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What is This?
Characterization of Facial Paresis in Hemifacial Microsomia

Jay M. Cline, MD¹, Katherine E. Hicks, MD¹, and Krishna G. Patel, MD, PhD¹

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Abstract

Objective. To provide an overview of the incidence, characteristics, and proposed etiologic mechanisms of facial paresis in patients with manifestations of hemifacial microsomia.

Data Sources. PubMed database for English-language studies with no date restrictions.

Review Methods. A comprehensive literature review was performed identifying all studies that discussed incidence, characterization, or etiologic mechanisms for facial paresis in hemifacial microsomia/oculo-auriculo-vertebral spectrum.

Conclusions. This review supports that the prevalence of facial weakness in the spectrum of hemifacial microsomia/oculo-auriculo-vertebral spectrum ranges from 10% to 45%. Most of these patients have involvement of all facial nerve branches or lower branches only. The most commonly involved single nerve branch has yet to be described. The 2 most common associated anomalies involve the mandible and auricle. Dysmorphogeneisis of the temporal bone and its effects on the facial nerve are most likely implicated in the cause of facial weakness.

Implications for Practice. There is a wide variety of facial nerve presentations seen within oculo-auriculo-vertebral spectrum for which the exact etiologic mechanism is unclear. Through a better understanding of the presentation and etiology surrounding facial paresis in hemifacial microsomia, improved treatment options may be offered in the management of the facial weakness.

Keywords
hemifacial microsomia, Goldenhar’s syndrome, oculo-aucuilo-vertebral, facial paresis, facial paralysis, craniofacial

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Hemifacial microsomia (HFM) is a condition characterized by underdevelopment of the first and second branchial arch structures. It has a wide range of phenotypical presentations but primarily includes developmental abnormalities of the facial skeleton (mandible, maxilla, zygoma, and/or temporal bone), ear, and facial soft tissues.¹³ Goldenhar syndrome is considered a variant of this condition that additionally includes epibulbar dermoids and vertebral anomalies.²⁴ Numerous case reports have described varying degrees of severity as well as additional associated anomalies involving the cardiac, renal, and musculoskeletal systems.⁵⁻¹⁰ Multiple names have been proposed and/or used over the years, including hemifacial microsomia, oculo-aucuilo-vertebral dysplasia, Goldenhar syndrome, and first arch syndrome.²¹ Oculo-aucuilo-vertebral spectrum (OAVS) is an encompassing term that was proposed by Gorlin in 1990, which includes HFM, Goldenhar syndrome, and all its associated anomalies and variations. There are no established criteria that are used for diagnosis. Regardless, when enough facial features are present, the facial phenotype provides sufficient information for diagnosis. The OMENS classification scheme is the most encompassing system available for OAVS. This includes skeletal, auricle, and soft-tissue categories. This was proposed by Vento et al¹² in 1991 as an acronym for orbital dystopia, mandibular hypoplasia, auricle, cranial nerve, and soft-tissue deficits. Each category is divided into 4 distinct levels based on the severity of the anomaly. An asterisk can be used at the end of the acronym to designate other less common anomalies such as cardiac or renal involvement.¹²

The incidence of OAVS is estimated to be 1 in 5600 live births.² There have been reports that it occurs more frequently in males (3:2) and on the right side (3:2); however, other studies report equivocal representation.²³⁻¹² Bilateral presentation occurs 10% to 30% of the time.²⁻¹³ As mentioned above, there can be a plethora of anomalies that are present within this spectrum; however, the most common are those included in the OMENS classification. Orbital involvement may be the most infrequent of the 5 categories, with reports of approximately 15% of cases.¹²

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Mandibular hypoplasia occurs more frequently, ranging from 89% to 100% of presentations. As mentioned, ear anomalies are the simplest and likely the most common form of OAVS. The estimated prevalence of ear anomalies is 65% to 99% and includes microtia, anotia, preauricular skin tags, middle ear (ossicle) defects, pinna abnormalities, and external auditory canal atresia. Soft-tissue defects occur in 17% to 95% of cases and include masticatory and facial muscle hypoplasia, parotid gland hypoplasia, involvement of subcutaneous tissue, and macrostomia (which can be associated with lateral clefts). CN involvement, and more specifically facial nerve involvement, have been reported in 10% to 45% of cases. It is unclear whether this is secondary to hypoplasia of embryologic mesenchymal elements and underdeveloped facial musculature, hypoplasia of neuroectodermal elements and an underdeveloped facial nerve, or a combination of both. It has been reported that the marginal mandibular branch is most commonly affected; however, there are little data to support this assertion. In addition, reports suggest that as the severity of auricular deformity increases, the likelihood of facial nerve paresis increases. This is related to temporal bone hypoplasia resulting in abnormal middle ear anatomy, anomalous facial nerve pathways, and atresia of the fallopian canal. There have been limited data previously reported on the exact presentation of facial nerve abnormalities as it relates to HFM.

The aim of this study is to review the literature related to facial nerve weakness within HFM/OAVS and provide an overview of the incidence, characteristics, and possible etiologic mechanism.

Methods

A comprehensive search was performed of the PubMed database with no restrictions. The search terms used were “hemifacial microsomia” OR “Goldenhar syndrome” OR “oculo-auriculo-vertebral syndrome” AND “facial paralysis” OR “facial paresis.” An additional search was performed using the terms “craniofacial microsomia” OR “first and second branchial arch syndrome” AND “facial paralysis” OR “facial paresis.” The reference lists of included studies were reviewed for additional potential sources. A total of 106 sources were identified and screened for discussion of the OAVS and any mention of facial paralysis. Among the combined 507 patients, there were 208 reports of facial weakness (41%) involving all 21 studies. Twelve of 21 studies described the involvement of specific nerve branches providing details for 126 of 208 CN VII palsies. This was categorized by involvement of upper branches only (19/126), lower branches only (42/126), all branches (47/126), or partial branches but not otherwise specified (NOS; 18/126). The right-to-left ratio was 3.2:2, which is very similar to the reported 3:2 ratio in the literature.

Results

There were 33 articles included for review, dating from 1963 to 2008. Twenty-one provided specific patient data regarding clinical manifestations of individuals with OAVS. Twelve studies did not provide patient data but were included for information related to the etiology of the OAVS and/or its association with facial nerve involvement. The patient-specific data from all 21 sources were combined in an effort to observe trends and common manifestations in the largest patient population possible. Not all studies described the same type of information; therefore, the number of contributing studies to given characteristic is reported with each finding as a marker of validity. There are obvious limitations with this method, which will be discussed later, but valuable information can be gleaned nonetheless. From the combined patient database, there were a total of 507 patients represented. Gender information was reported in 18 of 21 studies, representing 434 of 507 patients with 227 males and 207 females. Regarding the side of face involved, there were 256 right-sided, 158 left-sided, and 80 bilateral presentations recorded from 10 of 21 studies. The right-to-left ratio was 3.2:2, which is very similar to the reported 3:2 ratio in the literature.

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individualized patient. Many of the patients in the combined group had mandibular involvement; however, there were limited data to identify how often it occurred with facial weakness. There were 24 of 208 patients with definite mandible involvement, 8 of 208 without mandibular involvement, and 176 who were unable to be determined from the literature (Figures 3-5).

Discussion
There is a significant amount of literature on OAVS, dating back to the 1800s, that report a wide range of clinical manifestations and common associations. Facial weakness in OAVS has also been described on numerous accounts; however, many of the specifics regarding the nerve branch distribution, etiology, and severity of facial weakness are unclear.

Our literature search focused on studies that included facial weakness within the OAVS. Grabb\(^43\) reported CN VII

![Figure 2](image2.png) Total number of documented facial nerve palsies in 18 of 21 studies for the right and left side of the face, bilateral involvement, and those in which the side involved was not otherwise specified (NOS).

![Figure 3](image3.png) A patient with hemifacial microsomia (HFM) demonstrating left microtia, mandibular hypoplasia, epibulbar dermoids, and complete facial paralysis involving all branches of the facial nerve. The presence of epibulbar dermoids is one of the characteristics of Goldenhar syndrome, which is a more severe form of HFM.

![Figure 4](image4.png) A patient with hemifacial microsomia demonstrating right microtia, mandibular hypoplasia, and incomplete facial paresis involving the most severe weakness within the upper branches of the facial nerve.

![Figure 5](image5.png) Total number of common hemifacial microsomia anomalies that were documented from 21 studies.
involvement in 10% of cases of HFM, while Vento et al\textsuperscript{12} reported an incidence of 45% in his study of 154 patients. Our specific search for cases of facial weakness and OAVS reported a combined patient group incidence of facial nerve involvement in 41% of cases, which supports the previously estimated incidence of 10% to 45%. Gorlin et al\textsuperscript{2} specifically reported lower facial weakness occurring in 10% to 20% of patients.\textsuperscript{2}

Murray et al\textsuperscript{16} reported that the marginal mandibular and temporal branches were most commonly involved, while Mulliken and Kaban\textsuperscript{29} and MacQuillan et al\textsuperscript{14} reported that the marginal mandibular branch is most commonly involved. It is unclear from these studies what data are used to assert these claims of specific facial nerve branch predominance. Our combined data demonstrate that the most common occurrences, when the facial nerve is involved, are weakness in all branches (37%) or weakness of the lower branches (33%). It was not possible to delineate the specific involvement of the marginal branch in comparison with the others, but these data do provide some support to the higher incidence of lower branch involvement. Further, prospective studies would be needed to further delineate the specific involvement of the marginal branch.

It would be expected that the incidence of facial weakness would have a similar right-to-left ratio of 3:2 as reported for general characteristics of OAVS. This specific aspect of facial weakness has not been reported in the literature. Our combined data show nearly an equal distribution of right and left sides (18:15); this is likely secondary to the large number that were not specified in the included studies (64/98). In addition, the exact degree of weakness was not well defined in the literature.

Mulliken and Kaban\textsuperscript{29} and Murray et al\textsuperscript{16} reported that the severity of CN defects (specifically CN VII) increases as the severity of the ear deformity increases. They additionally noted that this correlation is not appreciated with facial nerve and mandibular/skeletal involvement. This suggests a stronger association of facial weakness with ear deformity. However, Carvalho et al\textsuperscript{18} did not find an association with facial weakness and auricular deformity, and Vento et al\textsuperscript{12} asserted that as the severity of mandibular hypoplasia increased, so did the severity of facial weakness. This suggests that the association with mandibular involvement may be stronger than earlier studies reported. From the 208 reports of facial weakness in our combined data set, there were more occurrences of ear involvement (62/208) than mandibular involvement (24/208). However, because exact ear/mandible involvement was unable to be determined in most patients reported with facial weakness, limited conclusions can be drawn from these data.

The primary treatment reported in the literature for facial weakness in OAVS consists of neurorraphy techniques including cross-face nerve grafting and parallels treatments used for other causes of facial paralysis. Ysunza et al\textsuperscript{39} reported using the sural nerve as a graft to provide innervation from the unaffected facial nerve to the musculature on the affected side. The sural graft was buried into the muscle mass, as opposed to anastomosis with a branch of the facial nerve, on the affected side because preoperative nerve conduction studies had failed to show any neural activity. Results were significantly better when this procedure was performed in children younger than 1 year, before the facial musculature was fully atrophied from lack of neural stimulation.\textsuperscript{27} Takushima et al\textsuperscript{36} reported using free muscle transfer with nerve grafting for the treatment facial weakness. They report a 2-stage procedure using a cross-face sural nerve graft followed by gracilis muscle transfer 1 year later, as well as a single-stage latissimus muscle transfer using the thoracodorsal nerve for nerve grafting. They had beneficial results in both groups of patients.\textsuperscript{36}

To date, it appears that OAVS is a heterogeneous disorder with causes linked to teratogen exposure, vascular disruption, and genetic involvement, and it ultimately translates into the underdevelopment of the first and second branchial arches.

Gorlin et al\textsuperscript{2} reported that the etiology of facial weakness in the OAVS is likely secondary to abnormal development of the temporal bone and the indwelling fallopian canal. A few case reports have described the histopathologic findings of the temporal bone in OAVS. The facial nerve has been found in an array of anatomical variants, including bifurcation and anterior displacement of the facial nerve; an anomalous course through the middle ear space, with the inferiorly directed limb proceeding down the posterior aspect of the middle ear as opposed to within the mastoid cavity; or complete absence of the facial nerve.\textsuperscript{34,35,37} The location or extent of facial weakness was not described in these studies, making it difficult to correlate the temporal bone findings with the clinical presentation.

There is definitive evidence for facial nerve involvement in many cases of OAVS; however, there are also reports that weakness may result from facial musculature hypoplasia, which arises from the second branchial arch.\textsuperscript{18,31} Electrophysiologic studies of the facial nerve and facial muscles have revealed a range from normal electromyography (EMG), normal conduction velocity, and mild clinical weakness to denervation on EMG with absent compound action potentials and full paralysis on clinical examination.\textsuperscript{21,27} All studies showed concomitant involvement of muscle and nerve, suggesting dysfunction within the facial nerve itself as the most common etiology.\textsuperscript{1,22,25,29,37} Further facial nerve histopathologic studies are needed to better discern the branch-specific etiology.

Our combined patient data set supports the current body of literature that facial weakness occurs in approximately 41% of patients with OAVS. Most of these patients seem to have involvement of all facial nerve branches or the lower branches only, which is in accordance with current literature. A clear definition of the most commonly involved branch of the facial nerve has yet to be proven. Likewise, the frequency of facial weakness severity was unable to be extrapolated from the data pool. There is evidence for innate facial nerve pathology being the key causative factor in facial weakness. Future studies involving histopathologic
evaluation of the different involved facial nerve branches and closer temporal bone anatomical evaluations will hopefully further elucidate the exact etiologic mechanism behind the wide variety to facial nerve presentations seen within OAVS. Through better understanding of the etiology and mechanisms surrounding facial paresis in HFM, improved treatment options may be offered in the management of the facial weakness.

Implications for Practice
There is a wide variety of facial nerve presentations seen within OAVS for which the exact etiologic mechanism is unclear. These presentations range from mild weakness of a single branch of the facial nerve to full paralysis of all facial nerve branches. Cross-facial nerve grafting and/or free muscle transfer with nerve grafting are some of the current surgical treatment options for patients with full paralysis. Through a better understanding of the etiology surrounding this facial paresis, improved treatment options may be offered in the management of facial weakness. For those with partial weakness, end-to-side neural amplification may be an additional surgical option. Early intervention with physical therapy or neurorhhaphy techniques, prior to muscle atrophy, may also be an advantageous treatment option that has not been clearly defined. Given the diverse presentation of facial paresis in OAVS, future studies involving histopathologic evaluation of the different involved facial nerve branches and closer temporal bone anatomical evaluations will, it is hoped, further elucidate the exact etiologic mechanism behind the variety of facial nerve presentations seen within OAVS.

Author Contributions
Jay M. Cline, substantial contributions to conception and design as well as analysis and interpretation of data, drafting the article and revising it critically for important intellectual content, final approval of the version to be published; Katherine E. Hicks, acquisition of data and analysis and interpretation of data, revising the article critically for important intellectual content, final approval of the version to be published; Krishna G. Patel, substantial contributions to conception and design as well as analysis and interpretation of data, revising the article critically for important intellectual content, final approval of the version to be published.

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