Correction of Excessive Gingival Display: Lip Repositioning with/without Myotomy

Austin Michael Dodge
Marquette University

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CORRECTION OF EXCESSIVE GINGIVAL DISPLAY: LIP REPOSITIONING WITH/WITHOUT MYOTOMY

by

Austin Dodge, DDS

A Thesis submitted to the Faculty of the Graduate School,
Marquette University,
in Partial Fulfillment of the Requirements for
the Degree of Master of Periodontics

Milwaukee, Wisconsin
May 2021
ABSTRACT
CORRECTION OF EXCESSIVE GINGIVAL DISPLAY: LIP REPOSITIONING WITH/WITHOUT MYOTOMY

Austin Dodge, DDS
Marquette University, 2021

Background: Lip repositioning (LR) is a conservative and reversible surgical method for correcting excessive gingival display (EGD).

Purpose: The study aims to compare two LR techniques. The objectives include 1) comparing the amount of gingival display reduction (GDR) after LR without (Group 1) and with (Group 2) myotomy, stratified in accordance with the etiology of the EGD 2) Comparing the gingival display rebound (GDRB) 3) compare subject satisfaction and morbidity.

Methods: After obtaining IRB approval, 20 human subjects with EGD (measured apical to the CEJ of #9) were randomly allocated for surgery without and with myotomy. Pre-operative, diagnostic information were collected to determine the patient's single or combined EGD etiology. Pre and post-operative measurements (up to 6 months) (gingival display [GD], lip length [LL], and vermillion border length [VB]) were taken with a digital caliper. The primary outcome parameters were the GDR, change in LL, change in VB, and GDRB. Secondary outcomes were assessed with a smile questionnaire and a visual analogue pain scale (VAS).

The obtained data were processed in SPSS (version 25.0) using ANOVA for metric parameters and xyz for scaled parameters. A p-value of < 0.05 was set as to be statistically significant.

Results: Combining both procedures, the results of the primary outcomes showed a total average GDR of 2.63mm (SD = 0.291 mm); a total average decrease in LL of 1.58mm (SD 0.592mm); a total average increase in VB width of 1.1mm (SD = 0.211mm). The differences in GDR and GDRB between the two surgical techniques were statistically significant with the myotomy group showing a greater average GDR and less GDRB. In addition, the differences between the two procedures were statistically significant for patients with degree I & 2 VME, HL, and all 4 etiologies. There were no statistically significant differences in patient satisfaction nor patient morbidity between the two surgical procedures.

Conclusion: LR with and without myotomy are considered treatment options for treating patients with EGD. Our study suggests that performing a myotomy increases the overall GDR achieved, deters GDRB, and improves results in certain etiologies.
ACKNOWLEDGEMENTS

Austin Dodge, DDS

I would like to profusely thank the following people for helping me with this research project (in no particular order): Dr. Mark Brunner for his vision and surgical expertise for this project, and also the many prayers and late nights to reach its conclusion. Dr. Arndt Guentsch for his many insights into how to make this project solid academic research. Dr. Andrew Dentino for his help in writing this manuscript and for helping me get back to see patients amidst a worldwide pandemic. Dr. “Moe” Kassab for his encouragement in difficult times. My co-residents: Laxmi, Keerthi, Kinan, Walaa, Jeff, Geoff, Mori, Juan, and Ajitesh for their advice and comradery during our time in the Graduate Periodontal department. My parents Mark and Kathy Dodge for the many free meals and pep talks to survive 10 years of school, and my wonderful wife Amanda without whom this would never have been finished.
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INTRODUCTION

In recent years the demand for esthetics has increased significantly, driven by increased patient awareness and the search for the ideal smile. Creating the perfect smile is a puzzling process that requires a multidisciplinary tactic and thorough treatment planning (Donitza, 2008). Excess gingival display (EGD) or more commonly known as ‘gummy smile’ is a smile that exposes more than 1.5-2mm of gingiva (Robbins, 1999). This excess display is generally considered to result in an unaesthetic smile. It is estimated that 7% of men and 14% of women suffer gummy smiles (Tjan, 1984).

This condition may be caused by any one of several etiological factors or a may be a result of their combined effect (Robbins, 1999). In general, there are tooth related factors (dentoalveolar discrepancies) and factors related to facial proportion (non-dentoalveolar discrepancies). Tooth related factors are well diagnosed, easily identified and treated. However, those related to facial proportions are not. There is a scarcity of information in the dental literature regarding the classification and ideal treatment for etiologic factors related to facial proportions. In order to fully understand the differences between these two groups of etiologic factors, they will be fully discussed.
Tooth related factors that contribute to EGD include: dentoalveolar extrusion and altered passive eruption (APE). Dentoalveolar extrusion will present with anterior teeth that possess a curved or concave gingival line in relation to the horizon (Robbins, 1999). This condition can affect any teeth in the mouth and can be caused by: teeth supraeruption secondary to incisal wear, supraeruption secondary to lack of opposing teeth, anterior teeth without appropriate opposing contact, or due to a developmental cant. Treatment options for dentoalveolar extrusion include: functional crown lengthening surgery, orthodontic intrusion—via temporary anchorage devices or surgically facilitated orthodontics—and the teeth are then restored at an appropriate incisal edge position. To fully explain the definition of APE, first passive eruption must be defined.

Passive eruption was first described as the biologic process of normal eruption of the developing tooth along the dental lamina (Gottlieb, 1933). Gottlieb and Orban described 4 steps involved in passive eruption (See Figure 2). Passive eruption causes an apical shift in the overall dento-gingival junction until it stabilizes at the cemento-enamel junction (CEJ). This process typically ends around 15 years of age (Morrow L, 2000). In
contrast, APE occurs when the marginal gingiva and dento-gingival junction are coronal to the CEJ; and, instead are mispositioned incisally (Goldman, 1968). Coslet, created an APE classification system that is based off the width of keratinized tissue (Type) and the distance measured from the CEJ to the alveolar crest (A or B) (Coslet, 1977). Type 1 presents with a wide band of keratinized tissue, while Type 2 presents with a narrow band (defined as < 2mm of keratinized tissue). An “A” subcategory indicates a normal distance from the CEJ to the alveolar crest (1.5mm), while a “B” subcategory indicates 0 mm between the CEJ and alveolar crest. This condition results in short clinical crowns, EGD, and CEJ’s that cannot be detected in the sulci. Similar to dentoalveolar extrusion, this condition has a well-established treatment protocol including: treatment by gingivectomy (Type 1 A or in conjunction with ostectomy/apically positioned flap in Type B), an apically positioned flap (Type 1 A or B; Type 2 A), or esthetic crown lengthening surgery (Type 1A,B; Type 2 A,B). Therefore, clearly the tooth related factors demonstrate a well-defined diagnosis and classification system and concise clinical guidelines for treatment.

**Figure 3:** Surgical protocol for APE according to Coslet's classification system (Pulliam, 2009)
Moving to the factors related to facial proportions, these include vertical maxillary excess (VME), a hypermobile lip (HL), a short upper lip (SL), and maxillary/mandibular deficiency. Schendel described VME as “the long face syndrome” in his landmark comparative study of VME with or without an open bite (Schendel, 1976). In the study, 31 Cephalometric tracings of 31 patients were completed in order to characterize VME. VME patients present with a longer lower 1/3rd vertical face height (Lower face height) measurement compared to normal. The lower face height measurement is taken from the base of the nose to the inferior border of the chin. In addition, the following cephalometric measurement trends will be noted: See Figure 4&8

- Excessive Total Face Height (TFH)
- Normal Upper Face Height (UFH)
- Excessive Lower Face Height (LFH)
- Excessive Posterior Face Height (PFH)
Cephalometric Measurements:

- High Mandibular Plane angle (MP-SN)
- Normal Occlusal Plane Angle (OP-SN) *If the patient has an open bite this measurement will be high.
- Normal SNA
- Decreased SNB
- Increased ANB
- Increased Posterior height of the Maxilla (OP-PP)
- Increased Mandibular Height at the Molar (OP-MP)

The exact etiology of VME is still being debated, but the general consensus is that, during childhood, blocked nasal airflow and “mouth-breathing” during facial bone development causes excess protrusion and inferior movement of the maxilla. Thus, creating the “longer lower face height. A VME classification based off the amount of gingival display and potential treatment options was suggested by Chu et al in 2004 (See Table 1).

**Vertical Maxillary Excess Classification**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Gingival Display</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2-4mm</td>
<td>Orthodontic intrusion only, Orthodontics and Periodontics, Periodontics and Restorative Therapy</td>
</tr>
<tr>
<td>II</td>
<td>4-8mm</td>
<td>Periodontics and Restorative Therapy; Orthognathic Surgery</td>
</tr>
<tr>
<td>III</td>
<td>&gt; 8mm</td>
<td>Orthognathic Surgery with or without adjunctive periodontal therapy and restorative therapy</td>
</tr>
</tbody>
</table>

*Table 1: VME classification (Chu, 2004)*
The next etiology, HL, is easily defined. The average lip mobility for any given patient is 6-8mm (Robbins, 1999) from repose to full smile. In the global diagnosis, measuring lip mobility is determined by measuring the height of the central incisor, placing the patient in repose and determining how much of the tooth (measured from incisal edge) shows in repose. If the lip covers the incisal edge, it is marked as a negative number. Then the patient is placed in full smile, and the amount of gingiva and tooth exposed is measured. These two measurements are then combined to determine the patient’s overall lip mobility in the following equation: \( \text{Gingival Display} + \text{Tooth length} - \text{Incisal display at rest} \). If a patient traverses more than the average 6-8 mm, then he or she has increased upper lip mobility and HL.

Next, SL is also defined by average measurements. Lip length, by Robbins, is measured in repose from the base of the nose to the inferior border of the maxillary lip. In a young adult female, the average measurements are 20-22 mm; for adult males the average measurements are 22-24mm (Robbins, 1999). If a patient has less than this average, they are diagnosed as having a “short upper lip.”

Although fully explained in the discussion section, a clarification regarding Robbin’s lip measurements and this study’s lip measurements is placed here to avoid confusion. To diagnose a HL or SL, Robbin’s measurements were used. These measurements included the philtrum and vermilion border lengths. However, in our study, the LL measurement recorded at initial and post-operative only comprised the philtrum length (see Figure 5).

Lastly, maxillary or mandibular deficiency is characterized by a lower third of the face that is shorter than the middle third (Robbins, 1999).
For facial proportion related etiologies, traditional treatment has involved combined orthodontic, restorative, periodontal, and oral surgical management. VME is treated via orthognathic surgery or Botox to mask the condition; maxillary/mandibular deficiency is treated by orthognathic surgery. However, cases of hypermobile and short lip have no ideal or standard treatment. Moreover, orthognathic surgery is an invasive and costly procedure that is accompanied by significant patient morbidity. In cases with minor discrepancy (VME 1) such procedures cannot be justified. In such patients, a conservative approach that has gained traction in the dental community within the last decade is a lip repositioning procedure (LR). LR is a conservative, permanent, and completely reversible surgical method for correcting EGD by limiting the retraction of the smile muscles ie. zygomaticus minor, levator anguli, orbicularis oris, and levator labii superioris (Gupta, 2010). Due to its considerably decreased morbidity and potential for reversal, LR is a more logical, appealing and accessible procedure for patients with minor facial proportion discrepancy and uncompromised airways.

LR is not a common dental procedure and there are slight variations to each technique. LR was originally described in 1973 by Rubinstein & Kostianovsky. The technique involved making an elliptical incision in the upper vestibule, removing the mucosa taken from that elliptical incision, and then suturing the mucosa to the inferior border of the initial incision line. This shortened the vestibule and limited the above-mentioned smile muscles’ pull; it is, in essence, a reverse vestibular extension procedure. The first major change in the technique involved moving the initial incision to the mucogingival junction instead of apical to the marginal groove of the maxillary central incisors (Rosenblatt, 2006). Next, an additional step that involved a myotomy of the
levator labii superioris muscle was added (Polo, 2011). Further advancements/alternative techniques involved: a modified LR technique where 2 individual “strips” of mucosa were removed on either side of the maxillary labial frenum (Silva, 2013), the use of lasers instead of a scalpel for the initial incision (Ozturan, 2014), and using continuous locking sutures to secure the mucosa to the mucogingival line (Dayakar, 2014). All methods of this technique have shown success, however there is no consensus as to the preferred technique or the limitations of each of these techniques (Tawfik, 2018). Since esthetics is personal and depends upon patient and clinician perception, it is difficult to obtain specific guidelines or a systematic approach that will lead to consistent results. As a result, this study aims to assess two variations in lip repositioning techniques regarding the improvement of esthetics, the decrease of gingival display, the change in LL, the change in VB width, and the overall stability for the reduction attained. Furthermore, we aim to evaluate the application of these techniques in various clinical situations and according to the EGD etiology.
PURPOSE

The study aims to compare two surgical techniques for lip repositioning in subjects with EGD.

Primary objectives: The objectives include 1) Comparing the amount of gingival display reduction (GDR) after LR without (Group 1) and with (Group 2) myotomy, stratified in accordance with the etiology of the EGD 2) Comparing the gingival display rebound (GDRB) between the two techniques from 3 to 6 months post-operative 3) To compare subject satisfaction and morbidity (swelling and pain) between the two techniques.

Primary Hypothesis: Subjects who receive LR with myotomy will see a statistically superior result (an increase in GDR and a decrease in GDRB) compared to those who receive lip repositioning alone.

Secondary objective: To compare subject satisfaction and subject morbidity (swelling and pain) when using LR with myotomy and LR without myotomy.

Secondary Hypothesis: Subjects who receive LR with myotomy and LR without myotomy will not report a statistically significant difference with respect to satisfaction (smile score) and morbidity (pain and swelling).
MATERIAL AND METHODS

20 subjects were recruited according to the following inclusion and exclusion criteria for the study:

<table>
<thead>
<tr>
<th>Inclusion Criteria:</th>
<th>Exclusion Criteria:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Subjects who, upon full smile, have more than 2mm gingival display apical to the CEJ of #9.</td>
<td>1. Subjects who smoke more than 10 cigarettes a day by report.</td>
</tr>
<tr>
<td>2. Subjects who are 18 years old or older</td>
<td>2. Subjects with uncontrolled diabetes (defined as an HbA1c &gt; 6.5%). Level will be recorded by report or confirmed by medical consult with physician if patient is not aware of their current HbA1c level.</td>
</tr>
<tr>
<td>4. Subjects with good oral hygiene</td>
<td>4. Subjects who have been diagnosed with periodontitis and/or gingival recession by report.</td>
</tr>
<tr>
<td>5. Subjects who can speak English</td>
<td>5. Subjects who are pregnant by report.</td>
</tr>
<tr>
<td></td>
<td>6. Subjects who are on blood thinners by report or by consult with physician if patient is unsure of medications.</td>
</tr>
</tbody>
</table>

Table 2: Study inclusion and exclusion criteria

After acceptance into the study and patient consent was obtained, patients were randomly allocated to group 1 (no myotomy) or group 2 (myotomy) by an excel
randomizer. This information was not shared with the individual performing the intra-oral measurements, nor the surgeon (until the day of surgery). Baseline diagnostic information was also recorded. This baseline diagnostic information included:

1) Frontal and profile standardized clinical photographs for maximum smile and repose.
   
   *The repose smile was reproduced according to the technique proposed by Robbins where patients are told to relax their facial muscles and say “M” or “Emma.” Allowing their lips to naturally part after vocalization.
   
   *Full smile was reproduced in patients with the intention of reproducing the “Duchenne” smile that fully engages all of the smile muscles (Duchenne, 1862). Duchenne in his classic study directly stimulated the smile muscles with electrodes; this was not completed in our study. Instead, we used the technique described by Robbins which his outlined below.
   
   *Photos were standardized by using the same camera settings, taken from the same distance away

2) Dynamic record of spontaneous smile via digital videography (only for research purposes)

3) Digital caliper measurement of gingival display (defined as the gingival display measured from the CEJ of #9 to the most superior point of gingival display in full smile)
   
   *This measurement was standardized in accordance with the technique described by Robbins where the patient’s zygomatic arch is tapped and the subject says the letter “E.”
4) Digital caliper measurement of LL (measured in repose from the base of the nose to the superior border of the maxillary lip at its most superior peak apical to #9)

5) Digital caliper measurement of the VB width (measured in repose from the superior border of the dry vermillion border to the inferior dry vermillion border)

6) CEJ detectability (by periodontal charting or with a dental explorer)

7) Lip mobility (measured from repose to full smile)
   a. As a review, measuring lip mobility is determined by measuring the height of the central incisor, placing the patient in repose and determining how much of the tooth (measured from incisal edge) shows in repose. If the lip covers the incisal edge, it is marked as a negative number. Then the patient is placed in full smile, and the amount of gingiva/tooth exposed is measured. These two measurements are then combined to determine the patient’s overall lip mobility (Robbins, 1999).

8) Urine Pregnancy test was given to female patients
   *This measurement was done prior to the radiographic procedural-lateral cephalometric x-ray unless subject reports being surgically sterile or at least 60 years of age and post-menopausal for at least two years.

9) Lateral Cephalometric X-Ray

10) Smile Questionnaire.
The Initial Smile Questionnaire given to the patients can be seen in Figure 7.
After the Screening appointment, the patient’s etiology(ies) for EGD were determined and patients were scheduled for their surgical appointment. The criteria for determining EGD etiology is listed in Table 3.

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Clinical Signs</th>
</tr>
</thead>
</table>
| APE      | 1) CEJ undetectability via dental explorer or periodontal charting  
|          | 2) Short clinical crowns |
| HL       | 1) >8 mm of lip movement from repose to full smile  
|          | (direct measurement with digital calipers or based off standardized static and dynamic photos) |
| SL       | 1) female patients with > 20 mm of LL; male patients with > 22mm of LL  
|          | (direct measurement with digital calipers or based off standardized static and dynamic photos) |
1) Cephalometric tracing and analysis. The Dolphin system digitized cephalometric tracing software was used to perform the analysis. VME etiology required the following cephalometric trends: (See Figure 8 for sample tracing)

- a. Excessive Total Face Height (TFH)
- b. Normal Upper Face Height (UFH)
- c. Long Lower Face Height (LFH)
- d. High Mandibular Plane angle (MP-SN)
- e. Normal SNA
- f. Decreased SNB
- g. Increased ANB

Table 3: EGD etiology determinants (Robbins, 1999; Schendel 1976)
**Surgical Procedure:**

All LR surgeries were completed by a single surgeon. For a basic schematic of the surgery please see Figure 9 and 10. For full color photos depicting the different groups please see Figures 13 and 14.
Intra-operatively, subjects were anaesthetized using standard dental infiltration technique (4% Septocaine with 1:200,000 epinephrine).

Measurements of the amount of excess gingival display were used to determine the position and distance of the incision lines. The position of the incision lines were marked by a surgical pen. The inferior incision was located at the mucogingival line/junction and the superior incision was determined by doubling the patient’s measured gingival display at full smile.
A single partial thickness elliptical incision was created with a number 15c blade that followed the outline. The stripe of outlined mucosa was removed, leaving behind a bed of exposed connective tissue. Care was taken to avoid damage to any minor salivary glands in the submucosa. At this point the operator was informed, by the surgical assistant, if muscle severance will take place or not. For the group receiving myotomy, muscle severance was done by creating a single incision along the muscles exposed in the area. Muscles were then pushed by blunt dissection, keeping the periosteum intact. After myotomy, suspension sutures were made with 5-0 Vicryl suture from the superior periosteum (*Figure 14C*), to the inferior incision margin. The suspension sutures created a void space that prevented immediate muscle re-attachment. Final suturing was completed by first approximating the area of frenectomy to ensure symmetry and proper midline placement. Closure was then completed bilaterally with resorbable 5-0 Vicryl suture. For closure the superior periosteum was sutured to the attached gingiva via interrupted or continuous sutures. Post-operative instructions and medications given to all patients included:

1) Medications
   
   a. Analgesic TID for 1 week: Ibuprofen 800mg, TID or Acetaminophen 1000mg TID
   
   b. Antiseptic mouthwash (0.12% chlorhexidine gluconate mouthwash) 10 mL for 1 min BID for 2 weeks (no “swishing” only gentle agitation by head movement).

2) Instructions
   
   a. Applying ice packs for the first 24 hours
b. Avoiding any mechanical trauma

c. Minimizing lip movements when smiling or talking for one week

The first follow-up visit was within 7-10 days to assess wound healing and have the patient fill out the VAS for post-operative pain and swelling (See Figure 11). The second follow-up visit was within 14-21 days for suture removal. The third and fourth follow-up visits were after 3 months and 6 months respectively. The standardized static and dynamic photos and digital caliper measurements were repeated at both 3 and 6 month follow up visits. A post treatment smile questionnaire was completed at the 6-month follow up visit (similar to Figure 7).

Figure 11: Pain scale (VAS)

The overall patient flow through the study is summarized in Figure 12.
<table>
<thead>
<tr>
<th>Patient Flow &amp; Measurements</th>
<th>Baseline</th>
<th>Surgery</th>
<th>7-10 days post op</th>
<th>14-21 days post op</th>
<th>3 months post op</th>
<th>6 months post op</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGD Etiology Determination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEJ detectability</td>
<td>X</td>
<td></td>
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<tr>
<td>Lateral Cephalometric X-Ray</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Lip Mobility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Standardized Static and Dynamic Photos</td>
<td>X</td>
<td></td>
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<td></td>
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<tr>
<td>Digital Caliper Measurements</td>
<td></td>
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<td></td>
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<tr>
<td>Gingival Display</td>
<td>X</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Lip Length</td>
<td>X</td>
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<tr>
<td>Vermillion Border</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Patient Reported Outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Pain Score (VAS)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smile Questionnaire</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suture Removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

*Figure 12: Patient flow*
Surgical Photos:

Figure 13: Group 1 (no myotomy)
Figure 14: Group 2 (myotomy) Note that lips were unevenly stretched during photo in figure A
Statistical Analysis:

The obtained data were processed in SPSS (version 25.0) using ANOVA for metric parameters and xyz for scaled parameters. A p-value of < 0.05 was set as to be statistically significant. A frequency table was created to determine the spread of EGD etiology present. Power was set to 0.8 and, based off previous studies (Gupta 2010, Polo 2011, and Tawfik 2018) an estimated total sample size of 20 (10 per group) was produced.
RESULTS

20 patients were successfully recruited and completed the study. Overall results (both groups) for the primary outcomes are listed in Table 4. Combining both procedures, the results of the primary outcomes showed a total average GDR of 2.63mm (SD = 0.291 mm); a total average decrease in LL of 1.58mm (SD 0.592mm); a total average increase in VB width of 1.1mm (SD = 0.211mm). The overall GDRB change was calculated to be 0.38 mm (SD = 0.298), which, overall was not statistically significant. All other changes (GDR, change in LL, and change in VB) were significantly different from baseline.

Figure 15 shows the overall changes.

<table>
<thead>
<tr>
<th>Mean (mm)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0 Gingival Display Baseline</strong></td>
<td>5.05</td>
</tr>
<tr>
<td><strong>2 Gingival Display 3 Month</strong></td>
<td>2.04</td>
</tr>
<tr>
<td><strong>3 Gingival Display 6-Month</strong></td>
<td>2.42</td>
</tr>
<tr>
<td><strong>GDR (0-6 months)</strong></td>
<td>2.63*</td>
</tr>
<tr>
<td><strong>GDRB (3-6 months)</strong></td>
<td>-0.380</td>
</tr>
<tr>
<td><strong>Change in LL</strong></td>
<td>1.57*</td>
</tr>
<tr>
<td><strong>Change in VB</strong></td>
<td>1.11*</td>
</tr>
</tbody>
</table>

* indicates significance.
In addition, two frequency analysis were completed on both a patient and an etiology level. The Frequency table by EGD etiology is in Table 5; the frequency distribution by patient is in Figure 16.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>APE</td>
<td>12</td>
</tr>
<tr>
<td>HL</td>
<td>16</td>
</tr>
<tr>
<td>SL</td>
<td>14</td>
</tr>
<tr>
<td>VME</td>
<td>13</td>
</tr>
<tr>
<td>VME_HL</td>
<td>12</td>
</tr>
<tr>
<td>VME_APE</td>
<td>9</td>
</tr>
<tr>
<td>VME_SL</td>
<td>10</td>
</tr>
<tr>
<td>HL_SL</td>
<td>10</td>
</tr>
<tr>
<td>HL_APE</td>
<td>10</td>
</tr>
<tr>
<td>SL_APE</td>
<td>11</td>
</tr>
<tr>
<td>VME_HL_APE</td>
<td>8</td>
</tr>
</tbody>
</table>
Mean baseline GD, LL, and VB values were calculated to ensure that the groups were comparable. Table 6 has the calculated baseline mean values. After, 2-tailed t-tests for means, all baseline values had a P-value > 0.05 indicating that, at baseline, the no myotomy and myotomy groups were equal in all tested parameters.
<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>No</th>
<th>Myotomy</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Myotomy</td>
<td></td>
<td></td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>GD (mm)</td>
<td>5.18</td>
<td>4.92</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>LL (mm)</td>
<td>16.22</td>
<td>16.83</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>VB (mm)</td>
<td>7.44</td>
<td>7.30</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

*Table 6: Baseline values*

When the primary and secondary outcomes were compared between the two surgical procedures the following averages were found (*Table 7*). Group 1, on average, had a 1.86mm (SD = 1.24 mm) GDR, GDRB of 0.80mm (SD = 1.800 mm), decrease in LL of 1.91mm (SD = 3.211 mm), and an increase in VB of 0.42mm (SD = 1.186). Group 2, on average had a GDR of 3.39mm (SD = 0.871 mm), GDRB of -0.05 mm (SD = 0.311mm), decrease in LL of 1.24mm (SD = 2.054), and a change in VB of 0.54mm (SD = 1.078). For both techniques, all changes were significantly different from baseline. The differences in GDR and GDRB between the two surgical techniques was statistically significant with the myotomy group showing a greater average GDR and less GDRB. However, no significant difference was found between the surgical techniques and a change in LL or VB. *Figure 17* is a graphical representation of 3 of the primary outcomes. In order to best appreciate the dramatic difference in GDRB between the groups, a separate graph (*Figure 18*) was made.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>Std. Error Mean</th>
<th>Sig. (2-tailed) P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDR</td>
<td>no myotomy</td>
<td>10</td>
<td>1.86</td>
<td>1.238</td>
<td>0.392</td>
<td></td>
<td>0.006*</td>
</tr>
<tr>
<td></td>
<td>myotomy</td>
<td>10</td>
<td>3.39</td>
<td>0.871</td>
<td>0.276</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDRB</td>
<td>no myotomy</td>
<td>10</td>
<td>0.80</td>
<td>1.800</td>
<td>0.570</td>
<td></td>
<td>0.003*</td>
</tr>
<tr>
<td></td>
<td>myotomy</td>
<td>10</td>
<td>-0.05</td>
<td>0.310</td>
<td>0.098</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL reduction</td>
<td>no myotomy</td>
<td>10</td>
<td>1.91</td>
<td>3.211</td>
<td>1.016</td>
<td></td>
<td>0.693</td>
</tr>
<tr>
<td></td>
<td>myotomy</td>
<td>10</td>
<td>1.24</td>
<td>2.054</td>
<td>0.650</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in VB</td>
<td>no myotomy</td>
<td>10</td>
<td>0.42</td>
<td>1.186</td>
<td>0.375</td>
<td></td>
<td>0.819</td>
</tr>
<tr>
<td></td>
<td>myotomy</td>
<td>10</td>
<td>0.54</td>
<td>1.078</td>
<td>0.341</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 7: Primary outcomes by group*

*Figure 17: Comparison of primary outcomes between groups*
Secondary outcome findings revealed no significant differences in patient satisfaction nor patient morbidity between the two surgical procedures. The results can be found in Table 8 and Figures 19 and 20.

<table>
<thead>
<tr>
<th>Secondary Outcomes: Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>Sig. (2-tailed) P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no myotomy</td>
<td>10</td>
<td>3.00</td>
<td>1.826</td>
<td>0.577</td>
<td>0.418</td>
</tr>
<tr>
<td>myotomy</td>
<td>10</td>
<td>3.70</td>
<td>1.947</td>
<td>0.616</td>
<td></td>
</tr>
<tr>
<td>Post-operative Smile Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no myotomy</td>
<td>10</td>
<td>7.9</td>
<td>1.101</td>
<td>0.348</td>
<td>0.251</td>
</tr>
<tr>
<td>myotomy</td>
<td>10</td>
<td>8.6</td>
<td>1.506</td>
<td>0.476</td>
<td></td>
</tr>
<tr>
<td>Change in Smile Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no myotomy</td>
<td>10</td>
<td>2.80</td>
<td>1.476</td>
<td>0.467</td>
<td>0.501</td>
</tr>
<tr>
<td>myotomy</td>
<td>10</td>
<td>3.30</td>
<td>1.767</td>
<td>0.559</td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Secondary outcomes
In addition, the differences between the two procedures were statistically significant for GDR when patients had: VME, HL or all 4 etiologies (VME + HL + SL + APE) in favor of lip repositioning with myotomy. There were no statistically significant differences in
patient satisfaction nor patient morbidity between the two surgical procedures (See Figure 21).

<table>
<thead>
<tr>
<th>GDR by etiology</th>
<th>N</th>
<th>Mean GDR</th>
<th>Std. Deviation</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VME+APE+HL+SL</td>
<td>1</td>
<td>3</td>
<td>0.7567</td>
<td>0.90941</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>3.2840</td>
<td>0.84707</td>
</tr>
<tr>
<td>HL</td>
<td>1</td>
<td>7</td>
<td>1.1100</td>
<td>0.86000</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>9</td>
<td>3.5500</td>
<td>0.75000</td>
</tr>
<tr>
<td>VME</td>
<td>1</td>
<td>5</td>
<td>0.9360</td>
<td>0.83000</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>8</td>
<td>3.1700</td>
<td>0.82000</td>
</tr>
</tbody>
</table>

Table 9: GDR by etiology

Figure 21: GDR based off etiology
DISCUSSION

To date, the authors are unaware of other studies in the dental literature that attempt to correlate the clinical results of a LR procedure with a patient’s EGD etiology. This study being the first of its kind, the authors hope that future studies will continue to elicit which LR surgical procedures work best for specific patients. The authors suspect, just like in treatment of any disease, that certain etiologies for EGD will have improved clinical results with specific LR surgical procedures.

In a systematic review by Tawfik, it was found that the average improvement of gingival display was 3.4 mm (95% confidence interval 3.0-3.8mm) (Tawfik, 2018). The GDR in this study was slightly lower than the average found in the systematic review. The authors speculate that the reason for this was the significant relapse that was noted in patients with all four etiologies of EGD in Group 1 (reference Figure 21). This relapse considerably dropped the overall average found and warrants further investigation.

A full clarification regarding Robbin’s lip measurements and this study’s lip measurements is required to eliminate confusion. To diagnose a HL or SL, Robbin’s measurements involve the length of the philtrum and vermillion border combined. When determining patient EGD etiology, these measurements were used. However, in our study, the LL measurement recorded at initial and post-operative only comprised the philtrum length. The VB width was measured separately. This separation of the two measurements was key to our study as the authors endeavored to explain the upper lip anatomic changes following LR. Based off our study, the LR procedure does limit the retraction of the smile muscles (as originally described by Rubinstein & Kostianovsky),
but it also shortens the philtrum length (measured as LL in our study) and increases the vermillion border width.

In regard to the follow up time frame for this study, follow up for LR ranges from 1 week to 4 years (Rao, 2015; Bhola, 2015). Although not related to the LR, we can turn to classic wound healing studies to decide whether 6 months is enough time to judge the stability of the procedure. The flap involved in a LR procedure is a split thickness flap so for connective tissue healing, Staffileno’s classic study on wound healing can be referenced. In the study, 4 beagle dogs received a split thickness flap and simple H&E histological analysis was completed. The study showed that by 60 days, the connective tissue fibers were fully mature by 60 days (Staffileno, 1962). Therefore, the connective tissue attachment would be fully mature by 60 days. In regard to muscle re-attachment, sports medicine literature will provide the answer. Maffulli provides a classification system for muscle injury, the subsequent time-frame for healing, and timeline for athletes to return to their respective sports. In all classifications, our blunt dissection of levator labii superioris muscle to its new position would be considered a sub-total muscle tear or a Type 4 injury according to the (Maffulli, 2013). According to the ISMuLT (Italian Society of Muscles, Ligaments, and Tendons) guidelines, a type 4 injury is a sub-total tear with more than 50% breakage of surface fibers or a complete tear of the muscle belly. The management of a Type 4 injury requires a minimum of 60 days for healing before an athlete returns to his or her respective sport. Therefore, the 6 months of healing at its new inferior position, allotted for in our follow up would be considered sufficient healing time for the levator labii superioris to return to normal function.
Lastly, in a similar study design, Tawfik 2018 completed a randomized clinical trial comparing LR with or without a myotomy. The results of our study are similar to this randomized clinical trial in that performing a myotomy in conjunction with LR was found to have improved overall gingival display reduction. However, Tawfik’s study failed to correlate any of the findings with the etiology of the patients’ gingival display.
SUMMARY AND CONCLUSION

LR with and without myotomy are considered treatment options for treating patients with EGD. Our study confirms that performing a myotomy increases the overall GDR achieved and deters GDRB. Also, our data expands on these findings by illustrating that LR with myotomy should be considered to significantly improve GDR in patients with: VME I & II, HL or all 4 etiologies (VME + HL + SL +APE) a myotomy should be considered to improve GDR.

The authors suggest that future LR studies continue to expand our understanding of various LR surgical techniques and their clinical results depending on EGD etiology.
BIBLIOGRAPHY


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