

## Original Investigation

# Association of Eyelid Position and Facial Nerve Palsy With Unresolved Weakness

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**IMPORTANCE** Understanding the prevalence and clinical features of eyelid malpositions in facial nerve palsy (FNP) may inform proper management of patients with FNP and supplement our knowledge of eyelid physiology.

**OBJECTIVE** To describe eyelid malposition in FNP.

**DESIGN, SETTING, AND PARTICIPANTS** In this retrospective cohort study, patients with FNP seen at the Center for Advanced Facial Plastic Surgery and Jules Stein Eye Institute between January 1, 1999, and June 1, 2014, were reviewed for study inclusion. Data collection was performed between June 1, 2014, to August 1, 2014, and data analysis was performed between June 15, 2014, to September 1, 2015. The distances from the center of the pupil to the upper eyelid margin (marginal reflex distance 1 [MRD1]) and to the lower eyelid margin (marginal reflex distance 2 [MRD2]) were measured on photographs of patients in the primary position and with full smile. Eyelid asymmetry, retraction, ptosis, synkinesis, and severity and duration of FNP were assessed. Eligible participants were adults with FNP at a private tertiary care clinic with primary position photographs. Exclusion criteria included prior history of procedures or medical conditions that could alter eyelid position.

**RESULTS** The 52 included patients were predominantly female (38 [73%]), with a mean (SD) age of 44.1 (13.8) years. Of this group, 34 patients (65%) were white, 8 (15%) were Asian, 8 (15%) were Hispanic, and 2 (4%) were African American. Retraction (MRD1, >5.0 mm) was present in 8 patients (15%), 3 of whom had eyelid asymmetry (MRD1, >1.0 mm). Overall, total asymmetry of greater than 1.0 mm was present in 14 patients (27%), with the FNP side higher in 12 (23%). Compared with those without asymmetry, patients with eyelid asymmetry were significantly more likely to have contralateral ptosis (42% vs 2.5%,  $P < .001$ ) but did not have a significantly shorter duration of FNP (12.3 months vs 13.8 months,  $P = .82$ ). Ptosis was noted in 4 patients and was also unrelated to duration of FNP (9.6 months in patients with ptosis vs 13.6 months in those without,  $P = .60$ ). Synkinesis was found in 24 patients (46%), but none had concomitant ptosis. Severe FNP (House-Brackmann score,  $\geq 4$ ) was present in 28 patients (54%), and these patients were 20 times more likely to have asymmetry greater than 1.0 mm, often with the FNP side higher.

**CONCLUSIONS AND RELEVANCE** Upper eyelid asymmetry is common in FNP. In most of the patients in this study, the FNP side was higher without demonstrating retraction, and the contralateral side was ptotic. Thus, contralateral ptosis surgery may benefit these patients. Furthermore, patients with severe facial weakness were more likely to have eyelid asymmetry, suggesting that the ability of the eyelid position maintenance system to adapt to weakness of eyelid protractors may be limited by the severity of this weakness.

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**F**acial nerve palsy (FNP) resulting from a lesion of the seventh cranial nerve may result in a range of ocular sequelae, including poor or incomplete blink, brow ptosis, lagophthalmos, and diminished tear production.<sup>1,2</sup> This dysfunction is of particular concern because it can lead to impaired protection of the ocular surface with the potential for exposure keratitis, corneal abrasion, ulceration, and, ultimately, visual impairment.<sup>3</sup>

Upper eyelid retraction after FNP has also been noted in the literature as a common sequela of FNP.<sup>1,2</sup> This phenomenon is typically attributed to the unopposed action of the eyelid retractors because the loss of innervation to orbicularis oculi (cranial nerve VII) presumably allows the levator superioris to act without opposition.<sup>1,2,4-6</sup> An alternative theory suggests that eyelid retraction in this setting may be related to the formation of stiff actin-myosin cross-bridges in the levator superioris muscle.<sup>1,2</sup> However, despite these descriptions and hypotheses regarding eyelid retraction in FNP, few studies have described its epidemiology and natural history.

Of interest, eyelid ptosis has also been described in FNP and is typically attributed to aberrant facial nerve regeneration, which is expected later in the disease course.<sup>7,8</sup> One study<sup>7</sup> suggests that increased tone in the orbicularis oculi and/or established synkinesis between the orbicularis oculi and oris can lead to a relative protraction of the upper eyelid. However, the evidence for this phenomenon is mostly based on small case series, and there is again little information regarding the incidence and clinical features.

The aim of the current study is to describe eyelid position in patients affected by FNP with unresolved facial weakness to understand the timing and characteristics of any eyelid malpositions. This understanding may provide insight into proper treatment of patients with FNP with eyelid malpositions and may additionally advance understanding of the physiologic mechanisms of the eyelid position maintenance systems.

## Methods

In this retrospective, cross-sectional cohort study, patients with FNP seen at the Center for Advanced Facial Plastic Surgery and Jules Stein Eye Institute from January 1, 1999, to June 1, 2014, were reviewed for study inclusion. Data collection was performed from June 1, 2014, to August 1, 2014, and data analysis was performed from June 15, 2014, to September 1, 2015. This study was approved by the University of California, Los Angeles, Institutional Review Board (IRB). Consent was waived for this study by the IRB because it was performed retrospectively on deidentified data. Patients whose images appear in this publication provided written consent for the publication of their photographs. Patients older than 18 years with active facial weakness were included if they had standard primary position photographs taken in repose and recorded House-Brackmann scores. Exclusion criteria included the following: history of previous eyelid or facial surgery, insufficient clinical or photographic data, botulinum toxin use within 5 months of the photograph, history of known eyelid malpositions before FNP, and

## Key Points

**Question** How does facial nerve palsy (FNP) affect eyelid position?

**Findings** In this retrospective cohort study of 52 adults with persistent facial weakness from FNP, eyelid retraction (present in 15% of patients) and eyelid ptosis (present in 8% of patients) were both unrelated to duration of FNP or synkinesis. Patients with severe facial weakness (54%) were 20 times more likely to have eyelid asymmetry, often with contralateral ptosis but not ipsilateral retraction.

**Meaning** Eyelid asymmetry is common among patients with FNP, especially those with severe facial weakness, indicating that the eyelid position maintenance system may be overwhelmed by severe weakness of eyelid protractors.

any past or present condition other than FNP that could significantly affect eyelid position, including thyroid orbitopathy and neuromuscular disease. However, data were insufficient to identify and exclude patients with subtle preexisting eyelid conditions, such as subclinical ptosis, that were unknown to the patient and/or physician.

Demographic characteristics, history and duration of FNP (from onset to time of photographic assessment), and surgical history were recorded. Standard digital photographs of patients seated parallel to the plane of the film in the primary position and with full smile were extracted from a prospectively maintained imaging database.

All measurements were performed with ImageJ software (National Institutes of Health). The mean corneal diameter for women (11.64 mm) and men (11.77 mm) was used as a reference to set the scale for each photograph.<sup>9</sup>

Marginal reflex distance 1 (MRD1) was measured as the vertical distance from the center of the pupil to the upper eyelid margin. Marginal reflex distance 2 (MRD2) was measured as the vertical distance from the center of the pupil to the lower eyelid margin. Palpebral fissure height was calculated as the sum of MRD1 and MRD2. In the single case of dermatochalasis obscuring the upper eyelid margin, a digitally drawn curve was fitted to the visible portion of the upper eyelid margin and used to determine MRD.

Primary outcome measures were prevalence of eyelid retraction and ptosis. Eyelid retraction was defined as MRD1 greater than 5.0 mm. Eyelid ptosis was defined as MRD1 less than 2.5 mm.

Secondary outcomes included palpebral fissure (PF) height, lower eyelid retraction, and total upper eyelid asymmetry. An increase in PF height was defined as a greater than 1.0-mm difference between the PF height of the FNP side and the contralateral side. Lower eyelid retraction was defined as an MRD2 on the FNP side greater than 1.0 mm lower than in the unaffected eyelid. Upper eyelid asymmetry was defined as an absolute difference in MRD1 between the FNP and contralateral side of greater than 1.0 mm, which was classified as asymmetry with the FNP side higher or asymmetry with the FNP side lower.

Two subgroup analyses were performed. Patients were organized into synkinesis vs no synkinesis and severe vs

**Figure 1. Synkinesis of the Right Eyelid in a Patient With Right-Sided Facial Nerve Palsy (FNP)**



One patient with right-sided FNP in the primary position (top) and full-smile (bottom) depicting synkinesis. The marginal reflex distance 1 of the FNP side decreases greater than 1.0 mm more than the contralateral eyelid.

mild-moderate facial weakness groups. Synkinesis was assessed in patients with photographs taken in repose and with full smile. It was defined as a decrease in MRD1 between smile and primary position for the FNP side of 1.0 mm more than that of the contralateral side (Figure 1). This measurement corresponds to a change of 1.0 SD greater than normal eyelid lowering in the smile position (based on pilot data). Severe FNP was defined as a House-Brackmann score of 4 or greater. The effects of duration of FNP on ptosis, retraction, and PF height were also assessed. Statistical analyses were conducted using SPSS statistical software, version 22.0 (SPSS Inc).

Statistical analyses were conducted between June 15, 2014, to September 1, 2015, using SPSS statistical software, version 22.0 (SPSS Inc). Chi-squared tests were used to determine the relationship between the following: asymmetry with the FNP side higher and contralateral ptosis, retraction and synkinesis, retraction and severity of FNP, ptosis and severity of FNP, synkinesis and severity of FNP, and asymmetry of eyelid position and severity of FNP. Independent samples *t* tests for equality of means were used to assess the differences in: duration of FNP between patients with and without eyelid asymmetry, duration of FNP between patients with and without ptosis, contralateral MRD1 between patients with and without asymmetry with the FNP side higher, duration of FNP between patients with and without asymmetry with the FNP side higher, duration of FNP between patients with and without lower eyelid retraction, duration of FNP between patients with and without increased PF height, age at onset between patients with and without severe FNP, and duration of FNP between patients with and without severe FNP. Logistical re-

**Table. Characteristics of the Study Patients<sup>a</sup>**

| Characteristic                | Finding (N = 52) |
|-------------------------------|------------------|
| Age, mean (SD), y             |                  |
| Onset of FNP                  | 36.6 (17.3)      |
| Assessment                    | 44.1 (13.8)      |
| Duration of FNP, mean (SD), y | 7.5 (7.9)        |
| Sex                           |                  |
| Female                        | 38 (73)          |
| Male                          | 14 (27)          |
| Race                          |                  |
| White                         | 34 (65)          |
| Asian                         | 8 (15)           |
| Hispanic                      | 8 (15)           |
| African American              | 2 (4)            |
| Cause of FNP                  |                  |
| Bell palsy                    | 35 (67)          |
| Surgery                       | 10 (19)          |
| Ramsay Hunt syndrome          | 4 (8)            |
| Other                         | 3 (6)            |

Abbreviation: FNP, facial nerve palsy.

<sup>a</sup> Data are presented as number (percentage) of patients unless otherwise indicated.

gression analyses were used to assess the relationship between asymmetry with the FNP side higher and duration of FNP, and ptosis and duration of FNP. The level of significance used in this study was 0.05.

## Results

The final sample included 52 patients, who were predominantly female (38 [73%]), with a mean (SD) age of 36.6 (17.3) years at the time of onset and 44.1 (13.8) years at the time of photographic assessment. Of this group, 34 patients (65%) were white, 8 (15%) were Asian, 8 (15%) were Hispanic, and 2 (4%) were African American. The most common causes of FNP were Bell palsy (67%) and surgery (19%) (Table).

Retraction (MRD1, >5.0 mm) on the FNP side was present in 8 patients (15%). For 5 of these patients (63%), the MRD1 on the FNP side was within 1.0 mm of the MRD on the contralateral side, indicating a bilateral, relatively symmetric elevated eyelid position. In the remaining 3 patients (38%), the MRD1 on the FNP side was greater than 1.0 mm higher than on the contralateral side and greater than 5.0 mm above the center of the pupil.

Asymmetry with the FNP side higher was present in 12 patients (23%). Within this group, contralateral ptosis was significantly more common (5 of 12 patients [42%]) than it was among patients outside this group (1 of 40 patients [2.5%]) ( $P < .001$ ). The mean contralateral MRD1 in patients with asymmetry with the FNP side higher (2.5 mm) was significantly lower than those without (4.0 mm) ( $P < .001$ ). Patients with asymmetry with the FNP side higher did not have a significantly shorter duration of FNP (12.3 months) than patients without (13.8 months) ( $P = .82$ ).

Figure 2. Reversal of Eyelid Position on Smiling in a Patient With Right-Sided Facial Nerve Palsy (FNP)



In the primary position (left), this patient with right-sided FNP has asymmetry with the FNP side higher and ptosis on the contralateral side. When smiling (right), the FNP side has synkinesis and the contralateral eyelid elevates.

Duration of FNP did not predict asymmetry with the FNP side higher in logistic regression analysis ( $P = .82$ ).

Ptosis (MRD,  $<2.5$  mm) on the FNP side was noted in 4 patients (8%). No significant difference in duration of FNP between patients with ptosis (9.6 months) and those without (13.6 months) ( $P = .60$ ) was noted. In logistic regression analysis, duration of FNP did not significantly predict the development of ptosis ( $P = .59$ ). Asymmetry with the FNP side lower was noted in 2 patients (4%). Total asymmetry of greater than 1.0 mm was noted in 14 patients (27%).

Synkinesis was present in 24 of 52 patients (46%). Within this group, 2 patients (8%) had retraction, and none had ptosis on the FNP side. Retraction was not more commonly found in patients with synkinesis than in those without ( $P = .73$ ). Concerning asymmetry, 5 of the 24 patients (21%) with synkinesis had asymmetry, and the FNP side was higher in each of these cases. One such patient with synkinesis and asymmetry with the FNP side higher had complete reversal of eyelid position when smiling (Figure 2).

Lower eyelid retraction on the FNP side was present in 9 patients (17%). Those with lower lid retraction did not have a significantly shorter duration of FNP (6 months) than those without (15 months) ( $P = .09$ ). Similar results were observed with increased PF height, which was present in 14 patients (27%). Patients with increased PF height did not have a significantly shorter duration of FNP (7 months) than those without (15 months) ( $P = .07$ ). Of the 9 patients with FNP with lower lid retraction, 7 (78%) also had an increased PF height.

A House-Brackmann score of 4 or above was noted in 28 patients (54%). No significant difference was found between the groups in age at onset or duration of FNP ( $P = .26$  and  $.19$ , respectively). Patients with House-Brackmann scores of 4 or higher were no more likely to have retraction (18% vs 13%,  $P = .59$ ), ptosis (14% vs 0%,  $P = .054$ ), or synkinesis (48% vs 52%,  $P = .77$ ). However, they were 20 times ( $P = .006$ ) more likely to have asymmetry (47%) than those with less severe facial weakness (4%). In 11 of the 13 patients, the asymmetry was with a higher facial nerve palsy eye.

## Discussion

Upper eyelid retraction, when defined as an MRD1 greater than 5.0 mm, was found in 8 individuals of our cohort of 52 patients with FNP. Five of these 8 patients did not have significant MRD1 asymmetry, suggesting that most such cases have a relatively high-normal eyelid position regardless of FNP. The remaining 3 (6% of the overall sample) had unilateral upper eyelid retraction. Thus, a small group of individuals appears to manifest eyelid retraction to an abnormal position at the corneal limbus as a sequela of FNP.

Asymmetry in MRD1 with the facial palsy eyelid higher was far more common. We noted that 12 patients (23%) in our sample had an MRD1 greater than 1.0 mm higher on the FNP side than on the contralateral side, yet 5 of these 12 patients (42%) had a relatively normal MRD1 on the FNP side with contralateral ptosis. In these cases, it is debatable whether the higher MRD1 on the FNP side is a direct consequence of retraction or simply a byproduct of ptosis (unmasked or preexisting) in the contralateral eyelid. This finding again suggests that the prevalence of isolated primary elevation of the FNP eyelid may be lower than expected, closer to 15% overall. The literature provides little guidance on the representativeness of this estimate because few reports have described the prevalence of FNP-related retraction, and they do not indicate whether true retraction or contralateral ptosis is expressed.<sup>1,2,4,5</sup>

Overall, although eyelid retraction is commonly thought to accompany FNP, ostensibly related to unopposed levator function, our data suggest that this retraction occurs relatively rarely. This disparity may be related to a number of factors. Preexisting ptosis on the contralateral side, for instance, can manifest as an apparent retraction on the FNP side. Compounding this effect, it is plausible to consider that the Hering forces on the FNP side may be more greatly manifest because of a weakness of the protractors.<sup>10-12</sup> One might therefore predict that contralateral ptosis surgery could have a positive effect on FNP eyelid position and thus aid in reestablishing eyelid symmetry. Further study will be required to make this determination.

Ptosis (MRD,  $<2.5$  mm) was overall uncommon on the FNP side, with a prevalence of only 8%. This estimate was not influenced by age at onset of FNP or duration of symptoms. In addition, despite almost half of the sample having synkinesis of the FNP eyelid, none had concomitant ipsilateral ptosis. Thus, we were unable to confirm the suspected association between synkinesis and ptosis on the FNP side. Notably, this result does not disprove the association between ptosis and synkinesis, which is clearly documented in the literature.<sup>7,8,13</sup> However, this investigation suggests that ptosis in FNP is heterogeneous and neither specifically nor consistently associated with synkinesis. The implication of this finding on the management of ipsilateral ptosis in patients with FNP is as follows. A few patients with FNP and ipsilateral ptosis may have underlying synkinesis that could benefit from neurotoxin therapy.<sup>8</sup> However, most patients with FNP and ipsilateral ptosis do not have ipsilateral synki-

nesis and thus would not be expected to benefit from neurotoxin therapy; conventional surgical approaches may be more beneficial to these patients.

When all cases of upper eyelid asymmetry are considered together, we found that 14 patients (27%) had upper eyelid asymmetry greater than 1.0 mm, with the FNP eyelid higher in most (12 of 14 [86%]) of these cases. Eyelid margin asymmetry appears to be more prevalent in patients with FNP than in the general population (<10%), where mean MRD1 asymmetry is reported to be less than 0.5 mm.<sup>14,15</sup> This observation points to a more generalized problem in FNP, namely, that patients with FNP have an overall dysregulation of the eyelid position maintenance system. Whether this dysregulation is manifest as retraction or ptosis on the FNP side could depend on a range of factors, including contralateral ptosis, ipsilateral synkinesis, or other factors that are currently not well understood. The additional finding that more severe facial weakness is highly associated with a greater probability of asymmetry further suggests that there may be a range of dysfunction that this system can tolerate, outside which asymmetry ensues. Future research will be required to elucidate the particulars of such a system; however, the epidemiologic findings are highly suggestive.

There are a number of key limitations to note in this study. Initially, we included in our sample only individuals with unresolved facial weakness. As such, our findings may not apply to patients with return of facial nerve function to a level closer to normal. We also excluded patients with previous eyelid or eyebrow surgery, which may have led to an underrepresentation of patients with FNP with indications for surgery, such as lagophthalmos and exposure keratopathy. However, all the patients presented for surgical intervention, and most underwent a facial reanimation procedure, although this is not the focus of this report. Furthermore, our definitions of re-

traction, ptosis, and asymmetry are somewhat arbitrary. However, there is little consensus regarding these definitions in the literature generally.<sup>16-18</sup> In addition, our selection of 1.0 mm for asymmetry calculations was based on data<sup>19</sup> suggesting that the general population can reliably identify between 1.0 and 1.5 mm of eyelid asymmetry. Thus, we chose 1.0 mm as a conservative measure of asymmetry. Moreover, we used full facial smile to evaluate synkinesis. In some cases, it is possible that other facial maneuvers could have elicited some synkinesis that was not evident on full smile. Finally, in cases of brow ptosis or dermatochalasis, MRD was approximated by fitting a curve to the contour of the eyelid, which introduced some error into the measurements. However, this was only necessary for a single case and is thus unlikely to have biased the results significantly.

## Conclusions

Overall, it is noteworthy that almost three-fourths of patients in this study with unresolved facial weakness after FNP maintained a relatively symmetric and normal eyelid position despite manifest weakness of the eyelid protractors. However, the incidence of asymmetry is still higher than one would expect in the general population. The totality of these findings again underscores the complexity of the eyelid position maintenance system. This system appears to have the capacity to recalibrate in response to changes in the balance of protracting and retracting forces in the eyelid, but that capacity seems to be limited in the setting of severe facial weakness, leading to an elevated incidence of eyelid asymmetry. More research is clearly required to better understand the complexities of maintaining eyelid position in states of health and disease.

### ARTICLE INFORMATION

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**Study concept and design:** Sinha, Rootman, Goldberg.

**Acquisition, analysis, or interpretation of data:** All authors.

**Drafting of the manuscript:** Sinha.

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