Review Article

Masticatory Performance After Orthodontic Treatment

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Abstract

Orthodontic treatment aims to enhance dental aesthetics and functionality. Its impact on masticatory performance, which encompasses the efficiency and effectiveness of chewing, remains an important area of study. Factors influencing masticatory performance include dental alignment, occlusal contact, and muscular coordination. This review aims to summarize both the relationship between masticatory performance after orthodontic treatment and the commonly used methods for measuring masticatory performance following orthodontic treatment. A systematic search of electronic databases (PubMed [including MEDLINE] and Scopus) was conducted for studies published from January 2000 up to May 2024, focusing on masticatory performance in patients undergoing orthodontic treatment. Studies were selected based on predefined eligibility criteria, data on study characteristics, orthodontic interventions, masticatory assessment methods, and key findings regarding masticatory changes that were extracted. Out of 797 records identified, 13 studies met the inclusion criteria. These studies evaluated masticatory performance before and after orthodontic treatment using both subjective and objective measurements, with maximum bite force and occlusal contact area being the most used methods. The review found that non-extraction orthodontic treatment generally improved masticatory performance, as evidenced by comminution tests and self-reported ability, although performance still lagged behind natural occlusion post-treatment. Extraction orthodontic treatment presented mixed results, with lower masticatory performance in the early retention phase that gradually increased, ultimately showing no significant differences in occlusal contact area or force between extraction and non-extraction groups over time. Orthognathic surgery enhanced masticatory function, but it still did not reach the levels observed in individuals with natural occlusion, despite improvements in bite force and occlusal contact area over time. Overall, non-extraction treatment showed improvements but remained inferior to controls, while extraction treatment had variable outcomes and orthognathic surgery improved function but fell short of natural occlusion.

Keywords: Chewing performance, Extraction, Malocclusion, Masticatory performance, Non-extraction, Orthodontic treatment, Orthognathic surgery

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Introduction

Orthodontic treatment primarily focuses on correcting dentofacial abnormalities to improve dental aesthetics and occlusal function (Proffit *et al.,* 2013). A key area of interest in research is the impact of orthodontic treatment on masticatory performance—the efficiency and effectiveness of chewing, which plays a crucial role in oral function and overall health.[1]

Masticatory performance refers to the ability to effectively break down and process food during chewing. Optimal chewing function relies on a complex interaction of factors, such as dental occlusion, tooth positioning, jaw movement, and neuromuscular coordination. Malocclusions, or misalignments of the teeth and jaws, can negatively impact masticatory efficiency by disrupting the smooth coordination of these factors, making chewing less effective.[2]

The relationship between orthodontic treatment and masticatory performance has been the subject of extensive research efforts, yielding a diverse array of findings. While some studies suggest that orthodontic interventions can improve masticatory function by correcting malocclusions and optimizing dental occlusion, others indicate that the presence of orthodontic appliances or the initial stages of treatment may temporarily impair chewing efficiency due to factors such as dental discomfort, altered occlusal contacts, and neuromuscular adaptations.[4]

Investigating the impact of orthodontic interventions on masticatory performance is crucial for both clinicians and patients. From a clinical perspective, understanding these effects helps guide treatment decisions, patient counseling, and the implementation of strategies to minimize any potential negative impacts on chewing function during treatment. For patients, being informed about these potential effects can help set realistic treatment goals and encourage necessary dietary or behavioral adjustments throughout the treatment process.[3]

This review aims to investigate the relationship between masticatory performance after orthodontic treatment and determine the most used measure of masticatory performance after orthodontic treatment.

1. Masticatory performance

Masticatory performance refers to the efficiency and effectiveness of the chewing process, which is critical for breaking food into smaller, more digestible particles. This ability can be measured using various methods, each designed to quantify different aspects of the masticatory process. One common approach is to assess an individual's capacity to comminute a standardized test food, such as almonds, or artificial materials like chewing gum or paraffin wax. These methods involve evaluating the particle size distribution after a set number of chewing cycles, thereby providing an objective measure of masticatory performance.[5,6]

In other words, masticatory performance refers to the individual's ability to grind a specimen of test food after a predetermined number of mastication cycles.While masticatory efficiency refers to the number of chewing cycles necessary to attain half the original particle size.[7-9]

2. Assessment of masticatory performance

This assessment typically involves measuring the ability to break down food, the number of chewing cycles, and the time taken to achieve a specific degree of food fragmentation. Methods include the use of artificial test foods, such as silicone-based particles or chewing gums, and natural foods like almonds or carrots. Objective measurements may involve particle size analysis through sieving or image processing, while subjective evaluations might include patient questionnaires on chewing ability and comfort. Factors influencing masticatory performance include dental status, occlusal patterns, muscle function, and the use of prosthetic appliances.[10]

Masticatory performance assessment refers to evaluating the outcome of the mastication process using various methodologies and techniques. The consensus paper outlines two primary approaches:

2.1 Objective assessment

Comminution tests: These involve chewing brittle food (e.g., nuts, raw carrots) for a predetermined number of cycles, followed by sieving or optical scanning of the chewed particles to analyze their size distribution.

Mixing ability tests: These use non-nutritive materials like two-colored chewing gum or wax, chewed for a fixed number of cycles, and then analyzed for color mixing to assess the kneading efficiency of the oro-facial system.

Other chewing tests: These include using gummy jelly or encapsulating granules with dyes to measure masticatory performance through spectrophotometric analysis.

Swallowing threshold: This assesses the number of chewing cycles until the food is ready to be swallowed and analyzes the particle size and textural properties of the bolus.

2.2 Objective assessment (indirect analysis)

Jaw kinematics: Recording jaw movements during chewing using magnetic, electromagnetic, or optical motion analysis systems.

Jaw muscle activity and bite force: Measuring muscle activity with surface electrodes and bite force with transducers.

Tongue and lip function: Assessing maximum tongue pressure and lip force.

Saliva: Measuring mechanically stimulated salivary flow rate and analyzing its composition.

2.3 Subjective assessment:

Self or proxy-assessed masticatory function: using questionnaires to evaluate the perceived quality of masticatory function and difficulties in chewing different types of food.

2.4 Advantages and Limitations

Each method has distinct advantages and limitations, which must be considered when selecting the appropriate assessment technique.

Comminution tests:

Advantages: Detailed, reliable, and suitable for a wide range of populations.

Limitations: Requires precise control of conditions and may not be suitable for all demographics.

Mixing ability tests:

Advantages: Quick, simple, and cost-effective.

Limitations: May not detect subtle differences in high-capacity chewers and requires immediate analysis.

Other chewing tests:

Advantages: Easy to apply and measure, suitable for epidemiological studies.

Limitations: Limited by the specificity of test materials and potential type II errors.

Swallowing threshold:

Advantages: Reflects real-life chewing behavior and provides comprehensive bolus characteristics.

Limitations: Highly influenced by food characteristics and individual variability.

Jaw kinematics and muscle activity:

Advantages: Detailed neuromuscular analysis and insights into chewing dynamics.

Limitations: Limited to laboratory settings and requires specialized equipment.

Subjective assessments:

Advantages: Captures patient perceptions and psychological factors.

Limitations: Poor correlation with objective measures and influenced by individual biases.

Materials and Methods

1. Search strategy

A digital electronic search of publications from three electronic databases—PubMed (including MEDLINE) and Scopus, was conducted up to May 2024. No publication date limits were applied, although only articles published in English were included. The search query was implemented using the following combinations of keywords: (Mastication OR Chewing) AND (performance or productivity or efficiency or success or outcomes) AND (orthodontic treatment. The digital search was implemented by manually searching the reference lists from full-text articles and related reviews. Detailed individual search strategies and word combinations were developed following the PICOS criteria. In addition, a hand-search of the references of the included articles was performed.

2. Eligibility criteria

The PICO criteria related to research questions are detailed below:

2.1 Population: patients with malocclusion and skeletal discrepancy.

2.2 Intervention: non-extraction, extraction, orthognathic surgery in the maxilla, mandible, or both.

2.3 Comparison: Control (normal occlusion) or before treatment vs. post-orthodontic treatment at any follow-up periods.

2.4 Outcome: Masticatory performance (chewing performance, masticatory efficacy, masticatory ability) evaluated using subjective and objective assessment of masticatory performance.

The inclusion criteria comprised randomized controlled trials, prospective controlled studies, and observational studies with a comparison group, as well as English-language publications focusing on orthodontic treatment.

The exclusion criteria consisted of studies that did not provide sufficient data to calculate the masticatory performance, case reports, literature reviews, and opinion articles.

3. Study selection

The electronic search was used to identify relevant studies, which then underwent an initial screening of titles, abstracts, and study designs by two independent reviewers. In cases where abstracts were ambiguous or insufficient, full-text articles were retrieved for detailed assessment. Selected studies were then reevaluated against predefined inclusion and exclusion criteria. Any disagreements between reviewers were resolved through discussion, and a third reviewer was consulted when consensus could not be reached. Data extraction was performed independently by two reviewers using a standardized form. Any discrepancies were addressed through rechecking source material and, when necessary, by contacting the original authors to obtain missing information related to masticatory performance.

4. Outcome measures / Measurement of treatment effect

Outcome measures aim to interpret masticatory performance after various types of orthodontic treatment, evaluated according to the criteria specified in the individual studies. As various assessment methods exist for evaluating masticatory performance, the clinical methods used were listed to create a dataset of efficacy criteria. Objective assessment of masticatory performance in this review is measured by three main parameters: the results from the comminution method, bite force, and occlusal contact area. Subjective assessment of masticatory ability is conducted using a self-perceived questionnaire.

Result

1. Study selection

The final electronic search on PubMed, which includes MEDLINE-indexed articles, and Scopus retrieved 797 studies. After removing 332 duplicates, 465 titles and abstracts were screened. A total of 349 studies were excluded for irrelevance. Of the remaining 66 studies, 27 were retrieved for full text review and 14 studies were excluded during full-text screening due to the absence of a control group, a requirement specified in our inclusion criteria. As a result, 13 studies met all inclusion criteria and were included in the final analysis.[26-38], as depicted in Figure 1.

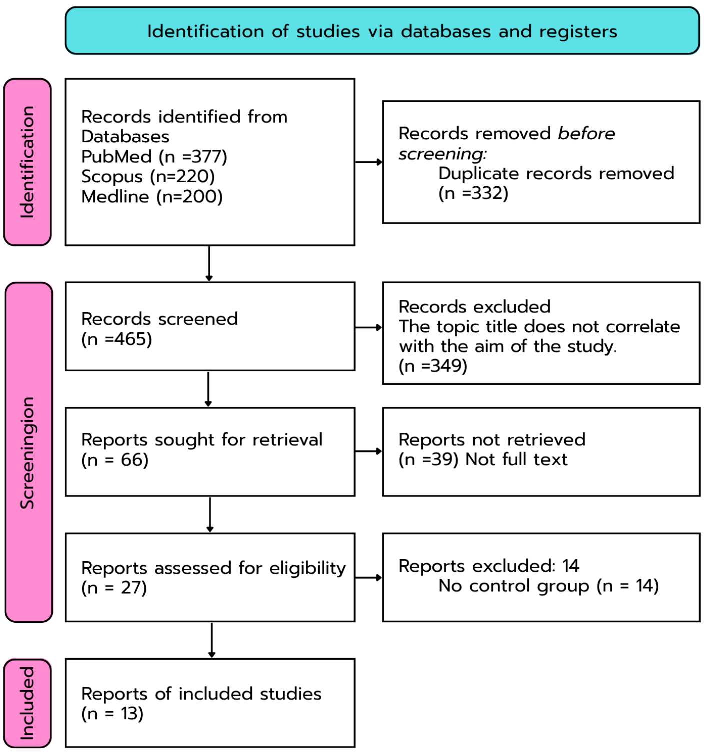

Figure 1 Flowchart diagram of the research search. Exclusions and final number included in the review.

2. Study characteristics

This literature review thoroughly collected and examined studies carried out on volunteer groups. These studies were then categorized into three main groups. These groups specifically explored the efficacy of masticatory function after orthodontic treatments. The studies within these categories concentrated on patients who underwent different orthodontic methods, including non-extraction, extraction, and combined surgical orthodontic procedures. The mean ages of participants in the included studies varied from 21 to 30 years. Additionally, gender information was available in the articles, comprising 629 females and 355 males. In one study, the gender of the volunteer participants was not specified. Furthermore, several articles examined various measures of masticatory performance. Regarding study design, the included studies comprised 13 prospective cohort studies as described in Table 1.[26-38]

Table 1 *Descriptive characteristics of the included studies.*

Author, Year	Study type	Number of Control group	Number of Experimental group	Type of Treatment
Gameiro *et al.,* 2002	prospective cohort study	30 (F15, M15)	17 (M9, F8)	Non-extraction
Henrikson *et al.,* 2009	prospective cohort study	F58	F65	Non-extraction
Lee *et al.,* 2023	prospective cohort study	20 (M10, F10)	18 (M9, F9)	Extraction
Yoon *et al.,* 2017	prospective cohort study	F36	F49	Extraction
Harada *et al.,* 2000	prospective cohort study	20 (M10, F10)	25 (M10, F15)	Surgery
Kato *et al.,* 2012	prospective cohort study	20 (M7, F13)	13 (M2, F11)	Surgery
Kobayashi *et al.,* 2001	prospective cohort study	40 (M24, F16)	27 (M7, F20)	Surgery
Nagai *et al.,* 2001	prospective cohort study	32 (M16, F16)	43 (M21, F22)	Surgery
Choi *et al.,* 2014	prospective cohort study	67 (M32, F35)	78 (M=39, F=39)	Surgery
Ohkura *et al.,* 2001	prospective cohort study	40 (M20, F20)	57 (M26, F31)	Surgery
Ueki *et al.,* 2014	prospective cohort study	40 (M20, F20)	54 (M26, F28)	Surgery
van den Braber *et al.,* 2004	prospective cohort study	12 (M4, F8)	11 (M5, F6)	Surgery
van den Braber *et al.,* 2006	prospective cohort study	12 (M8, F4)	12 (M8, F4)	Surgery

3. Assessment of masticatory performance

The assessment of masticatory performance, based on an intensive analysis of 13 research publications, highlights the variety of approaches used to evaluate masticatory performance in patients following orthodontic procedures. This study reveals that research may employ a broad array of approaches, exceeding the limitations of a single methodology, thereby increasing the efficacy and comprehensiveness of the assessment process. Parameters indicating masticatory performance (comminution, bite force, occlusal contact area, and self-perceived questionnaires) were measured pre-treatment and post-treatment in before-and-after studies. The studies provided post-treatment data compared with control patients (normal occlusion).

The findings from the inclusion studies, as summarized in Table 2, reveal that the most frequently utilized parameters for assessing masticatory performance following orthodontic treatment are maximum bite force and occlusal contact area. These metrics were employed in 11 of the 13 selected studies. Comminution (median particle size X50) and masticatory efficiency were the second most used parameters, featuring in three of the 13 studies. Furthermore, the mixing ability test and self-perceived masticatory ability were each reported in one study. These diverse measures are applied across multiple studies, offering a comprehensive evaluation that encompasses both the objective and subjective facets of masticatory performance.

Table 2 Summary of frequently used measures of masticatory performance of inclusion studies.

Parameter	Method	Studies	sum
Maximum Bite Force or Occlusal Contact Area	Bite on the pressure-sensitive film for a few seconds	Lee *et al.* (2023), Yoon *et al.* (2017), Choi *et al.* (2014), Harada *et al.* (2000), Kato *et al.* (2012), Kobayashi *et al.* (2001), Nagai *et al.* (2001), Ohkura *et al.* (2001), Ueki *et al.* (2014) van den Braber *et al.* (2004, 2006)	11
Comminution (Median Particle Size X50)	Chewing artificial test food (Optocal) or silicon impression material (Optosil® Bayer) for specific cycles	Gameiro *et al.* (2002), van den Braber *et al.* (2004, 2006)	3
Masticatory Efficiency	Chewing silicon impression material (Optosil® Bayer) for specific cycles	Henrikson *et al.* (2009), Kato *et al.* (2012), Kobayashi *et al.* (2001)	3
Mixing Ability Test	Chewing two-color gum on the preferred chewing side for specific cycles	Lee *et al.* (2023)	1
Self-Perceived Masticatory Ability	Questionnaire visual analog scale	Henrikson *et al.* (2009)	1

4. Relationship between masticatory performance after orthodontic treatment

This is an overview of this literature review on investigations on masticatory performance following orthodontic treatment. Participants were classified into many groups compared to a control group that did not get such an intervention. The selection process yielded 13 academic articles for review, categorized as follows: two studies investigated participants undergoing non-extraction orthodontic treatment, two studies examined those receiving tooth extraction orthodontic interventions, and nine studies delved into cases involving orthodontic treatment coupled with orthognathic surgical procedures.

4.1 Masticatory performance after non-extraction orthodontic treatment

Two studies examined participants treated orthodontically without tooth extractions and compared them to a control group with natural occlusion that did not receive orthodontic therapy. Objective measurements were used in these studies to assess masticatory performance. In this context, measurements related to masticatory performance were collected by comparing the control and post-treatment groups using a comminution test for chewing synthetic test food, colorimetric analysis with a spectrophotometer, and the distribution of occlusal load. The subjective evaluation of masticatory performance assessed self-reported masticatory capacity using a Visual Analog Scale questionnaire.

The masticatory performance in the malocclusion patients during the baseline examination was notably reduced compared to the control group. The X50 (median) particle size after 15 strokes of chewing was higher in the malocclusion group, at 5.7 mm, than it was in the control group, at 4.8 mm, suggesting less effective mastication. The improvement in masticatory performance after orthodontic treatment in the malocclusion group was significant. After 15 chewing strokes, the median particle size was reduced to 5.1 mm, closer to the 4.8 mm of the control group. This indicates that orthodontic treatment managed to enhance the patients' chewing performance.[26]

The swallowing performance was as expected. The malocclusion group also presented a higher median particle size at the instance of swallowing (X50-sw) than the control group before treatment (4.5 mm vs. 3.0 mm). This indicates that patients with malocclusion were swallowing larger particles, reflecting poor masticatory performance. In the post-treatment group, the X50-sw was 3.4 mm. In the malocclusion group, which was not significantly different from the control group the X50-sw was at 3.0 mm. This indicates a considerable increase in the ability of patients to reduce food particle size in the mouth before swallowing, making it comparable to the controls.

The self-perceived masticatory ability in prospective and longitudinal studies evaluate both self-perceived masticatory ability and objectively tested masticatory efficiency. The study evaluated the impact of orthodontic treatment on self-perceived masticatory ability and masticatory efficiency among adolescent girls with Class II malocclusion, comparing them to untreated Class II and normal occlusion groups. The self-perceived masticatory ability significantly increased in the Orthodontic group from a mean score of 74.4 to 86.4 (p=0.001), indicating that orthodontic treatment had a positive effect on how these individuals perceived their chewing ability. In contrast, the untreated Class II group and the Normal group showed no significant changes over the two-year period. Initially, the Normal group had significantly higher self-perceived masticatory ability scores than both Class II groups (p<0.001), but after two years, there were no significant differences between any groups.[27]

Masticatory efficiency, measured by the Masticatory Efficiency Index (MEI), improved in all groups over the two-year period. The Orthodontic group's MEI increased from 10.3 to 15.2 (95% CI = 1.9-7.1; p=0.001), while the Class II group's MEI increased from 12.4 to 16.4 (95% CI = 1.7-6.5; p=0.001), and the Normal group's MEI rose from 17.1 to 21.5 (95% CI = 2.1-6.4; p<0.001). Despite these improvements, the Normal group consistently had a significantly higher MEI compared to both the Orthodontic and Class II groups at both the start and after two years (p<0.001 for both comparisons). No significant differences in MEI were observed between the Orthodontic and Class II groups at any point, suggesting that orthodontic treatment did not bring the masticatory efficiency of treated individuals up to the level of those with normal occlusion.

The study also examined preferred chewing sides and occlusal characteristics. No significant differences were found between groups regarding preferred chewing sides both at the start and after two years. However, significant improvements in occlusal characteristics were observed in the Orthodontic group, such as reduced overjet and normalization of sagittal and transverse relationships, demonstrating the effectiveness of orthodontic treatment in correcting occlusal issues.

While orthodontic treatment significantly enhances self-perceived masticatory ability. it does not completely normalize masticatory efficiency compared to individuals with normal occlusion. The increase in masticatory efficiency across all groups likely reflects natural growth and development rather than the effect of orthodontic treatment alone.

4.2 Masticatory performance after orthodontic treatment and tooth extraction

All groups (non-extraction, two maxillary premolar extraction, and four premolar extraction) exhibited a significant reduction in occlusal contact area and force immediately after treatment. Over the two-year post-treatment period, these metrics gradually increased. The non-extraction and two maxillary premolar extraction groups achieved full recovery to pre-treatment levels, while the four premolar extraction group did not fully regain its initial occlusal contact area.[28]

Statistical analysis revealed that the changes in occlusal contact area and force were significantly correlated with the time elapsed since treatment (P < .001). This correlation underscores the gradual improvement in masticatory performance over the two-year period. The non-extraction and two maxillary premolar extraction groups demonstrated a positive correlation between the recovery of occlusal function and improved masticatory performance, as indicated by the full recovery of occlusal contact area and force to pre-treatment levels (P > .05). Conversely, the four premolar extraction group, which did not fully recover its occlusal contact area, highlighted a negative correlation, suggesting that more extensive extractions could have a lasting adverse effect on masticatory performance. While orthodontic treatment initially impairs occlusal function, significant recovery is observed over two years, positively correlating with improved masticatory performance in non-extraction and two maxillary premolar extraction cases. The incomplete recovery in the four premolar extraction groups indicates a potential long-term negative impact on masticatory performance which is supported by the statistical evidence showing a significant correlation between the degree of extraction and the extent of functional recovery.

Immediately after orthodontic treatment, the experimental groups (non-extraction and extraction) demonstrated lower mixing ability (MA), maximum bite force (MBF), and occlusal contact area (OCA) compared to the normal occlusion group. This initial deficiency highlighted the immediate impact of orthodontic treatment on masticatory performance.[29]

Over the one-year retention period, significant improvements were observed in all three parameters for both experimental groups. Mixing ability (MA), measured as the standard deviation of hue (SDHue) in chewed gum, improved significantly over time. By one-month post-treatment (T1), MA levels in both experimental groups were comparable to those in the normal occlusion group. This improvement continued, with MA reaching levels similar to the normal occlusion group by one-year post-treatment (T3). These results indicate a positive recovery trajectory for chewing efficiency post-orthodontic treatment.

Maximum bite force (MBF) and occlusal contact area (OCA) also showed significant increases during the retention period. However, despite these improvements, both MBF and OCA remained lower than those in the normal occlusion group at all measured time points (T1, T2, and T3). Statistical correlations between these parameters provided further insights. There was a significant negative correlation between MA and MBF (correlation coefficient: -0.382, $P < 0.01$) and between MA and OCA (correlation coefficient: -0.350, $P < 0.01$). This implies that as mixing ability improves (i.e., SDHue decreases), both maximum bite force and occlusal contact area tend to increase. Additionally, a strong positive correlation was found between MBF and OCA (correlation coefficient: 0.899, $P < 0.01$), indicating that higher bite force is strongly associated with a larger occlusal contact area.

The MP immediately after orthodontic treatment in the experimental groups was lower than that in the normal occlusion group but increased gradually over time during the retention period and improved to levels similar to those in the normal occlusion group at 1-month post-treatment (T1). Furthermore, extraction did not affect the recovery of the MP after orthodontic treatment.

4.3. Masticatory performance after orthognathic surgery

Assessment of masticatory performance following orthognathic surgery shows that while surgical orthodontic treatment improves function—particularly bite force and occlusal contact area—these gains often fall short of those seen in individuals with normal occlusion. Nine studies evaluated masticatory performance using parameters such as absorbance from the comminution method, bite force, and occlusal contact area.

Across these studies, outcomes like masticatory efficiency and electromyographic (EMG) activity were measured both before and at various intervals after surgery. Harada *et al.* reported that bite force and occlusal contact area were lowest at two weeks postoperatively, recovered to baseline between eight weeks and three months, and exceeded preoperative levels by six months—yet remained below those of healthy subjects. Kobayashi *et al.* similarly noted improvements in masticatory efficiency, occlusal contacts, and muscle activity, though still significantly lower than in control groups. Nagai *et al.* observed that occlusal contact area and bite force declined further one-month post-surgery but gradually improved over the year. While occlusal pressure peaked at one month and neared control values by 12 months, overall performance remained below that of individuals with normal occlusion.

Ohkura *et al.* supported these findings, reporting significant improvements in bite force and occlusal contact area after surgery that exceeded preoperative levels by six months, though still remaining below control levels even at three years post-surgery.[32] In contrast, van den Braber *et al.* presented mixed results: one study found no significant changes in chewing efficiency, maximum bite force, or EMG activity post-surgery, while another observed notable improvements in chewing performance five years after surgery without a corresponding increase in maximum bite force.[33,34] Kato *et al.* and Ueki *et al.* both documented significant postoperative gains in masticatory efficiency, occlusal contacts, and maximal occlusal force, particularly among patients who engaged in masticatory exercises, although these parameters remained inferior to those of individuals with normal occlusion.[35,36]

Overall, these studies consistently show post-operative improvements in masticatory function, with many parameters gradually recovering and sometimes surpassing pre-surgery levels—but still falling short of healthy controls. Various assessment methods, including Dental-Prescale, ATP granules, and EMG analysis, provided strong evidence supporting these trends. Collectively, the findings highlight the importance of ongoing postoperative monitoring and suggest that masticatory exercises can further enhance recovery.

Some discrepancies exist regarding the overall effectiveness of surgical interventions. For instance, van den Braber et al. found no significant changes in chewing efficiency, maximum bite force, or EMG activity, contrasting with other studies that reported improvements in these parameters.[33] Additionally, while Kato *et al.* and Ueki *et al.* emphasized the positive impact of masticatory exercises on recovery, this factor was not consistently addressed across all studies. These variations highlight the diversity in recovery outcomes and underscore the need for personalized rehabilitation strategies to optimize masticatory function after orthognathic surgery.[35,36]

Overall, time plays a critical role in masticatory recovery, with significant improvements observed up to two years post-surgery. However, persistent deficits relative to individuals with normal occlusion indicate the necessity for comprehensive postoperative care and potentially adjunctive therapies to maximize functional outcomes. The findings also stress the importance of standardized assessment protocols in future research to enhance comparability and reliability, facilitating a better understanding of long-term effects and improving rehabilitation strategies following orthognathic treatment.

Discussion

The primary objective of this study is to summarize the relationship between masticatory performance and orthodontic treatment. Participants were divided into two groups: those who have had dental extractions, those who have not, and orthodontic treatment. The study examines various aspects of masticatory performance over periods ranging from one month to two years after orthodontic stabilization. Additionally, the secondary aim is to identify the most used metric for evaluating masticatory performance after orthodontic treatment.

Masticatory performance can be affected by factors such as tooth alignment and occlusion, muscle strength, and neuromuscular coordination. Orthodontic treatment has the potential to enhance masticatory performance by improving dental alignment and occlusion.

1. Assessment of masticatory performance

The findings from the inclusion studies reveal that the most frequently utilized parameters for assessing masticatory performance following orthodontic treatment are maximum bite force and occlusal contact area. These metrics were employed in 11 of the 13 selected studies. Comminution (median particle size X50) and masticatory efficiency were the second most used parameters, featuring in three of the 13 studies. Furthermore, the mixing ability test and self-perceived masticatory ability were each reported in one study. These diverse measures are applied across multiple studies, offering a comprehensive evaluation that encompasses both the objective and subjective facets of masticatory performance.

Bite force and occlusal contact area are critical parameters in assessing masticatory performance during orthodontic treatment because they provide objective measures of the functional efficiency and health of the masticatory system. Research indicates that these metrics are reliable indicators of improvements in muscle activity, occlusal stability, and overall dental function. Bite force and occlusal contact area are commonly used for masticatory assessment in orthodontic treatment due to several reasons.[39-41]

2. Relation of masticatory performance after orthodontic treatment

2.1 Masticatory performance after non-extraction orthodontic treatment

Orthodontic treatments without extractions have been shown to enhance masticatory performance, with studies providing both objective and subjective measures. Gameiro *et al.* found significant improvements in masticatory efficiency post-treatment, evidenced by a reduction in the median particle size of chewed food. These findings are consistent with the overall literature, which supports the positive impact of orthodontic treatments on masticatory function.[26,42,43]

Thor Henrikson *et al.* reported improvements in self-perceived masticatory ability in adolescent girls with Class II malocclusion but noted that masticatory efficiency remained higher in peers with normal occlusion. This suggests that natural growth and development may play a more significant role than orthodontic treatment alone. This view is supported by van den Braber *et al.,* who found that skeletal morphology and muscle strength are critical factors in masticatory efficiency, with no significant improvements observed post-mandibular advancement surgery.[33]

Ashok *et al.* further confirmed increased chewing efficiency after orthodontic treatment in Class II malocclusion cases using fixed functional appliances. They reported improvements in the molar extinction coefficient and occlusal load distribution, emphasizing the benefits of functional jaw orthopedics in promoting proper nutrition and growth in adolescents.[41] Shim et al. demonstrated that post-orthodontic dental occlusion significantly impacts masticatory performance, stressing the importance of maintaining proper occlusal relationships. This aligns with findings from studies that show improved masticatory functions and enhanced quality of life post-orthodontic treatment.[45] The reviewed studies provide strong evidence of the functional and psychological benefits of such treatments. However, continued research is necessary to further validate these findings and explore the long-term impacts of non-extraction orthodontic treatments across diverse patient populations.

2.2 Masticatory performance after orthodontic treatment and tooth extraction

The impact of orthodontic treatment involving tooth extraction on masticatory performance has been studied extensively, revealing both consistent and differing findings. Lee *et al.* observed significant improvements in mixing ability, bite force, and occlusal contact area over a year. However, these measures did not return to normal occlusion levels, indicating only partial recovery of masticatory function post-treatment. Similarly, Yoon *et al.* found that recovery varied with the extent of tooth extractions, with less extensive extractions showing better recovery compared to more extensive ones.[28,29,46]

Zanon *et al.* reported enhancements in masticatory and chewing functions following orthodontic treatment, leading to improved health-related quality of life.[3] However, this recovery is contingent on the extent of the extractions, with fewer extractions associated with better functional outcomes.[46,47]

A notable point of difference arises in the long-term functional outcomes. Yoon et al. emphasized the long-term adverse effects of more extensive extractions, which contrasts with Nasir *et al.,* who suggested that proper orthodontic treatment can mitigate these negative impacts. Additionally, Gözler et al. emphasized the importance of long-term follow-up for achieving optimal masticatory performance, aligning with the findings of Sabzevari *et al.,* who demonstrated significant enhancements in masticatory performance and quality of life through a meta-analysis.[28,46,48,49]

The occlusal contact area and force recovery correlate significantly with time post-treatment, highlighting the necessity of longitudinal assessments. The precise orthodontic detailing of occlusion contributes to balanced muscle activation and more efficient muscle recruitment, though it does not significantly improve chewing efficiency. This underscores the complexity of factors influencing masticatory performance recovery and the need for individualized treatment planning.[45]

The consensus across these studies suggests that while orthodontic treatment involving premolar extractions initially impairs masticatory performance, significant recovery is achievable, particularly with fewer extractions. The extent of extractions plays a critical role in long-term outcomes, and long-term monitoring and individualized treatment plans are crucial for optimizing functional recovery. Future research should further explore the nuances of different extraction patterns and retention strategies to refine orthodontic treatment protocols.

2.3 Masticatory performance after orthognathic surgery.

The study of masticatory performance following orthognathic surgery offers key insights into functional outcomes post-treatment. Findings indicate a significant decline in masticatory performance—measured by the comminution method—at three months post-surgery, primarily due to postoperative discomfort and muscle adaptation. However, a gradual recovery was observed at six months and one year, although performance remained below that of individuals with normal occlusion. This trend is supported by Bunpu *et al.,* who reported improvements in absorbance values and particle size reduction over time, yet consistently lower than in control groups.[39] Bite force assessments similarly revealed marked reductions at three months post-surgery, followed by notable improvements at six months, one year, and two years. Regression analyses confirmed a positive correlation between postoperative duration and bite force recovery. Nonetheless, even two years post-surgery, bite force levels in surgical patients remained below those of individuals with normal occlusion, underscoring the need for extended follow-up and potential adjunctive therapies to support full functional restoration.[50]

Likewise, the occlusal contact area—which reflects the contact surface between upper and lower teeth during occlusion—showed significant early reductions, with progressive recovery over time. The pattern paralleled that of bite force improvements, yet occlusal contact area values remained lower than those of control groups at the two-year mark. This persistent deficit highlights the importance of comprehensive postoperative care and the establishment of standardized assessment protocols to ensure consistency and comparability in future studies.[51]

In conclusion, while orthognathic surgery significantly improves masticatory performance, the outcomes often fall short of normal occlusion benchmarks. Ongoing deficits in absorbance values, bite force, and occlusal contact area underscore the need for long-term monitoring and adjunctive interventions. Future research should aim to refine assessment methodologies and explore therapeutic strategies to optimize functional recovery after surgery.

Despite the rigorous methodology, this review has several limitations. Restricting inclusion to English-language studies may have introduced language bias. Study heterogeneity in design, outcomes, and populations limited meta-analysis. Some studies had small sample sizes or insufficient reporting, affecting reliability. Publication bias remains a concern, and the exclusion of unpublished or gray literature may have led to an incomplete evidence base. This review provides sufficient evidence that non-extraction orthodontic treatment, extraction orthodontic treatment, and orthognathic surgery all contribute to improvements in patients' masticatory performance.

Conclusion

The literature review highlights the effectiveness of orthodontic treatments in improving masticatory performance, with varying results depending on the treatment approach. Key points include:

1. Non-Extraction Orthodontic Treatments: These treatments generally lead to significant improvements in masticatory performance, often approaching normal chewing function. The improvements tend to be quicker and more consistent in non-extraction cases.

2. Extraction Orthodontic Treatments: These treatments, which involve tooth extractions, usually result in slower recovery of masticatory performance. The long-term effects depend on the number of extractions performed. Studies suggest that patients undergoing extraction treatments take longer to achieve optimal chewing function compared to those undergoing non-extraction treatments.

3. Orthognathic Surgery: This is effective in correcting severe malocclusions and can lead to significant improvements in masticatory function. However, it requires a prolonged recovery period and meticulous postoperative care to achieve optimal outcomes. Continued follow-up is essential to monitor progress and address any functional deficits during the recovery process.

The review recommends that future research focus on creating standardized assessment protocols and developing supplementary therapies to enhance recovery, which would provide a more comprehensive approach to improve masticatory performance following orthodontic treatment.

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