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The influence of malocclusion, sucking habits and dental caries in the masticatory function of preschool children

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Abstract: The aim of this study was to evaluate the association of malocclusion, nutritive and non-nutritive sucking habits and dental caries in the masticatory function of preschool children. A cross-sectional study was conducted with a sample of 384 children aged 3–5 years. A single examiner calibrated for oral clinical examinations performed all the evaluations (kappa > 0.82). Presence of malocclusion was recorded using Foster and Hamilton criteria. The number of masticatory units and of posterior teeth cavitated by dental caries was also recorded. The parents answered a questionnaire in the form of an interview, addressing questions about the child's nutritive and non-nutritive sucking habits. The masticatory function was evaluated using Optocal test material, and was based on the median particle size in the masticatory performance, on the swallowing threshold, and on the number of masticatory cycles during the swallowing threshold. Data analysis involved simple and multiple linear regression analyses, and the confidence level adopted was 95%. The sample consisted of 206 children in the malocclusion group and 178 in the non-malocclusion group. In the multiple regression analysis, the masticatory performance was associated with age ($p = 0.025$), bottle feeding ($p = 0.004$), presence of malocclusion ($p = 0.048$) and number of cavitated posterior teeth ($p = 0.030$). The swallowing threshold was associated with age ($p = 0.025$), bottle feeding ($p = 0.001$) and posterior malocclusion ($p = 0.017$). The number of masticatory cycles during the swallowing threshold was associated with the number of cavitated posterior teeth ($p = 0.001$). In conclusion, posterior malocclusion, bottle feeding and dental caries may interfere in the masticatory function of preschool children.

Keywords: Mastication; Deglutition; Malocclusion; Dental Caries.

Introduction

The shredding of foods during mastication aids in the enzymatic action of the digestive system and facilitates the absorption of nutrients, which is fundamental for a child's growth and development.[1] The masticatory function is frequently evaluated by analyzing the masticatory performance and the swallowing threshold.[2,3] The masticatory performance measures how much the food was crushed after a standardized number of masticatory cycles.[4] The swallowing threshold enables evaluating the number of masticatory cycles required for swallowing, and the size of the particles to be swallowed.[3,5]

Studies have shown that a higher body mass index, dental caries, a higher frequency of pasty food ingestion, a lower number of masticatory units,[3,5] lower mandibular movement[6] and malocclusion[7] are associated with poor masticatory function. Comparing these factors, the literature shows a controversy among the results related to malocclusion. A study carried out with preschool children observed a better food shredding ability among the group of children with no malocclusion, compared with those with open bite and posterior crossbite.[7] More recently, another study[5] also conducted with a sample of preschoolers did not find this association. In schoolchildren, a greater number of studies have indicated the existence of an association between malocclusion and masticatory function.[8,9,10,11] This association is explainable given the lower inter-occlusal contact with malocclusion in individuals. Despite the frequent association between malocclusion and masticatory function, this oral condition does not seem to affect the number of chewing cycles.[10]

The prevalence of malocclusion in preschoolers may reach 87.0%.[12] However, it ranges according to the parameters used for its diagnosis. Bear in mind that other studies have reported lower rates.[13,14] A high prevalence of malocclusion in preschoolers may be associated with the presence of non-nutritive sucking habits.[15] Therefore, the presence of these habits may also interfere in the masticatory function. In addition to non-nutritive sucking habits, it is important to consider the use of a feeding bottle. Prolonged use of a feeding bottle has been associated with excessive milk intake.[16,17] This higher consumption of milk may contribute to the child's lower predilection to more consistent foods, such as fruits and meat.[18] This is particularly important, because the consumption of less consistent food is associated with poorer masticatory performance.[5]

Thus, the objective of this study was to evaluate the association of malocclusion, nutritive and non-nutritive sucking habits and dental caries in the masticatory function of preschool children.

Methodology

Ethics considerations

This study was approved by the Human Research Ethics Committee of the Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brazil (UFVJM) under registration number CAAE: 52487415.3.0000.5108. Those responsible for the children signed a free and informed consent form consenting to the child's participation in the study.

Study design and sample size

This was a cross-sectional study carried out with a sample of three-to five-year-old children enrolled in daycare centers and schools in the city of Diamantina, Brazil, who were called to attend the pediatric dentistry clinic of the UFVJM. The sample size was calculated based on the results of a pilot study of 30 children similar to those composing the main study sample. Sample calculations were performed for each dependent variable in relation to malocclusion and sucking habit, and the calculation that provided the largest sample size was chosen. This calculation used a standard deviation of +1.262 for the median particle size in the masticatory performance among children with malocclusion, and + 1,646 for that among children with no malocclusion. An average difference of 0.44 mm in the median particle size among children with and without malocclusion was considered clinically relevant. Considering a statistical power of 80% and standard error of 5%, the minimum sample size was 175 children per group (groups of children with and without malocclusion). Thirty-four children were added to each group to offset the losses. Performance of this pilot study enabled not having to change the initially proposed methodology.

The sample was recruited by convenience at six preschools in the city. Children with systemic or neurological disorders, and those who used drugs that could affect muscle activity (antidepressants, muscle relaxants or sedatives) were excluded. Children who used any type of orthodontic appliance were also excluded.

Clinical data collection

The oral clinical examination was performed by a single dentist who had undergone a training and calibration exercise for all the evaluated oral clinical conditions. The interexaminer (compared with an expert) and intraexaminer kappa concordance coefficients were greater than 0.82 for all oral conditions evaluated. The training was conducted with images, and the calibration was done with children from the institution's pediatric dentistry clinic, who were the same children as those of the pilot study. During the examination, the child remained lying on a portable reclining stretcher. Each preschool child's teeth were brushed before the oral evaluation.

The presence of malocclusion was defined according to the criteria proposed by Foster and Hamilton,[19] and all the evaluations were performed with the teeth in occlusion. The presence of anterior or posterior cross bite, anterior open bite and/or overjet equal to or greater than 3 mm were the clinical parameters adopted to determine the presence of malocclusion. These evaluations were performed using a millimeter probe. The children were divided into anterior and posterior malocclusion groups; a child who had both conditions was assigned to both groups.

The number of masticatory units was determined by occlusal pairs (posterior opposing teeth in occlusion). Therefore, a child with eight occlusal molars had four occlusal units[5]. Caries lesions were evaluated using the International Caries Detection and Assessment System (ICDAS) criteria.[20] The presence of cavitated caries lesions was considered when ICDAS codes 3, 5 and 6 were recorded. The data analysis took into account the number of cavitated posterior teeth.

Collection of non-clinical data

Those responsible for the children answered a questionnaire with questions regarding the child's characteristics, such as age, sex, and both nutritive and non-nutritive sucking habits. The habits were recorded in a questionnaire applied in the form of an interview with the person responsible for the child, who was asked whether or not he/she was currently bottle-fed, about past and present history of digital sucking habit and about the use of a pacifier. Responses for finger and pacifier suction were given for current and non-current use. The exams for oral clinical assessments were performed with a head lamp (PETZL, Tikka XP, Crolles, France), mouth mirrors (PRISMA, São Paulo, Brazil), WHO millimeter probes (Golgran, São Paulo, Brazil) and dental gauze to dry the teeth.

Masticatory function

The masticatory function was evaluated by observing the masticatory performance and the swallowing threshold. The material chosen for the chewing test was Optocal.[4,5] It was manipulated and inserted into molds to form cubes measuring 5.6 mm^3. The cubes were then placed in an electric oven at 60°C for 16 h to ensure complete polymerization. Portions of 17 cubes measuring approximately 3 cm^3 and weighting 3.2 g were separated and stored in plastic containers until the tests were performed.[21]

The masticatory performance was evaluated according to the median particle size (MP X_{50}) triturated after 20 masticatory cycles. The children were submitted to a training session to become familiarized with the taste and consistency of the artificial food tested.[21] A trained examiner instructed the children to chew on 17 cubes of the material and told them when to expel the cubes into the collector. The child's mouth was rinsed with filtered water to remove all the particles, which were also expelled into the collector. All particles remaining in the oral cavity were removed with a clinical clamp and placed in the collector.

The swallowing threshold was determined by the mean particle size (ST X_{50}) expelled when the children felt the desire to swallow, and by the number of masticatory cycles performed up to that point (ST cycles). The children were instructed to chew 17 Optocal cubes and raise their hand when they felt like swallowing. The examiner counted the masticatory cycles visually,[22] and the children raised their hand when they were ready for the collector to help expel the particles.

The following steps were the same as those performed in evaluating masticatory performance. The samples from each collector were deposited on a paper filter, disinfected with 70% alcohol spray and dried at room temperature for three days. The particles were then weighed and placed in the first of a set of nine sieves (Bertel Ltda, Caieiras, Brazil) with a mesh size decreasing from 5.6 mm to 0.60 mm. The sieves were coupled to a machine (Bertel Ltda, Caieiras, Brazil) that vibrated each sample for 20 minutes. The particles retained in each sieve were removed and weighed using an analytical balance with an accuracy of 0.001 g (AD500, Marte, São Paulo, Brazil). The accumulated weight of the particles in each sieve was determined, and the median particle size (X_{50}) was calculated for each child using the Rosin-Rammler equation[23] obtained with the Statistical Package for the Social Sciences (SPSS® 22.0). The X_{50} was calculated for the masticatory performance and swallowing threshold of each child.

Statistical analysis

SPSS® 22.0 software was used to perform all the analyses. The descriptive analysis was performed. Data normality was tested using the Kolmogorov-Smirnov test. Non-normal distribution data were logarithmized to the power of 10 (log^{10}) to adjust the normality of the data to its use in linear regression. Simple and multiple linear regression analyses were performed to determine the strength and direction of the associations. The explanatory variables were selected to perform the multiple linear regression model using the backward method to determine which independent variables remained associated with the masticatory function. Values were considered significant when $p < 0.05$.

Results

A total of 384 (90.8%) children participated up to the end of the study, 206 of whom had and 178 did not have malocclusion. The main reason for the losses was the child's lack of cooperation during the evaluations. A total of 58.3% of the children had malocclusion and 41.7% did not. Among those with malocclusion, 7.6% had malocclusion affecting their posterior teeth. The mean age was 4.19 years. In relation to sucking habits, 16.9% were being bottle-fed, 10.4% had the habit of digital suction either in the present or the past, and 34.1% used pacifiers in the present or the past. The number of masticatory units ranged from 1 to 4 (mean 3.92 + 0.36). The prevalence of dental caries in posterior teeth was 37%, and the mean number of decayed posterior teeth was 1.06 (+ 1.84). The masticatory function was evaluated with a mean particle size of 5.06 + 1.94 mm in the masticatory performance, swallowing threshold of 4.25 + 2.10 mm, and mean number of masticatory cycles performed until the swallowing threshold of 30.73 cycles (+ 14.66). Table 1 shows the characterization of the sample according to each parameter of the masticatory function evaluation.

Simple linear regression analysis showed that a larger median particle size, masticatory performance and swallowing threshold were associated with a lower age (MP X_{50}: B -0.331, Beta -0.131, 95%CI -0.583 to -0.079, $p = 0.010$ and ST X_{50}: B -0.413, Beta -0.150, 95%CI -0.686 to -0.140, $p = 0.003$), bottle feeding (MP X_{50}: B +0.853, Beta +0.165, 95%CI +0.340 to +1.366, $p = 0.001$ and ST X_{50}: B +1.112, Beta +0.189, 95%CI +0.558 to +1.666, $p < 0.001$), and posterior malocclusion (MP X_{50}: B +0.911, Beta +0.124, 95%CI +0.179 to +1.644, $p = 0.015$ and ST X_{50}: B +1.087, Beta +0.136, 95%CI +0.292 to +1.881, $p = 0.007$). A higher number of masticatory cycles until the swallowing threshold were associated with bottle feeding (ST cycles: B -4.287, Beta -0.110, 95%CI -8.192 to -0.382, $p = 0.032$), and higher number of cavitated posterior teeth (ST cycles: B +1.399, Beta +0.176, 95%CI +0.612 to +2.186, $p = 0.001$) (Table 2).

In the final multiple regression model, the median particle size in the masticatory performance and the swallowing threshold were associated with age (MP X_{50}: B -0.294, Beta -0.116, 95%CI -0.551 to -0.037, $p = 0.025$ and ST X_{50}: B -0.315, Beta -0.114, 95%CI -0.590 to -0.039, $p = 0.025$), bottle feeding (MP X_{50}: B +0.775, Beta +0.150, 95%CI +0.254 to +1.296, $p = 0.004$ and ST X_{50}: B +0.956, Beta +0.170, 95%CI +0.395 to +1.517, $p =0.001$), and posterior malocclusion (MP X_{50}: B +0.774, Beta +0.100, 95%CI +0.006 to +1.483, $p = 0.048$ and ST X_{50}: B +0.967, Beta +0.119, 95%CI +0.173 to +1.761, $p = 0.017$).

Masticatory performance was also associated with the number of cavitated posterior teeth (MP X_{50}: B +0.117, Beta +0.111, 95%CI +0.012 to +0.233,

Table 1. Characterization and distribution of independent variables according to parameters of masticatory function (n = 384, Diamantina, Brazil).

Independent variables	n	%	Masticatory performance (X50)	Swallowing threshold (X_{50})	Swallowing threshold (number of cycles)
			Mean (±SD)	Mean (±SD)	Mean (±SD)
Sex					
Female	206	53.6	4.970 (2.021)	4.152 (1.921)	30.379 (14.772)
Male	178	46.4	5.157 (1.846)	4.363 (2.306)	31.137 (14.570)
Bottle feeding					
Absent	319	83.1	4.912 (1.920)	4.062 (2.048)	31.456 (14.874)
Present	65	16.9	5.765 (1.905)	5.174 (2.169)	27.169 (13.121)
Digital suction					
Absent	345	89.6	5.06 (1.928)	4.29 (2.142)	30.90 (15.027)
Present	39	10.4	5.01 (2.105)	3.84 (1.701)	29.12 (11.213)
Pacifier					
Absent	253	65.9	5.01 (1.732)	4.30 (2.117)	30.52 (14.915)
Present	131	34.1	5.13 (2.297)	4.13 (2.093)	31.12 (14.216)
Anterior malocclusion					
Absent	178	46.35	5.100 (1.896)	4.339 (2.192)	31.165 (14.830)
Present	206	53.65	5.022 (1.981)	4.180 (2.041)	30.385 (14.557)
Posterior malocclusion					
Absent	355	92.4	4.988 (1.902)	4.168 (2.035)	30.751 (14.645)
Present	29	7.6	5.899 (2.236)	5.255 (2.699)	30.483 (15.162)

X_{50}: median particle size; SD: standard deviation.

p = 0.030). The number of masticatory cycles at the swallowing threshold was associated only with the number of cavitated posterior teeth (ST cycles: B +1.321, Beta +0.166, 95%CI +0.526 a +2.115, p =0.001) (Table 3).

Discussion

The present study demonstrated that younger children with a history of bottle-feeding and subsequent malocclusion had greater difficulty breaking down the test food into smaller particles, according to their masticatory performance and swallowing threshold. In addition, children with a higher number of cavitated posterior teeth performed a greater number of masticatory cycles before attaining the swallowing threshold, and had worse masticatory performance.

In the present sample, younger children failed to break down the test food into smaller particles based on their masticatory performance up to the swallowing threshold, compared to the older ones. This is a common finding in other studies[5,24] and seems to be associated with older children having larger masticatory muscles, and with chewing being a function that develops and matures over time.[25]

Posterior malocclusion, represented in this crossbite study, was responsible for worse trituration of the test material during the masticatory performance test up to the swallowing threshold. This finding is similar to that reported by Gavião et al.,[7] who investigated Brazilian children in the same age range as that of this study. Inadequate contact of the teeth during mastication decreased the available area for trituration of foods that should be chewed with adequate fitting of the cuspids.[26,27] For this reason, the food is not ground efficiently, and results in larger particles.[27] According to Henrikson et al.,[8] 30% of the change in masticatory efficiency can be explained by inadequate occlusal contact and accentuated prominence. Hence, future studies should investigate whether the correction of posterior crossbite has an impact on the improvement of masticatory performance and swallowing threshold.

Conversely, Soares et al.[5] found no such association. What might explain the divergence in results is the calculation of the sample size. In the study mentioned,

Table 2. Simple linear regression using the test of association between independent variables and parameters for masticatory function (n = 384, Diamantina, Brazil).

Dependent variables	Independent variables	B	Standard error	Beta	95%CI (lower-upper)	t	*p-value
Masticatory performance (X_{50})	Age	-0.331	0.128	-0.131	-0.583 to -0.079	-2.579	**0.010**
	Sex	0.187	0.199	0.048	-0.204 to 0.578	0.942	0.347
	Bottle feeding	0.853	0.261	0.165	0.340 to 1.366	3.270	**0.001**
	Digital suction	-0.045	0.329	-0.007	-0.672 to 0.602	-0.136	0.892
	Pacifier	0.124	0.209	0.03	-0.288 to 0.535	0.591	0.555
	Anterior malocclusion	-0.079	0.200	-0.020	-0.471 to 0.314	-0.394	0.694
	Posterior malocclusion	0.911	0.373	0.124	0.179 to 1.644	2.445	**0.015**
	Number of masticatory units	-0.531	0.270	-0.100	-1.061 to 0.001	-1.967	0.050
	Number of cavitated posterior teeth	0.090	0.054	0.085	-0.016 to 0.195	1.672	0.095
Swallowing threshold (X_{50})	Age	-0.413	0.139	-0.150	-0.686 to -0.140	-2.973	**0.003**
	Sex	0.211	0.216	0.050	-0.213 to 0.635	0.977	0.329
	Bottle feeding	1.112	0.282	0.189	0.558 to 1.666	3.949	**< 0.001**
	Digital suction	-0.448	0.356	-0.064	-1.149 to 0.253	-1.257	0.210
	Pacifier	-0.170	0.227	-0.038	-0.617 to 0.276	-0.750	0.453
	Anterior malocclusion	-0.159	0.217	-0.038	-0.585 to 0.267	-0.735	0.463
	Posterior malocclusion	1.087	0.404	0.136	0.292 to 1.881	2.690	**0.007**
	Number of masticatory units	-0.033	0.294	-0.006	-0.612 to 0.546	-0.112	0.911
	Number of cavitated posterior teeth	-0.002	0.058	-0.002	-0.117 to 0.113	-0.038	0.969
Swallowing threshold (number of cycles)	Age	0.538	0.977	0.028	-1.383 to 2.459	0.551	0.582
	Sex	0.759	1.502	0.026	-2.195 to 3.712	0.505	0.614
	Bottle feeding	-4.287	1.986	-0.110	-8.192 to -0.382	-2.158	**0.032**
	Digital suction	-1.771	2.482	-0.037	-6.652 to 3.109	-0.714	0.476
	Pacifier	0.595	1.580	0.019	-2.513 to 3.702	0.376	0.707
	Anterior malocclusion	-0.779	1.508	-0.026	-3.745 to 2.186	-0.517	0.606
	Posterior malocclusion	-0.268	2.836	-0.005	-5.844 to 5.308	-0.094	0.925
	Number of masticatory units	-1.894	2.046	-0.047	-5.917 to 2.129	-0.926	0.355
	Number of cavitated posterior teeth	1.399	0.400	0.176	0.612 to 2.186	3.493	**0.001**

Bold values: significance for $p < 0.05$; CI: confidence interval; *Simple linear regression; X50: median particle size.

Table 3. Multiple linear regression using the test of association between independent variables and parameters for masticatory function (n = 384, Diamantina, Brazil) (backward method).

Dependent variables	Independent variables	B	Standard error	Beta	95%CI (lower-upper)	t	*p-value
Masticatory performance (X_{50})	Age	-0.294	0.131	-0.116	-0.551 to -0.037	-2.249	**0.025**
	Bottle feeding	+0.775	0.265	+0.150	+0.254 to +1.296	2.924	**0.004**
	Posterior malocclusion	+0.774	0.375	+0.100	+0.006 to +1.483	1.983	**0.048**
	Number of cavitated posterior teeth	+0.117	0.054	+0.111	+0.012 to +0.233	2.184	**0.030**
Swallowing threshold (X_{50})	Age	-0.315	0.140	-0.114	-0.590 to -0.039	-2.248	**0.025**
	Bottle feeding	+0.956	0.285	+0.170	+0.395 to +1.517	3.353	**0.001**
	Posterior malocclusion	+0.967	0.404	+0.119	+0.173 to +1.761	2.396	**0.017**
Swallowing threshold (number of cycles)	Bottle feeding	-3.550	1.983	-0.091	-7.449 to +0.350	-1.790	0.074
	Number of cavitated posterior teeth	1.321	0.404	+0.166	+0.526 to +2.115	3.269	**0.001**

Bold values: significance for $p < 0.05$; CI: confidence interval; * Multiple linear regression; X_{50}: median particle size.

the sample calculation was performed to detect the difference in masticatory performance among overweight / obese, low weight and normal weight children. In this respect, they may have found no association, because the sample size was too small to enable such an association.

To date, no evidence has been identified that addresses the association between sucking habits and median particle size in determining masticatory performance and swallowing threshold in preschoolers. Children who were bottle-fed up to the time of data collection had a worse masticatory function. A Chinese study[18] conducted with a sample of 649 children aged 18 to 48 months showed that those who adopted bottle feeding for milk intake up to 24 months of age consumed a smaller amount of meat. Moreover, children who were bottle-fed up to 48 months of age consumed less fruit. Thus, bottle feeding was associated with a lower consumption of consistent foods. The preference for fewer consistent foods may lead to less f exercising of chewing muscles, resulting in a worse masticatory function.[5]

In the present investigation, after making the statistical adjustment, only the number of cavitated teeth remained associated with the number of masticatory cycles at the swallowing threshold. Thus, the greater the number of cavitated teeth, the more chewing cycles a child performed until he felt the urge to swallow. Cavitated caries lesions contribute to reducing the occlusal contact area, and can also lead to pain, resulting in worse masticatory performance.[28] However, in this study, children with cavitated lesions were able to perform more masticatory cycles to obtain better trituration of food, thus offsetting a worse result in masticatory performance. In addition, since the occlusal surface was cavitated, the other surfaces may have also been affected.

The association between number of masticatory units and masticatory performance of preschoolers has been reported in the literature.[5] When there are no masticatory units, there are also no surfaces available for trituration of the food, thus damaging both masticatory performance and swallowing threshold[29]. In this study, the results did not confirm this association, because there was a low frequency of tooth loss. The mean occlusal units of the study sample were 3.98, considering a maximum value of 4.00.

This study may have some limitations, such as the lack of food consistency and prolonged breastfeeding data. We believe that the interference of using or not using a bottle is related to consuming a liquid and pasty diet. Unfortunately, we have not yet investigated breastfeeding as a protective factor for malocclusion, or prolonged bottle use as a risk factor. This was a limitation of the study; therefore, we cannot clarify if there is indeed an association. Currently, our team has been collecting data to minimize these limitations. In addition, the results have limited external validity, since the sample was recruited by convenience. Despite these limitations, our intent was to demonstrate the oral conditions that may interfere with masticatory function, and consequent growth and development. It is also important to highlight how evaluation of chewing can be done objectively to reduce the risk of bias, compared with subjective evaluation using a self-administered questionnaire. Longitudinal studies are encouraged to observe the effects of breastfeeding duration on masticatory function.

In conclusion, posterior malocclusion, bottle feeding and dental caries interfered with the masticatory function of the preschool children evaluated in this study. Posterior malocclusion was associated with poor masticatory performance and a worse swallowing threshold, as was bottle feeding. Children with a higher number of cavitated caries lesions in posterior teeth performed a greater number of masticatory cycles until they felt comfortable to swallow.

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