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External levator resection for involutional ptosis: is intraoperative suture adjustment necessary for good outcomes?

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\textbf{ABSTRACT}

\textbf{Purpose:} To directly compare an algorithmic external levator resection technique with the choice of intraoperative adjustment to the same technique without intraoperative adjustments.

\textbf{Methods:} A sequential controlled prospective comparative cohort study. Two cohorts were compared: a historical control adjustment, and an experimental non-adjustment group. Fourteen patients, 25 eyelids, were in the historical cohort; and 15 patients, 23 eyelids, were in the non-adjustment cohort. Primary acquired ptosis patients who met inclusion criteria were considered. All patients underwent a standardized external levator resection technique. Intraoperative adjustments were performed only in the historical cohort. Age, follow-up time, surgical time, and marginal reflex distance 1 (MRD1) were collected. Statistical analysis was performed using the Mann–Whitney U test. Statistical significance was \( p < 0.05 \). Primary and secondary outcome measures were postoperative MRD1 minus goal MRD1, and surgical time, respectively.

\textbf{Results:} Twenty-five historical eyelids were compared with 23 non-adjusted eyelids. The average patient age was 68.4 years (range 19–84) and 59.3 years (range 24–83) for the adjusted and non-adjusted groups. Six-month postoperative (postoperative minus goal) MRD1 was \(-0.1\) mm (95% CI \(-0.3–0.1\)) and \(-0.2\) mm (95% CI \(-0.5–0.0\)) (\( p = 0.33 \)), and surgical time was 13.8 min (95% CI 12.6–15.1) and 9.5 min (95% CI 9.0–10.1) (\( p < 0.001 \)) for the adjusted and non-adjusted cohort, respectively.

\textbf{Conclusions:} The external levator resection, utilizing a standardized algorithm approach, is an efficacious technique for involutional eyelid ptosis. With sound technique, this method can be performed without the need for intraoperative adjustment, thereby saving operative time and achieving similar results.

\textbf{INTRODUCTION}

Initially, an external technique utilizing the intricate knowledge of the upper lid anatomy was described to repair upper eyelid ptosis.\textsuperscript{1} In a capable surgeon’s hands, external ptosis repair techniques have been met with success, high satisfaction, and low re-operative rates.\textsuperscript{2} Furthermore, these techniques provide the ability to adjust the eyelid height and contour both intra- and postoperatively, helping to ensure satisfactory surgical results. However, the steep surgical learning curves, lack of algorithms, longer operating times, and varying parameters such as patient cooperation and local anesthesia effects have swayed many to utilize a more standardized method, such as a Müller’s muscle-conjunctival resection.

Alternative internal approaches have been designed over time to simplify and improve upon some of the complexities of external ptosis repair.\textsuperscript{3–5} Utilizing algorithms, these techniques provide reproducible, equivalent results with good aesthetics, shorter operating times, and decreased technical challenges.\textsuperscript{3–8} Although increasingly popular, the internal ptosis repair is limited by the difficulty in correcting more than moderate eyelid ptosis and the inability for early postoperative adjustments. Last, internal ptosis techniques may shorten and damage unaffected tissue such as the conjunctiva.\textsuperscript{1,9} Therefore, a combination of the advantages of both external and internal approaches would be ideal.

Collaborative contributions to the literature from numerous investigators have advanced the external ptosis approach over time. Lucarelli and Lemke in 1999 introduced a small-incision technique to limit incision size and operative trauma.\textsuperscript{10} This was followed by Ahuero \textit{et al.}, whose work expanded on the small-
Martin in 2015 reported a 2:1 aponeurosis resection:lid elevation algorithm to determine the amount of lift provided by levator resection based on the preoperative ptosis amount. This was then extrapolated on in a cohort by Repp et al., which displayed successful correction of upper eyelid ptosis using a small-incision levator aponeurectomy incorporating an algorithm and a constant force on the aponeurosis with a spring scale, taking into account the aponeurosis’ extensible nature. In that uncontrolled descriptive study, the surgeon had the choice to adjust or not adjust the eyelid after intraoperative eyelid height and contour inspection of the awake and alert patient. However, it was noted that almost one-half of eyelids did not require any suture adjustment to achieve satisfactory results, and those that were adjusted were similarly close to the postoperative eyelid height goal. Herein the authors introduce a comparative level 2 evidence cohort study performing the levator resection technique devised by Repp et al., focusing on the necessity of intra-operative adjustment. It is the authors’ belief that with sound principles and learned surgical skill, this technique can provide reliable results without intraoperative adjustments.

Methods
This comparative cohort study consisted of two groups. One patient population received repair of acquired ptosis utilizing a small-incision external levator resection technique with a defined algorithm without any intraoperative suture adjustment. The other group was a historical control group, described previously, in which all eyelids were checked intraoperatively for height and contour in the awake and alert patient, with the choice to adjust the sutures, if deemed necessary. The study was approved by the Western Institutional Review Board and adhered to the Declaration of Helsinki. Written informed consent was signed prior to inclusion in the study and surgery, and all components of the research were undertaken with HIPAA compliance.

The prospective experimental cohort is defined as follows, and the historical control group has been described previously, although one patient of age 17 was excluded in this analysis in order to better comply with and compare to the experimental cohort’s exclusion criteria. All patients were evaluated preoperatively by the senior author (BSS). They had upper eyelid involutional ptosis (defined as a margin to reflex distance 1 [MRD1] of less than or equal to 2 mm); had normal levator function (defined as levator function of 12 or more); and had more than 6 months of follow-up. Excluded were patients who had other concurrent surgery ipsilateral to the surgical side, prior history of upper eyelid or orbital surgery, prior history of orbital radiation, history of myogenic/neurogenic ptosis, history of thyroid eye disease, history of neurotoxin use within the past 3 months, use of brimonidine or ipiidine, age less than 18 years, non-English speakers, pregnant patients, patients off of aspirin for <7 days prior to surgery, and patients on blood thinners in the perioperative time frame in which there was additional bleeding risk.

Age, sex, pre-operative and post-operative MRD1, levator function, surgical time, and post-operative adjustment (if performed) were documented. The postoperative goal MRD1 was decided prior to surgery considering ethnicity, dry eye state, and the MRD1 of the contralateral side. In bilateral cases, eyelid height goals for European ancestry and Asian ancestry were set at 3.5 mm and 3.0 mm, respectively. The amount of aponeurosis to be resected was based on the difference of the goal and pre-operative MRD1 using a 2 to 1 ratio (2 mm aponeurosis resection for every 1 mm of desired ptosis correction).

All surgical procedures were performed under monitored anesthesia care by the senior author (BSS). A 1 cc 50/50 mixture of 2% lidocaine with 1:100,000 epinephrine and 0.5% Marcaine was instilled into the surgical site on each eyelid. The small-incision external levator resection technique introduced by Repp et al. was used to provide a prospective historical control group. The technique was identical except no intra-operative adjustment was performed (Video 1). Briefly, following the dissection, a 2:1 resection of the aponeurosis under 6 g of force using a spring scale (Pesola) was performed. The superior one-third of the tarsus was then cleaned, and sutures were passed partial thickness through the superior edge of the tarsus. The initially placed 6–0 polypropylene sutures in the two pre-marked locations, one at the nasal pupil and the other at the lateral limbus, were tied down immediately after placement, without evaluation of the eyelid height or contour with patient cooperation. The skin was then closed with interrupted 6–0 polypropylene sutures, incorporating the orbicularis muscle centrally for crease formation. The surgical time was noted for each eyelid, and for bilateral cases, it was divided by 2 to estimate each individual eyelid surgical time.

Patient follow-up was at approximately 1–2 weeks, 2–3 months, and 6 or more months postoperatively. Surgical success was defined as postoperative MRD1 value that differed from the goal MRD1 by 1 mm or
less, with less than 1 mm of height asymmetry bilaterally. Statistical analysis was performed using Mann–Whitney U test, as we could not assume a normal distribution with the sample size. The non-adjusted cohort was compared to the historical adjusted control group. A statistically significant value was determined to be $p < 0.05$.

**Results**

Fourteen patients (6 males and 8 females) or 25 eyelids (11 bilateral and 3 unilateral) were in the historical cohort, and 15 patients (4 males and 11 females) or 23 eyelids (8 bilateral and 7 unilateral) were in the non-adjustment cohort. The average age was 68.4 years (range 19–84) and 59.3 years (range 24–83) for the historical and non-adjusted groups, respectively ($p = 0.04$). The average follow-up time was 192 days (95% CI 149–234) for the historical cohort and 201 days (95% CI 176–225) for the non-adjustment cohort ($p = 0.40$) (Table 1).

The average preoperative MRD1 for the historical and non-adjusted group was 0.5 mm (95% CI 0.2–0.7) and 0.6 mm (95% CI 0.2–0.9), respectively ($p = 0.56$).

<table>
<thead>
<tr>
<th>Table 1. Patient demographics of historical cohort versus no-adjust cohort.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average age (years)</strong></td>
</tr>
<tr>
<td>Male/female</td>
</tr>
<tr>
<td>Number of eyelids</td>
</tr>
<tr>
<td>Average follow-up (days)</td>
</tr>
</tbody>
</table>

* Mann–Whitney U test.
* Chi-squared test.

The average goal MRD1 was 3.4 mm (95% CI 3.2–3.5) and 3.2 mm (95% CI 3.0–3.4) respectively ($p = 0.25$). The average postoperative MRD1 at the final office visit for the historical and non-adjusted group was 3.2 mm (95% CI 3.1–3.4) and 3.0 mm (95% CI 2.8–3.2), respectively ($p = 0.08$; Figure 1). The primary outcome, average postoperative distance from goal MRD1 (postoperative minus goal), was −0.1 mm (95% CI −0.3–0.1) and −0.2 mm (95% CI −0.5–0.0) for the historical and non-adjusted group, respectively ($p = 0.33$; Table 2, Figure 2).

In addition, a secondary objective of surgical time was measured. The average surgical time for the historical group was 13.8 min (95% CI 12.6–15.1), while the average surgical time for the non-adjustment group was 9.5 min (95% CI 9.0–10.1). This was found to be statistically significant ($p < 0.001$; Table 3).

A sub-analysis comparison was further performed in order to eliminate potential confounding factors as not all eyelids in the historical group received adjustment. Eyelids in the historical cohort that received any intraoperative suture adjustment were compared with the non-adjustment cohort. Twelve patients (5 males and 7 females) or 13 eyelids received intraoperative adjustment, and 15 patients (4 males and 11 females) or 23 eyelids did not receive adjustment. The average preoperative MRD1 for the adjusted and non-adjusted group was 0.4 mm (95% CI 0.1–0.7) and 0.6 mm (95% CI 0.2–0.9), respectively ($p = 0.55$). The average goal MRD1 was 3.3 mm (95% CI 3.1–3.5) and 3.2 mm (95% CI 3.0–3.4) respectively ($p = 0.49$). The average postoperative MRD1 at final office visit for the adjusted and non-adjusted group was 3.2 mm (95% CI 2.9–3.4) and 3.0 mm (95% CI 2.8–3.2), respectively ($p = 0.23$; Figure 1). The primary outcome, average postoperative

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**Figure 1.** Example of preoperative (A) and postoperative (B) results of a non-adjusted patient.
distance from goal MRD1 (postoperative minus goal), was −0.2 mm (95% CI −0.4−0.1) and −0.2 mm (95% CI −0.5−0.0) for the adjusted and non-adjusted group, respectively ($p = 0.52$; Table 3).

In the no-adjustment group, two patients had early postoperative, in-office suture adjustments. One had a release of the lateral contour suture for lateral flare at 22 days postoperatively, adjusting only contour and not height. The lid remained at a stable height prior and after adjustment with ultimately symmetric contour. The second had a replacement of the nasal suture for height at 19 days postoperatively. Prior to adjustment, the MRD1 was 4 mm right side and 0.5 mm left side, and following both was 4 mm. The improved height was maintained at 6 months follow-up. No complications were observed.

## Discussion

Eyelid surgeons over time have been confronted by the challenges of correcting upper lid ptosis. Techniques have evolved, but external ptosis repair remains a challenging approach with more emphasis on artistic and surgical expertise versus standardization. We present a systematic procedure using a defined 2:1 algorithm of levator resection with a standardized aponeurotic force of 6 g using a spring scale (Pesola) and with 2 distinct suture placements to provide reliable results meeting MRD1 goals with excellent cosmesis. We found no statistically significant difference in the ability to meet MRD1 goals using this technique without intraoperative suture adjustment when compared to a historical cohort with the choice of suture adjustment as presented by Repp et al. This was further supported by the sub-analysis comparison. However, by withholding suture adjustments, we achieved statistically significant shorter operating time.

In this study, success was determined as the ability to achieve the goal MRD1, which was decided preoperatively, while maintaining satisfactory contour. Of the 23 eyelids studied, 21 of the eyelids met this goal (91.3%) with an average distance away from goal being 0.2 mm. This, when compared to the adjustment cohort (0.1 mm away from goal), was not statistically significant, indicating an

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**Table 2. Results of historical cohort versus no-adjust cohort.**

<table>
<thead>
<tr>
<th></th>
<th>Historical</th>
<th>No-adjust</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative MRD1 (mm)</td>
<td>0.5 (95% CI 0.2–0.7)</td>
<td>0.6 (95% CI 0.2–0.9)</td>
<td>0.56</td>
</tr>
<tr>
<td>Goal MRD1 (mm)</td>
<td>3.4 (95% CI 3.2–3.5)</td>
<td>3.2 (95% CI 3.0–3.4)</td>
<td>0.25</td>
</tr>
<tr>
<td>Resection amount (mm)</td>
<td>5.8 (95% CI 5.2–6.3)</td>
<td>5.2 (95% CI 4.7–5.8)</td>
<td>0.12</td>
</tr>
<tr>
<td>Postoperative MRD1 (mm)</td>
<td>3.2 (95% CI 3.1–3.4)</td>
<td>3.0 (95% CI 2.8–3.2)</td>
<td>0.08</td>
</tr>
<tr>
<td>Postoperative – Goal MRD1 (mm)</td>
<td>−0.3 (95% CI −0.3–0.1)</td>
<td>−0.2 (95% CI −0.5–0.0)</td>
<td>0.33</td>
</tr>
<tr>
<td>Surgical time per eyelid (min)</td>
<td>13.8 (95% CI 12.6–15.1)</td>
<td>9.5 (95% CI 9.0–10.1)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

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**Figure 2.** Distribution of postoperative MRD1 from the goal MRD1 for historical and no-adjust cohorts.
Table 3. Sub-analysis results of adjust cohort versus no-adjust cohort.

<table>
<thead>
<tr>
<th></th>
<th>Adjust</th>
<th>No-adjust</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative MRD1 (mm)</td>
<td>0.4 (95% CI 0.1–0.7)</td>
<td>0.6 (95% CI 0.2–0.9)</td>
<td>0.55</td>
</tr>
<tr>
<td>Goal MRD1 (mm)</td>
<td>3.3 (95% CI 3.1–3.5)</td>
<td>3.2 (95% CI 3.0–3.4)</td>
<td>0.59</td>
</tr>
<tr>
<td>Postoperative MRD1 (mm)</td>
<td>3.2 (95% CI 2.9–3.4)</td>
<td>3.0 (95% CI 2.8–3.2)</td>
<td>0.23</td>
</tr>
<tr>
<td>Postoperative – Goal MRD1 (mm)</td>
<td>–0.15 (95% CI −0.4–0.1)</td>
<td>–0.2 (95% CI −0.5–0.0)</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Without intraoperative suture adjustment, postoperative adjustments were entertained at the first visit following the surgery based on early recommendations by Jordan and Anderson, and Dortzbach and Kronish. Bartley, Lowry, and Hodge in 1996 further posited that 1 week post-operative results were an excellent predictor of the 3-month result. In 1999, however, Tucker and Verhulst observed that only 40% of eyelids in their case series had reached their final height after 1 week of surgery. Therefore, unless only minimal-to-moderate eyelid swelling existed, they encouraged waiting rather than revising. We followed similar guidelines. Revision was only approached with an assurance that swelling and reduced levator function was not a contributing factor. Two postoperative adjustments occurred in our cohort. The first was due to contour flare abnormality in the temporal suture that with release improved overall cosmesis and maintained a stable satisfactory eyelid height. The second was the only true eyelid height revision as there was an asymmetry between the eyelids >1 mm in a bilateral case. The ptotic eyelid was raised to an acceptable height via a nasal suture replacement at the postoperative visit and maintained good height and symmetry at the 6-month follow-up. This illustrates that postoperative revision is a safeguard that can be performed with little stress in a procedure room with minimal need for dissection and local anesthesia due to the immaturity of the wound.

**Limitations**

There were several limitations to our study. Although it was a prospective comparative controlled cohort study, the patients were sequentially chosen rather than randomized. In addition, the surgeon at follow-up was not masked. Therefore, the authors aimed to minimize bias by not reviewing preoperative or goal MRD1 prior to examining the patient at postoperative visits. A further limitation was the relatively small sample size. However, the strength of the statistical results and large exclusion criteria reinforces the accuracy of the conclusions.
Conclusions

To our knowledge, this is the first comparative prospective cohort analysis of upper lid external ptosis repair focusing on eliminating intraoperative adjustments. This study provides further support for the efficacy and efficiency of the algorithm-based levator resection technique. Elimination of adjustment is an evolution in the approach of external upper eyelid ptosis surgery. The old model of “dissect, suture placement, and adjust” may be replaced with a simpler more objective “dissect and suture placement.” This minimizes surgical time, operating room costs, and patient time under anesthesia. A future larger study with randomization would be further supportive in displaying the efficacy of this surgical approach as a next step in the advancement of external ptosis surgery. The authors encourage any eyelid surgeon with good working knowledge of the levator palpebrae superioris muscles’ surgical anatomy to consider validating this technique by adding this to their armamentarium when approaching the challenge of external upper lid ptosis repair.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

References