

Review Article

The influence of malocclusion on masticatory performance

A systematic review

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ABSTRACT

Objective: To systematically review the relationship between malocclusions and masticatory performance. In addition, we will perform a qualitative analysis of the methodological soundness of the studies.

Materials and Methods: A literature survey was done by applying the Medline database (www.ncbi.nlm.nih.gov) in the period from January 1965 to June 2009, using the “Medical Subject Headings” term malocclusion crossed with various combinations of the following terms: masticatory performance, masticatory efficiency, and chewing efficiency. The articles were separated into two main topics: (1) the influence of malocclusion treatment (orthognathic surgery) and (2) the influence of malocclusion type and severity.

Results: The search strategy used identified 78 articles. After selection according to the inclusion/exclusion criteria, 12 articles qualified for the final analysis. The research quality and methodological soundness were high in one study, medium in 10 studies, and low in one study. The most serious shortcomings comprised the clinical trials and controlled clinical trials designs with small sample sizes and inadequate description of selection criteria. Lack of method error analysis and the absence of blinding in measurements were other examples of shortcomings.

Conclusions: Malocclusions cause decreased masticatory performance, especially as it relates to reduced occlusal contacts area. The influence of malocclusion treatment (orthognathic surgery) on masticatory performance is only measurable 5 years after treatment. (*Angle Orthod.* 2010;80:981–987.)

KEY WORDS: Masticatory performance; Malocclusion; Orthognathic surgery; Systematic review

INTRODUCTION

Mastication represents the first stage of the digestive process, during which foods are physically broken down into smaller particles to increase their surface area, thereby facilitating enzymatic processing during later stages of digestion.^{1,2} Mastication can be mea-

sured by several means, including masticatory ability, efficiency, and performance. Masticatory ability is a subjective measure, a perception of how well subjects think they break down foods.³ Efficiency pertains to the number of masticatory cycles (ie, number of chews) required to reduce foods to a certain size,⁴ and masticatory performance, the most common and powerful measure used, pertains to the particle size distribution of food chewed after a standardized number of cycles.^{4,5}

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Table 1. Initial Inclusion and Exclusion Criteria for the Retrieved Studies

Inclusion Criteria	Exclusion Criteria
Studies using objective parameters to evaluate masticatory performance	Case reports and case series Review articles and abstracts Dental mutilated patients
Studies with untreated/normal controls	Systemic and neurologic diseases Cleft lip and/or palate or other
Articles written in English	craniofacial syndrome diagnosis

Table 2. Masticatory Performance Studies in Orthognathic Surgical Patients^a

Author	Study Design	Study Groups	Sample Size	Age, y	Methods/Measurements	Outcome Measurements: Orthognathic Surgery or Orthopedics Functional Treatment
Zarrinkelk et al. ¹⁸	L, CCT	I: Patients before and after orthognathic surgery II: Control: skeletal and dental Class I relationships	n = 18 (12 females, 6 males) n = 49 (26 females, 23 males)	14–55 (mean, 29) 22–33 (mean, 26)	Masticatory performance (median particle size of carrots–20 cycles), swallowing threshold	Patients produced a significantly larger median particle size than controls both before and after surgery. The average decrease in median particle size between preoperative and postoperative trials for patients was not statistically significant. No significant difference between patients and controls was detected with regard to the swallowing threshold.
Van den Braber et al. ¹⁵	L, CCT	I: Skeletal and dental Class II patients before and after orthognathic surgery II: Control: Class I molar relation	n = 11 (5 males, 6 females) n = 12 (4 males, 8 females)	24.8 (±6.4) 25.1 (±5.9)	Masticatory performance (median particle size of Optosoft–30 cycles), bite force, EMG, chewing cycle duration	Controls presented a better masticatory performance than patients both before and after surgery. The orthognathic surgery did not improve the masticatory performance in retrognathic patients, and no change was found in the bite force, EMG values, and chewing cycle time.
Van den Braber et al. ¹⁶	L, CCT	I: Skeletal and dental Class II patients before and after orthognathic surgery II: Control: Class I molar relation	n = 11 (5 males, 6 females) n = 12 (4 males, 8 females)	24.8 (±6.4) 25.1 (±5.9)	Masticatory performance (median particle size of Optosoft–15 and 30 cycles), selection and breakage in one-chew experiment	Controls presented a better masticatory performance than patients both before and after surgery. The orthognathic surgery did not improve the masticatory performance. Controls had a better selection and breakage than patients, and these variables did not improve after treatment.
Van den Braber et al. ¹⁷	L, CCT	I: Skeletal and dental Class II patients before and after orthognathic surgery II: Control: Class I molar relation	n = 12 (8 males, 4 females) n = 12 (6 males, 6 females)	24.2 (±5.1) 25.1 (±5.9)	Masticatory performance (median particle size of Optosoft–15 cycles), bite force	There was a significant improvement in masticatory performance 5 y after surgery. An increase of the maximum bite force was not observed.

^a CCT indicates controlled clinical trials; L, longitudinal; and EMG, surface electromyography.

Several factors influence masticatory performance, including body size, bite force,⁶ number of functional tooth units,⁷ occlusal contact area,⁸ and malocclusions.⁹ Although not as potent a factor as the mutilated dentition, malocclusions can negatively affect subjects' ability to process and break down foods.¹⁰ Unfortunately, most of the studies evaluating the relationship between malocclusions and mastication are not conclusive in terms of identifying the subtle influences of the different types of malocclusions on masticatory performance.

Given this background, a systematic review was warranted, focusing on the relationship between malocclusions and masticatory performance. Furthermore, a qualitative analysis of the methodological soundness of the studies in the review was performed.

MATERIALS AND METHODS

Search Strategies

A literature survey was done by applying the Medline database (www.ncbi.nlm.nih.gov) in the period from January 1965 to June 2009, using the "Medical Subject Headings" term malocclusion crossed with various combinations of the following terms: masticatory performance, masticatory efficiency, and chewing efficiency.

Selection Criteria

The inclusion and exclusion criteria are given in detail in Table 1.

Table 3. Masticatory Performance Studies Regarding Different Malocclusion Types^a

Author	Study Design	Study Groups	Sample	Age, y	Methods/ Measurements	Outcome Measurements: Malocclusion
Pancherz and Anehus ²²	CT	I: Relapse of overjet after activator treatment	n = 9 (1 male, 8 females)	28.9	Masticatory performance (median particle size of Optosil–20 cycles), occlusal contacts, EMG activity of masseter and temporal	Patients with relapse of overjet presented a poor masticatory performance, a reduced EMG activity, and fewer occlusal contacts in the anterior dental arch when compared to stable ones. The poor masticatory performance was associated with fewer intermaxillary tooth contacts and diminished EMG activity of the masticatory muscles.
		II: Stability of overjet after activator treatment	n = 10 (3 males, 7 females)	28.7		
Tate et al. ²³	CCT	I: Preorthognathic surgery patients	n = 35 (23 females, 12 males)	15–56 (mean, 28.8)	Masticatory performance (median particle size of carrots–20 cycles), bite force, EMG activity of masseter, anterior and posterior temporalis	Masticatory performance was significantly lower in patients than in controls. The differences with regard to bite force and EMG activity were not statistically significant.
		II: Control: Class I molar relation	n = 58 (31 females, 27 males)	23–35 (mean, 27.2)		
Henrikson et al. ²⁴	CCT	I: Class II orthodontic group	n = 65 (females)	12.8 (±1.1)	Masticatory performance (chewing efficiency index–Optosil–20 cycles), masticatory ability (visual analog scale), occlusal contacts	The normal group presented better masticatory performance than the two Class II groups, which did not differ between each other. Few occlusal contacts and a large overjet predicted a reduced masticatory performance.
		II: Class II group (without any planned orthodontic treatment)	n = 58 (females)	12.9 (±1.0)		
		III: Normal group	n = 60 (females)	12.7 (±0.7)		
Van den Braber et al. ²⁵	CCT	I: Skeletal and dental Class II patients before orthognathic surgery	n = 12 (4 males, 8 females)	24.9 (±5.5)	Masticatory performance (median particle size of Optosoft–15 and 30 cycles), masticatory efficiency (number of cycles needed to halve the initial median particle size), selection and breakage in one-chew experiment	Both the masticatory performance and efficiency of the patients were lower than that of the controls. Patients also had an impairment of both selection and breakage of particles.
		II: Control: Class I molar relation	n = 12 (6 males, 6 females)	25.1 (±5.9)		
Gavião et al. ²⁶	CCT	I: Normal occlusion	n = 10 (both genders)	3–5.5	Masticatory performance (particle size area and perimeter of Optosil–20 cycles)	The normal occlusion group presented a better masticatory performance than did those in the groups with posterior cross bite and anterior cross bite, which did not differ between each other.
		II: Posterior cross bite	n = 10 (both genders)			
		III: Anterior open bite	n = 10 (both genders)			
Owens et al. ⁸	CCT	I: Class I subjects	n = 14 (6 males, 8 females)	10.5–49.0 (±14.7)	Masticatory performance (median particle size and broadness of particle distribution of Cuttersil–20 cycles), masticatory ability (swallowing threshold), occlusal contacts	Subjects with normal occlusion had significantly larger occlusal contacts than did those with Class I, Class II, and Class III malocclusions, in descending order, but only the difference for broadness of particles was statistically significant with regard to the masticatory performance.
		II: Class II subjects	n = 13 (5 males, 8 females)			
		III: Class III subjects	n = 6 (2 males, 4 females)			
		IV: Normal occlusion	n = 18 (6 males, 12 females)			

Table 3. Continued

Author	Study Design	Study Groups	Sample	Age, y	Methods/ Measurements	Outcome Measurements: Malocclusion
English et al. ¹⁰	CCT	I: Normal occlusion	n = 38	7–37	Masticatory performance (median particle size and broadness of particle distribution of Cuttersil–20 cycles), masticatory ability (visual analog scale), swallowing threshold	Subjects with normal occlusion had significantly smaller particle sizes and broader particle distributions than subjects with malocclusion. Patients with malocclusion also perceived chewing disabilities with the harder foods. The swallowing threshold did not differ between groups.
		II: Class I malocclusion subjects	n = 56			
		III: Class II malocclusion subjects	n = 45			
		IV: Class III malocclusion subjects	n = 46 (48% males, 52% females)			
Toro et al. ²⁷	CCT	I: Normal occlusion	n = 139 (86 males, 53 females)	6–15	Masticatory performance (median particle size and broadness of particle distribution of Cuttersil–20 cycles)	Children with normal occlusion had a better masticatory performance than those with a Class I malocclusion. No differences were found between normal occlusion and Class II malocclusion. Angle classification and the Peer Assessment Ratio (PAR) index could not explain most of the variation in masticatory performance.
		II: Class I malocclusion	n = 112 (76 males, 36 females)			
		III: Class II malocclusion	n = 84 (62 males, 22 females)			

^a CCT indicates controlled clinical trials; CT, clinical trial; and EMG, surface electromyography.

Data Collection and Analysis

Data were collected on the following items: author, year of publication, study design, study groups, methods/measurements, and outcome measurements. The articles were separated into two main topics: (1) the influence of malocclusion treatment (orthognathic surgery) (Table 2) and (2) the influence of malocclusion type and severity (Table 3).

In addition, to document the methodological soundness of each article, a quality evaluation was performed with respect to preestablished characteristics,^{11,12} evaluating the following eight variables: (1) study design (randomized clinical trials, prospective trials, or controlled clinical trials [CCTs]—3 points; clinical trials [CTs]—1 point); (2) adequate sample size—1 point; (3) adequate selection description—1 point; (4) valid measurement methods—1 point; (5)

Table 4. Quality Evaluation of the Retrieved Studies^a

Articles	Study Design	Sample Size	Selection Description	Valid Measurement Methods	Method Error Analysis	Blinding in Measurement	Adequate Statistics Provided
Pancherz and Anehus ²²	CT	Inadequate	Adequate	Yes	ND	ND	Yes
Tate et al. ²³	CCT	Inadequate	Inadequate	Yes	ND	ND	Yes
Zarrinkelk et al. ¹⁸	CCT, L	Inadequate	Adequate	Yes	Yes	ND	Yes
Henrikson et al. ²⁴	CCT	Adequate	Adequate	Yes	Yes	ND	Yes
Gavião et al. ²⁶	CCT	Inadequate	Adequate	Yes	ND	ND	Yes
Van den Braber et al. ²⁵	CCT	Inadequate	Adequate	Yes	ND	ND	Yes
Owens et al. ⁸	CCT	Inadequate	Inadequate	Yes	ND	ND	Yes
English et al. ¹⁰	CCT	Adequate	Adequate	Yes	ND	ND	Yes
Van den Braber et al. ¹⁵	CCT, L	Inadequate	Adequate	Yes	ND	ND	Yes
Van den Braber et al. ¹⁶	CCT, L	Inadequate	Adequate	Yes	ND	ND	Yes
Van den Braber et al. ¹⁷	CCT, L	Inadequate	Adequate	Yes	ND	ND	Yes
Toro et al. ²⁷	CCT	Adequate	Adequate	Yes	ND	ND	Yes

^a CCT indicates controlled clinical trial; RCT, randomized clinical trial; CT, clinical trial; L, longitudinal; ND, not declared; EMG, surface electromyography; and TMD, temporomandibular joint dysfunction.

use of method error analysis—1 point; (6) blinding in measurement—1 point; (7) adequate statistics provided—1 point; and (8) confounders included in analysis—1 point. Each study was categorized as low (0–5 points), medium (6–8 points), or high (9 or 10 points). The data extraction and quality scoring from each article were assessed independently by two researchers who selected the articles by reading the title and abstracts. All of the articles that appeared to meet the inclusion criteria were selected. One hundred percent agreement was obtained in this phase between the two researchers. The reference lists of the selected articles were also searched manually for additional relevant publications that might have been missed in the database searches.¹³

RESULTS

The search strategy yielded 78 articles. After selection according to the inclusion/exclusion criteria, 12 articles qualified for the final analysis (Tables 2 and 3). The research quality and methodological soundness were high in one study, medium in 10 studies, and low in one study (Table 4). The most serious shortcomings were the CT and CCT designs with small sample sizes and inadequate description of selection criteria. Lack of method error analysis and the absence of blinding in measurements were other examples of shortcomings. However, the choice of statistical methods was explained in all articles. Considering the use of confounding variables, only two studies did not report any factor. In all other reports, confounding variables, such as surface electromyography, occlusal contacts, bite force, signs and symptoms of temporomandibular joint dysfunction, and anthropometric measurements,

were declared. All measurement methods used in the studies were valid.

DISCUSSION

This systematic review aimed to select all clinical trials verifying the relationship between malocclusion and masticatory performance. No previous review study could be found. Twelve studies were retrieved. From a methodological point of view, it was notable that all of the studies used examination methods without blinding design. In all studies, the methods used to detect and analyze the relationship between malocclusion and masticatory performance were valid and well known. However, great variations in test food and number of cycles were observed, which could make comparisons among all studies difficult.^{1,14} On the other hand, studies^{15–17} published by the same group were found, allowing more comprehensive conclusions based on their results.

The influence of malocclusion treatment (orthognathic surgery) on masticatory performance showed that mastication was still hampered in comparison to results obtained from controls, even after surgical correction. In addition, surgical correction did not improve masticatory performance significantly.^{15,16,18} However, it was suggested that after surgery, some time is needed in order for the muscles to adapt to the new bone position. The muscle fibers are stretched and may also decrease bite force when compared to the situation before surgery.^{15,19} This fact was confirmed when a significant increase in masticatory performance was noted 5 years after surgery.¹⁷

According to these results, it is important to consider that longitudinal studies with short postsurgical time evaluation should be observed cautiously, since the musculature may need a long time to readapt the new incorporated modifications. It seems that at least 5 years are needed to measure a real improvement in masticatory performance.¹⁷

In addition, simultaneous evaluation of number and area of occlusal contacts, bite force, muscle thickness, amount of lateral jaw movement, pain, and muscle activity are encouraged in order to control all co-variables after orthognathic surgery, once masticatory performance may be influenced by all of these factors.^{6,20,21}

The influence of malocclusion type and severity on masticatory performance was also investigated. In general, malocclusions caused decreased masticatory performance.^{8,10,22–27} Undoubtedly poor masticatory performance is associated with fewer intermaxillary tooth contacts. In addition, a diminished muscle activity was noted.²² A reduced platform to grind the food affects

Table 4. Extended

Confounder Factors Considered	Judged Quality Standard: Low (0–5 points), Medium (6–8 points), or High (9 or 10 points)
EMG and occlusal contacts	Low
EMG and bite force	Medium
Skeletal and dental relationship	Medium
Signs and symptoms of TMD, occlusal contacts	High
Yes, body weight and height	Medium
ND	Medium
Occlusal contacts area	Medium
Body weight and height	Medium
Bite force and EMG	Medium
ND	Medium
Bite force	Medium
Anthropometric measurements	Medium

masticatory performance.⁶ Subjects with a reduced occlusal contacts area cannot pulverize their food to the same extent as subjects with more occlusal units, in a fixed number of chewing strokes. Fontijn-Tekamp et al.²⁸ reported that the number of occlusal units was the most important factor that affected the median particle size of masticatory performance and the swallowing threshold. Similar results were previously reported.⁷ Occlusal contacts promote mandibular stability at maximal intercuspation²⁹ and have an influence on chewing function⁸ and masticatory muscle activity.³⁰

Masticatory performance is also influenced by bite force. It is believed that bite force increases with teeth in occlusal contact.^{31,32} In all selected studies, only Tate et al.²³ evaluated bite force and masticatory performance in orthodontic patients. The differences with regard to bite force in preorthognathic surgery patients and Class I molar relation was not statistically significant. However, in this study, sample size and selection description were considered inadequate for drawing any further conclusions. Therefore, the correction of malocclusion through orthodontic treatment becomes an important resource with which to improve occlusal contacts and, consequently, masticatory performance.

CONCLUSIONS

- Malocclusions cause decreased masticatory performance, especially as it relates to a reduced occlusal contacts area.
- The influence of malocclusion treatment (orthognathic surgery) on masticatory performance is only measurable 5 years after treatment.

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