

Relationship among malocclusion, number of occlusal pairs and mastication

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Abstract: This study evaluated the relationship among malocclusion, number of occlusal pairs, masticatory performance, masticatory time and masticatory ability in completely dentate subjects. Eighty healthy subjects (mean age = 19.40 ± 4.14 years) were grouped according to malocclusion diagnosis ($n = 16$): Class I, Class II-1, Class II-2, Class III and Normocclusion (control). Number of occlusal pairs was determined clinically. Masticatory performance was evaluated by the sieving method, and the time used for the comminute test food was registered as the masticatory time. Masticatory ability was measured by a dichotomic self-perception questionnaire. Statistical analysis was done by one-way ANOVA, ANOVA on ranks, Chi-Square and Spearman tests. Class II-1 and III malocclusion groups presented a smaller number of occlusal pairs than Normocclusion ($p < 0.0001$), Class I ($p < 0.001$) and II-2 ($p < 0.0001$) malocclusion groups. Class I, II-1 and III malocclusion groups showed lower masticatory performance values compared to Normocclusion ($p < 0.05$) and Class II-2 ($p < 0.05$) malocclusion groups. There were no differences in masticatory time ($p = 0.156$) and ability ($\chi^2 = 3.58/p = 0.465$) among groups. Occlusal pairs were associated with malocclusion ($\rho = 0.444/p < 0.0001$) and masticatory performance ($\rho = 0.393/p < 0.0001$), but malocclusion was not correlated with masticatory performance ($\rho = 0.116/p = 0.306$). In conclusion, masticatory performance and ability were not related to malocclusion, and subjects with Class I, II-1 and III malocclusions presented lower masticatory performance because of their smaller number of occlusal pairs.

Descriptors: Mastication; Malocclusion; Dental Occlusion.

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Introduction

Mastication is defined as the act of comminuting food through the efficient exposure of a mouthful to available occlusal surfaces regulated by neuromuscular control.¹ The alteration of occlusal pattern, contact area, number of teeth or number of occlusal pairs can decrease the masticatory capacity due to mechanical disadvantage.²

The effect of malocclusion on mastication has been studied³⁻⁵ and contradictory findings are reported. Owens *et al.*³ found no differences in masticatory performance among subjects presenting Normocclusion, Class I, II and III malocclusions. In contrast, according to English *et al.*,⁴ subjects presenting Class II or III malocclusions had lower masticatory performance compared to Normocclusion or Class I malocclusion. Ad-

ditionally, presurgical subjects presenting malocclusion have a reduced masticatory performance.¹ The cause of poor mastication showed by these subjects is not completely understood,⁵ but it is partially justified by the small number and area of occlusal contacts and near occlusal contacts.^{1,3,4} However, neither the presence of second molars and anterior teeth,³ nor the number of occlusal pairs^{1,4} were considered in the occlusal evaluation of these studies, and these factors would be more important for mastication than malocclusion itself.

The determination of all anterior and posterior occlusal pairs is a strong approach of the masticatory capacity.² Subjects presenting Class II division 1 malocclusion might show no occlusal contact on anterior and mandibular second molars regions due to mandibular retrusion and alteration on teeth position.⁶ Class III malocclusion can determine no contact on upper second molars and anterior teeth because of mandibular protrusion.⁷ In Class I malocclusion, crowding, tooth misalignment, cross-bites or buccally displaced canines can also produce a lack of contact in some teeth.⁸ Thus, in spite of presenting all teeth, subjects with malocclusions may have less occlusal pairs, which can impair their mastication. Furthermore, anatomical differences between divisions 1 and 2 of Class II malocclusion were not considered in previous studies,³⁻⁵ and both were included in a single set of evaluation when they should rather form two distinct groups. Division 1 has a higher skeletal discrepancy than division 2 and presents muscular deficiencies. Division 2 presents a sagittal skeletal pattern similar to that of a Class I relationship⁹ with accentuated curve of Spee, deep bite and hypodivergent pattern or short face, conditioning to a higher masticatory force¹⁰ and probably a better masticatory performance.

Differences on mastication can also be seen through masticatory time. The duration of the masticatory cycle is affected by changes in the occlusal guidance,¹¹ which is present in subjects with malocclusion due to variations on the position of anterior teeth.^{12,13} On the other hand, subjects with decreased masticatory performance can also alter their masticatory time, since they adapt to chewing for a longer period of time.¹⁴

Masticatory ability can affect food selection, conditioning the consumption of certain foods according to their relative hardness.^{4,15} Class III subjects reported the greatest difficulty to chew fresh vegetables and meat, followed by Class II, I and Normocclusion subjects.⁴ However, as previously mentioned, control of the 'occlusal pairs' variable is necessary for consideration of this evidence.

As the relationship between malocclusion classifications and masticatory function remains unclear, the aim of this study was to verify the relationship among Normocclusion, Class I, II-1, II-2 and III malocclusions, number of occlusal pairs, masticatory performance, masticatory time and masticatory ability of subjects with complete dentition.

Material and Methods

One thousand five hundred and four students from the College of Stomatology of Cayetano Heredia Peruvian University, Lima, Peru were examined. Eighty young adult subjects were recruited, being 46 females (mean age 18.89 ± 3.80) and 34 males (mean age 20.09 ± 4.53). The participants were selected according to the following inclusion criteria: good general health, normal body mass index ($20-25 \text{ kg/m}^2$),⁴ presence of complete natural dentition (excluding third molars) and no previous orthodontic treatment. Presence of systemic disease, medical prescription diet, symptoms of temporomandibular dysfunction, xerostomy, prosthetic restorations, periodontal disease or pregnancy were considered as exclusion criteria. Subjects were divided into 4 groups ($n = 16$) by an orthodontic specialist, according to Angle's criteria diagnosis of malocclusion: Class I, Class II division 1, Class II division 2, and Class III. A group ($n = 16$) composed by Normocclusion subjects was considered as control. All selected subjects signed an informed consent form approved by the local Research Ethics Committee.

The number of occlusal pairs was clinically determined by counting antagonist teeth in occlusion. Doubts about contacting area were clarified by visual inspection of plaster models related in maximum intercuspal position.

The masticatory performance of all subjects was evaluated using a sieve method.³⁻⁵ Subjects chewed

artificial test food made of silicone rubber (Optosil Plus®, Heraeus Kulzer, Hanau, Germany) by 20 chewing strokes. The silicone was prepared according to the manufacturer’s instructions and was inserted in molds to form cylinders of 20 mm in diameter, 5 mm of height and weighing approximately 2.5 g.³⁻⁵ Each cylinder was cut into four quarters and stored for up to 5 days at room temperature. Each patient was offered three quarters of a portion weighing approximately 2 g, and they were instructed to chew on them in a habitual way. After 20 chewing strokes, counted by the examiner, the particles were expectorated into a Becker, followed by mouth rinsing with 200 mL of water and expectorating of this water into the same container. The procedure was repeated 5 times until approximately 10 g of test food had been comminuted. The chewed particles obtained were rinsed with 200 mL of water, dried in an oven (Odontobrás EL-1.1, Ribeirão Preto, SP, Brazil) at 80°C for 25 min, and sieved through a stack of up to 10 sieves with mesh sizes of 0.5, 0.71, 1, 1.4, 2, 2.8, 4, 5.6, 8 and 11.2 mm, in a Ro-Tap sieving machine (Ro-Tap RX-29, Laval Lab inc, Quebec, Canada) for 2 minutes. The test material retained in each sieve was collected and weighed on a 0.01 mm analytical balance (M-220, Denver Instrument, Denver, Colorado, USA). Masticatory performance was determined by the median particle size (X_{50}) using the Rosin-Rammler equation (non-linear regression analysis):

$$Q_w^-(X) = 100 \cdot \{1 - \exp[-(X/X_{50}) \cdot b \cdot \ln(2)]\}$$

where Q_w^- is the percentage by weight of particles with a size smaller than X; X_{50} is the aperture of a theoretical sieve through which 50% of the weight can pass, and b represents the breadth of

the distribution.³⁻⁵

Therefore, a large median particle size indicates a lower masticatory performance.

The necessary time to complete the 20 masticatory strokes during the masticatory performance test was recorded in seconds and defined as the masticatory time.

Masticatory ability was evaluated by a dichotomous self-perception questionnaire,¹⁶ which obtained a high reproducibility ($\kappa = 0.97$) in a pilot study with a similar sample. The subjects were asked if they were able to chew in general and to chew the following foods: apples, carrots, cooked vegetables, meat and lettuce.¹⁶ They answered “yes” or “no”, according to their subjective experience.

Normality assumption was evaluated using Kolmogorov-Smirnov test. The values of masticatory performance and masticatory time among groups were evaluated using one-way ANOVA and LSD *post-hoc* tests. ANOVA on ranks and Dunn’s *post-hoc* tests were used to compare the number of occlusal pairs, and the Chi-Square test was used to compare the masticatory ability among the groups. The relationship among the variables was verified by Spearman’s correlation. All statistical analyses were performed at a confidence level of 95%.

Results

Comparisons of number of occlusal pairs, masticatory performance and masticatory time among groups are presented in Table 1. Class II-1 ($p < 0.001$) and III ($p < 0.0001$) malocclusion groups presented the smallest number of occlusal pairs. Masticatory performance values were also significantly reduced for these groups and for Class I malocclusion ($p < 0.05$).

Table 1 - Number of occlusal pairs, masticatory performance and masticatory time (Mean ± S.D.) for Normocclusion (control) and Malocclusion groups.

Variables	Control	Malocclusion			
		Class I	Class II-1	Class II-2	Class III
NPO	14.0 ± 0.0A	12.9 ± 1.9A	11.4 ± 2.3B	13.9 ± 0.2A	9.1 ± 3.3B
MP (mm ²)	3.2 ± 0.9A	4.1 ± 1.3B	4.0 ± 1.1B	3.1 ± 1.1A	4.2 ± 1.2B
MT (s)	18.8 ± 3.7A	19.2 ± 4.3A	19.9 ± 4.9A	22.1 ± 6.4A	22.9 ± 7.4A

NPO = Number of occlusal pairs; MP = Masticatory performance; MT = Masticatory time. Mean values followed by different letters differ statistically ($\alpha = 0.05$).

Table 2 - Frequency of masticatory ability answers for malocclusion groups.

Groups	Masticatory ability											
	In general		Carrot		Lettuce		Meat		Vegetables		Apple	
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Control	1	15	0	16	0	16	1	15	0	16	1	15
Class I	1	15	1	15	0	16	2	14	0	16	1	15
Class II-1	4	12	1	15	0	16	2	14	0	16	4	12
Class II-2	2	14	2	14	0	16	1	15	0	16	2	14
Class III	3	13	0	16	0	16	2	14	0	16	3	13

$\chi^2 = 3.58$. $p = 0.465$.

Table 3 - Correlations (rho) and significance (p) between studied variables.

Variables		1	2	3	4
1	Malocclusion	-	-	-	-
2	Number of occlusal pairs	rho = 0.444 $p < 0.05$	-	-	-
3	Masticatory performance	rho = 0.116 $p = 0.306$	rho = 0.393 $p < 0.05$	-	-
4	Masticatory time	rho = 0.244 $p < 0.05$	rho = 0.195 $p = 0.083$	rho = 0.131 $p = 0.246$	-
5	Masticatory ability	rho = 0.128 $p = 0.257$	rho = 0.050 $p = 0.661$	rho = 0.143 $p = 0.206$	rho = 0.046 $p = 0.688$

No differences were found in terms of masticatory time ($p = 0.156$) among the groups.

The frequency of answers for masticatory ability of all malocclusion groups are shown in Table 2. No differences ($\chi^2 = 3.58$, $p = 0.465$) between the several classes of malocclusions and masticatory ability to chew different kinds of food were found.

Spearman's correlation (Table 3) showed that the number of occlusal pairs was correlated with malocclusion (rho = 0.444, $p < 0.05$). A correlation with masticatory performance (rho = 0.393, $p < 0.05$) was also observed. No correlation was found between masticatory performance and malocclusion (rho = 0.116, $p = 0.306$).

Discussion

The relationship between the presence of malocclusion and the number of occlusal pairs and mastication was verified by this cross-sectional study. The results showed that Class II division 1 and Class III subjects presented a smaller number of occlusal pairs. This finding may be related to dental and skeletal differences of these subjects.^{6,7,9,17-19}

Class II division 1 subjects present anteroposterior discrepancies, which could determine proclined maxillary anterior teeth with a large overjet as well as lingual displacement of second molars due to mandible with inadequate space.^{17,18} Furthermore, they might have a hyperdivergent skeletal pattern, with a steep mandibular plane angle and a long anterior lower face height with open bite tendency.⁶ These characteristics, depending on malocclusion severity, may eventually determine the lack of anterior⁶ or mandibular second molar contacts, thus decreasing the number of occlusal pairs. Subjects with Class III malocclusion present mandibular prognathism, maxillary deficiency and/or hypodivergent skeletal pattern with a low mandibular plane angle and short lower facial height.¹⁷ As a consequence, it is common to find Class III subjects with a smaller number of occlusal pairs due to an anterior open bite with negative overjet¹⁹ or lack of contact in upper second molars, depending on whether the alteration is produced by discrepancy on mandibular or maxillary size, or mandibular protrusion or maxillary retrusion. Although there are no studies comparing

the number of occlusal pairs and malocclusions, these features could contribute to the results.

Comparisons of masticatory performance among malocclusion classes showed that Class I, Class II division 1 and Class III subjects presented the highest values of median particle size. These findings are in agreement with those of English *et al.*,⁴ who verified that Class I, II, and III malocclusions had median particle sizes approximately 9%, 15%, and 34% larger than those of the group with Normocclusion, respectively. Also, Toro *et al.*⁵ and Henrikson *et al.*¹⁵ found a decreased masticatory performance for Class I and Class II subjects, respectively, when compared to Normocclusion group. However, Owens *et al.*³ found no differences among median particle sizes of malocclusion groups, and Toro *et al.*⁵ also showed no differences between Normocclusion and Class II malocclusion. These contradictory results can be explained by methodological differences, such as inclusion of subjects presenting a wide age range (10.5 to 49.0 years) and different dentition stages,³ as well as failure to mention the number of occlusal pairs evaluated.³⁻⁵ In the present study, a homogeneous sample with all teeth erupted was used.

Anatomic and functional features could also contribute to the masticatory performance values found in the present study. The mispositioned teeth presented by Class I malocclusion subjects, and skeletal or alveolar discrepancies presented by subjects with Class II division 1, and Class III malocclusions may alter or eliminate the occlusal guidance.^{12,13} The anterior teeth of Class II division 1 subjects do not provide the protection and guidance normally provided by horizontal and vertical overlap. The maximum opening is lower due to the smaller size of the mandible, and protrusion is the dominant movement. Posterior teeth must function from centric relation forward to an anterior separation, bearing the full force of occlusion.¹² These conditions may alter the balance of mandibular movement pattern and possibly the masticatory performance. Class III subjects present an anterior relationship that provides no excursive movements determined by canines or anterior teeth, being their mandibular

movement regulated by articular eminence or posterior teeth.¹³ This pattern determines a more limited function than that of Class I or II subjects, describing a smaller protrusive movement and a greater maximum opening due to the length of mandible.¹³ These conditions also determine an altered rhythm of masticatory movements,²⁰ supporting the lower masticatory performance values showed by these subjects.

Data of masticatory time showed no differences among groups. This is in accordance with Pröschel and Hofmann,¹¹ who found that subjects with Class II division 2 and Class I malocclusions presented similar times and speed of masticatory cycle. However, these authors also found that Class III subjects have high opening-closing time and sagittal amplitude, as well as a lower opening-closing velocity cycle, which could also alter the masticatory time.¹¹ The lack of statistical differences in the present study may be justified by the fact that subjects with malocclusion presenting lower masticatory performance adapt to an increasing the number of masticatory cycles or swallowing particles of greater size.^{14,21} This condition could alter the time or speed of cycle phases, showing similar registered time up to 20 masticatory cycles.

It was observed a similarity in masticatory ability values for different foods in all groups. As previously mentioned, the possible adaptive mechanisms^{14,21} can condition subjects with malocclusion not to feel difficulty in chewing hard foods, regardless of their incapacity to chew on them properly.

No correlation was found between masticatory performance and malocclusion (Table 3). Masticatory performance seemed to be more influenced by the number of occlusal pairs than malocclusion condition, justifying the moderate correlation between the number of occlusal pairs and malocclusion. Studies comparing malocclusion groups with different severity degrees in subjects with complete dentition are necessary, but they must include the analysis of occlusal variables of all teeth.

Conclusion

Within the limitations of this study, it may be

concluded that masticatory performance, masticatory time and masticatory ability were not related to malocclusion, and the number of occlusal pairs was related to masticatory performance and malocclu-

sion. Subjects with Class I, Class II division 1 and Class III malocclusions presented lower masticatory performance because of their smaller number of occlusal pairs.

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