnea: a systematic review and meta-analysis. Laryngoscope 2016; Epub ahead of print.
7. Pommer B, Tepper G, Gahleitner A, Zechner W, Watzek G. New safety margins for chin bone harvesting based on the course of the mandibular incisive canal in CT. Clin Oral Implants Res 2008; 19:1312-1316.
8. Vu DD, Brockhoff HC, Yates DM, Finn R, Phillips C. Course of the mandibular incisive canal and its impact on harvesting symphysis bone grafts. J Oral Maxillofac Surg 2015; 73:258.e1-258.e12.