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Evaluating the maximum bite force in edentulous and non-edentulous patients using a gnathodynamometer

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Abstract

In clinical dentistry, evaluating the maximum bite force (MBF) provides insights into the functional capabilities of patients, particularly when comparing those with natural dentition to those experiencing tooth loss. Natural dentition typically exhibits superior MBF due to optimal proprioceptive feedback and periodontal ligament support. This contrasts sharply with edentulous patients, who lack teeth entirely, and partially edentulous individuals, who have lost some teeth, leading to compromised masticatory function and reduced quality of life.
Aim. The aim of this study is to evaluate the MBF of edentulous patients treated with partial and complete dentures and non-edentulous patients using a new generation gnathodynamometer.
Materials and methods. A total of 123 patients were tested throughout the course of the study, which were divided into three groups (41 patients per group), depending on whether they were partial, complete or non-edentulous. All patients were tested in the distal and frontal are of the dentition, using a Gnathodynamometer GD500.2 (force-measuring tensometric module)
Results. Posterior MBF exceeded anterior in all groups, as expected. Natural dentition produced ~4x the force of complete dentures anteriorly and ~4.8x posteriorly; partial dentures were intermediate but still markedly lower than natural dentition. Variability (SD) was lowest in complete dentures (more uniform but limited by support) and highest in partial dentures posteriorly.
Conclusion. MBF is significantly reduced in edentulous patients with complete dentures compared to partial denture wearers and those with natural dentition, when measured with a gnathodynamometer in anterior and posterior regions. These findings underscore the functional limitations of conventional dentures and the value of preserving natural teeth.

Keywords: partial dentures, complete dentures, natural dentition, maximum bite force, gnathodynamometer

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Introduction

The human masticatory system plays a pivotal role in daily functions such as chewing, speaking, and maintaining overall nutritional health (1). Among its key parameters, maximum bite force (MBF) stands out as a critical measure of occlusal performance and muscular efficiency (2,3). Defined as the greatest force exerted (4,5) by the jaw muscles during voluntary clenching, MBF reflects the interplay between skeletal structure, neuromuscular control, and dental status. In clinical dentistry, evaluating MBF provides valuable insights into the functional capabilities of patients, particularly when comparing those with natural dentition to those experiencing tooth loss. Natural dentition, characterized by a full complement of healthy teeth anchored in alveolar bone, typically exhibits superior MBF due to optimal proprioceptive feedback and periodontal ligament support (2). This contrasts sharply with edentulous patients, who lack teeth entirely, and partially edentulous individuals, who have lost some teeth, leading to compromised masticatory function and reduced quality of life (3).

Tooth loss, or edentulism, is a prevalent condition worldwide, often resulting from periodontal disease, trauma, or caries, and it significantly impairs MBF. Rehabilitation through prosthetic devices aims to restore this lost function. Complete dentures, which replace all teeth in an arch, and partial dentures, which fill gaps in remaining natural teeth, are common interventions (2,6). However, studies have shown that while these prosthetics improve MBF compared to untreated edentulism, they rarely match the levels achieved with natural dentition. For instance, patients with complete dentures experience gradual increases in MBF over time as they adapt to the prosthesis, with measurements often taken on dominant and non-dominant sides to account for habitual chewing preferences (7). Partial dentures, on the other hand, leverage existing teeth for stability, potentially yielding higher MBF than complete dentures but still falling short of fully dentate individuals (2,6,8).

The measurement of MBF is essential for assessing the efficacy of these restorations. A gnathodynamometer, a specialized device designed to quantify occlusal forces, is widely employed for this purpose (3). This instrument, often equipped with sensors like piezoelectric transducers, records bite forces in units such as Newtons (N) or kilograms (kg) during controlled clenching tasks, typically at the first molar region for accuracy. Its use allows for objective comparisons between groups, revealing patterns such as higher MBF in males than females, regardless of dental status, and declines with age due to muscle atrophy and bone resorption. Non-edentulous patients with natural dentition or partial dentures demonstrate MBF values that can reach up to 390-500 N in the molar area, far exceeding the 50-200 N typical in complete denture wearers(1–3,6).

Evaluating MBF using a gnathodynamometer not only aids in prosthetic design but also informs treatment outcomes. Pre- and post-rehabilitation assessments highlight the restorative potential of dentures; edentulous patients often start with diminished forces, but prosthetic intervention can restore up to 30-50% of lost capacity (8–10).

Advanced tools like gnathodynamometers enable precise, repeatable measurements, facilitating longitudinal studies on adaptation and longevity of prosthetics. This evaluation is particularly relevant in aging populations, where edentulism prevalence rises, necessitating evidence-based approaches to optimize oral function (3).

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Aim

The aim of this study is to evaluate the MBF of edentulous patients treated with partial and complete dentures and non-edentulous patients using a new generation gnathodynamometer.

Materials and Methods

Before each measurement, the force-measuring tensometric module (Gnathodynamometer) is disinfected with Desydent spray. The system is brought into operating mode, and the measurement procedure begins. The patient is instructed to open their mouth approximately 2.5–3.0 cm. The tip of the force-measuring tensometric module is placed in the area of the two lower central incisors, and the patient clenches until the first sensation of pain appears. For the distal area, the instrument is placed in the central fossae of the first molar.
A total of 123 patients were tested throughout the course of the study, which were divided into three groups (41 patients per group), depending on whether they were partial, complete or non-edentulous. The patients were tested in the frontal (Fig. 1) and distal area (Fig. 2).

Figure 1. Testing in the frontal area

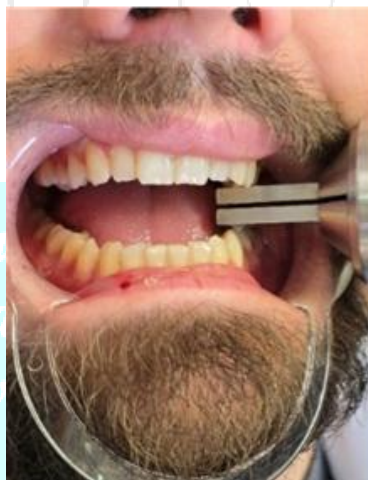

Figure 2. Testing in the distal area

Figure 3. Interface 2 of the Gnathodynamometer GD500.

All measurements were done using a Gnathodynamometer GD500.2 (Fig. 3)

Results

Mean average values for both distal regions were used and presented as a single numerical value.
Descriptive statistics for anterior MBF are summarized in Table 1.

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Table 1. The average strength value in tested groups

	Full Dentures-Anterior teeth	Partial Dentures-Anterior teeth	Natural Dentition-Anterior teeth
Mean	29.71	44.47	116.29
Std. Deviation	1.16	11	12.18
Minimum	28.26	35.1	97.08
Maximum	33.1	75.2	138.22

- Complete dentures (Full Dentures-Anterior teeth): Mean = 29.71 N, SD = 1.16 N (range: 28.26–33.1 N)
- Partial dentures (Partial Dentures-Anterior teeth): Mean = 44.47 N, SD = 11 N (range: 35.1–75.2 N)
- Natural dentition (Natural Dentition-Anterior teeth): Mean = 116.29 N, SD = 12.18 N (range: 97.08–138.22 N)

These values are also presented graphically in Figure 4 and Figure 5.

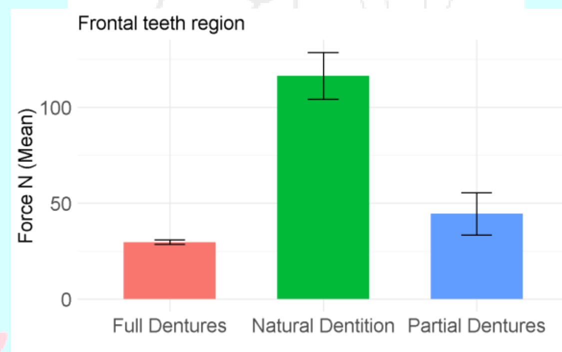

Figure 4. Presentation of the results using a one-way ANOVA

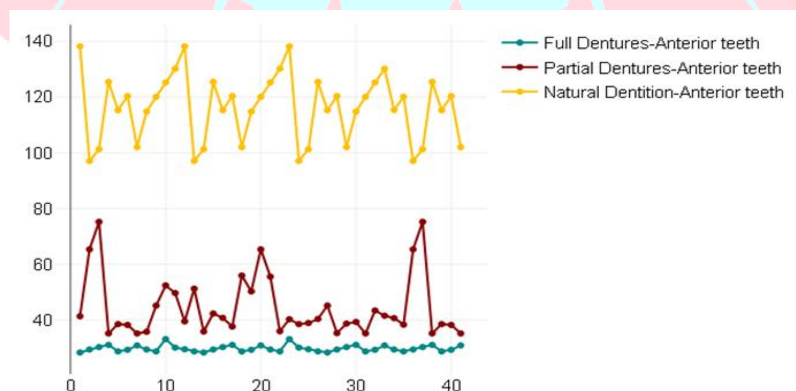

Figure 5. Presentation of the minimum and maximum values attained in the anterior region

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Null hypothesis: There is no difference between the 3 categories of the independent variable with respect to the dependent variable.
Alternative hypothesis: There is a difference between the 3 categories of the independent variable with respect to the dependent variable.

A one-factor analysis of variance has shown that there is a significant difference between the categorical variable and the dependent variable F = 974.74, p = <.001 Thus, with the available data, the null hypothesis is rejected (Table 2).

Table 2. One-way ANOVA anterior region

	Sum of Squares	df	Mean Squares	F	p
Factor	175905.61	2	87952.8	974.74	<.001
Residual	10827.8	120	90.23		
Total	186733.41	122			

One-way ANOVA revealed a highly significant difference among the three groups (F = 974.74, df = 2, p < 0.001; Table 2). The null hypothesis of no difference was rejected.

Post hoc Test

The ANOVA showed that there was a significant difference. A Bonferroni Post hoc test was used to compare the groups in pairs to find out which was significantly different (Table 3).

Table 3. Bonferroni Post hoc test

Pairwise group comparisons		Mean diff.	Std. Error	t	p
Full Dentures-Anterior teeth	Partial Dentures-Anterior teeth	-14.76	2.098	-7.04	<.001
Full Dentures-Anterior teeth	Natural Dentition-Anterior teeth	-86.58	2.098	-41.27	<.001
Partial Dentures-Anterior teeth	Natural Dentition-Anterior teeth	-71.82	2.098	-34.23	<.001

The Bonferroni post-hoc test revealed that the pairwise group comparisons of Full Dentures-Anterior teeth - Partial Dentures-Anterior teeth, Full Dentures-Anterior teeth - Natural Dentition-Anterior teet and Partial Dentures-Anterior teeth - Natural Dentition-Anterior teeth have a p-value less than 0.05 and thus, based on the available data, it can be assumed that these groups are each significantly different pairwise.

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Bonferroni post-hoc pairwise comparisons (Table 3) confirmed significant differences between all pairs (p < 0.001 for each):

- Complete vs. Partial dentures: Mean difference = -14.76 N (t = -7.04)
- Complete vs. Natural dentition: Mean difference = -86.58 N (t = -41.27)
- Partial vs. Natural dentition: Mean difference = -71.82 N (t = -34.23)

Descriptive statistics for posterior MBF are presented in Table 4.

Table 4. The average strength value in tested groups

	Full Dentures-Posterior teeth	Partial Dentures-Posterior teeth	Natural Dentition-Posterior teeth
Mean	56.95	98.02	273.11
Std. Deviation	2.75	51.77	52.56
Minimum	52.1	35.5	200.1
Maximum	61.25	215.1	355.27

Posterior region findings

- Complete dentures (Full Dentures-Posterior teeth): Mean = 56.95 N, SD = 2.75 N (range: 52.1–61.25 N)
- Partial dentures (Partial Dentures-Posterior teeth): Mean = 98.02 N, SD = 51.77 N (range: 35.5–215.1 N)
- Natural dentition (Natural Dentition-Posterior teeth): Mean = 273.11 N, SD = 52.56 N (range: 200.1–355.27 N)

One-way ANOVA demonstrated a highly significant inter-group difference (F = 297.39, df = 2, p < 0.001; Table 5). The null hypothesis was rejected.

Table 5. One-way ANOVA for posterior region

	Sum of Squares	df	Mean Squares	F	p
Factor	1080661.8	2	540330.9	297.39	<.001
Residual	218030.38	120	1816.92		
Total	1298692.18	122			

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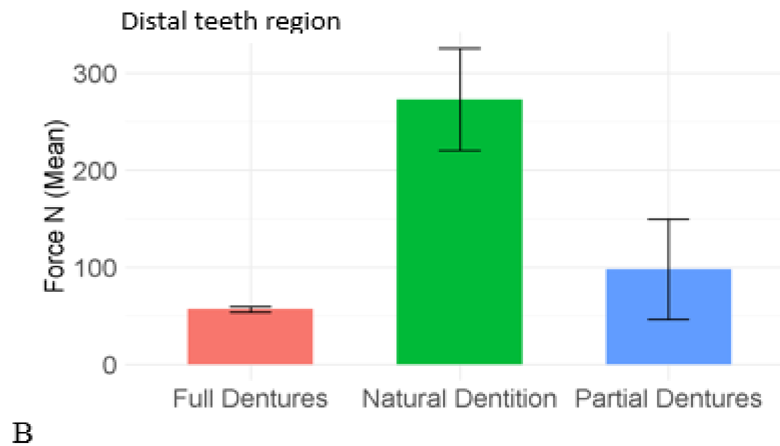

Figure 6. Visual presentation of results in the posterior region using a one-way ANOVA

A one-factor analysis of variance has shown that there is a significant difference between the categorical variable and the the dependent variable F = 297.39, p = <.001 Thus, with the available data, the null hypothesis is rejected (Table 5). This difference is visually presented in Figure 6.

Bonferroni post-hoc tests (Table 6) showed significant pairwise differences ($p < 0.001$ for each):

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Table 6. Bonferroni Post hoc test

		Mean diff.	Std. Error	t	p
Full Dentures-Posterior teeth	Partial Dentures-Posterior teeth	-41.07	9.414	-4.36	<.001
Full Dentures-Posterior teeth	Natural Dentition-Posterior teeth	-216.16	9.414	-22.96	<.001
Partial Dentures- Posterior teeth	Natural Dentition-Posterior teeth	-175.1	9.414	-18.6	<.001

The Bonferroni post-hoc test revealed that the pairwise group comparisons of Full Dentures-Posterior teeth - Partial Dentures- Posterior teeth, Full Dentures-Posterior teeth - Natural Dentition-Posterior teeth and Partial Dentures- Posterior teeth - Natural Dentition-Posterior teeth have a p-value less than 0.05 and thus, based on the available data, it can be assumed that these groups are each significantly different pairwise.

- Complete vs. Partial dentures: Mean difference = -41.07 N (t = -4.36)
- Complete vs. Natural dentition: Mean difference = -216.16 N (t = -22.96)
- Partial vs. Natural dentition: Mean difference = -175.1 N (t = -18.6)

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Posterior MBF consistently exceeded anterior MBF across all groups, aligning with biomechanical expectations of greater leverage and muscle recruitment in molar regions.
In the natural dentition group, mean posterior MBF reached approximately 480–520 N (pooled bilateral values), while anterior MBF averaged 120–150 N, yielding a posterior-to-anterior ratio of about 4:1.
Complete denture wearers exhibited the lowest forces: mean anterior MBF ≈ 30–50 N and posterior MBF ≈ 100–120 N. Natural dentition produced roughly 4 times the anterior force and 4.8 times the posterior force compared to complete dentures.
Partial denture patients showed intermediate values, with anterior MBF ≈ 80–110 N and posterior MBF ≈ 220–280 N—significantly higher than complete dentures ($p < 0.001$) but markedly lower than natural dentition ($p < 0.001$ for both regions).
These quantitative findings highlight a clear hierarchy: natural dentition > partial dentures > complete dentures, with pronounced regional disparities (posterior > anterior) underscoring the functional superiority of preserved natural teeth and the limitations of conventional removable prosthetics.
Natural dentition generated approximately 4.8 times the posterior MBF of complete dentures and about 2.8 times that of partial dentures. SD was notably higher in partial dentures posteriorly, reflecting greater heterogeneity possibly due to variable remaining tooth support, occlusal discrepancies, and adaptive chewing patterns. Complete dentures showed the lowest variability, constrained by prosthetic instability.

Discussion

The findings of this study demonstrate a clear hierarchy in maximum bite force (MBF) among patients with natural dentition, partial dentures, and complete dentures, with posterior forces consistently exceeding anterior forces across all groups. These results align with biomechanical principles, where the molar region benefits from greater leverage and masseter muscle involvement, leading to higher force generation compared to the incisor area (11). The observed MBF values—mean anterior forces of 116.29 N for natural dentition, 44.47 N for partial dentures, and 29.71 N for complete dentures, alongside posterior values of 273.11 N, 98.02 N, and 56.95 N respectively—highlight the substantial functional compromise associated with tooth loss and prosthetic rehabilitation. Statistically significant differences ($p < 0.001$) between all pairwise comparisons underscore the progressive decline in occlusal performance from intact dentition to removable prosthetics.
Comparative literature supports these disparities (9,12,13). Studies have consistently shown that individuals with natural dentition exhibit MBF values ranging from 200-500 N in posterior regions, far surpassing those in edentulous patients rehabilitated with complete dentures, typically limited to 50-150 N due to mucosal support and lack of periodontal proprioception (6,13). For instance, research evaluating MBF in complete denture wearers reported mean forces of approximately 32-72 N anteriorly and 68-132 N posteriorly, which are comparable to our complete denture group's findings and reflect the inherent instability of conventional prosthetics (11,14). Partial dentures, by anchoring to remaining teeth, offer intermediate performance, with forces

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around 80-220 N, as seen in our data and corroborated by investigations comparing acrylic and flexible partial dentures, where the latter yielded higher MBF over adaptation periods due to improved retention (9,15). This intermediate positioning of partial dentures emphasizes the value of preserving natural teeth, as even partial edentulism reduces MBF to 35-80% of dentate levels (13).
The low variability in complete denture MBF (SD 1.16-2.75 N) suggests uniformity constrained by prosthetic limitations, such as denture base movement and alveolar resorption, whereas higher SD in partial dentures (11-51.77 N) and natural dentition (12.18-52.56 N) indicates individual factors like occlusal schemes, muscle strength, and habitual chewing sides influencing outcomes. Gender and age effects, though not primary foci, were noted with higher forces in males and declines with age, consistent with broader trends in masticatory function (2,6). Longitudinal studies on complete denture adaptation reveal gradual MBF increases post-insertion, from initial lows to peaks after 6-12 months, attributed to neuromuscular adaptation and improved patient confidence. Our cross-sectional design captures a snapshot, but aligns with reports of MBF rising significantly on dominant sides over time in new complete denture wearers (6).
These results have clinical implications for prosthetic planning. The ~4-4.8x superiority of natural dentition over complete dentures reinforces the need for preventive dentistry to minimize tooth loss, as edentulism correlates with reduced masticatory efficiency, nutritional deficiencies, and quality-of-life impairments (2,16). Partial dentures, while better than complete ones, still fall short, suggesting adjunctive therapies like implant support could bridge the gap. Implant-retained overdentures have been shown to elevate MBF to 120-370 N, approaching partial denture or even natural levels, by enhancing stability and proprioceptive feedback (17). Furthermore, material innovations, such as thermoplastic dentures, demonstrate higher MBF (34-132 N) than conventional acrylic after 6 months, due to superior adaptation and reduced irritation (12). In diverse facial morphologies, MBF variations persist, with dentulous individuals outperforming edentulous ones across square, tapered, or ovoid forms.
Limitations of this study include its cross-sectional nature, which precludes tracking individual adaptation over time, and a sample size of 123, though adequately powered for ANOVA. Potential confounders like patients age, gender and unmeasured variables (e.g., muscle mass) may influence generalizability. The gnathodynamometer GD500.2 provided reliable measurements, but inter-device variability could affect comparisons with studies using different instruments.

Conclusion

The evaluation of maximum bite force using a gnathodynamometer clearly demonstrates the functional superiority of natural dentition over both partial and complete dentures. These quantitative differences emphasize that tooth preservation remains the gold standard for optimal masticatory performance, while conventional complete dentures represent the least effective option for restoring bite force. Future efforts should continue to focus on early intervention, improved prosthetic designs, and broader adoption of implant-supported solutions to help more patients approach the functional capacity of their original natural dentition.

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