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The Epidemiology and Clinical Features of Blepharoptosis in Taiwanese Population

Chia-Chen Lee[1] · I-Jung Feng[2] · Hsin-Ti Lai[3] · Shu-Hung Huang[3] · Yur-Ren Kuo[1,3] · Chung-Sheng Lai[3]

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Abstract

Background Blepharoptosis describes a condition of low-lying upper eyelid that may affect individuals of all ages under various etiologies. It may be of congenital or acquired form by the timing of onset or be divided into myogenic, neurogenic, aponeurotic, or mechanical types according to the mechanism. Our goal was to report the characteristics of age-specific blepharoptosis and to analyze the association between levator function (LF) and ptosis severity of each ptosis subtype.

Materials and Methods The retrospective, single-center, cross-sectional study consisted of patients diagnosed with blepharoptosis in the plastic surgery practice at a medical center between September 2009 and May 2017. We reported patients' age at presentation, sex, laterality of ptosis, etiology, classification, and evaluation of ptosis including levator function and ptosis severity.

Results During a nine-year span of study, a total of 1975 eyelids of 1164 Taiwanese patients aged between 2 and 88 years were enrolled in the research (mean = 57.73 ± 13.41 years). The female-to-male ratio was 2.72 (95% confidence interval [CI]: $p < 0.0001$). Acquired blepharoptosis and bilateral blepharoptosis were more frequently observed (55.85%, $p < 0.0001$ and 69.67%, $p < 0.0001$, respectively). In age-specific relative incidence of blepharoptosis, myogenic ptosis was the majority in patients younger than 40 years. Early onset of aponeurotic ptosis was observed in young contact lenses wearers. Aponeurotic blepharoptosis was the predominant type of ptosis in the senior population older than 40 years ($p < 0.0001$). Among the subtypes, mechanical ptosis had the most preserved LF ($p < 0.0001$). LF and MRD1 had statistically positive correlations in all subtypes of blepharoptosis, in which neurogenic ptosis demonstrated the severest levator dysfunction for each millimeter in MRD1 reduction.

Conclusions Of the 1164 Taiwanese patients, blepharoptosis had a higher propensity for female gender and the age between the second to fourth decades. Bilateral involvement of blepharoptosis with acquired type was frequently diagnosed. Myogenic ptosis had a preponderance in age younger than 40 years, while aponeurotic ptosis usually affects senile population. Many mild degree myogenic ptosis was simultaneously recognized in young-aged adults seeking aesthetic double eyelid surgery. Early onset of acquired aponeurotic ptosis was also observed in contact lens wearers given the trend of decorative contact lens use. Levator dysfunction was implicated in the pathology of not only myogenic ptosis but aponeurotic, mechanical, and neurogenic ptosis. Moreover, levator function of neurogenic ptosis was most severely impacted in each MRD_1 reduction among all subtypes of blepharoptosis.

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✉ Chung-Sheng Lai
chshla@kmu.edu.tw

[1] Department of Surgery, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan

[2] Department of Healthcare Administration and Medical Informatics, Chi-Mei Medical Center, Tainan, Taiwan

[3] Division of Plastic Surgery, Department of Surgery, Kaohsiung Medical University Hospital, No.100, Tzyou 1st Rd, Kaohsiung 807, Taiwan

Keywords Blepharoptosis · Myogenic ptosis · Double eyelid surgery · Contact lenses · Aponeurotic ptosis · Involutional ptosis · Taiwan

Introduction

For most patients, blepharoptosis can be disturbing if the drooping eyelid interferes with the visual field or causes cosmetic deformity. However, it may herald other severe diseases such as myasthenia gravis, eyelid tumor, or oculomotor nerve palsy with traumatic, vascular, or neoplastic etiologies. In Taiwan, a huge number of patients present to the oculoplastic clinics with various conditions of ptosis every year. A detailed history taking of the patient, clinical ocular examination and eyelid measurement are essential for subsequent surgical planning or proper referral. In general, there are two types of ptosis: true ptosis and pseudoptosis. True ptosis is a result of dysfunction of the levator complex, which includes the levator palpebrae superioris muscle, levator aponeurosis, and Muller muscle. The etiology can be congenital or acquired depending on the time of onset and can be further categorized into neurogenic, myogenic, aponeurotic, or mechanical types based on etiology [1–3]. Myogenic ptosis is the result of levator myopathy, dysgenesis, or impaired transmission of impulses at the neuromuscular junction. Neurogenic ptosis is the consequence of oculomotor nerve or facial nerve palsy that is associated with brain tumor, arteriovenous malformation or aneurysm. Aponeurotic ptosis is the weakening of levator aponeurosis either through chronic microtraumatic influences during the natural aging process or contact lens wearing. Mechanical ptosis is caused by increased eyelid weight due to tumor or inflammatory reaction. Classically, myogenic ptosis has poor levator function (LF), whereas aponeurotic ptosis usually presents with normal LF. Despite that the inclusion criteria varied, previous studies have revealed a correlation between LF and ptosis severity in involutional blepharoptosis [4, 5]. However, since more and more people in East Asia have been held to high standards for beauty, the demand for cosmetic double eyelid surgery or cosmetic contact lens use has immensely increased during nearly the past decades. Considering the growing sociocultural influences, we aim to report the demography of blepharoptosis of Taiwanese from a single-center experience and to analyze the relations between levator function and ptosis severity of each ptosis subtype.

Materials and Methods

Study Design and Patients

This was a retrospective, single-center, cross-sectional study conducted between September 2009 and May 2017. The permission of the institution review board committee of Kaohsiung Medical University Hospital was obtained for this study [KMUHIRB-E(II)-20180282]. During a series of detailed ophthalmic, neurologic, and eyelid examinations, each potential patient for blepharoptosis was clinically diagnosed by the experienced oculoplastic surgeon (Lai, CS). All cases were collected from the database of the Kaohsiung Medical University Hospital. The study consisted of the demographic characteristics including age and sex, and medical history, laterality of ptosis, etiology, mechanism, ptotic severity, levator function, and marginal reflex distances (MRDs). Distribution of the ptotic conditions was generated for 20-year intervals: < 20 years, 20–39 years, 40–59 years, and > 60 years of age. Testing for Hering's law was done by performing a covering test for assessing contralateral eyelid drop; positive Hering phenomenon indicated droopiness of contralateral eyelid about 1 to 2 mm. The 95% confidence intervals were reported when appropriate by using assumptions based on a Poisson distribution. The linear regression was processed by using SAS software v.9.4 [SAS Institute Inc., Cary, NC, USA].

Definition of Blepharoptosis and Terminology

Blepharoptosis represented a drooping upper eyelid margin below its normal position. A thorough ophthalmic and eyelid examination was the mainstay for clinical diagnosis. In this study, 12 eyelid conditions based on different degrees of ptosis severity and levator function (LF) were employed for clinical upper eyelid measurement [5].

Unilateral ptosis was defined as an asymmetry of the palpebral fissure > 1 mm (the distance between the upper and lower eyelid in vertical alignment) between two upper eyelids. Bilateral ptosis was defined as a MRD < 2.0 mm of both eyes. MRD_1 represents the distance from the upper eyelid to the pupillary light reflex in primary gaze position, normally 4–5 mm [3]. The MRDs were categorized into three subgroups: (1) mild ($MRD_1 \geq 2.0$ mm); (2) moderate ($2 \text{ mm} > MRD_1 \geq 0$ mm); and (3) severe ($MRD_1 < 0$ mm). The LF test was performed to assess levator superioris muscle functionality by measuring the upper eyelid excursion from extreme downgaze to upgaze [4, 5]. LF was categorized into (1) excellent ($LF \geq 13$); (2) good ($13.0 \text{ mm} > LF \geq 10.0$ mm); (3) fair ($10 \text{ mm} > LF \geq 6$ mm); and (4) poor ($LF < 6$ mm). Patients with congenital

blepharoptosis was clinically diagnosed by the absence or weakness of the upper eyelid crease or a "lid lagging" or "hanging up" appearance when gazing downward due to the stiff tissue of the upper eyelid [5]. Also, initial- or late-presenting congenital ptosis was determined based on a detailed parental history taking of each individual; otherwise, an acquired etiology was recorded. Patients were further classified into true blepharoptosis and pseudoptosis. Pseudoptosis refers to the ptotic appearance without dysfunction of levator complex. True blepharoptosis comprises myogenic, neurogenic, aponeurotic, mechanical, and mixed-type ptosis based on different mechanisms. Myogenic ptosis is characterized by reduced levator function. The differential diagnosis of myogenic ptosis comprises congenital myopathy, acquired muscular dystrophy, myasthenia gravis (MG), oculopharyngeal muscular dystrophy (OPMD), chronic progressive external ophthalmoplegia (CPEO) [6], blepharophimosis, ptosis, epicanthus inversus syndrome (BPES), Meige's syndrome, Freeman–Sheldon syndrome (FSS), and floppy eyelid syndrome (FES), myotonic dystrophy. Neurogenic ptosis is associated with oculomotor nerve or facial nerve palsy. Common acquired etiologies include oculomotor damage or malfunction resulting from traumatic brain injury, brain tumors, arteriovenous malformation (AVM), and aneurysms; common congenital causes are oculomotor palsy, Marcus Gunn syndrome, Marin-Amat syndrome. Aponeurotic ptosis is related to the attenuation or dehiscence of the levator aponeurosis. We defined involutional (senile) degenerative attenuation of aponeurosis for patients older than 40 years of age. Contact lens-induced aponeurosis is diagnosed in either hard or soft contact lens wearers. Mechanical ptosis is the consequence of increased weight of the upper eyelid. It is frequently seen in patients with blepharochalasis, fat, eyelid tumor, scarring, or post-traumatic swelling [7]. A mixed-type ptosis represents two or more pathogenic lesions occurring in the affected eyelids. Hering's law is the masking phenomenon of the contralateral eyelid that appears less ptotic or normal because of the same neurostimulation of the affected eyelid on the contralateral one [5, 7, 8].

Results

A total of 1975 eyelids of 1164 Taiwanese patients diagnosed with blepharoptosis were included during a nine-year study period. There were 131 patients (11.25%) under the age of 20 years, 488 patients (41.92%) between the ages of 20 to 39 years, 298 patients (25.60%) between 40 to 59 years of age, and 247 patients (21.22%) were more than 60 years old ($p < 0.0001$). The mean age at presentation was 57.73 ± 13.41 years. There were 851 females (73.11%) and 313 males (26.89%) in this population ($p < 0.0001$). Bilateral involvement presented in 811 patients (69.67%), whereas the other 353 patients (30.33%) presented with unilateral ptosis ($p < 0.0001$). The demographic form is shown in Table 1.

As demonstrated in Table 2, there were 1975 affected eyelids recorded in this study. Thirteen eyelids with pseudoptosis were excluded. Laterality of the ptotic eyelids was statistically equivalent (right eye: 49.77%; left eye: 50.23%) ($p = 0.8396$). A total of 872 (44.15%) ptotic eyelids were congenital by the time of onset, and 1103 (55.85%) ptotic eyelids had an acquired etiology ($p < 0.0001$). For the ptosis classification, 1143 eyelids of myogenic ptosis comprised 57.81% of the majority population, followed by aponeurotic ptosis (38.39%), mechanical ptosis (2.38%) and neurogenic ptosis (1.32%) ($p < 0.0001$). There were four cases of mixed-type ptosis, in which two were the combination of myogenic and aponeurotic origin, another with myogenic and neurogenic origin, and the other showed myogenic and mechanical origin. The majority of myogenic ptosis cases were congenital ptosis (63.70%), followed by myasthenia gravis (MG) (18.37%), acquired muscular dystrophy (AMD) (13.47%), blepharophimosis, ptosis, epicanthus inversus syndrome (BPES) (1.40%), chronic progressive external ophthalmoplegia (CPEO) (0.52%), oculopharyngeal muscular disorder (OPMD) (0.35%), Meige's syndrome (0.26%), Freeman–Sheldon syndrome (FSS) (0.17%), floppy eyelid syndrome (FES) (0.17%), and myotonic dystrophy (0.17%) ($p < 0.0001$). Neurogenic ptosis was usually the consequence of oculomotor nerve palsy (73.08%) followed by Marcus Gunn syndrome (19.23%), and Marin-Amat syndrome (7.69%) ($p < 0.0001$).

Senile-related degenerative attenuation of the levator aponeurosis usually affected individuals older than 40 years of age and has shown to be the major cause of aponeurotic ptosis (94.33%). Nevertheless, aponeurotic

Table 1 Demographic features of 1164 patients with blepharoptosis

Age at operation (years)	No. of patients (%)	*p* value
< 20	131 (11.25)	< 0.0001
20–39	488 (41.92)	
40–59	298 (25.60)	
≥ 60	247 (21.22)	
Gender		< 0.0001
Female	851 (73.11)	
Male	313 (26.89)	
Ptosis		< 0.0001
Unilateral	353 (30.33)	
Bilateral	811 (69.67)	

Table 2 Data for 1975 ptotic eyelids

	No. of affected eyelids (%)	*p* value
Laterality	1975	
Right	983 (49.77)	0.8396
Left	992 (50.23)	
Etiology		
Congenital ptosis	872 (44.15)	< 0.0001
Acquired ptosis	1103 (55.85)	
Mechanism		
Myogenic	**1143 (57.81)**	
Congenital myopathy	744/1143 (63.70)	
MG	210/1143 (18.37)	
Acquired muscular dystrophy	154/1143 (13.47)	
BPES	16/1143 (1.40)	
CPEO	6/1143 (0.52)	
OPMD	4/1143 (0.35)	
Meige's syndrome	3/1143 (0.26)	
Freeman–Sheldon syndrome	2/1143 (0.17)	
Floppy eyelid syndrome	2/1143 (0.17)	
Myotonic dystrophy	2/1143 (0.17)	
Neurogenic	**26 (1.32)**	
Oculomotor nerve palsy	19/26 (73.08)	
Marcus Gunn syndrome	5/26 (19.23)	
Marin-Amat syndrome	2/26 (7.69)	
Aponeurotic	**759 (38.39)**	
Degenerative attenuation of aponeurosis	716/759 (94.33)	
Contact lens-induced ptosis	43/759 (5.67)	
Mechanical	**47 (2.38)**	
Post-inflammatory swelling	37/47 (78.72)	
Cicatrization	7/47 (14.89)	
Eyelid tumor	3/47 (6.38)	
Pseudoptosis	**13**	
Herring's law[a]	84/132 (11.95)	

Bold value indicates the ptotic mechanism with a p-value < 0.0001 from Chi-Square test, in which four ptotic types were compared; pseudoptosis was excluded from the test

[a]Per patient

MG myasthenia gravis

CPEO chronic progressive external ophthalmoplegia

FES floppy eyelid syndrome

BPES blepharophimosis, ptosis, epicanthus inversus syndrome

FSS Freeman–Sheldon syndrome

OPMD oculopharyngeal muscular disorder

MRD_1 margin reflex distance 1

ptosis was also observed in 43 eyelids of younger patients who had reported a history of contact lens wear with a mean duration of 11.26 ± 5.23 years. Previous studies have suggested that contact lens use had an increased risk for developing blepharoptosis [9–11]. These eyelids with aponeurotic ptosis were linked to contact lens use (5.67%) ($p < 0.0001$). Among 47 eyelids with mechanical ptosis, 37 ptotic eyelids were associated with post-inflammatory swelling (37/47, 78.72%). These cases presented with eyelid edema following facial trauma (8/37, 21.62%), allergic conjunctivitis (12/37, 32.43%), orbital cellulitis (4/37, 10.81%), ocular herpes (2/37, 5.41%), and cataract surgery (29.73%). In addition, seven cases were secondary to eyelid scarring (7/47, 14.89%) and three cases were found to have eyelid tumor (3/47, 6.38%). Among the seven cases of cicatricial blepharoptosis, four had a history

of upper blepharoplasty with iatrogenic partial severance of levator muscles, and three had a history of eyelid trauma. The primary cause for blepharoptosis following previous surgery was under correction of the eyelids, which were otherwise classified into myogenic, neurogenic, mechanical, or aponeurotic ptosis according to their initial ptotic etiologies. Positive findings of Hering's law were reported in 84 out of 132 patients (11.95%) in the population.

The age-specific incidences of blepharoptosis subtypes in 20-year intervals are summarized in Table 3 ($p < 0.0001$). Myogenic ptosis comprised 91.35% of the ptotic eyelids in the age group younger than 20 years, followed by mechanical (3.85%), aponeurotic (2.88%), and neurogenic ptosis (1.92%). In the age group between 20 to 39 years, myogenic ptosis remained the most common type of ptosis (88.58%), but the percentage of aponeurotic ptosis increased by 1.94-fold (5.58%); mechanical ptosis was 4.06% and neurogenic ptosis was 1.78%. Between 40 to 59 years, the incidence of aponeurotic was 62.18%, myogenic ptosis was 35.67%; neurogenic and mechanical ptosis were 1.17% and 0.97%, respectively. For patients older than 60 years, aponeurotic ptosis affected 83.69% of the senile group. On the contrary, 15.45% of the patients were influenced by myogenic ptosis; neurogenic (0.43%) and mechanical ptosis (0.43%) were relatively rare. Figure 1 illustrates the age-specific incidence of blepharoptosis subtypes. Myogenic ptosis represented the major type of ptosis in the population younger than 40 years old, whereas the occurrence of aponeurotic ptosis drastically increased in the elder population. There was no significant gender difference of each type of ptosis ($p = 0.1555$). Levator function and MRD_1 of each classification were also recorded. Mechanical ptosis had a mean LF of 14.19 ± 3.98 mm (2–20 mm) better than that of aponeurotic [13.56 ± 3.10 mm (0–20 mm)], myogenic [12.55 ± 4.71 mm (0–29 mm)], and neurogenic ptosis [9.15 ± 5.75 mm (1–17 mm)] ($p < 0.0001$). Collectively, 95.24% of mechanical ptosis and aponeurotic ptosis (93.24%) presented with excellent or good LF, whereas myogenic and neurogenic ptosis had inferior LF (77.17%, 52.63%) ($p < 0.0001$). Levator function of each subtype of blepharoptosis is shown in Fig. 2. Meanwhile, the mean

Table 3 Data for 1975 ptotic cases

Types of ptosis	Myogenic	Neurogenic	Aponeurotic	Mechanical	*p* value
N = 1975 (%)	1143	26	759	47	
Age					< 0.0001
<20	190 (91.35)	4 (1.92)	6 (2.88)	8 (3.85)	
20–39	698 (88.58)	14 (1.78)	44 (5.58)	32 (4.06)	
40–59	183 (35.67)	6 (1.17)	319 (62.18)	5 (0.97)	
≥ 60	72 (15.45)	2 (0.43)	390 (83.69)	2 (0.43)	
Gender					0.0010
Male	330 (28.87)	6 (23.08)	177 (23.32)	22 (46.81)	
Female	813 (71.13)	20 (76.92)	582 (76.68)	25 (53.19)	
Levator function (LF)					
Mean ± SD (min, max)	12.55 ± 4.71 (0, 29.00)	9.15 ± 5.75 (1.00, 17.00)	13.56 ± 3.10 (0.00, 20.00)	14.19 ± 3.98 (2.00, 20.00)	< 0.0001
LF quality					< 0.0001
Excellent (LF ≥ 13)	695 (53.71)	10 (0.77)	552 (42.66)	37 (2.86)	
Good (10 ≤ LF < 13)	202 (57.39)	2 (0.57)	142 (40.34)	6 (1.70)	
Fair (6 ≤ LF < 10)	95 (66.43)	6 (4.20)	42 (29.37)	0 (0.00)	
Poor (LF < 6)	151 (81.18)	8 (4.30)	23 (12.37)	4 (2.15)	
Preoperative MRD_1					
Mean ± SD (min, max)	0.76 ± 2.09 (− 8.00, 8.00)	− 0.08 ± 2.31 (− 4.00, 5.00)	0.51 ± 2.11 (− 6.00, 5.00)	0.47 ± 2.09 (− 5.00, 5.00)	0.0205
Ptosis severity (mm)					0.1595
Mild ($MRD_1 \geq 2$)	448 (59.57)	6 (0.80)	280 (37.23)	17 (2.26)	
Moderate ($0 \leq MRD_1 < 2$)	457 (59.04)	10 (1.29)	287 (37.08)	20 (2.58)	
Severe ($MRD_1 < 0$)	238 (52.89)	10 (2.22)	192 (42.67)	10 (2.22)	
β (*p* value)[a]	1.18 (< 0.0001)	1.17 (0.0153)	0.60 (< 0.0001)	1.12 (< 0.0001)	

[a]β is the regression coefficient of the linear regression model of the LF (dependent variable) and MRD1(independent variable)

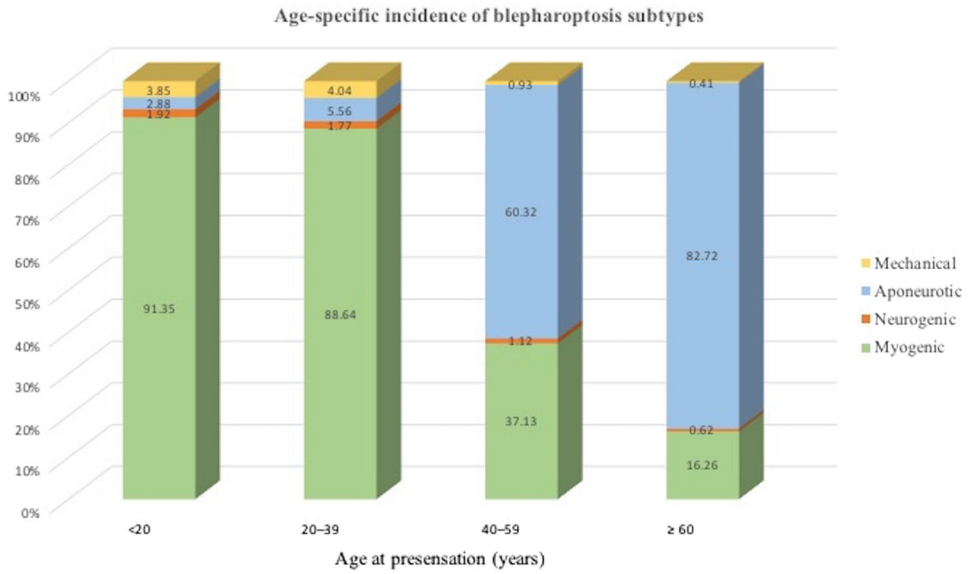

Fig. 1 Age-specific incidence of blepharoptosis subtypes. The age-specific incidence of blepharoptosis ptosis showed that myogenic ptosis had the highest incidence rate in all age groups, especially in patients younger than 40 years. The rate of aponeurotic ptosis increased with aging in patients over 40 years old

MRD_1 ranked from the best to worst was aponeurotic (1.32 ± 1.43 mm), myogenic (0.81 ± 1.97 mm), mechanical (0.69 ± 1.85 mm), and neurogenic ptosis (0.05 ± 2.22 mm) ($p = 0.0422$). The degrees of ptosis severity were statistically insignificant among the four categories of blepharoptosis ($p = 0.1782$).

Not only for myogenic ptosis, but the simple linear regression model also showed positive correlation between LF and MRD_1 in neurogenic, aponeurotic, and mechanical ptosis (Fig. 3). In this report, the data of the aponeurotic ptosis model were compatible with a previous study [10]. Neurogenic ptosis resulted in the most severe levator dysfunction in each millimeter of MRD_1 reduction. The result suggested that muscular dysfunction was implicated in all subtypes of ptosis despite the difference of mechanisms.

Discussion

Blepharoptosis, or drooping of the upper eyelid, is clinically defined as an upper eyelid margin covering the limbus greater than 2 mm by length, or the MRD_1 measuring less than 4 mm [5]. A detailed ocular and eyelid examination is necessary during the assessment of blepharoptosis to achieve the best surgical result. Based on the etiology, blepharoptosis can be categorized into myogenic, aponeurotic, neurogenic, and mechanical ptosis. Patients who suffer from the illness usually seek medical attention owing to various reasons, including cosmetic deformity, attendant visual field obstruction, or prefrontal headache due to over use of frontalis muscle in an attempt to elevate the upper eyelid [3, 4, 8]. In this study, 1164 patients were divided

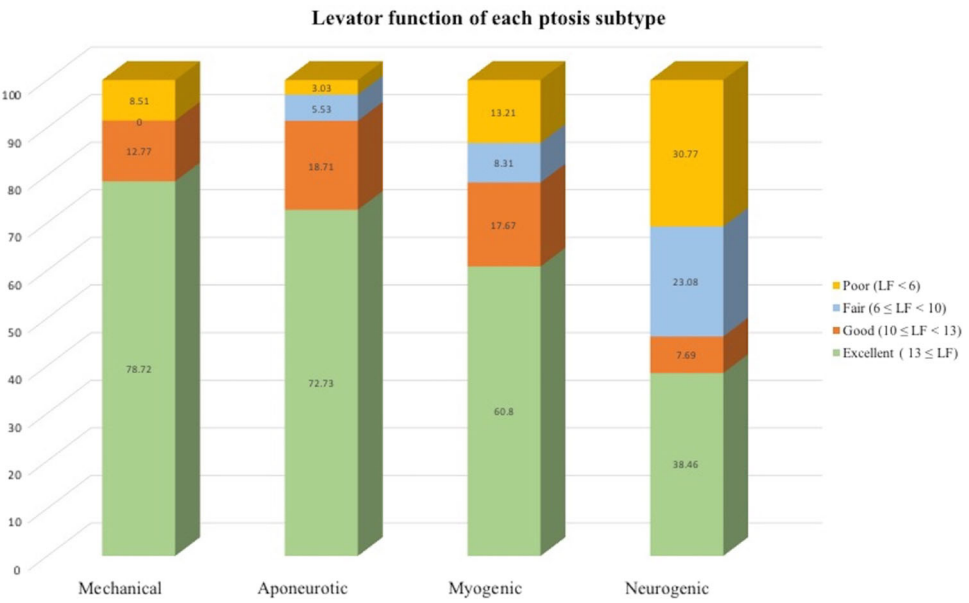

Fig. 2 Levator function of ptosis subtypes. LF of aponeurotic ptosis was preserved, which was compatible with the findings of the previous literature. LF of mechanical ptosis was nearly unaffected. Neurogenic ptosis demonstrated the poorest LF than that of myogenic ptosis, indicating that the disruption of the oculomotor innervation also resulted in levator dysfunction

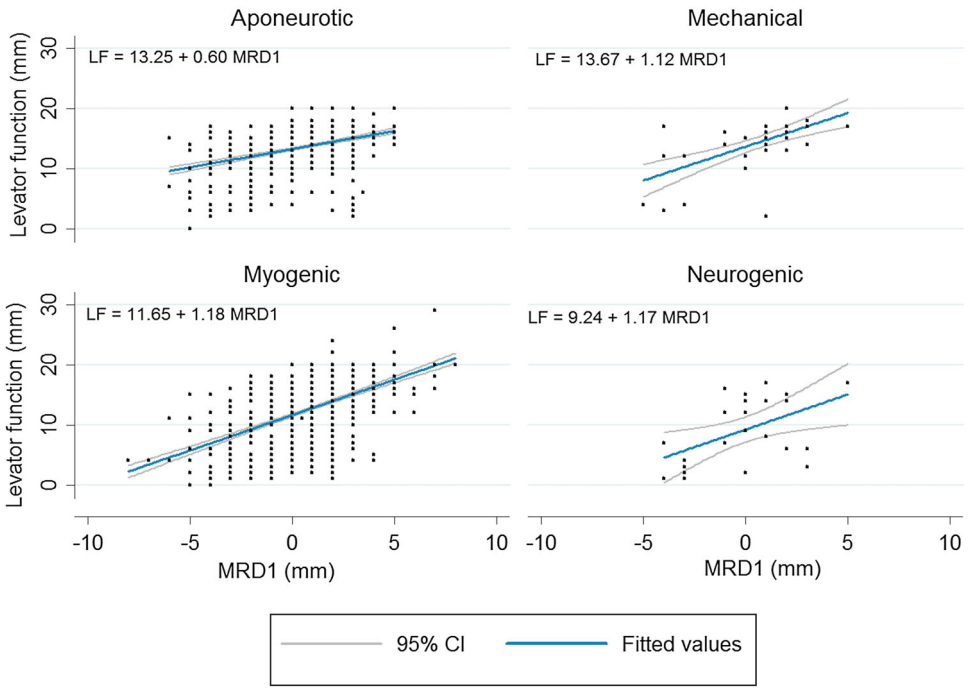

Fig. 3 Levator function versus ptosis severity (MRD_1) in the subtypes of blepharoptosis. Scatterplot and regression line between LF and ptosis severity demonstrating that not only for myogenic ptosis, LF of neurogenic, aponeurotic, mechanical ptosis was also positively correlated with ptosis severity. In particular, neurogenic ptosis had the highest degrees of levator function reduction for each millimeter in MRD_1 decrease

into four age groups by 20-year intervals to analyze the age-specific structure of blepharoptosis. Myogenic ptosis represented the most frequent type of blepharoptosis in the younger groups (91.35% in age < 20 years and 88.58% in 20–39 years), which was consistent with the age structures in previous studies [12–14]. On the contrary, aponeurotic ptosis increased with aging and was the predominant type of blepharoptosis in the elder groups (62.18% in 40–59 years and 83.69% in age > 60 years) given that it was mainly caused by senile degenerative attenuation. A high relative incidence rate of aponeurotic ptosis was reported by Lim et al. [15] In addition, a Korean national study also proposed similar demographic features [16].

The majority of cases were diagnosed between 20 to 39 years of age, in which simple congenital myopathy was the most frequent form and that 49.28% (344/498 eyelids) of the eyelids were graded mild in ptosis severity (mean age at presentation: 26.18 years). Due to different anatomical features of the eyelids, East Asians usually present with puffy eyelids and an absent double upper eyelid crease [17–19]. As a result, the demands for cosmetic double eyelid surgery to create creases in the eyelid for the appearance of a bigger eye have increased under the popular beauty standards. In out study, the age cutoff of 20 years was marked for the potential age with cosmetic pursuits. We suspect that early diagnosis of mild-type blepharoptosis in patients intended for double eyelid surgery may contribute to the result. In contrast, 78.42% of the cases younger than 20 years presented with moderate to severe form of ptosis (149/190 eyelids).

Epstein and Putterman [9] first reported contact lens wearing as the major cause of acquired aponeurotic ptosis in young to middle-aged adults. Van den Bosch et al. reported a mean MRD reduction by 5 mm in contact lenses wearers than the control group [11]. A systematic review and meta-analysis suggested that contact lens wearing has an increased risk for blepharoptosis in both hard and soft contact lens wearers compared to nonwearers [20]. Both hard and soft contact lenses were associated with acquired aponeurotic dysfunction [10, 11, 21–25]. The incidence of unspecified acquired aponeurosis secondary to hard and soft contact lens wear ranged from 23 to 57% and 26 to 69%, respectively [10, 11, 23, 24]. It was hypothesized that long-term contact lens wear was causative to levator disinsertion, dehiscence, or Müller muscle fibrosis as was observed in involutional aponeurosis [9–11]. Possible mechanisms were proposed by Van den Bosch et al. that the simultaneous, antagonistic action of the orbicularis and levator muscle while exerting excessive traction on the levator aponeurosis to remove the lens may result in levator disinsertion. Also, sideward pulling of the upper eyelid and forceful blinking during failed attempts at lens insertion or removal may cause thinning or disinsertion of the levator aponeurosis [11]. Irritations such as eye drying, deposits, and tear stagnation behind the lenses, hypoxia, hypercapnia, and erosions all lead to possible abnormal blinking and eye rubbing, causing palpebral edema, papillary conjunctivitis, and blepharospasms [26]. Oxidative stress was reported to play a role in the process of aponeurotic degeneration [27]. As a result, we extrapolated that first, for patients younger than 40 years of age who presented with acquired aponeurotic ptosis without other identifiable causes, contact lens wearing may have played a potential

causative role for the development of blepharoptosis. Second, contact lens-induced aponeurotic ptosis may not be uncommon in the younger population given that Taiwanese have been one of the largest consumers of contact lenses for medical or cosmetic use. In this study, 43 eyelids of acquired aponeurotic ptosis were reported in 35 young adults with a history of contact lens use. No specific causes other than contact lens wear such as allergy or preceding surgical history, myogenic or neurogenic etiologies were identified at the same time. These patients' ages ranged between 12 to 38 years with a mean age of 28.95 years, accounting for 5.67% of the ptotic eyelids that shared the same origin. In particular, 28 of the 35 patients had been wearing soft contact lenses (mean duration: 9.42 ± 4.02 years) while seven others had been wearing hard contact lenses (mean duration: 16 ± 5.12 years). The mean duration of hard contact lens wearing was longer than soft contact lens use ($p < 0.0001$). Previous studies revealed similar results [23]. Twenty-seven of these patients had unilateral blepharoptosis, and the rest had bilateral involvement ($p < 0.0004$). These contact lens-induced ptotic eyelids had excellent LF (mean: 14.88 mm). The mean MRD_1 of the affected eyelids was 1.53 mm.

LF was reported to positively correlate with MRD_1 in involutional ptosis, indicating the contributory role of levator degeneration in the pathogenesis [4, 5, 16]. In this study, degenerative attenuation of the aponeurosis, LF and MRD_1 values showed consistency (mean: 13.56 ± 3.10 mm and 0.51 ± 2.11 mm, respectively) with the previous literature [4, 5, 28–30]. The linear correlation between LF and MRD_1 yielded a regression coefficient coinciding with the result from the previous study by showing a 0.6 mm reduction of LF for each millimeter in MRD_1 decrease [30]. Levator dysfunction was not the only result of pathophysiological abnormality of the LPS muscle; oculomotor nerve damage or disrupted neuromotor innervation of LPS may also be implicated in poor levator performance. We found that impaired levator function was accountable for the development of neurogenic and mechanical ptosis. It was observed that neurogenic ptosis had the poorest average LF and MRD_1 among all subtypes of blepharoptosis. By definition, neurogenic ptosis results from oculomotor nerve palsy, which is responsible for innervation of the levator palpebrae superioris. Of the 26 cases of neurogenic ptosis in the study, 19 ptotic eyelids were caused by oculomotor nerve palsy, in which 12 cases resulted from traumatic brain injuries, four were associated with brain tumors (three with pituitary tumor and one with meningioma), one with cavernous angioma, and two with congenital oculomotor nerve palsy. Five eyelids were affected by the aberrant connection between the motor branch of the trigeminal nerve and oculomotor nerve that innervate the external pterygoid muscle and LPS simultaneously, as known as Marcus Gunn syndrome. Two ptotic eyelids were also caused by misinnervation of the LPS between the oculomotor and trigeminal nerve but in the opposite way, which was conventionally termed Marin-Amat syndrome [31, 32]. The result suggested that levator muscle degeneration may not be the only cause for LF reduction; oculomotor nerve abnormality also contributes to levator muscle dysfunction, resulting in a proportional decrease in the LF measurement and MRD_1.

In mechanical ptosis, the oculomotor nerve function has been shown to remain intact during neurologic examination. It was theoretically associated with periocular edema or hemorrhage during infection or post-traumatic swelling phase, eyelid tumor, or cicatrization that lead to excessive weight of the upper eyelid for the muscle to lift [5]. Particularly, in our study, 11 ptotic eyelids of 37 mechanical ptosis that presented with eyelids swelling were diagnosed following cataract surgery (mean age: 69.33 ± 8.98 years). Previous studies revealed that the rigid speculum used for eyelid retraction during cataract surgery was associated with a high occurrence of eyelid edema [33]. The mechanical intraoperative traction applied to the eyelids was linked to postoperative eyelid swelling, which might result in attenuation or disinsertion of the levator muscles, causing blepharoptosis after cataract surgery, especially in the elderly patients [34–36]. These predisposing factors were associated with levator dysfunction in mechanical ptosis as opposed to previous understanding. We suspect that eyelid neoplasm, local inflammation, or scarring of the surrounding structures may interfere with the full attachment of the levator muscle to the insertion sites, causing disruption of levator muscle function [37].

It would be essential to propose an age-specific analysis to investigate the epidemiology of blepharoptosis because age and its associated factors have been shown to influence the demographic structure of the illness. However, the single-center study has limitations in the interpretation of the result. Patients who did not complete the ophthalmic and eyelid examination were excluded from the study, which could pose selection bias. A population-based study will be needed to estimate the prevalence of blepharoptosis for the generalizability of ethnicity-specific population.

Conclusions

Multiple cultural and external factors have contributed to the distinct demographic features of blepharoptosis. Our study showed that myogenic ptosis represented the highest incidence rate in young adulthood. This may be linked to the fact that a mild degree myogenic ptosis was often simultaneously recognized owing to the growing trends of double eyelid plastic surgery in East Asia. In addition, aponeurotic ptosis was not exclusive to the middle to old age population but also in young contact lens wearers for

the increasing cosmetic and decorative contact lens use. As opposed to previous studies, we found that MRD1 positively correlated with levator dysfunction of myogenic ptosis, aponeurotic, neurogenic, and mechanical ptosis. Among the ptosis subtypes, ptosis severity of aponeurotic ptosis was least affected by levator dysfunction, while that of neurogenic ptosis was most impacted. In conclusion, when assessing a patient with blepharoptosis, all factors including age, life styles such as contact lens wearing, and levator function of the ptotic eyelids should be carefully evaluated to facilitate diagnosis and future operative planning to achieve the optimal surgical outcome.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflicts of interest.

Human and Animal Rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent For retrospective study, formal consent is not required.

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