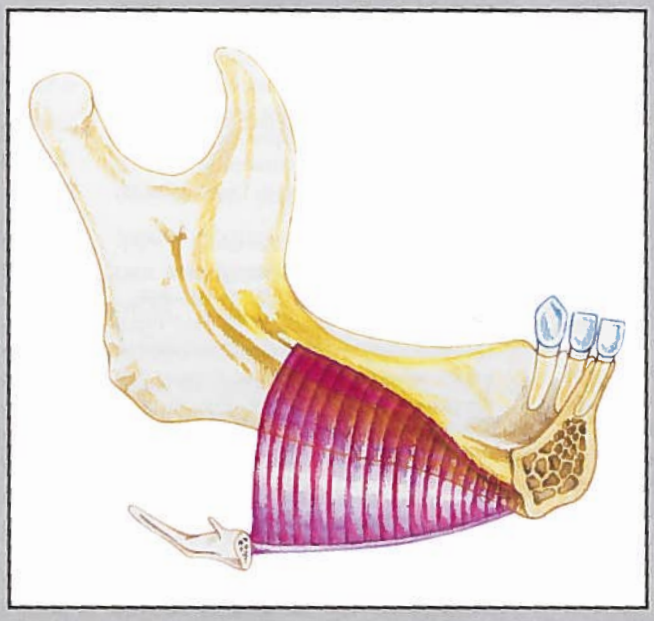

Effectiveness of Two Different Lingual Flap Advancing Techniques for Vertical Bone Augmentation in the Posterior Mandible: A Comparative, Split-Mouth Cadaver Study

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Vertical ridge augmentation in the posterior mandible is a technique-sensitive procedure that requires adequate anatomical knowledge and precise surgical skills to minimize the risk of complications. One of the most important but also challenging aspects of the surgical technique is proper flap management to allow for passive flap closure and reduce the chances of postoperative complications affecting deep anatomical spaces. This article presents a detailed description of a novel lingual flap advancement technique and its validation via a split-mouth, comparative study using a cadaver model. A total of 12 fresh cadaver heads presenting bilateral posterior mandibular edentulism were selected. Sides were randomized to receive a classic lingual flap release technique (control) or the modified technique presented here, which involves the intentional preservation of the mylohyoid muscle attachment to the mandible. Vertical flap release was measured at three different zones using standard forces. The mean difference between the test and control group in zones I (retromolar pad area), II (middle area), and III (premolar area) was 8.273 ± 1.794 mm (standard error of the mean [SEM] = 0.5409 mm), 10.09 ± 2.948 mm (SEM = 0.8889 mm), and 10.273 ± 2.936 mm (SEM = 0.8851 mm), respectively, reaching very strong statistical significance (P <.0001) in all three zones. Int J Periodontics Restorative Dent 2018;38:35–40. doi: 10.11607/prd.3227

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Successful and predictable management of complex clinical scenarios to facilitate prosthetic-driven implant placement via vertical bone augmentation in severely resorbed edentulous ridges requires profound anatomical knowledge, understanding of essential biologic principles, and refined surgical skills. Understanding the implications of local anatomical structures respective to the planned surgical technique and the possible challenges and complications that may arise intra- and postoperatively is fundamental.[1]

Vertical ridge augmentation in the posterior mandible remains a technique-sensitive procedure associated with increased risk of damage to key anatomical structures, such as the lingual nerve, the sublingual artery, and the Wharton's duct.[2–5] To properly achieve primary closure, minimize the occurrence of complications, and maximize long-term regenerative outcomes, adequate flap release of the buccal and lingual flaps is required.[6,7] In recent years, different flap management techniques for bone augmentation in the posterior mandible have been proposed in the literature. However, the evidence is limited to technical descriptions and case series studies.[8,9] Additionally, these classic techniques present limitations associated with complete[8] or partial[9] detachment of the mandibular insertion of

the mylohyoid muscle, which may lead to serious postoperative complications. Hence, one purpose of this article is to describe a more conservative and predictable approach consisting of the advancement of the lingual flap via blunt preparation in three different anteroposterior zones while preserving the entire mylohyoid muscle attachment.

No comparative, controlled studies have investigated the amount of soft tissue release that may be achieved by applying different flap-releasing techniques in the posterior mandible. Hence, this comparative, split-mouth cadaver study was primarily aimed at evaluating the effectiveness, in terms of extent of lingual flap release, of the novel nondetaching technique to the classic muscle-detaching technique on fresh human cadaver heads. It was hypothesized that the novel technique is less invasive, is safer, and leads to more extensive flap release without the need to detach the mylohyoid muscle.

Materials and Methods

Sample and Randomization

This study was conducted at the Institute of Anatomy of the Medical University of Vienna. Ethical approval to conduct the study was obtained from this same institution. A total of 12 fresh human cadaver heads missing all posterior mandibular teeth bilaterally and with comparable extents of alveolar ridge resorption were selected. In this split-mouth study, the surgical technique corresponding to each side was randomly assigned with a coin toss. All surgical procedures were performed by the same surgeon (IU) under the same environmental conditions to control for technical consistency.

Flap Management Technique

The control technique consisted of the classic mylohyoid release approach, as described elsewhere.[8,9] The test side received the mylohyoid preservation technique, which considers three key anatomical zones (Fig 1) and follows a prescribed sequence.

Tunneling and Lifting of the Retromolar Pad: Zone I

Following a straight supracrestal incision within the keratinized mucosa, the facial and lingual flap are carefully elevated. A periosteal instrument is used to gently reflect the retromolar pad (RP) from the bone and then pull it up in a coronal direction. Since this tissue tends to be very elastic and resistant, this step is relatively easy. This allows for the incorporation of the RP into the lingual flap (Fig 2a), which maximizes flap release and reduces the risk of perforation when working on zones II and III.

Flap Separation with Mylohyoid Muscle Preservation: Zone II

After visual identification of the mylohyoid muscle insertion, the soft tissue superior to the muscle is gently pushed with blunt instruments in a lingual direction (Fig 2b). This way, the flap can be separated from the superior fibers of the muscle in a minimally invasive fashion, without detachment of the muscular insertion.

Anterior, Semiblunt Periosteal Release: Zone III

At the premolar region, where the mylohyoid muscle is attached deep in the mandible, flap reflection should be no deeper than in zone II. A semiblunt periosteal incision is performed with a no. 15 blade at a rotated perpendicular angle, using a sweeping motion (zone III) toward the middle zone (zone II). This maneuver provides flexibility to zone III and helps in preventing postoperative wound dehiscences, which typically occur if flap management is not adequate (Fig 2c). If adequately performed, this technique typically allows for sufficient flap release to achieve passive primary closure (Fig 2d).

Outcome Measurements

The amount of vertical flap release was measured bilaterally at zones I, II, and III from the alveolar crest to the margin of the lingual flap at two different timepoints: after initial flap elevation but before flap advancement maneuvers were initiated (baseline), and after flap release was completed (final). At baseline on both sides, the lingual flap was stretched until it reached its maximum passive stretch using a high-precision force gauge (SN-20 Series Force Gauge, Sundoo Instruments) connected to a straight

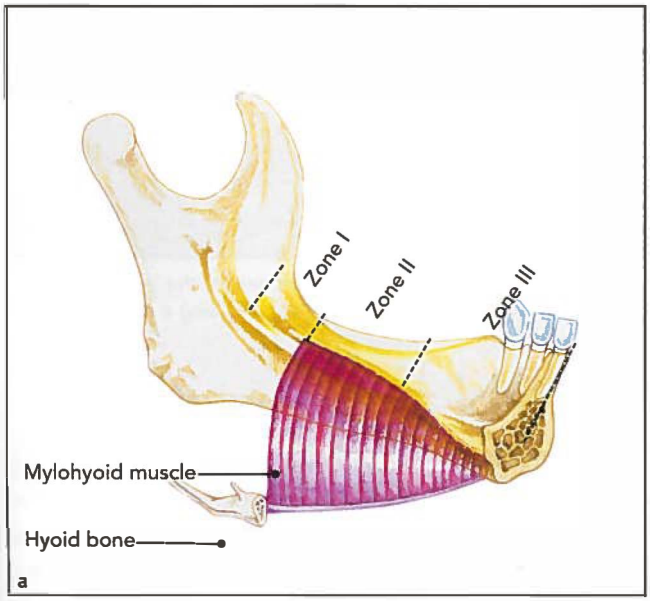


Fig 1 *Illustration* (a) *and photograph* (b) *showing the anatomy of the typical insertion of the mylohyoid muscle on the internal aspect of the mandibular body and the location of zones I, II, and III.*

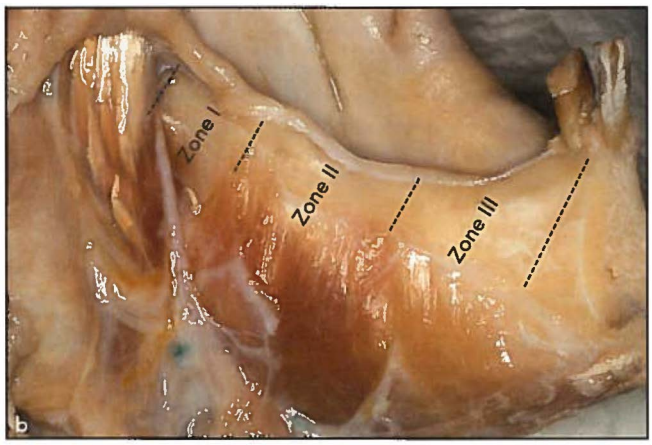
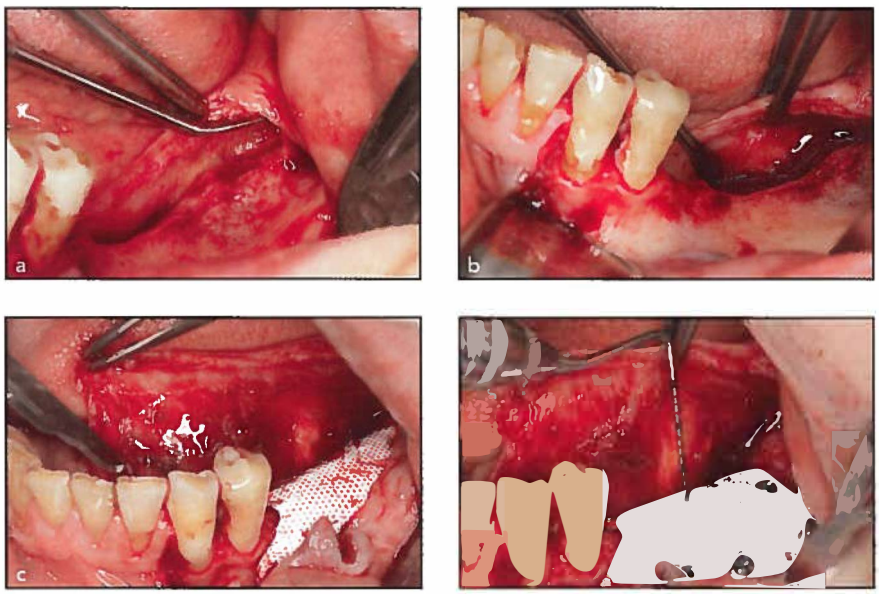


Fig 2 (a) *Elevation of the retromolar pad (zone I).* (b) *Careful elevation of the soft tissue located above the superior fibers of the mylohyoid muscle using a blunt instrument (zone II).* (c) *Semiblunt periosteal release using the back end of a number 15C blade on the anterior area of the flap (zone III).* (d) *Demonstration of vertical flap release (~20 mm).*



mosquito forceps, as illustrated in Fig 3. The force was applied in a vertical direction following a perpendicular vector respective to the floor of the mouth. The same standard force was applied to stretch the flap after complete release was achieved to maintain consistency between the baseline and final measurements at each surgical site. The standard force ranged from 1 to 1.2 N, depending on the inherent elastic properties of each specimen. Two previously trained and calibrated examiners (B.B. and I.U.) performed all the measurements in duplicate using a surgical probe scaled at intervals of 1 mm (Fig 4). When an agreement was not reached, independent measurements from both examiners were

Fig 3 *Force gauge connected to straight mosquito forceps to pull the released flap in a perpendicular direction respective to the floor of the mouth. Notice the applied force of ~1.1 N.*

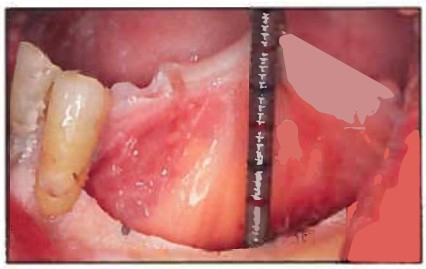


Fig 4 *Measurement of the amount of vertical flap release using a calibrated probe.*

Table 1 Shapiro-Wilk Normality Test of the Study Data

	Zone I		Zone II		Zone III	
	Control	Test	Control	Test	Control	Test
Values (n)	11	11	11	11	11	11
W	0.8634	0.8969	0.9400	0.9342	0.8755	0.9203
P	.0637	.1694	.5200	.4552	.0911	.3209
Passed normality test?	Yes	Yes	Yes	Yes	Yes	Yes

averaged and rounded up to the nearest millimeter. The mean values of all duplicate measurements were used for statistical analysis.

Statistical Analyses

The differences between measurements per zone, expressed in millimeters, and the percentage of change between baseline and final flap advancement between the two techniques were calculated. Shapiro-Wilk normality test was performed to assess whether there was normality in the data set for both groups. Paired *t* test was performed to calculate flap release differences between the two surgical techniques per region, with the significance at $\alpha = .05$.

Results

Specimen 3 suffered a flap tear on the control side at the time of establishing the baseline standard force, which prevented a fair comparison with the test side. Therefore, the data from this specimen were excluded from the analyses, resulting in a final sample of 11 heads and 22 surgical sites (11 test and 11 control). All the remaining data passed the normality test (Shapiro-Wilk) with $P > .05$ (Table 1).

The difference between the test and control group in zones I (RP area), II (middle area), and III (premolar area) was 8.273 ± 1.794 mm (standard error of the mean [SEM] = 0.5409 mm), 10.09 ± 2.948 mm (SEM = 0.8889 mm), and 10.273 ± 2.936 mm (SEM = 0.8851 mm), respectively, reaching very strong statistical significance ($P < .0001$) in all of them (Table 2 and Fig 5). In proportional terms relative to the control, the test technique allowed for 8.2, 2.5, and 5.3 times more flap release in zones I, II, and III, respectively.

Discussion

In this comparative, split-mouth cadaver study, a novel technique (test) for the advancement of the lingual flap in posterior mandibular sites was found to be more effective than a classic flap management approach (control). The mean differences between techniques in terms of flap release were overwhelmingly in favor of the test, regardless of the anatomical zone, ranging from 8.273 to 10.273 mm (Table 2). Although the mean difference in release between groups in zone I (8.273 mm) was inferior to that observed in zones II (10.09 mm) and III (10.273 mm), that difference was proportionally far superior since the flap was released 8.2 times more in zone I, while in zones II and III the difference was 2.5 and 5.3, respectively.

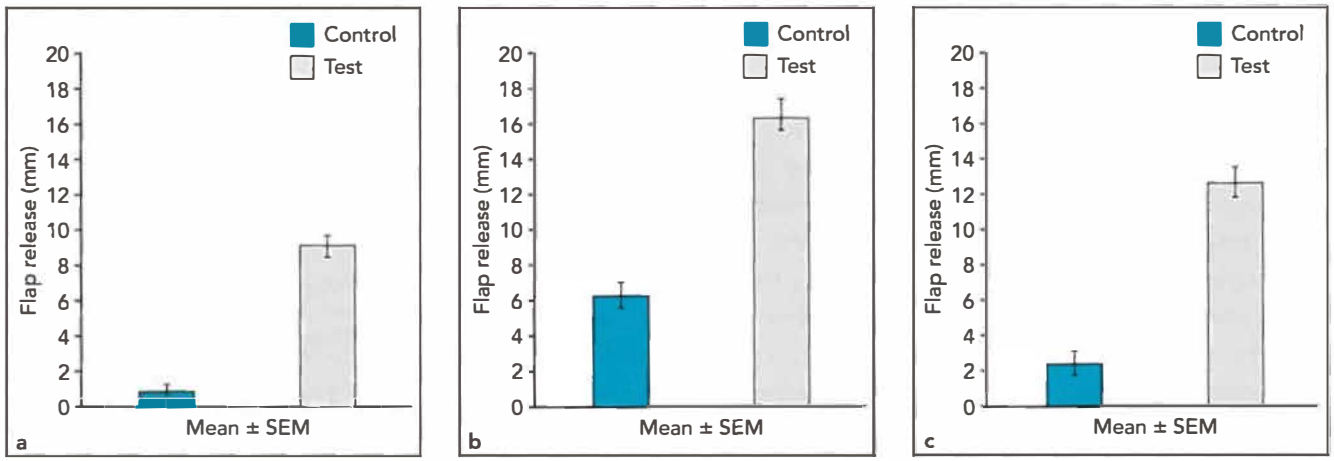


Fig 5 *The mean and standard error of the mean for each group in zones I* (a), *II* (b), *and III* (c).

Unfortunately, it is not possible to contrast the present results with others since no other study involving a similar design and outcome measures was identified, leading the present authors to believe that this is the first study of its kind available in the literature.

Deliberate preservation of the mylohyoid muscle attachment to the body of the mandible in the present modified technique is intended to prevent the incidence of serious complications. As mentioned earlier, classic techniques involve either complete[8] or partial[9] detachment of the mylohyoid muscle from its mandibular insertion at the mylohyoid ridge. Complete detachment, however, may lead to disruption of the diaphragm of the floor of the mouth and may subsequently create a communication between the surgical area and the sublingual and/or submandibular space, which could trigger a severe medical complication in case of a postoperative infection. Partial reflection of the mylohyoid from the internal part of the flap may result in excessive thinning of the central aspect of the flap when attempting primary closure, as well as possible exposure of the graft to the oral environment in the early stages of

Table 2 Flap Release Data (in mm) from Baseline to Final Flap Advancement for Each Zone on the Control and Test Sites

	Zone I		Zone II		Zone III	
Specimen	Control	Test	Control	Test	Control	Test
1	1	12	5	14	1	13
2	3	10	8	17	2	18
4	2	10	11	18	2	16
5	0	6	6	19	0	10
6	0	8	8	12	1	10
7	0	7	2	12	0	11
8	1	12	9	20	3	14
9	1	10	5	17	4	10
10	2	12	6	17	6	14
11	0	8	5	20	1	9
12	1	7	5	15	6	14
Mean	1	9.272	6.363	16.45	2.363	12.636
SD	1	2.195	2.46	2.876	2.157	2.873
SEM	0.301	0.661	0.741	0.867	0.65	0.866
Difference	8.273		10.09		10.273	
P	< .0001		< .0001		< .0001	

Zero values in the control group denote no change in flap release from baseline to final advancement.

healing. Additionally, these techniques primarily advocate for the advancement of the middle portion of the flap, without the inclusion of zones I and III. This classic approach is generally not conducive to passive primary closure, particularly in the anterior area (zone III), because unless there is severe ridge atrophy, the mylohyoid muscle insertion tends to be deeper respective to the alveolar ridge crest.

The present study is not exempt from limitations. For example, the examiners were not blinded to the technique applied on each surgical site. However, an attempt was made to control the reliability and reproducibility of the measurements by applying the same tensile force to the lingual flap on both control and test sites within the same specimen, and the same scaled probe was used for all the flap release assessments. Measurements were obtained in duplicate to minimize the error, and the same experienced surgeon performed all the procedures to ensure technical consistency. Another potential limitation is that although the specimens were carefully selected to include sites that were comparable between sides, posterior atrophic mandibular ridges rarely present a flat architecture and perfect symmetry. These anatomical variations may have influenced the measurements. However, the primary outcome in this study was the relative difference in flap release from the crest (fiduciary landmark) to the margin of the flap, both at baseline and after complete flap advancement. To increase reproducibility, the point of reference on the ridge crest was marked with a surgical pen (as displayed in Fig 4) so the final measurement could be made from the same reference. For this reason, the authors believe the results should not be largely affected by possible anatomical discrepancies between the control and the test sites.

Conclusions

In light of the findings from this study, the novel approach for lingual flap advancement in the posterior mandible described here is associated with two major advantages: increased chance of achieving passive primary stability and avoiding premature wound dehiscences, and decreased risk of a medical complication involving deeper anatomical spaces (ie, sublingual or submandibular) due to the intentional preservation of the mylohyoid muscle attachment to the mandibular bone.

Acknowledgments

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