The effects of myotonic dystrophy and Duchenne muscular dystrophy on the orofacial muscles and dentofacial morphology

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This article takes a closer view of two of the less rare myopathies, myotonic dystrophy (MyD) and Duchenne muscular dystrophy (DMD). A high prevalence of malocclusions was found among the patients affected by these diseases. The development of the malocclusions in MyD patients seems to be strongly related to the vertical aberration of their craniofacial growth due to the involvement of the masticatory muscles in association with the possibly less affected suprahyoid musculature. Thus, a new situation is established around the teeth transversely. The lowered tongue is not in a position to counterbalance the forces developed during the lowering of the mandible by the stretched facial musculature. This may affect the teeth transversely, decreasing the width of the palate and causing posterior crossbite. The lowered position of the mandible, in combination with the decreased biting forces, may permit an overeruption of the posterior teeth, with increased palatal vault height and development of anterior open bite. The development of the malocclusions in DMD patients also seems to be strongly related to the involvement of the orofacial muscles by the disease. However, the posterior crossbite is not developed owing to the narrow maxillary arch, as is the case in MyD patients. On the contrary, the posterior crossbite in DMD is due to the transversal expansion of the mandibular arch, possibly because of the decreased tonus of the masseter muscle near the molars, in combination with the enlarged hypotonic tongue and the predominance of the less affected orbicularis oris muscle. □ *Craniofacial growth; malocclusion; masticatory muscles; myopathies; neuromuscular diseases*

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Many clinical and experimental studies have shown an association between the functional condition of the orofacial muscles and craniofacial growth (for review, see 1). Neuromuscular disorders comprise different types of diseases with a great variety of molecular genetic characteristics, pathologies, and clinical pictures. Weller et al. (2) classified the neuromuscular diseases into four major categories on the basis of their pathology:

1) Neurogenic muscle disease: In these disorders the neurons or axons supplying the muscles are damaged, and the muscles themselves show changes of denervation and reinnervation.

2) Disorders of neuromuscular transmission: In these diseases there is little histologic change in the muscle itself, except in the structure of the end-plates and terminal arborizations of motor nerves. The clinical and electrophysiologic effects, however, can be significant.

3) Primary muscle diseases—myopathies:

a. Destructive myopathies: In these myopathies the anatomic integrity of the muscle fiber is destroyed by segmental damage and necrosis.

b. Primary biochemical abnormalities: In these disorders there is abnormal muscle function due to enzyme defects or abnormalities of cell organelles or membranes. Destruction of muscle fibers is not usually seen.

4) Myopathies associated with systemic disorders (endocrine diseases, neoplasia, diabetes, etc.): The most common histologic change in the muscle in such disorders is selective type II fiber atrophy.

Since many muscular disorders result in weak muscles, a closer view of deviations occurring in the craniofacial growth of affected patients may give better insight into the influence of muscle function on dentofacial growth and morphology.

The aims of this article are to take a closer view of two of the less rare myopathies, myotonic dystrophy (MyD) and Duchenne muscular dystrophy (DMD), review the influence of these diseases on the orofacial muscles, describe the common characteristics and the differences in the dentofacial morphology in patients with these myopathies, and try to explain the factors that may have contributed to the specific dentofacial morphology.

Myotonic dystrophy

MyD is a muscle disease of autosomal dominant inheritance, affecting the sexes equally. The incidence has been estimated at approximately 5 persons per 100,000. MyD is caused by a mutation in the length of a trinucleotide (CTG) repeat in the 3′ untranslated region of the MyD gene located on chromosome 19q13.3. The normal gene has between 5 and 27 CTG repeats, whereas minimally affected individuals have at least 50 repeats and more severely affected patients up to several thousand repeats (3–5). However, the

pathogenetic mechanism of the disease is not fully elucidated (5). The progress of the disorder is, in general, extremely slow, and the muscles involved become atrophic and weak. The disease has a primary distal distribution, especially in the muscles of the hands, forearms, distal limbs, neck, tongue, and face. The disorder is characterized by myotonia, that is, a continued contraction of a skeletal muscle after the individual has stopped his or her voluntary effort to stimulate the muscle. MyD also affects other parts of the body, such as the cardiovascular, respiratory, alimentary, endocrine, and neurologic systems. The age of onset varies; most of the individuals affected by MyD are first recognized as having the disease during adolescence or in adulthood. One of the earliest and most constant features is facial weakness, with an expressionless face, sagging cheeks, and severe ptosis of the eyelids (6).

Orofacial muscles

The functional capacities of the anterior and posterior portions of the temporal muscle and the masseter muscle were evaluated by electromyographic (EMG) recordings in a group of MyD patients and a group of healthy individuals (7).

In the postural position no statistically significant differences were found in the mean voltage amplitude between the patient group and the control group for any of the three muscles studied.

Concerning the EMG activity during chewing, no differences were found for the activity in the posterior temporal muscle between the groups, while significant differences were found for the anterior temporal and masseter muscles. For these two muscles the patient group showed approximately half the mean EMG activity of the control group. The MyD patients needed approximately 2.5 times longer time and 2.5 more chewing cycles to triturate and chew before swallowing. No significant difference was found in the chewing velocity between the groups. During maximal clenching the patients had approximately 3 times less mean EMG activity than the healthy individuals. This was in accordance with the approximately 3 times weaker maximal bite force measured in the MyD group, compared with healthy controls (8). It is interesting that Gazit et al. (9) measured the strength of the orbicularis oris muscle by pomometer in a group of MyD patients and found their muscles to be 3 times weaker than those of healthy subjects.

A standardized ultrasound imaging technique was applied to measure the thickness and examine the internal structure of the masseter muscle in a group of adult MyD patients and a group of healthy individuals matched by age, sex, and number of occluding teeth. This was performed bilaterally, under two different conditions: when the muscle was relaxed, and when contracted during maximal clenching (10).

Under both conditions the masseter muscle in the MyD group was approximately 22% thinner than in healthy individuals. The thin muscle measured revealed an obvious atrophy of the masseter in the MyD group, which may have contributed to the weak maximal bite force and the low EMG activity mentioned above.

Healthy muscles have a heterogeneous speckled appearance in cross-section on an ultrasound scan because of the irregular connective tissue bundles that randomly permeate their structure. Thus, in the healthy individuals, the masseter muscle itself was scarcely echogenic, and the ultrasound waves found little resistance to reaching the tendinous structures and the bone surface, which were clearly echogenic and easily seen in the ultrasound image. In contrast, the intensity of the intramuscular echo (echogenicity) is higher when pathologic changes in the muscle occur, as was the case in MyD, which makes the penetration of the ultrasound waves more difficult. Thus, when the echo is reflected from the connective tissue septa, the tendinous structures and bone surface are less intense than in the healthy individuals.

The most common histopathologic changes in a muscle due to MyD have been described with reference to the biceps brachii muscle (11). The severity of muscular weakness was related to the predominance of type 1 fibers, the reduction in number of hypertrophic type 2 fibers, and the accumulation of adipose cells. Thus, the ultrasound image from the masseter in MyD with a brightly speckled pattern of increased echo was probably due to adipose tissue, which indicates fatty degeneration of the muscle. Thus, besides the atrophy of the masseter, the sign of degeneration of the contractile elements in the muscle adds one more reason for the low EMG activity and weak maximal bite force measured in the MyD patients.

The findings presented by Bakke et al. (12) in a 19-year-old man with muscular dystrophy showed different wasting patterns of mandibular elevator and depressor muscles after histologic examination of muscle specimens and functional examination comprising electromyography and force measurements. Pronounced histopathologic changes were present in the masseter muscle, whereas pathologic findings in the anterior digastric muscle were limited to an increased number of cells in slightly enlarged interfiber connective tissue. The depressor strength corresponded more to reference values, whereas the strength of the mandibular elevator muscles was less than one-third of the norm, as it was found in previously mentioned studies (7, 8). If this case report reflects the general pattern by which the disease affects the masticatory muscles, an imbalance is caused resulting in the lowering of the mandible, due to either gravitation or the activity of the possibly less affected suprahyoid muscles. This may explain the excessive interocclusal distance found in MyD patients (9). Increased frequency of mouthbreathing, poor chewing ability, and unclear speech have also been reported by the same authors, using patients' subjective evaluations.

Dentofacial morphology (Fig. 1)

The dentofacial morphology of groups of MyD patients was compared with that of healthy individuals (8, 9, 13–

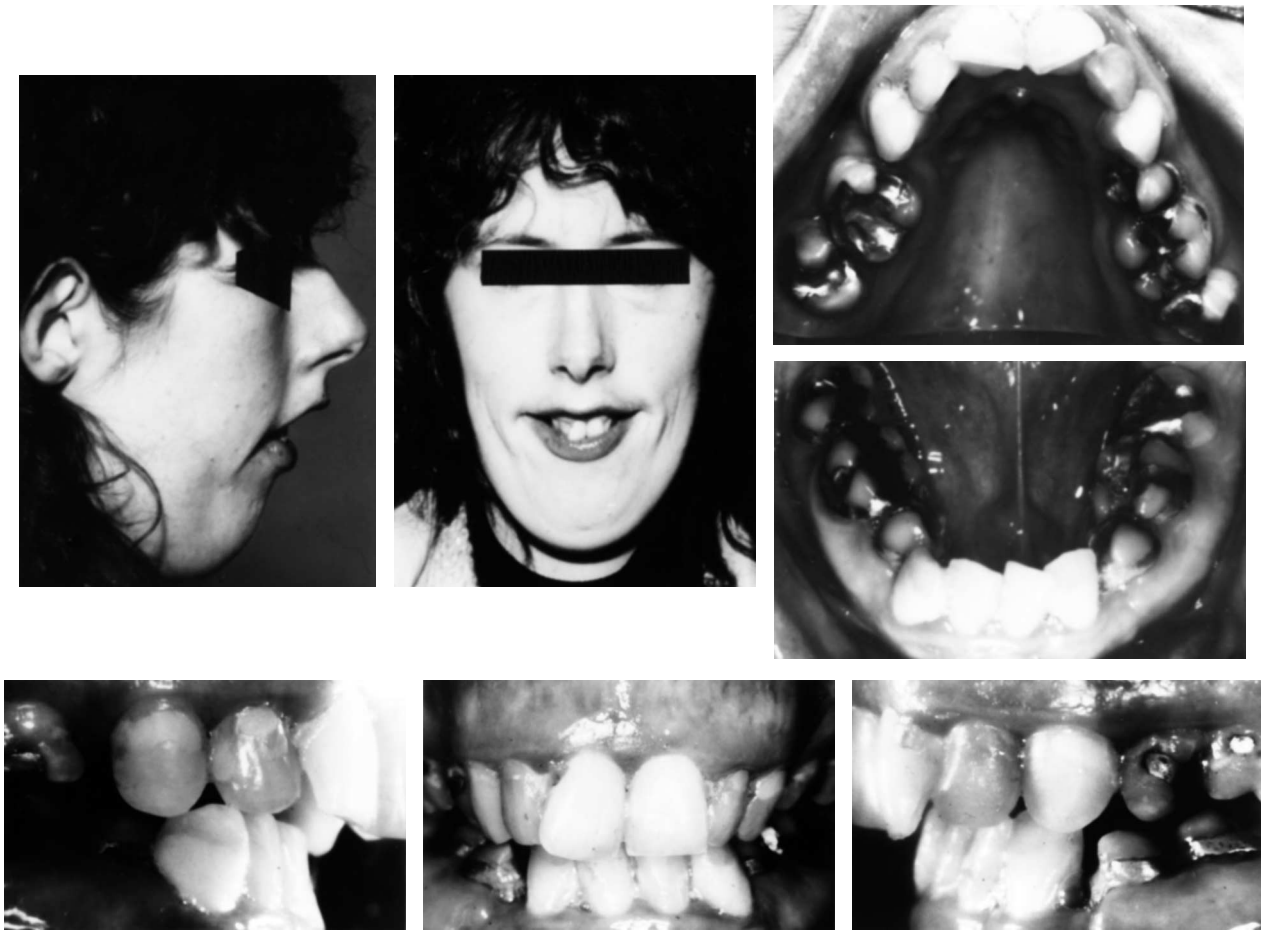

Fig. 1. Patient with myotonic dystrophy (MyD). Notice the facial weakness and sagging cheeks, as well as the long expressionless face, with large anterior lower facial height and narrow bizygomatic width. A high prevalence of malocclusions has been found among patients with MyD. Deep and narrow palate is one of the oral characteristics of these patients.

15). A high prevalence of malocclusions was found among patients with MyD. The most predominant malocclusions reported were anterior open bite and posterior crossbite, with a large overjet and often distal occlusion (8). Measurements were performed on dental casts to evaluate the dimensions of the palatal vault. Patients with MyD have a narrow upper dental arch and a deep palatal vault, as shown by both absolute and relative values (8, 9, 15).

Anthropometric measurements or facial measurements from photos revealed that MyD patients had narrow bizygomatic face width, narrow nose breadth, and narrow faces at the eye and lip levels (16).

The craniofacial morphology of the MyD patients showed a vertical aberration, characterized by a large angle between the mandibular and palatal planes and a large gonial angle. Their anterior lower facial height is relatively large (8, 9, 15, 17). These findings seem to be most pronounced in patients with an early onset of the disease, especially when there is a congenital muscular dystrophy, as shown in a case report by Kreiborg et al. (18). The patient exhibited a marked vertical development of the face with an extreme backward rotation of the mandible.

A possible explanation of these findings is that the involvement of the masticatory muscles by MyD may have caused a lowering of the mandible, due to either gravitation or the activity of the possibly less affected suprahyoid muscles. Lowering of the mandible can, in turn, affect the tongue position and head posture. Thus, a new situation is established around the teeth transversally. The lowered tongue is not in a position to counterbalance the forces developed during the lowering of the mandible by the stretched facial musculature. This may affect the teeth transversely, decreasing the width of the palate and causing crossbite. The lowered position of the mandible, in combination with the decreased bite forces, may permit an overeruption of the teeth. In this case the palatal vault height is possibly increased because of the overeruption, and the mandible rotates posteriorly, causing an increased angle between the mandibular and palatal planes. The big overjet in MyD patients may be attributable to the posterior rotation of the mandible. The large gonial angle

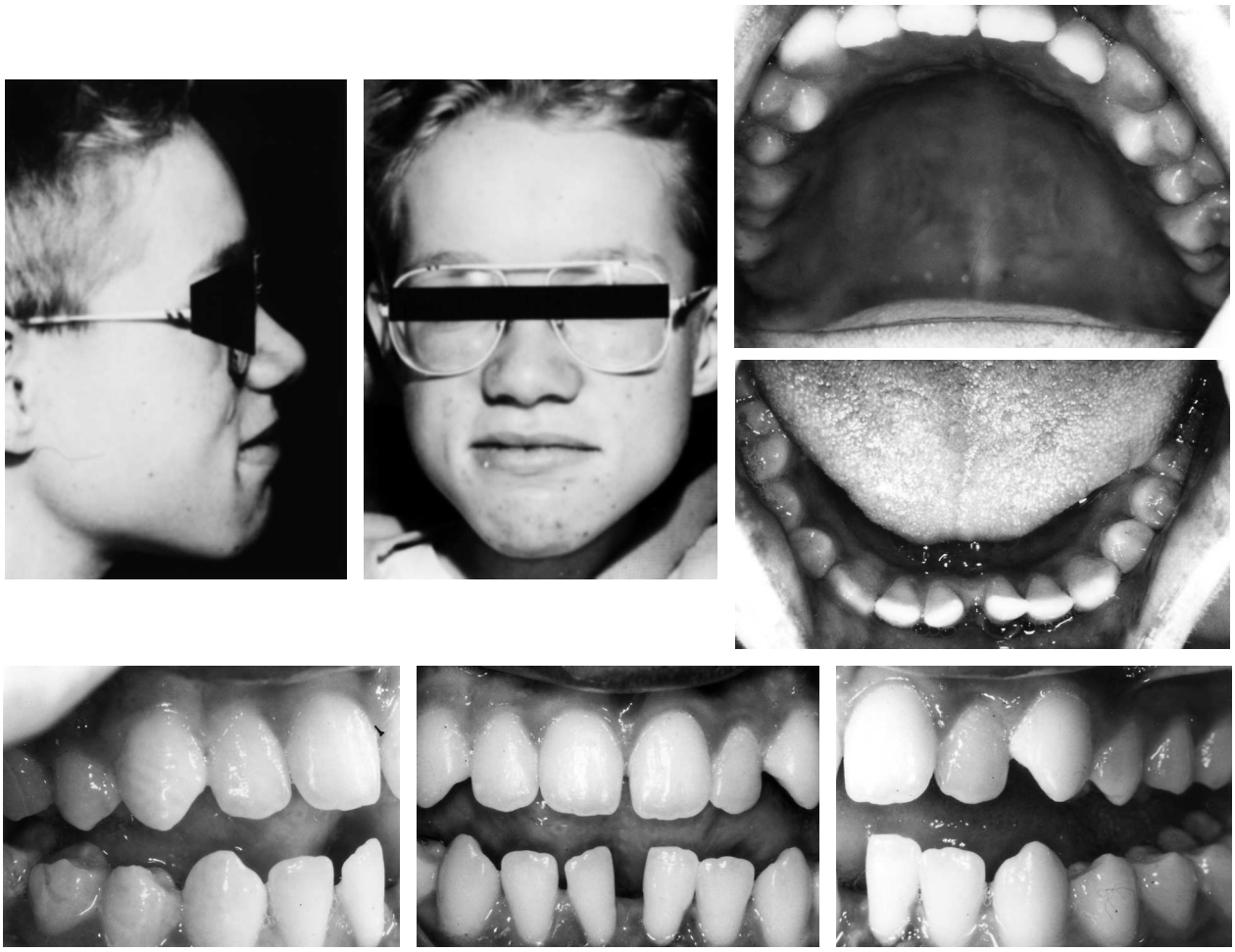

Fig. 2. Patient with Duchenne muscular dystrophy. Notice the wide maxillary and mandibular dental arches, with posterior crossbite and anterior open bite (the patient is in occlusion of the second molars).

of the mandible means that the form of the mandible was changed, since the tension applied on the bony structures by the masticatory muscles was low.

Duchenne muscular dystrophy

This severe form of destructive myopathy is an X-linked recessive disorder that affects 1 in 3500 live-born males (2). The affected gene has been localized in the short arm of the X-chromosome at the Xp21.2 site (2), and its protein product has been identified and called dystrophin (19). Dystrophin is absent or hardly detectable in DMD (2).

The disease has an average age of presentation of 3.5 years, but in the majority of cases the delay in motor function is recognized by the parents earlier. From the age of 7–8 years the progression of the disease is dramatic; the patients become wheelchair-bound at an age of 10–12 years with subsequent progressive loss of muscle strength in the upper limbs and development of scoliosis (2). The life expectancy is low; most patients die of respiratory failure between the ages of 16 and 21 years.

Orofacial muscles

Although the impairment and disability profile of this disease have been comprehensively described (20), few studies have dealt with the condition of the orofacial muscles in DMD patients (21–23). Eckardt & Harzer (23) longitudinally recorded the bite force and lip force of 15 DMD patients and found that these forces started declining after increasing to a certain point, whereas in the control group both lip and bite force increased continuously throughout the investigation period. The interesting finding was an observed difference in time between the attack on the orbicularis oris muscle and that on masticatory muscles. The activity of the jaw muscles diminished 2 years earlier compared with that of the perioral muscles, which started on average at 10 years of age. The tongue size was estimated transversally by

measuring the extension of the tongue with the mouth slightly open, and it was found to be bigger than in the controls. The tongue motility was measured on the basis of the maximum tongue extension, and it was found to be smaller than in the controls. Ghafari et al. (24) estimated that 42% of the Duchenne patients studied had 'large tongue'. Nevertheless, there are difficulties in establishing an objective method of evaluating the size of the tongue because of the interaction between tongue size, position, and behavior. It should be also considered that there may be an effect on the occlusion caused by the tongue. A tongue of normal size may be classified as large when it is protruded to clear the airway. Similarly, a normal-sized but broad and flat tongue covering the angles of the mouth may be characterized as a large one (25).

Dentofacial morphology (Fig. 2)

There is general agreement that the widths of the upper and lower dental arches in DMD patients are greater than in controls, the differences being more pronounced in the mandible than in the maxilla (23). The length of the dental arch is smaller in both arches than in controls. Transversal overdevelopment and sagittal shortening of the dental arch lead to reduction of overbite and overjet. The more pronounced differences in the width of the mandibular arch when compared with the maxillary one create the conditions for the development of posterior crossbite, which seems to be the most common malocclusion in DMD patients, ranging from 100% (23, 26) to 50% (24, 27–29). Anterior open bite is also represented among the DMD patients, but it is less frequent (ranging from 55% to 21% (24, 30)) than the posterior crossbite. In a group of 43 DMD patients, mouthbreathing was associated with open bite in five of the nine patients with anterior open bite, which means that there was no significant relation between mouthbreathing and anterior open bite, since every second DMD patient was a mouthbreather (24). Analysis of the longitudinal changes in dental and occlusal characteristics showed worsening of open bite and posterior crossbite, progressive widening of the dental arches and diastemata, and a more mesial jaw relation with time (30). Concerning the dental development in DMD patients, all the studies agree that there is 1-year delay in dental emergence (24, 29).

The facial morphology of patients with DMD has been shown to be retrognathic, with sagittal underdevelopment of the cranial, maxillary, and mandibular base and relatively large lower facial height. The interincisal angle is small, with retrusion of the incisors. Bizygomatic width is greater in DMD patients than in controls (23).

A possible explanation of the dentofacial morphology in DMD is the earlier involvement of the elevator muscles of the mandible by the disease, when compared with the perioral musculature (23). In this study the activity of the jaw muscles diminished 2 years earlier than that of the orbicularis oris muscle; in relation to the hypertrophy of the base of the tongue, this may have contributed to the development of extremely broad dental arches. Specifically, the decreased tonus of the masseter muscle near the molars, in combination with the enlarged hypotonic tongue and the predominance of the orbicularis oris muscle, created suitable conditions for the transversal expansion of the dental arches, especially for the lower one, at the expense of the sagittal dimension of the dental arches.

Concluding remarks

A closer view of two of the less rare myopathies, myotonic dystrophy and Duchenne muscular dystrophy, has revealed a high prevalence of malocclusions among patients affected by these diseases. The development of malocclusions in MyD patients seems to be strongly related to vertical aberration of craniofacial growth due to involvement of the masticatory muscles in association with the possibly less affected suprahyoid musculature. This may lead to the lowering of the mandible and the tongue, which is not in a position to counterbalance the forces developed by the stretched facial musculature. The new situation may affect the teeth transversely, decreasing the width of the palate and causing posterior crossbite. The lowering of the mandible, in relation to decreased bite forces, may permit an overeruption of the posterior teeth, with development of anterior open bite and deep palatal vault.

The development of malocclusions in DMD patients also seems to be strongly related to involvement of the orofacial muscles by the disease. However, the posterior crossbite is not developed owing to the narrow maxillary arch, as is the case in the MyD patients. On the contrary, the posterior crossbite in DMD is due to the transversal expansion of the mandibular arch, because of the decreased tonus of the masseter muscle near the molars, in combination with the enlarged hypotonic tongue and the predominance of the less affected orbicularis oris muscle.

It is obvious that any progress in the medical field that improves the condition of patients with neuromuscular disorders may be useful in decreasing the severity of their dentofacial anomalies. But this is not enough. Systematic efforts should be made to estimate the effects of therapeutic exercise on masticatory function in patients with neuromuscular disorders. The adaptability of the healthy masticatory muscles to training has been already proved (31, 32). Positive results have been published after introduction of therapeutic exercise of the stomatognathic system in patients with DMD (33). Improvement of the patients' masticatory function has been demonstrated, helping them gain better chewing ability and thus increasing their quality of life.

The importance of prospective longitudinal studies to elucidate the abnormal craniofacial growth and development of malocclusions in individuals affected by neuromuscular disorders is obvious. To our knowledge, not a

single prospective study has longitudinally recorded the alterations in the oral musculature and related them to the dentofacial changes that occur. This information is important for patients with various neuromuscular diseases, in order to improve their functional conditions and help them toward normal dentofacial growth.

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