Oral sugar clearance and other caries-related factors in patients with myotonic dystrophy

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The aim of the investigation was to try to explain why patients with myotonic dystrophy (MD) have a high caries prevalence. Seventeen MD patients, 15 of whom had been examined 8 years earlier, and 17 matched, healthy controls participated. In connection with this follow-up examination, the oral sugar clearance was evaluated after chewing a glucose tablet. A paraffin-stimulated whole saliva sample was collected for determination of secretion rate, buffer capacity, and numbers of mutans streptococci and lactobacilli. Dietary score, plaque index, oral muscular coordination, and self-cleaning ability were also recorded. For all factors, the MD patients showed less favorable mean values than the controls; the differences between the groups were statistically significant, except for the bacterial counts and the salivary buffer capacity. Thus, the high caries prevalence in MD patients may be explained by longer oral sugar clearance time, lower salivary secretion rate, higher intake frequency of sugar-containing products, higher plaque index, and less pronounced oral muscular coordination and self-cleaning ability than in healthy individuals. □ *Dental caries; myotonia atrophica; oral clearance; saliva*

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Myotonic dystrophy (MD) is a genetically determined disorder. This dystrophic muscle disease is accompanied by myotonia and by specific abnormalities of various other systems (1). It is not the only disorder characterized by myotonia but is by far the commonest and the only one in which progressive muscle weakness and wasting occur to a significant extent and in which extramuscular features are seen. In northern Sweden the prevalence of MD is 0.06–0.4 per thousand (2). According to Mahadevan et al. (3), there is a global incidence of 1 in 8000 individuals. The clinical picture of MD, including the age of onset, is highly variable (1). Some individuals born to a mother who is afflicted with MD develop a congenital form of the disease that is characterized by severe hypotonia and developmental delay (4). The median age of onset is 20 to 25 years.

Facial weakness is one of the earliest and most constant features (1). According to Kiliaridis et al. (5), MD patients have weak masticatory muscles. In a case report of one MD patient, Thayer & Crenshaw (6) state that there does not seem to be any greater incidence of periodontal disease or caries among patients with this disease. However, in a previous study (7), including 27 MD patients, we showed that persons with MD have fewer teeth, a higher caries prevalence, and more plaque than a control group. This may be due to their impaired oral muscular capacity.

It has been shown that a high salivary sugar concentration and a long oral retention time after food intake increase the risk of caries (8). Oral clearance is influenced by many factors, such as salivary secretion rate and movements of the lips and tongue after the food has been swallowed (9, 10). The clearance pattern of sugar is an individual property that is rather constant over time (11), although it deteriorates somewhat with age (12). There are no studies of oral sugar clearance in MD patients that we are aware of. The aim of the present study was therefore to try to explain why patients with MD have a high caries prevalence by examining various caries-related factors, including oral sugar clearance.

Materials and methods

Subjects

This follow-up examination was carried out in 1993. The 27 patients with a diagnosis of MD who took part in our previous study in 1985 (7) were invited to participate in the present investigation also. They were all living within a distance of 100 km of the city of Göteborg. Fifteen of them were able to enter the study, and two new MD patients were recruited. Thus, the MD group comprised 17 individuals, 7 men (mean age, 52.7 years) and 10 women (mean age, 48.7 years). The 27 control patients from the previous study were also contacted, and 11 responded. Six new patients in the control group were enrolled from a Public Dental Clinic in Göteborg. Thus, the control group consisted of 17 individuals, 7 men (mean age, 51.4 years) and 10 women (mean age, 47.0 years). Thus, the two groups were matched with regard to sex and age.

Fourteen of the MD patients had other diseases in addition to MD; most common were gallbladder or liver disorders, low blood pressure, and thrombosis. In the control group eight of the patients reported diseases

related to high blood pressure or allergy. One MD patient and two control patients reported taking medication that might influence saliva secretion.

Questionnaire

A standardized questionnaire from the Public Dental Service in Göteborg was used for information about general health. To this, specific questions were added about dental care, oral hygiene habits, and use of fluorides. Moreover, questions about intake frequency of 25 cariogenic food products were included. The intake frequency of each product was given a score from 1 to 21 in accordance with Kristofferson et al. (13); score 1 = every week; score 7 = every day; score 14 = 2–3 times a day, score 21 = >3 times a day. The individual intake frequency was calculated by adding the scores for all 25 products.

Dental caries

Caries and restorations were recorded by one of the authors (M. Engvall) by means of clinical investigation with a mirror and probe and on bitewing radiographs. Only manifest caries lesions (diagnosed clinically) and lesions involving both enamel and dentin (diagnosed radiographically) were included in the DMFT, DMFS, and DFS indices.

Oral hygiene and gingival pockets

The presence of plaque on eight tooth surfaces was recorded: the mesial surface of the first molars and the distal surface of the central incisors in both jaws. If any of these teeth were missing, the same surface on the closest tooth was recorded. The recordings were based on the Silness & Löe index (14); score 0 = no plaque; score 1 = a film of plaque adhering to the free gingival margin and adjacent area of the tooth and detected with the probe; and score 2 = moderate to abundant plaque that can be seen with the naked eye. Pocket depths of 4 mm or more were recorded for the same eight tooth surfaces.

Salivary and microbial variables

Stimulated whole saliva was collected after paraffin-chewing for 5 min. The secretion rate was expressed as milliliters per minute. Salivary buffer capacity, expressed as final pH, was measured in accordance with Ericsson (15).

One milliliter of the collected saliva was transferred to VMG II transport medium (16). Bacteriologic culture on selective agar media was performed within 24 h of collection. The numbers of mutans streptococci and lactobacilli were estimated as described by Klock & Krasse (17) and expressed as number of colony-forming units (CFU) per milliliter of saliva.

Salivary glucose clearance

Salivary clearance was measured by the method described by Hase et al. (12). The patient was asked to chew a glucose tablet (Dextrosol Naturell®, CPC Svenska Livsmedel AB, Kristianstad, Sweden), weighing approximately 3.4 g (containing 89.5% glucose, which is equivalent to 3 g glucose per tablet). Before (0 min) and 1, 3, 5, 7, 9, 11, and 15 min after intake, two circular paper discs (diameter, 4.0 mm), punched from filter paper (Millipore AP25, Millipore Corp., Bedford, Mass., USA), each absorbing approximately 20 µl of saliva, were placed in the vestibulum in the molar region, one on each side of the lower jaw. After 10 sec the discs were removed from the mouth and transferred to two test tubes, each containing 1.0 ml of distilled water. The tubes were shaken vigorously, placed in boiling water for 5 min, and then frozen (−20 °C) until analyzed. After they had been thawed, the concentration of glucose was analyzed enzymatically (God Perid®, Boehringer Mannheim, Mannheim, Germany) and expressed as millimoles per liter.

The mean values of the two locations—that is, the left and right side of the vestibulum—were used for calculation of the following three clearance variables: 1) initial concentration, 2) clearance time, and 3) area under the curve (AUC). The initial salivary glucose concentration was defined as the glucose concentration (millimoles per liter) found 1 min after the tablet intake. The salivary glucose clearance time was defined as the time necessary for the glucose concentration in saliva to drop to 5 mmol/l. This level was chosen because it corresponds to 0.1%, as suggested by Swenander Lanke (9). The individual clearance time was calculated on the basis of the mathematical formula described by Swenander Lanke (9). The AUC for the salivary glucose concentration was calculated (in millimoles × minutes) by computer (Caleidagraph, Abelbeck Software, USA).

Oral muscular coordination ability (MA test)

Oral muscular coordination was measured by the method described by Landt (18). The patient was instructed to assemble test pieces consisting of two parts, a matrix and a patrix, by manipulating them within the mouth. There were two pairs, one round and one square. The assembly was repeated three times with each pair, and the time for each test was recorded, after which the mean value for the three trials was calculated. If a patient did not succeed in assembling the test pair in 3 min, the test was regarded as a failure, and a maximum mean time of 3 min was recorded.

Self-cleaning ability and finger force

A punched circular disc of green articulation wax (diameter, 2 mm) was placed on the buccal tooth surface of a premolar, incisor, or canine in the upper jaw after

Table 1. Mean values and standard deviation (s) of dietary score, caries indices (DMFT, DMFS, and DFS), plaque index, and number of gingival pockets ≤4 mm in the myotonic dystrophy (MD) group and the control group. P value denotes significance levels for differences between the groups

	MD group (n = 17)		Control group (n = 17)		
	Mean	s	Mean	s	P value
Dietary score	46.8	25.2	26.2	17.7	<0.01
DMFT	22.9	3.5	18.6	4.7	<0.01
DMFS	67.4	16.0	53.2	22.2	<0.05
DFS	21.3	6.0	14.7	6.0	<0.01
Plaque index	1.3	0.5	0.2	0.2	<0.001
Gingival pockets	2.8	2.5	0.6	0.9	<0.01

the surface had been cleaned with a moist cotton roll. The time (in seconds) for the patient to remove each wax piece with the lips and tongue was recorded. This procedure was repeated three times, and the mean time for the three tests calculated. If a patient was not able to remove the wax disc in 10 sec, the test was regarded as a failure, and the maximum time of 10 sec was recorded.

Finger force was measured by letting the subject squeeze a specially designed force transducer using a 'key-grip' in accordance with Helkimo et al. (19). The signals were transferred to a recorder (Speedomax Recorder, Leeds & Northrup, Birmingham, UK) and measured in newtons (N).

Statistical method

Student's t test for unpaired data was used to compare the differences between the groups. The variables studied were also analyzed in a multiple regression model. $P < 0.05$ was considered statistically significant.

Table 2. Mean values and standard deviation (s) of salivary and microbial variables in the myotonic dystrophy (MD) group and the control group. P value denotes significance levels for differences between the groups (NS = not significant)

	MD group (n = 17)		Control group (n = 17)		
	Mean	s	Mean	s	P value
Secretion rate (ml/min)	1.0	0.6	1.8	0.6	<0.01
Buffer capacity (final pH)	4.6	1.2	5.3	1.6	NS
Mutans streptococci* (log CFU/ml)	5.8	1.2	5.3	0.5	NS
Lactobacilli* (log CFU/ml)	4.9	1.3	4.4	1.3	NS

* One value in each group is missing; thus n = 16. CFU = colony-forming units.

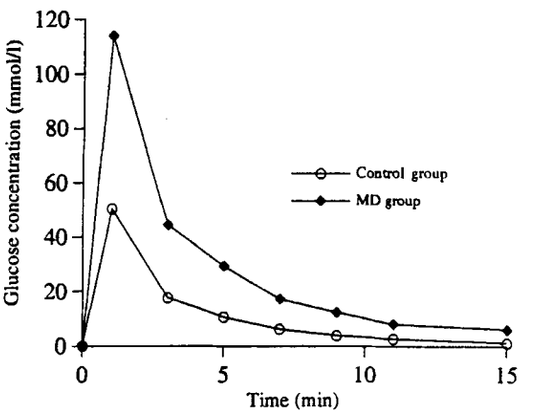

Fig. 1. Mean salivary glucose concentration after chewing a glucose tablet in the muscular dystrophy (MD) group (n = 17) and the control group (n = 17).

Results

Questionnaire

Ten of the 17 MD patients reported difficulties in swallowing their food, whereas none in the control group had these problems. All of the MD patients and two controls reported mouth breathing when sleeping. Fourteen MD and four control patients complained of dry mouth. Fluoride toothpaste was used by all participants, and the mean number of toothbrushing occasions per day was 1.7 in the MD group and 2.1 in the control group. Prophylactic measures besides brushing with fluoride toothpaste, such as daily rinsing with a fluoride solution and flossing, were used only sporadically by the MD group but somewhat more frequently by the control group.

There was a statistically significant difference ($P < 0.01$) in the dietary score between the two groups (Table 1). This was to a large extent due to frequent intake of sweet beverages between meals in the MD group.

Clinical variables

The data are presented in Table 1. There were statistically significant differences between the groups for all variables—that is, DMFT, DMFS, DFS, plaque index, and gingival pockets ≥4 mm ($P < 0.05$, $P < 0.01$, or $P < 0.001$).

Salivary and microbial variables

The data are presented in Table 2. The values in the MD group were less favorable for all variables than in the control group, but only the salivary secretion rate differed significantly between the groups ($P < 0.01$).

Table 3. Mean values and standard deviation (*s*) of initial concentration, clearance time, and area under the curve (AUC) in the myotonic dystrophy (MD) group and the control group. *P* value denotes significance levels for differences between the groups

	MD group (n = 17)		Control group (n = 17)		
	Mean	*s*	Mean	*s*	*P* value
Initial concentration (mmol/l)	114.0	104.9	50.4	34.0	<0.05
Clearance time (min)	12.3	5.6	7.5	3.0	<0.01
AUC (mmol × min)	419.5	343.3	165.0	117.2	<0.01

Oral sugar clearance

The mean salivary glucose concentrations are presented in Fig. 1. At all time points the MD group showed higher values than the control group. The initial concentration, clearance time, and AUC in the two groups are presented in Table 3. The differences between the groups were statistically significant for all three clearance variables ($P < 0.01$). The mean initial concentration was 2.3 times higher in the MD group than in the control group. The corresponding values for the clearance time and AUC were 1.6 and 2.5 times, respectively.

MA test, self-cleaning ability, and finger force

The data are presented in Table 4. Two of the MD patients could not assemble the test pieces in the MA test within the stipulated time of 3 min. In the self-cleaning ability test three in the MD group failed but none in the control group. The mean values of the MA test, self-cleaning ability, and finger force were less favorable in the MD group than in the control group. The differences were statistically significant for all three variables ($P < 0.05$, $P < 0.01$, or $P < 0.001$).

Table 4. Mean values and standard deviation (*s*) of muscular ability (MA test), self-cleaning ability, and finger force in the myotonic dystrophy (MD) group and the control group. *P* value denotes significance levels of the differences between the groups

	MD group (n = 17)		Control group (n = 17)		
	Mean	*s*	Mean	*s*	*P* value
MA test: round (sec)	56.3	63.1	13.4	9.2	<0.01
MA test: square (sec)	67.5	62.3	25.1	22.5	<0.05
Self-cleaning ability (sec)	4.9	3.0	2.4	1.1	<0.01
Finger force (N)	17.3	8.4	68.6	32.8	<0.001

Discussion

In our previous study we found that the MD patients, as compared with a healthy control group, had more caries, plaque, and gingival pockets ≥4 mm (7). The present follow-up study confirms these differences. To try to explain the reasons why patients with MD have a higher caries prevalence, we measured different factors that were believed to be related to caries. The present study showed that the MD patients had a longer oral sugar clearance time, lower salivary secretion rate, higher intake frequency of sugar-containing products, higher plaque index, and less pronounced oral muscular coordination and self-cleaning ability than the healthy controls. The differences were statistically significant. However, since the groups differ in many respects other than disease/no disease, and there are correlations between many of the variables studied, it is difficult to point out a specific variable as causing the differences found. By necessity, this study is observational and not randomized, since the number of patients with the disease in the Göteborg area is limited. An attempt to verify the difference due to disease/no disease by means of a multiple regression model failed for these reasons and gave for DFS significant explanatory power only for number of remaining teeth and for DMFS only for age. Considering these circumstances, the results of the statistical analysis should be interpreted with caution.

There is extensive support in the literature for a negative correlation between salivary flow rate and oral sugar clearance (8–10). This may be one explanation of the slower clearance in the MD group, since many of them (10 of 17) had a salivary secretion rate of less than 1.0 ml/min. Another reason may be the less pronounced muscular coordination and self-cleaning ability. All these tests, including the finger force measurement, showed dramatic differences between the groups, although great interindividual variations were found. The strong correlation between muscular coordination and self-cleaning ability, on the one hand, and oral sugar clearance, on the other, has been shown by others (9, 10). We therefore believe that the high caries prevalence in the MD patients may be due to their reduced ability to eliminate food particles from the mouth after eating. The same situation has been found for hospitalized elderly persons (12).

Another explanation of the high caries prevalence in the MD patients may be their relatively frequent intake of sweet products, especially beverages. As many of the MD patients complained of dry mouth, this observation was not surprising. It is well known that consumption of sugar-containing products between meals increases the risk of dental caries (20) and that this may be accentuated in individuals with dry mouth (21, 22). The MD patients in our study and in other investigations (23, 24) have reported difficulties in swallowing. This leads to avoidance of food that is hard to chew and preference of products that do not need chewing. This

could also, on a long-term basis, affect the salivary factors negatively and thereby increase the risk of dental caries.

A longitudinal comparison between our previous study (7) and the present investigation, carried out in 1985 and 1993, respectively, does not show any marked increase in the DMFT or DMFS indices when comparing the MD group and the control group. It must be remembered, however, that the two groups are small, and there were many dropouts (n = 12) between the two examinations. The MD patients who did not participate in the second examination were mostly older and sicker than the rest of the MD group, which means that the most caries-active MD patients were lost. In the control group the dropouts were, on the other hand, mostly young individuals. Moreover, the method of recording caries and restorations differs in the two studies. In the 1985 study (7) recordings were made only on radiographs, whereas the present investigation also included a clinical examination. This makes the comparison between 1985 and 1993 even more uncertain.

In conclusion, individuals with MD should be considered risk patients for dental caries on the basis of the fact that many of them have a long oral sugar clearance time, low salivary secretion rate, high intake frequency of sugar-containing products, and high plaque index. They therefore need special attention and should be given individual advice regarding fluoride, oral hygiene, and diet.

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