



# Congenital ptosis repair in children: comparison of frontalis muscle suspension surgery and levator muscle surgery

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## Abstract

**Purpose** Comparing the surgical and refractive outcomes of congenital ptosis repair by different surgical techniques.

**Methods** This longitudinal cohort study reviewed medical records of 101 patients who underwent congenital ptosis repair, from 2006 to 2022 in a single center. Analysis was performed for demographic background, co-morbidities, pre-operative and post-operative ocular examinations and refraction, complications, reoperations, and success rates.

**Results** Following exclusion criteria, we remained with 80 patients (103 eyes) who underwent either frontalis muscle suspension surgery (FMS) (55 eyes) or levator muscle surgery (LM) (48 eyes). Patients in the FMS group were younger (mean age of 3.1 vs. 6.0 years,  $p < 0.001$ ) and had worse pre-operative ocular assessments including prevalence of visual axis involvement, chin-up head position, ptosis severity, and levator muscle function (LF) ( $p < 0.001$ ). Both groups had a 25% rate of reoperation, however while in the LM group reoperation was required solely due to under-correction, in the FMS group various indications prompted reoperation. Success rate was higher in the FMS group (87.3% vs. 60.4%,  $p = 0.002$ ). While pre-operative astigmatism was higher in the LM group ( $p = 0.019$ ), no significant differences were observed post-operatively. Spherical and spherical equivalent changes over time were significant only in the FMS group ( $p = 0.010$  and  $p = 0.004$ , respectively).

**Conclusions** Within our cohort, a higher success rate of congenital ptosis repair was observed among patients who underwent FMS compared to LM, despite similar reoperation rates. In cases of severe ptosis and moderate LF, LM demonstrated a lower-than-anticipated success rate. Astigmatic changes following ptosis repair were not consistent in either group.

**Keywords** Congenital ptosis · Frontalis suspension · Levator resection · Amblyopia · Astigmatism

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## Key messages

### *What is known:*

- Granuloma formation represents a rare complication of frontalis muscle suspension surgery, and is typically associated with the exposure of the sling material or a localized infection
- Selection of the optimal surgical technique for congenital ptosis is contingent upon the severity of the ptosis as well as the functionality of the levator muscle

### *What this study adds:*

- Suturing of the sling material to the tarsus might predispose to an eyelid granuloma formation
- Bilateral operations may improve eyelid symmetry and increase success rates
- Patients with severe ptosis coupled with moderate levator muscle function may benefit from a frontalis muscle suspension operation

## Introduction

Congenital ptosis is a condition in which the eyelid droops abnormally over the eye before the age of one year. Most cases present unilaterally and are diagnosed within weeks of birth. Typically, this condition is isolated, non-syndromic, and idiopathic, with varying severities of levator palpebrae superioris muscle dysgenesis and dysfunction. Other etiologies include mechanical ptosis resulting from eyelid lesions (e.g., neurofibromas or hemangiomas), anatomical malposition such as blepharophimosis, or neurogenic due to various conditions such as Horner's syndrome, Marcus Gunn jaw-winking syndrome (MGJWs), third nerve palsy, and congenital muscle dysfunction. Additionally, congenital ptosis may have underlying chromosomal alterations [1].

A major concern with congenital ptosis is the risk for amblyopia, resulting from either visual deprivation when the visual axis is obstructed by the low-lying eyelid [1–4] or secondary to refractive changes due to the pressure of the eyelid on the eyeball, although this concern is controversial [4–8].

Several surgical approaches exist, depending on ptosis severity and levator muscle function (LF) [1, 9]: (A) Levator muscle intervention with advancement and/or resection, is usually preferred when the levator muscle has adequate function of over 4 mm; (B) Frontalis muscle suspension, is used when LF is lower than 4 mm. This technique connects the tarsus in the upper eyelid to the frontalis muscle, causing the eyelid to move upward when the frontalis muscle contracts. A range of materials can be used as a sling in this operation [10–13]: autologous materials, banked fascia lata, or synthetic materials such as expanded polytetrafluoroethylene (ePTFE), silicone, silk, and more; (C) Müller's-muscle conjunctival resection or similar surgeries can be considered for mild cases when phenylephrine test is positive.

Our aim was to evaluate the outcomes of the various techniques in our large cohort of congenital ptosis cases and to share our experience in comparison to the available literature. This information might assist in the decision-making process of tailoring the best surgical technique for each individual patient.

## Methods

This longitudinal cohort study was approved by the Institutional Review Board (IRB) of Tel Aviv Medical Center and performed in accordance with the declaration of Helsinki.

The medical records of all patients who underwent congenital ptosis repair from January 2006 to January 2022 at the Tel-Aviv Medical Center, were retrospectively reviewed.

Included in this study are patients who were operated on before 18 years of age, completed at least one month of follow-up post-operatively, and had pre-operative ocular assessment data available for review. Patients excluded from the study were those with mechanical ptosis due to neurofibromas or other lesions in the eyelid, and patients who had undergone ptosis repair elsewhere. Initially, we included a small group of patients who underwent Müller's-muscle conjunctival resection (6 patients, 8 eyes). However, given the small sample size, statistical analysis and comparison were not feasible, and consequently excluded from the study.

The following parameters were obtained during data collection: age at surgery, gender, laterality, ptosis etiology, prior ocular surgeries, and previous medical history. Detailed ocular examination of both eyes before the operation and post-operatively at 1-month, 3-months, 6-months, 12-months, and at final follow-up were also recorded. The

examination included the following factors: visual acuity, cycloplegic refraction by a pediatric ophthalmologist, presence of amblyopia and strabismus, eye movements, Marginal to Reflex Distance 1 (MRD1), LF, presence of visual axis involvement (partially or fully covered) and abnormal chin-up head position. Visual acuity was assessed in pre-verbal patients with the central-steady-maintained (CSM) approach, and in verbal patients with Lea's symbols or Snellen's numbers eye chart, depending on age. For statistical purposes, logMAR values (logarithm of the Minimum Angle of Resolution) were calculated for measures of visual acuity, by the negative log (in base 10) of the Snellen's / Lea's visual acuity fraction [14]. LF was measured by the difference between upper eyelid position when looking down and up, while eliminating frontalis muscle action manually. LF of 4 mm or less was considered as poor function, 5 – 8 mm as moderate, and 9 mm or more was considered as good.

The following data at post-operative visits were also analyzed: complications, reoperations, upper eyelid position, contour and symmetry compared to the fellow eye (asymmetry was considered > 1 mm difference between the eyelids' height), and cycloplegic refraction changes.

Success was defined as: good post-operative eyelid height ( $2 < \text{MRD1} \leq 4.5$  mm with a correction of at least 2 mm from baseline), contour, and symmetry (up to 1 mm difference between both eyes).

## Surgical technique

Two types of surgeries for congenital ptosis repair were included in this study: levator muscle surgery (LM) and frontalis muscle suspension surgery (FMS).

All surgeries were performed under general anesthesia due to the patients' age. Local anesthesia with Lidocaine 2% + Marcaine + Epinephrine (1:100000) was administered prior to skin incisions.

FMS was performed with ePTFE (Ptose-Up® 3 mm (FCI S.A.S., France)) in most patients except for four eyes with a silicon sling and three eyes with a 2 – 0 silk suture. All materials were soaked in Cefazolin or Gentamicin, according to the surgeon's preference, prior to use. Intraoperative Amoxicillin/Clavulanic acid was given intravenously in a pediatric dosage according to weight.

The surgery was performed with the Fox's Pentagon technique, utilizing 5 small skin incisions for passing the sutures. Incisional sites were marked and administered with local anesthesia prior to incision. Two eyelid incisions were performed approximately 2 mm supraciliary corresponding to the limbal edges, another two incisions were performed above the brow (one medial and one lateral), and a fifth incision in the forehead. Sling materials were passed in the sub-orbicularis plane with a Wright's

needle to the corresponding incision above the brow, followed by the forehead incision, where the two ends of the sling are met and tied. In seven eyes, the sling was sutured to the tarsus with Ethibond 5 – 0. Skin incisions were closed with absorbable sutures and topical neomycin/polymyxin b/dexamethasone ointment was applied. All patients continued the topical ointment for 1 – 2 weeks post-operatively. Oral Amoxicillin/Clavulanic acid for a week and intensive eye lubrication were also prescribed.

LM was carried out in the standard anterior approach. A skin incision was performed along the lid crease, and following exposure of the tarsus and levator aponeurosis, the levator aponeurosis was disinserted from the tarsus and later reattached to it. The medial and lateral horns were disinserted before resection of the levator muscle was carried out. The skin was closed with an absorbable suture and topical neomycin/polymyxin b/dexamethasone ointment was applied.

## Statistical analysis

All statistical tests were 2 – sided and  $p < 0.05$  was considered statistically significant. SPSS software was used for all statistical analyses (IBM SPSS Statistics for Windows, version 27, IBM corp., Armonk, New York, USA, 2020). Categorical variables were reported as frequency and percentage and compared between the two surgeries using the Chi-Square test or Fisher's exact test. Paired t-test was used for the unilateral cases when the two eyes were compared. Continuous variables were presented as mean  $\pm$  standard deviation and range in brackets and compared between the two surgeries using the Mann–Whitney test.

## Results

The records of 101 patients (129 eyes) were reviewed. After sorting according to the inclusion/exclusion criteria and withdrawing from analysis the very small group of patients who underwent Müller's-muscle conjunctival resection (6 patients, 8 eyes), 80 patients (31 females, 49 males), totaling 103 eyes, remained. Of those, 38 patients (55 eyes) underwent frontalis muscle suspension surgery (FMS group) and 42 patients (48 eyes) underwent levator muscle surgery (LM group). The mean age at operation was  $4.6 \pm 3.9$  years (range 1.5 months – 16.9 years) for the total cohort, 3.1 years (1.5 months – 13.1 years) in the FMS group compared to 6.0 years (5 months – 16.9 years) in the LM group, with a statistical significance of  $p < 0.001$ . The mean follow-up was 27.5 months (range 1 – 134 months), with a longer mean follow-up of 33.2 months (1 – 103 months) in

**Table 1** Pre-operative ocular assessment of the operated eyes

	Frontalis suspension surgery, <i>n</i> = 55 (%)	Levator muscle surgery, <i>n</i> = 48 (%)	<i>P</i> value	Total, <i>n</i> = 103 (%)
Laterality				
Right eye	28 (50.9)	19 (39.6)	0.290	47 (45.6)
Left eye	27 (49.1)	29 (60.4)		56 (53.4)
Bilateral surgery	34 (61.8)	12 (25.0)	0.002	23 (22.3)
MRD1, mm (range)	0.35 ± 1.23 (-5 <sup>a</sup> to 3)	1.12 ± 0.85 (-1 to 3.5)	< 0.001	0.71 ± 1.14 (-5 to 3.5)
Levator muscle function <sup>b</sup>				
Poor	51 (92.7)	2 (4.2)	< 0.001	53 (51.5)
Moderate	3 (5.5)	19 (39.6)		22 (21.4)
Good	1 (3.6)	27 (56.2)		28 (27.2)
Visual axis involvement				
Opened	5 (9.1)	25 (52.1)	< 0.001	32 (31.1)
Partially opened	26 (47.3)	19 (39.6)	> 0.050	43 (41.7)
Blocked	24 (43.6)	4 (8.3)	< 0.001	28 (27.2)
Amblyopia	6 (10.9)	6 (12.5)	0.802	12 (11.7)
Strabismus	3 (5.5)	5 (10.4)	0.468	8 (7.8)
Chin-up head position (per patient)	28/38 (73.7%)	8/42 (19.1%)	< 0.001	36/80 (45%)

<sup>a</sup> Minus sign marks the eyelid position below the corneal light reflex. -5 represents a full ptosis

<sup>b</sup> Levator muscle function scale that was used: poor when ≤ 4 mm, moderate when 5 mm to 8 mm, and good when ≥ 9 mm

**Table 2** Refraction results of the operated eyes at last follow-up

	Frontalis suspension surgery	Levator muscle surgery	<i>P</i> value	Total
Visual acuity (logMAR)*				
Pre-op	0.16 ± 0.14	0.14 ± 0.15		0.14 ± 0.15
Post-op	0.13 ± 0.14	0.11 ± 0.12	> 0.500	0.12 ± 0.12
Mean change	-0.03 ± 0.12	-0.03 ± 0.13		-0.03 ± 0.13
Sphere (D)				
Pre-op	1.62 ± 1.19	1.25 ± 1.93	0.631	1.53 ± 1.40
Post-op	1.01 ± 1.39	1.31 ± 3.97	0.267	1.11 ± 2.30
Mean change	-0.61 ± 1.34	0.06 ± 2.25	0.027	-0.42 ± 1.63
Cylinder (D)				
Pre-op	-0.71 ± 0.95	-1.58 ± 1.51	0.019	-0.93 ± 1.17
Post-op	-0.76 ± 0.92	-1.48 ± 1.55	0.128	-0.96 ± 1.14
Mean change	-0.05 ± 0.96	0.10 ± 0.61	0.834	-0.02 ± 0.89
Spherical equivalent (D)				
Pre-op	1.27 ± 0.95	0.46 ± 2.41	0.230	1.06 ± 1.48
Post-op	0.63 ± 1.27	0.57 ± 4.35	0.171	0.63 ± 2.42
Mean change	-0.64 ± 1.21	0.11 ± 2.15	0.022	-0.43 ± 1.53

\* logMAR (Logarithm of the Minimum Angle of Resolution) for numeric visual acuity only

D diopters

the FMS group compared to 22.3 months (1 – 134 months) in the LM group, *p* = 0.038.

Pre-operative assessments and patient characteristics are summarized in Table 1. A bilateral surgery was performed in 17 patients in the FMS group and 6 in the LM group,

*p* = 0.002. Ocular movement deficiency was recorded in 7 eyes only (6.8%). Abnormal chin-up head position was observed in 36 patients (45.0%), over 75% of them in the FMS group, *p* < 0.001. Pre-operative prevalence of amblyopia and strabismus were not statistically different between the two groups.

Refraction results at the last follow-up are summarized in Table 2. The preoperative cylinder was statistically different between the two groups:  $-0.71 \pm 0.95$  D in the FMS group compared to  $-1.58 \pm 1.51$  D in the LM group,  $p = 0.019$ . No significant post-operative change in refraction was documented in the LM group. The FMS group, however, had a statistically significant change in the sphere ( $p = 0.010$ ) and the spherical equivalent (SE) ( $p = 0.004$ ), but not in the cylinder ( $p = 0.873$ ). The final cycloplegic refraction was more myopic, which may correlate to the emmetropization process of younger patients in this group.

We conducted a sub-analysis on the 57 patients with unilateral ptosis, using the non-ptotic eye as a control. The change in refraction after the surgery was not significantly different between the operated and the unoperated eyes. Eight patients (14.0%) had an astigmatic inter-ocular difference of 1 D or more, six of them (10.5%) featured a higher cylinder with the ptotic eye. Axis was against-the-rule in three eyes, oblique in two eyes, and with-the-rule in one eye. All eyes exhibited severe ptosis with MRD1 of 0 – 1 mm.

The final success rate at the last follow-up (including good eyelid position, contour, and symmetry), was 74.8% (77 eyes). The success rate was higher in the FMS group 87.3% (48 eyes) versus 60.4% (29 eyes) in the LM group,  $p = 0.002$ .

A similar reoperation rate was demonstrated in both groups: 14 eyes (25.5%) in the FMS group and 12 eyes (25.0%) in the LM group,  $p > 0.999$ . The leading causes for repeated surgery were recurrent ptosis and asymmetry greater than 1 mm between the eyes: 10/14 in the FMS group (including three eyes with recurrent ptosis secondary to trauma within a month after surgery) and 12/12 in the LM group. Granuloma / abscess formation was observed in 4/14 in the FMS group, and none in the LM group;  $p = 0.006$ . Among them, three eyes had a silicon sling sutured to the tarsus with Ethibond suture in the primary operation with the granuloma formed in the eyelid, and one ePTFE sling in which the granuloma formed above the eyebrow. All cases of granuloma were successfully treated by removing it along with the sling material, resulting in a final successful outcome.

All the reoperations of the FMS group due to recurrent ptosis consisted of recurrent frontalis muscle suspension, one of them combined with levator muscle resection. Two reoperations had unfavorable results due to lagophthalmos and lid retraction. The success rate of the FMS reoperation group was 85.7%.

Within the LM reoperation group, 11/12 had a recurrent levator muscle intervention (one of them combined with a frontalis muscle silicon suspension operation) with four eyes having unsatisfactory results: three eyes due to undercorrection and one eye due to overcorrection. One patient had

a frontalis muscle ePTFE suspension surgery with a final good result. The success rate of the LM reoperation group was 66.7%.

Upon sub-analyzing the LM group according to pre-operative LF, we found 19 eyes with a moderate LF. Success after the primary surgery was seen in 6/19 eyes (31.6%). Among the unsuccessful cases (13/19), only six chose to perform a reoperation, and three of them reached final successful results. Meaning, this subgroup of preliminary moderate LF had a low success rate after the primary LM operation of 31.6% rising to 47.4% (9/19 eyes) after reoperations. In the FMS group, three eyes had a moderate LF and all three of them achieved successful results with no reoperation needed.

A further sub-analysis was done for neurological or anatomical ocular syndromes, contributing to the eyelid position. This subgroup comprises 12 patients: six MGJWs, four Blepharophimosis syndrome, one Horner's syndrome, one Persistent Fetal Vasculature (PFV) with microphthalmia. Amblyopia was diagnosed in two patients in the ptotic eye and was treated with glasses and penalization treatment with part-time patching, resulting in final good vision. FMS was done in 13/15 eyes in this group. There were two unsuccessful operations: a patient with MGJWs who had a levator surgery with undercorrection and multiple reoperations with levator resection and frontalis muscle suspension. The second patient, with PFV and microphthalmia, had FMS using a silk suture with undercorrection, reoperation in the same technique resulted in eyelid retraction.

No intraoperative complications were recorded. Short-term complications included dry eyes and a few corneal erosions that were treated with topical antibiotics and lubrication. Long-term complications included eyelid retraction, lagophthalmos, and undercorrection, as described before. We had four cases of granuloma / abscess formation in the FMS group as previously mentioned.

## Discussion

Congenital ptosis may lead to amblyopia and abnormal head position, therefore early assessment is important. Follow-up should be carried out by both an oculoplastic surgeon and a pediatric ophthalmologist for the optimal timing of ptosis repair. Patients should be regularly evaluated for amblyopia, and treated as needed.

In our study group, we found significantly younger patients in the FMS group, with a worse pre-operative baseline (see Table 1): lower MRD1 with a higher percentage of visual axis involvement and chin-up position. This can be explained by the severe ptosis presentation necessitating early intervention.

Unlike previous reports indicating a high prevalence of amblyopia ranging from 15 to 48%, and strabismus ranging

from 10 to 32% [2–4, 6, 7, 15–18], our cohort exhibited a lower percentage of amblyopia (Table 1). This may be attributed to the collaborative efforts of our medical center's Oculoplastic and Pediatric Ophthalmology teams, as well as increased awareness of the importance of careful vision assessment and operating prior to amblyopia development.

Previous studies reflect the controversy over the refractive changes caused by the lower position of the ptotic eyelid. Several reports found significant anisometropia (sphere and/or cylinder) between the ptotic and non-ptotic eyes pre-operatively, however incidence varied greatly from 10 to 34% [5–8, 15, 19, 20]. Our unilateral cases sub-analysis revealed that 17.5% of cases had an anisometropia of 1 D or more, mainly due to astigmatism with the higher cylinder in the ptotic eye. Theory suggests that the ptotic eyelid causes pressure on the cornea, creating astigmatism. This theory may explain the higher mean astigmatism in the LM group, as the children in this group were operated on at an older age, allowing the ptosis a longer period for astigmatic change to evolve. However, there is no persistent data regarding the amount, axis, and frequency of astigmatism, as each study reports different results.

An astigmatic change following ptosis repair surgery was reported previously. Some studies showed a reduction in astigmatism of the operated eye [21–24], while others found a high percentage of worsening or creation of astigmatism in the operated eye [5, 7, 20, 21]. They speculated that surgeries involving the levator muscle may create more pressure on the peripheral cornea when the eyelid is elevated. Holck et al. [25] were the first to use corneal topography for astigmatic follow-up and showed an astigmatic increase after levator advancement for congenital ptosis. Gandhi et al. [23] showed an astigmatic reduction post frontalis suspension surgery with the steepening of the flatter meridian, while Assadi et al. [24] showed flattening of the steepest meridian. The discrepancy between the studies could be attributed to the chosen operation technique, topography method, and duration of follow-up, as eyelid edema may contribute to modifications in astigmatism. In our unilateral cases analysis, the astigmatic inter-ocular difference changed post-operatively by 0.75 D or more in 26.9% of patients, with similar rates of improved or worsened astigmatic power in the ptotic eye. We found no correlation between the surgical modality, success, and astigmatic change.

The reoperation rate was similar in both groups. While the etiologies were varied in the FMS group: undercorrection, trauma with recurrent ptosis and granuloma / abscess formation, all reoperations in the LM group were due to undercorrection. In our cohort, seven eyes had the sling sutured to the tarsus with an Ethibond suture in the primary surgery, of which three (with a silicon sling) developed a

granuloma requiring surgery. Although this is a small sample size, our experience indicates that suturing of the sling to the tarsus might be a risk factor for granuloma formation and should be avoided.

Success rates for the FMS and LM groups were 87.3% and 60.4%, respectively. These results are comparable to the literature [6, 9, 15, 26–30]. Difference between the groups may be due to more bilateral surgeries in the FMS group allowing more symmetrical results. Additional support can be obtained by sub-analyzing only the bilateral ptotic cases, which reveals increased success rates in both groups, specifically 94.1% (16/17 patients) in the FMS group and 83.3% (5/6 patients) in the LM group.

Furthermore, we found a lower success rate in eyes in the LM group in which the pre-operative LF was considered moderate. Ptosis severity and LF are among the most important factors affecting surgeons' choice of the preferred operating method. Previous studies showed a correlation between lower LF and lower success rate and undercorrection. Therefore, poor to no LF is generally agreed to be the main indication for a FMS operation [1, 9, 26, 28, 31]. However, cases of severe ptosis with moderate LF are vaguely depicted in the surgical algorithm of congenital ptosis treatment and are left to the surgeon's discretion. In our cohort, the combination of moderate LF with severe ptosis showed a low success rate after primary LM operation, leading us to believe that these cases should be considered for a frontalis muscle suspension operation as primary operation. It is possible that measurements of LF in infants and non-cooperative toddlers are more challenging, which may result in an overestimation of the true LF. This can potentially lead to a suboptimal surgical approach.

Maximal levator resection has been recently studied and shows comparable results to the frontalis muscle suspension operation [29, 32], but was not done in our study group and requires further studies on larger study groups with a prospective design.

Our study is limited by its retrospective design with pre-operative differences among the groups, particularly in terms of age and severity of ptosis. Additionally, some patients had a short follow-up period. Finally, our cohort is comprised of surgeries done mainly by three surgeons, which may confound the results.

In conclusion, our findings indicate that the frontalis muscle suspension surgery yields a high success rate in repairing congenital ptosis, higher than the levator muscle intervention and despite similar reoperation rates. Undercorrection was the sole reason in the LM group for reoperation, compared to various reasons in the FMS group, and higher success rates were observed when performing a bilateral surgery in both groups. This should be considered and explained to the

parents prior to the operation. We consider sling materials such as ePTFE, without suturing to the tarsus, to achieve better results with fewer reoperations. Considering the lower success rate in the LM group, especially with a preoperative moderate LF combined with severe ptosis, we propose consideration of a frontalis muscle suspension operation in cases of severe congenital ptosis with moderate levator function, for better results.

**Authors' contribution** All authors contributed for the interpretation of data, critical revising of drafts, approval of final version, and agree to be accountable for all aspects of the work and its integrity. RBC, ABZ and OFT are responsible for the conception and design of the study. OFT and ET were responsible for medical data extraction and analysis.

## Declarations

**Ethics approval** This longitudinal cohort study was approved by the Institutional Review Board (IRB) of The Tel Aviv Medical Center and performed in accordance with the declaration of Helsinki.

**Conflict of interest** The authors declare no conflict of interest.

## References

- Marengo M, Macchi I, Macchi I et al (2017) Clinical presentation and management of congenital ptosis. *Clin Ophthalmol* 11:453–463. <https://doi.org/10.2147/OPTH.S111118>
- Dray J-P, Leibovitch I (2002) Congenital ptosis and amblyopia: a retrospective study of 130 cases. *J Pediatr Ophthalmol Strabismus* 39:222–225. <https://doi.org/10.3928/0191-3913-20020701-10>
- Lin LK, Uzcategui N, Chang EL (2008) Effect of surgical correction of congenital ptosis on amblyopia. *Ophthalmol Plast Reconstr Surg* 24:434–436. <https://doi.org/10.1097/IOP.0b013e31818ab497>
- Wang Y, Xu Y, Liu X et al (2018) Amblyopia, strabismus and refractive errors in congenital ptosis: a systematic review and meta-analysis. *Sci Rep* 8:8320. <https://doi.org/10.1038/s41598-018-26671-3>
- Klimek DL, Summers CG, Letson RD, Davitt BV (2001) Change in refractive error after unilateral levator resection for congenital ptosis. *J Am Assoc Pediatr Ophthalmol Strabismus* 5:297–300. <https://doi.org/10.1067/mpa.2001.118215>
- Skaat A, Fabian ID, Spierer A et al (2013) Congenital ptosis repair—surgical, cosmetic, and functional outcome: a report of 162 cases. *Can J Ophthalmol* 48:93–98. <https://doi.org/10.1016/j.jcjo.2012.09.010>
- Chisholm SAM, Costakos DM, Harris GJ (2019) Surgical timing for congenital ptosis should not be determined solely by the presence of anisometropia. *Ophthalmol Plast Reconstr Surg* 35:374–377. <https://doi.org/10.1097/IOP.0000000000001284>
- Zeng X-Y (2020) Effects of congenital ptosis on the refractive development of eye and vision in children. *Int J Ophthalmol* 13:1788–1793. <https://doi.org/10.18240/ijo.2020.11.16>
- Gazzola R, Piozzi E, Vaianti L, Wilhelm BaruffaldiPreis F (2018) Therapeutic algorithm for congenital ptosis repair with levator resection and frontalis suspension: results and literature review. *Semin Ophthalmol* 33:454–460. <https://doi.org/10.1080/08820538.2017.1297840>
- Leibovitch I, Leibovitch L, Dray J-P (2003) Long-term results of frontalis suspension using autogenous fascia lata for congenital ptosis in children under 3 years of age. *Am J Ophthalmol* 136:866–871. [https://doi.org/10.1016/S0002-9394\(03\)00466-5](https://doi.org/10.1016/S0002-9394(03)00466-5)
- Ben Simon GJ, MacEdo AA, Schwarcz RM et al (2005) Frontalis suspension for upper eyelid ptosis: evaluation of different surgical designs and suture material. *Am J Ophthalmol* 140:877–885. <https://doi.org/10.1016/j.ajo.2005.05.031>
- Hayashi K, Katori N, Kasai K et al (2013) Comparison of nylon monofilament suture and polytetrafluoroethylene sheet for frontalis suspension surgery in eyes with congenital ptosis. *Am J Ophthalmol* 155:654–663.e1. <https://doi.org/10.1016/j.ajo.2012.10.022>
- Pacella E, Mipatrini D, Pacella F et al (2016) Suspensory materials for surgery of blepharoptosis: a systematic review of observational studies. *PLOS ONE* 11:e0160827. <https://doi.org/10.1371/journal.pone.0160827>
- Holladay JT (2004) Visual acuity measurements. *J Cataract Refract Surg* 30:287–290. <https://doi.org/10.1016/j.jcrs.2004.01.014>
- Berry-Brincat A, Willshaw H (2009) Paediatric blepharoptosis: a 10-year review. *Eye* 23:1554–1559. <https://doi.org/10.1038/eye.2008.311>
- Griepentrog GJ, Diehl N, Mohny BG (2013) Amblyopia in childhood eyelid ptosis. *Am J Ophthalmol* 155:1125–1128.e1. <https://doi.org/10.1016/j.ajo.2012.12.015>
- Griepentrog GJ, Mohny BG (2014) Strabismus in childhood eyelid ptosis. *Am J Ophthalmol* 158:208–210.e1. <https://doi.org/10.1016/j.ajo.2014.04.001>
- Gautam P, Adhikari R, Sharma BR (2016) Etiopathogenetic patterns of blepharoptosis in Western Nepal : an overview. *Nepal J Ophthalmol* 8:36–40. <https://doi.org/10.3126/nepjoph.v8i1.16154>
- Paik J-S, Kim S-A, Park SH, Yang S-W (2016) Refractive error characteristics in patients with congenital blepharoptosis before and after ptosis repair surgery. *BMC Ophthalmol* 16:177. <https://doi.org/10.1186/s12886-016-0351-9>
- Merriam WW, Ellis RD, Helveston EM (1980) Congenital blepharoptosis, anisometropia, and amblyopia. *Am J Ophthalmol* 89:401–407. [https://doi.org/10.1016/0002-9394\(80\)90011-2](https://doi.org/10.1016/0002-9394(80)90011-2)
- Cadera W, Orton R, Hakim O (1992) Changes in astigmatism after surgery for congenital ptosis. *J Pediatr Ophthalmol Strabismus* 29:85–88. <https://doi.org/10.3928/0191-3913-19920301-06>
- Savino G, Battendieri R, Riso M et al (2016) Corneal topographic changes after eyelid ptosis surgery. *Cornea* 35:501–505. <https://doi.org/10.1097/ICO.0000000000000729>
- Gandhi A, Mehta A, Naik M (2020) Does frontalis sling surgery for congenital ptosis change the corneal topography and refractive characteristics postoperatively? *Clin Ophthalmol* 14:3667–3673. <https://doi.org/10.2147/OPTH.S264732>
- Assadi F, Narayana S, Yadalla D et al (2021) Effect of congenital ptosis correction on corneal topography- A prospective study. *Indian J Ophthalmol* 69:1527. [https://doi.org/10.4103/ijo.102650\\_20](https://doi.org/10.4103/ijo.102650_20)
- Holck DEE, Dutton JJ, Wehrly SR (1998) Changes in astigmatism after ptosis surgery measured by corneal topography. *Ophthalmol Plast Reconstr Surg* 14:151–158. <https://doi.org/10.1097/00002341-199805000-00001>
- Cates CA, Tyers AG (2001) Outcomes of anterior levator resection in congenital blepharoptosis. *Eye* 15:770–773. <https://doi.org/10.1038/eye.2001.247>
- Lee V, Konrad H, Bunce C et al (2002) Aetiology and surgical treatment of childhood blepharoptosis. *Br J Ophthalmol* 86:1282–1286. <https://doi.org/10.1136/bjo.86.11.1282>
- Nguyen CT, Hardy TG (2017) Levator resection for congenital ptosis: Does pre-operative levator function or degree of ptosis

- affect successful outcome? *Orbit* 36:325–330. <https://doi.org/10.1080/01676830.2017.1337179>
29. Dawood AS, Hassan OA, El Sayed MO (2021) Maximal levator resection versus Gore-Tex® sling for congenital blepharoptosis with poor levator function. *Oman J Ophthalmol* 14:173–178. [https://doi.org/10.4103/ojo.ojo\\_127\\_21](https://doi.org/10.4103/ojo.ojo_127_21)
  30. Nabie R, Manouchehri V, Aminmozaffari S et al (2022) Levator muscle resection for simple congenital ptosis: its impact on preoperative levator function and dose-response ratio. *Can J Ophthalmol* S0008418222000138. <https://doi.org/10.1016/j.jcjo.2022.01.008>
  31. Kamal Z, McNab A (2001) Refinement of anterior levator resection algorithm for congenital ptosis. *J Coll Physicians Surg Pak* 11:639–641
  32. Lee J-H, Aryasit O, Kim Y-D et al (2017) Maximal levator resection in unilateral congenital ptosis with poor levator function. *Br J Ophthalmol* 101:740–746. <https://doi.org/10.1136/bjophthalmol-2016-309163>

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