

Evaluation And Comparison of Maximum Bite Force in Complete Denture, Single Complete Denture and Overdenture – An In Vivo Study

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Abstract:

Background: Restoring masticatory function in edentulous patients is crucial for their overall health and quality of life. Prosthetic options like complete dentures (CD), single complete dentures (SCD), and overdentures (OD) vary in their ability to withstand and distribute occlusal forces, influencing patients maximum bite force (MBF). Understanding MBF differences among these prostheses is essential for optimizing treatment outcomes. This topic was selected to address the significant variations in literature regarding MBF capacities of these prostheses, aiming to provide clearer insights for clinical decision-making and improving patient satisfaction.

Materials and Methods: This prospective comparative study was conducted at Dr. Ziauddin Ahmad Dental College and Hospital, Aligarh, from July 2022 to April 2024, involving 45 patients aged ≥ 40 years, divided into three groups: complete dentures ($n=15$), single complete dentures ($n=15$), and overdentures ($n=15$). MBF was measured using a digital dynamometer with a bite fork positioned in the first molar region. Measurements were taken thrice for each subject with two-minute intervals. Statistical analysis was performed using SPSS version 21, employing ANOVA, post-hoc Bonferroni, and independent sample t-tests.

Results: The study included 27 men and 18 women, Mean $\pm$ SD MBF values were 4.41 ± 2.22 kg for complete dentures, 6.58 ± 2.36 kg for single complete dentures, and 8.55 ± 1.78 kg for overdentures, showing significant differences ($p=0.001$). Post-hoc analysis revealed significant differences between complete dentures and overdentures ($p=0.001$), complete dentures and single complete dentures ($p=0.024$), and single complete dentures and overdentures ($p=0.046$). No significant gender differences in MBF were observed in all groups. No significant differences in MBF were found between upper and lower single complete dentures ($p=0.426$), nor between tooth-supported and implant-supported overdentures ($p=0.648$). However, lower implant-supported overdentures had significantly higher MBF than lower single complete dentures ($p=0.025$). MBF was also significantly higher in patients with overdentures on both arches compared to complete dentures on both arches ($p=0.001$).

Conclusion: MBF was highest in overdenture wearers, followed by single complete denture and complete denture wearers. Gender did not significantly affect MBF. These findings underscore the superior functional performance of overdentures in enhancing masticatory efficiency and overall quality of life in edentulous patients.

Key Word: Maximum bite force; Complete denture; Single complete denture; Implant supported Overdenture; Tooth supported overdenture; Masticatory function

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I. Introduction

One of the most critical aspects of rehabilitating edentulous patients is restoring their masticatory function. The primary prosthetic options available includes complete dentures, single complete dentures, and overdentures, each have distinct advantages and disadvantages. Their ability to withstand and distribute occlusal forces, closely linked to the patient's maximum bite force (MBF), is vital for their effectiveness. Understanding the relative biting pressures associated with these dental prostheses is essential for optimizing treatment outcomes and enhancing patient satisfaction.

Masticatory pressures and movements are regulated by the brain using data from sensory organs in and around the mouth. Periodontal mechanoreceptors, located in the ligaments attaching the tooth to the alveolar bone, encode patterns of forces on the dentition and play a significant role in controlling masticatory forces.¹ The number of teeth present and the absence of dental contact are key factors influencing masticatory function.² Reduced bite power results in laborious chewing, requiring more masticatory cycles and leading to the ingestion of coarser food particles. This can prompt individuals to favor soft foods, carbohydrates, fats, and sweets over proteins, fibres, and vegetables, increasing the risk of malnutrition and frailty.³ While individuals with full dentition maintain masticatory efficiency and a varied diet, edentulous persons face difficulties in swallowing and digesting food due to their inability to comminute particles effectively.^{4,5,6}

Complete dentures, despite being the most affordable and commonly used prosthesis for edentulous patients, often result in inadequate retention and stability during mastication. The movement and compression of the dentures during chewing can cause pain and limit muscle contraction efficiency.^{4,7} Specifically, wearers of traditional complete dentures in the lower arch exhibit masticatory function that is 2.5 times worse than that of dentate subjects.⁸ Additionally, complete denture wearers report diminished taste and texture perception due to full palate coverage.⁹ An alternative for edentulous arch restoration is the implant-retained overdenture. Supported by one or two implants and retained by attachments like telescopic attachments, locators, bars, or balls, this option improves dental function and quality of life compared to conventional dentures.^{4,7} Clinical studies have shown shorter chewing times, smaller bolus particles ready for swallowing, and improved MBF in patients receiving dental implant rehabilitation.^{4,10}

Maximal bite force is a critical metric for evaluating functional performance of dental prostheses. Despite advances in prosthodontic materials and methods, there is significant variation in the literature regarding the MBF capacities of overdentures, single complete dentures, and complete dentures. Bite force measurement, derived from the activity of the jaw elevator muscles and influenced by craniomandibular biomechanics, is common in dentistry and significant for identifying abnormalities in the stomatognathic system. Bite force can be measured directly by placing a suitable transducer between teeth, offering a practical means of determining MBF.

This study aims to systematically assess and compare the maximal bite force in individuals wearing complete dentures, single complete dentures, and overdentures. By employing statistical analysis and standardized measuring procedures, this research seeks to provide a comprehensive understanding of the functional performance of complete denture, single complete denture and overdenture. Ultimately, this study aims to enhance treatment planning, guide clinical decision-making, and improve the quality of life for edentulous patients by thoroughly examining their bite force capabilities.

II. Material And Methods

This prospective comparative study was carried out on patients of Department of Prosthodontics at Dr. Ziauddin Ahmad dental college and Hospital, Aligarh muslim university, Aligarh, Uttar Pradesh from July 2022 to April 2024. A total 45 adult subjects (both male and females) of aged ≥ 40 years were for in this study.

Study Design: Prospective open label observational study

Study Location: This was a tertiary care teaching hospital based study done in Department of Prosthodontics, at Dr. Ziauddin Ahmad dental college and Hospital, Aligarh muslim university, Aligarh, Uttar Pradesh.

Study Duration: July 2022 to April 2024.

Sample size: 45 patients.

Sample size calculation: A power analysis was established by G*power, version 3.0.1(franz faul universitat, kiel, germany). A sample size of 45 (15 per group) would yield 80% power to detect significant differences, with assuming the effect size of 0.5 and significance level at 0.05.

Subjects & selection method: Patients undergoing prosthodontic treatment (complete denture, single complete denture and tooth supported or implant supported overdenture) in the department of prosthodontics crown and bridge, Dr Ziauddin Ahmad Dental College and Hospital, On the basis of inclusion and exclusion criteria and willingness to sign informed consent, sample was divided into three group.

Patients were divided into three groups (each group had 15 patients) according to the type of denture. The groups were as follows:

Group 1 (n=15) – Subjects wearing conventional complete dentures in both arches,

Group 2 (n=15) – Subjects wearing single complete dentures in one arch, and

Group 3 (n=15) – Subjects wearing overdentures (Tooth supported or Implant supported) in one or both arches.

Inclusion criteria:

1. Subjects wearing conventional complete dentures in both arches
2. Subjects wearing single complete dentures in one arch

3. Subjects wearing overdentures (Tooth supported or Implant supported) in one or both arches.

Exclusion criteria:

1. Neuromuscular disorders and brain diseases.
2. Any malignancy and patient undergoing chemotherapy.
3. Temporomandibular joint ankylosis, and pain.
4. Participant with parafunctional oral habits.
5. Articular/muscular, dental or spontaneous pain.
6. Prosthesis wearing less than 3 months.
7. Poor oral hygiene.
8. Periodontitis.
9. Dental mobility.
10. Implant mobility.
11. Flabby ridge.

Procedure methodology

After written informed consent was obtained, a well-designed questionnaire was used to collect the data of the recruited patients retrospectively. The questionnaire included age, gender, type of denture, duration of use.

The MBF was measured of each subjects using a Digital dynamometer [Kinetic scale, Digital weighing scale, An iso 9001:2000 certified co. Model: LPF 200, Min-400g, Max- 200kg] with a Bite Fork. The bite fork was each time, covered to avoid contamination and placed on the first molar region, since 80% of the total bite force is exerted in the first molar area,¹¹ patient bites as powerfully as possible on the device for 5's in upright position. The measured value is reported in kg, and was repeated three times with two minutes interval in between and it was detected in both right and left side. The average of the right and left MBF values was calculated in each subject. The mean of right and left MBF value for each subject was recorded and used for statistical analysis. Instrumentation, methods, and operator was same for all groups.



Digital Dynamometer



Surgical gloves covering bite fork



Recording Bite force

Statistical analysis

SPSS (statistical package for social sciences) version 21. (IBM SPASS statistics [IBM CORPORATION: NY, USA]) was used to perform the statistical analysis, Data was entered in the excel spread sheet. Descriptive statistics of the explanatory and outcome variables were calculated by mean, standard deviation for quantitative variables, frequency and proportions for qualitative variables. Inferential statistics like Chi-square test was applied for qualitative variables to find the association; Anova test was applied to compare the mean maximum bite force among the groups with post-hoc bonferroni for inter group comparison; Independent sample t test was applied to compare the quantitative parameters between the groups. The level of significance is set at 5%.

III. Result

Forty-five participants took part in the study, 27 men and 18 women (Table 1), 9 males in and 6 females in each group, with a Mean $\pm$ SD age for complete denture, single complete denture and overdenture were 61.93 ± 8.51 , 54.2 ± 8.68 , and 56.00 ± 8.95 years respectively (Table 2).

Table no 1: Distribution of the Subjects Based on Gender

Gender		Groups-classified			Total
		Complete Denture	Single Complete Denture	Overdenture	
Females	Count	6	6	6	18
	%	40.0%	40.0%	40.0%	40.0%
Males	Count	9	9	9	27
	%	60.0%	60.0%	60.0%	60.0%
Total	Count	15	15	15	45
	%	100.0%	100.0%	100.0%	100.0%

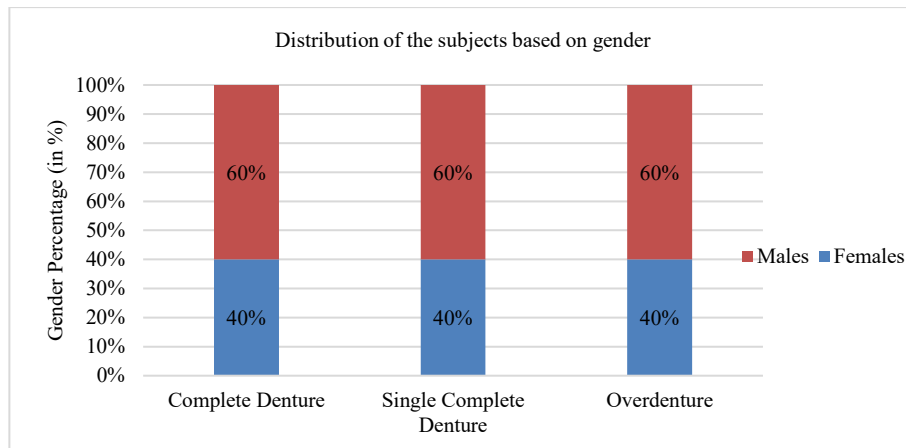
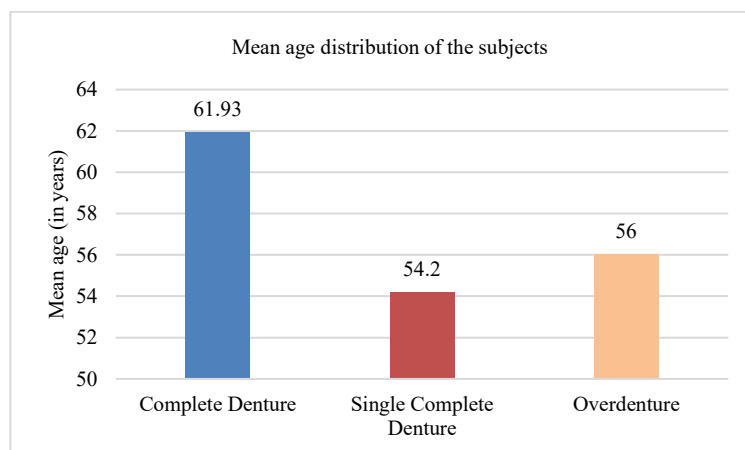


Table no 2: Mean Age Distribution of The Subjects (In Years).

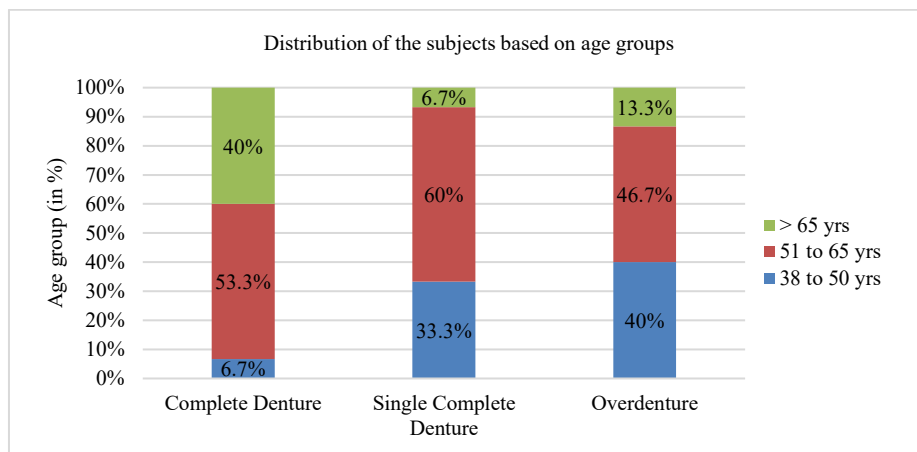
Groups	N	Minimum	Maximum	Mean	S.D
Complete Denture	15	45.0	74.0	61.93	8.51
Single Complete Denture	15	38.0	71.0	54.20	8.68
Overdenture	15	43.0	72.0	56.00	8.95



There is no significant association with age groups (Table 3).

Table no 3: Distribution of the subjects based on age groups (in years)

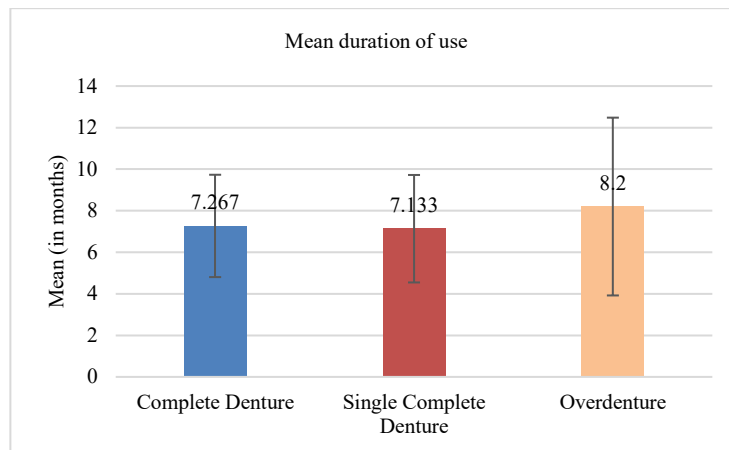
Age Groups		Groups-classified			Total
		Complete Denture	Single Complete Denture	Overdenture	
38 to 50 yrs	Count	1	5	6	12
	%	6.7%	33.3%	40.0%	26.7%
51 to 65 yrs	Count	8	9	7	24
	%	53.3%	60.0%	46.7%	53.3%
> 65 yrs	Count	6	1	2	9
	%	40.0%	6.7%	13.3%	20.0%
Total	Count	15	15	15	45
	%	100.0%	100.0%	100.0%	100.0%
Chi-square value- 8.41					
p value- 0.077					



Mean $\pm$ SD duration of use for Complete denture, Single complete denture and Overdenture were 7.26 $\pm$ 2.46, 7.13 $\pm$ 2.58, 8.20 $\pm$ 4.27 months respectively (Table 4).

Table no 4: Mean duration of use (in months)

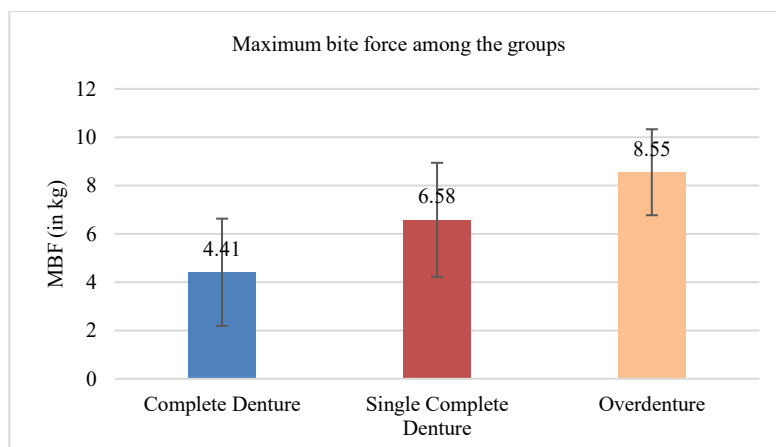
Groups	N	Minimum	Maximum	Mean	S.D
Complete Denture	15	4.0	14.0	7.267	2.4631
Single Complete Denture	15	4.0	13.0	7.133	2.5875
Overdenture	15	3.0	16.0	8.200	4.2795



Mean Maximum bite force(kg) of each group was compared using ANOVA, it was statistically highly significant ($P= 0.001$) with Mean $\pm$ SD MBF for Complete denture, Single complete denture and Overdenture were 4.41 ± 2.22 , 6.58 ± 2.36 , 8.55 ± 1.78 respectively (Table 5).

Table no 5: Maximum bite force (kg) among the groups using ANOVA

Groups	Minimum	Maximum	Mean	S.D	p value
Complete Denture	2.22	11.33	4.41	2.22	0.001*
Single Complete Denture	3.13	9.93	6.58	2.36	
Overdenture	5.12	11.20	8.55	1.78	



Maximum bite force was compared between the groups using post-hoc bonferroni with 95% confidence interval (Table 6). It was statistically highly significant between complete denture and overdenture ($p=0.001$), whereas it was statistically significant between complete denture and single complete denture ($p=0.024$), also between single complete denture and overdenture ($p=0.046$).

Table 6: Comparison of the maximum bite force (in kg) between the groups using post-hoc Bonferroni

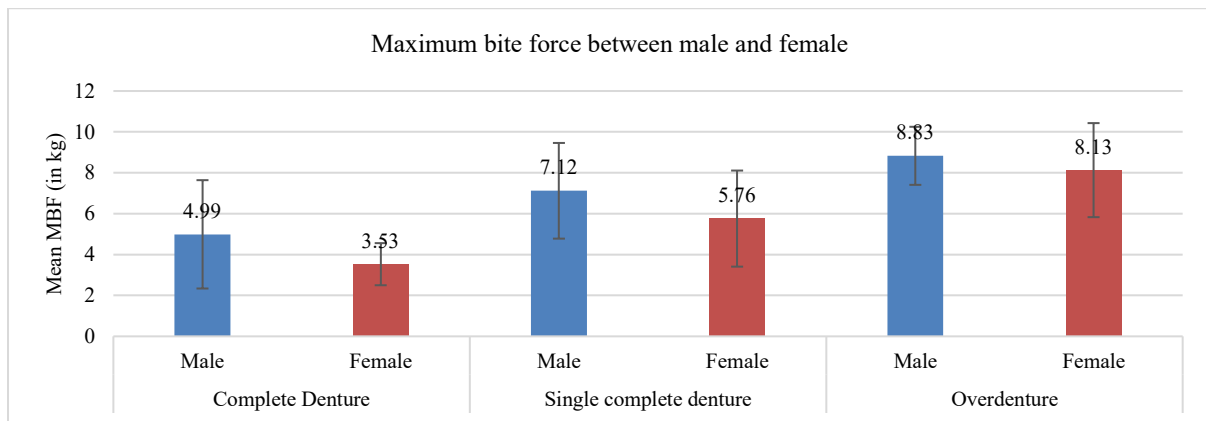
	Groups	Mean Difference	P value	95% Confidence Interval	
				Lower Bound	Upper Bound
Mean MBF (kg) (Mean left and right)	CD Vs Single CD	-2.170	.024*	-4.12	-0.23
	CD Vs Overdenture	-4.141	.001*	-6.09	-2.20
	Single CD Vs Overdenture	-1.960	.046*	-3.91	-0.02

Further intragroup comparison was performed using independent sample t test.

There was no statistically significant difference in maximum bite force between males and females in all the three groups. (p value= 0.224 in CD; 0.292 in SCD ;0.479 in OD) (Table 7).

Table 7: Comparison of maximum bite force (in kg) between males and females among the groups using independent sample t test

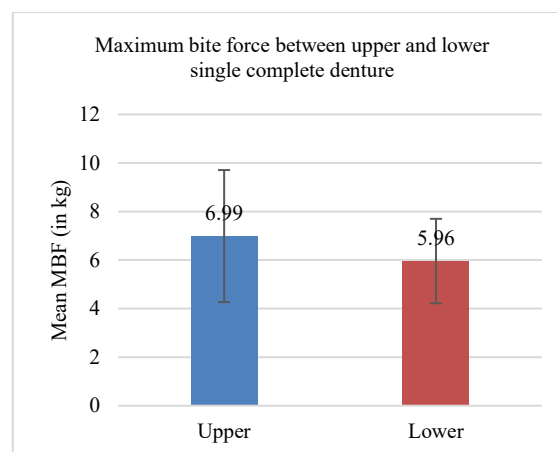
Groups	Gender	N	Minimum	Maximum	Mean	S.D	Mean diff	p value
Complete Denture	Male	9	2.38	11.33	4.99	2.65	1.46	0.224
	Female	6	2.22	5.35	3.53	1.03		
Single complete denture	Male	9	3.42	9.93	7.12	2.34	1.35	0.292
	Female	6	3.13	9.88	5.76	2.35		
Overdenture	Male	9	6.58	10.98	8.83	1.42	0.695	0.479
	Female	6	5.12	11.2	8.13	2.3		



Mean $\pm$ SD MBF for upper single complete denture and lower single complete denture were 6.99 ± 2.72 , 5.96 ± 1.74 respectively. With Mean difference 1.034. There was no significant difference in maximum bite force within the single complete denture group, between the upper single complete denture and lower single complete denture. (p value= 0.426) (Table 8).

Table 8: Comparison Of Maximum Bite Force (In Kg) Between Upper Single Complete Denture and Lower Single Complete Denture Using Independent Sample T Test

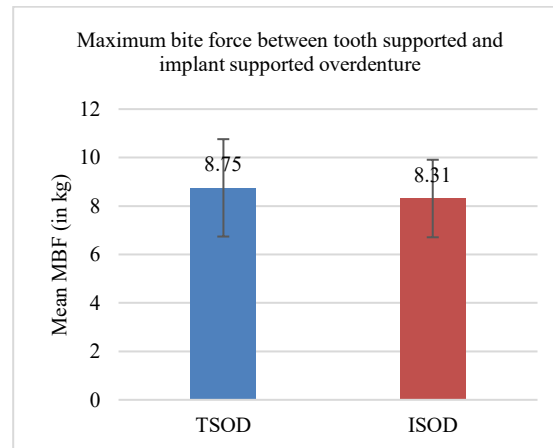
Single Complete Denture	N	Minimum	Maximum	Mean	S.D	Mean diff	p value
Upper SCD	9	3.42	9.93	6.99	2.72	1.034	0.426
Lower SCD	6	3.13	7.68	5.96	1.74		



Mean $\pm$ SD MBF for tooth supported overdenture and implant supported overdenture were 8.75 ± 2.01 , 8.31 ± 1.60 respectively. With mean difference 0.442. There was no significant difference in maximum bite force within the overdenture group, between the tooth supported overdenture and implant supported overdenture. (p value= 0.648). (Table 9).

Table 9: Comparison Of Maximum Bite Force (In Kg) Between Tooth Supported Overdenture and Implant Supported Overdenture Using Independent Sample T Test

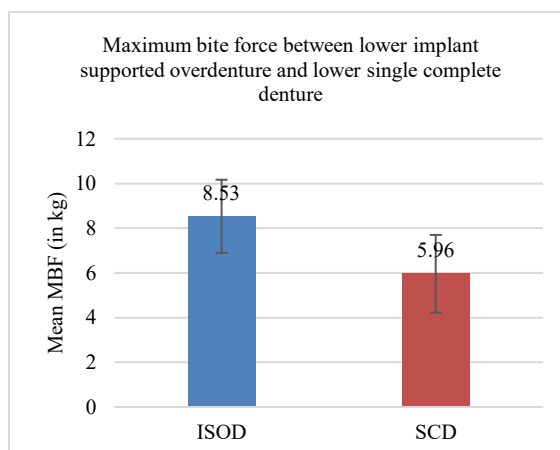
	N	Minimum	Maximum	Mean	S.D	Mean diff	P value
TSOD	8	5.12	11.20	8.75	2.01	0.442	0.648
ISOD	7	6.45	10.98	8.31	1.60		



Mean $\pm$ SD MBF for lower implant supported overdenture and lower single complete denture were 8.53 ± 1.64 , 5.96 ± 1.74 respectively. With mean difference 2.57. There was statistically significant difference in maximum bite force between lower implant supported overdenture group and lower single complete denture group. (p value= 0.025). (Table 10).

Table 10: Comparison Of Maximum Bite Force (In Kg) Between Lower Implant Supported Overdenture and Lower Single Complete Denture Using Independent Sample T Test

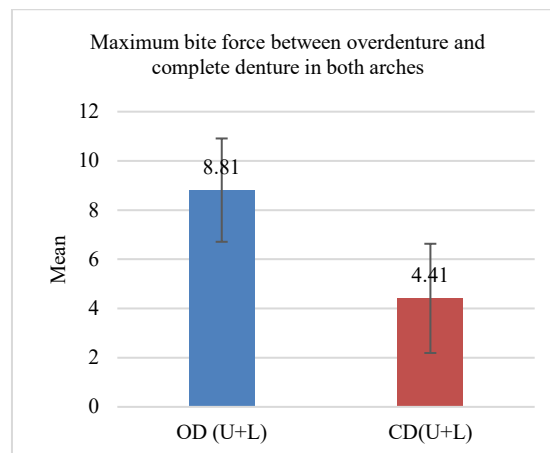
Lower	N	Minimum	Maximum	Mean	S.D	Mean diff	P value
ISOD	6	6.45	10.98	8.53	1.64	2.57	0.025*
SCD	6	3.13	7.68	5.96	1.74		



Mean $\pm$ SD MBF for overdenture on both arches and complete denture on both arches were 8.81 ± 2.10 , 4.41 ± 2.22 respectively. With mean difference 4.40. There was statistically highly significant difference in maximum bite force between overdenture on both arch and complete denture on both arches. (p value= 0.001) (Table 11).

Table 11: Comparison of maximum bite force (in kg) between overdenture in both arches and complete denture in both arches using independent sample t test

	N	Minimum	Maximum	Mean	S.D	Mean diff	P value
OD (U+L)	7	5.12	11.20	8.81	2.10	4.40	0.001*
CD(U+L)	15	2.22	11.33	4.41	2.22		



IV. Discussion

The present study examined bite force capabilities among individuals with different types of dentures: complete dentures, single complete dentures, and overdentures. The findings highlight functional differences in bite force across these groups, contributing to our understanding of prosthetic dentistry and its implications for oral health and quality of life.

The study comprised 45 participants, with a slightly higher representation of men (27) compared to women (18). The mean ages varied across the groups, with complete denture wearers being the oldest (mean age: 61.93 years), followed by single complete denture wearers (mean age: 54.2 years), and overdenture wearers (mean age: 56.00 years). The age difference was not significant.

The results revealed significant discrepancies in MBF across the groups, with complete denture wearers exhibiting the lowest mean MBF (4.41 kg), followed by single complete denture wearers (6.58 kg), and overdenture wearers displaying the highest mean MBF (8.55 kg). This pattern suggests that the type of denture significantly influences an individual's bite force capabilities. Post-hoc Bonferroni tests further elucidated the observed differences in MBF among the groups. A highly significant disparity in MBF was noted between complete dentures and overdentures, with overdentures showing superior bite force compared to conventional complete dentures. Additionally, a significant difference in MBF was observed between complete dentures and single complete dentures, although to a lesser extent. In this study, all implant-supported overdentures were supported by two implants with ball attachments and Tooth supported overdentures were supported by two teeth with metal coping.

Several clinical investigations have demonstrated that maximum bite force is higher in overdenture wearers compared to complete denture wearers. Overdentures held in place by implants enhance function, stability, appearance, and retention while protecting remaining bone, particularly in the mandible. This highlights how edentulous patient's biting forces may be greatly increased by implant-supported overdentures, improving both their masticatory efficiency and patient satisfaction (Hamam et al. 2023; Qazi et al. 2022; Kumar et al 2022; Al-Sulaihi 2020)^{12,13,14,15}.

The study did not find any significant difference in MBF between genders across all groups, suggesting that gender may not be a significant factor influencing bite force among individuals with different types of dentures (Manzon et al 2021)³. However, certain research indicates that men often display more MBF (Shala et al 2018)¹⁶.

A significant difference in MBF was observed between lower implant-supported overdentures and lower single complete dentures, underscoring the potential benefits of implant-supported overdentures in enhancing bite force, particularly in the mandibular arch where stability and retention are crucial for efficient chewing function (Kumar et al. 2022; Al-Sulaihi et al. 2020)^{14,15}. Conversely, no significant difference in MBF was found between tooth-supported and implant-supported overdentures. This unexpected result suggests that the type of support may not significantly impact bite force among overdenture wearers, warranting further investigation.

The findings underscore the importance of considering denture type and design in optimizing bite force and chewing function for edentulous individuals. The results highlight the potential benefits of both tooth-supported and implant-supported overdentures in enhancing bite force compared to conventional complete dentures and single complete dentures.

Major limitations include the lack of a control population to set up baseline values and the relatively small sample size of 45 participants, which may limit the generalizability of the findings. Additionally, the gender distribution was not equal, with a higher proportion of men than women. Variability in the prostheses delivered by different clinicians introduces potential inconsistencies in prosthesis fabrication, fit, and clinical protocols, which may confound bite force measurements. The age range within each group was not specified, and age can affect bite force. The study focused solely on maximum bite force as the primary outcome measure, without assessing other factors such as chewing efficiency, masticatory comfort, and patient satisfaction.

Future research could explore additional factors influencing bite force, such as denture stability, occlusal scheme, and patient-specific factors (e.g., bone quality, muscle strength). Including a broader range of outcome measures would provide a more comprehensive understanding of the functional differences between denture types. The number of implants and the type of attachment used for implant overdentures play significant role. Incorporating body mass index (BMI) data and electromyography (EMG) assessments of masticatory muscles would have enriched the analysis and offered a broader perspective on the functional implications of denture type. Longitudinal studies could investigate the long-term effects of different denture types on bite force maintenance and oral health outcomes, providing valuable insights for prosthetic treatment planning and patient care.

In conclusion, this study advances our understanding of bite force capabilities among individuals with different types of dentures, emphasizing the functional advantages of overdentures in enhancing chewing efficiency. By elucidating the factors influencing bite force and prosthetic performance, this research contributes to ongoing efforts to improve oral health outcomes and quality of life for edentulous individuals.

V. Conclusion

Within the limitations of this study, the following conclusions were made from the present study:

1. The maximum bite force (MBF) was highest in overdentures, followed by single complete denture, and least in complete denture wearers.
2. There was no significant difference of maximum bite force between males and females in all the groups (i.e., complete denture, single complete denture and overdenture).
3. There was no significant difference of maximum bite force between upper single complete denture and lower single complete denture.
4. There was no significant difference of maximum bite force between implant supported overdenture (ISOD) and tooth supported overdenture (TSOD).
5. Lower implant supported overdenture (ISOD) showed higher bite force than lower single complete denture.
6. Overdenture in both arches showed higher bite force than complete denture in both arches.

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