

Evaluation of the Mean Bite Force and Masticatory Performance of Maxillary and Mandibular Complete Dentures vs Mandibular Implant-supported Over Denture

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ABSTRACT

Aim: To compare and evaluate the mean bite force and masticatory performance of conventional complete dentures (CD) in comparison with the lower implant-supported overdenture opposing an upper CD by using a strain gauge transducer and a test material respectively, in the same patient over a different period of time.

Materials and methods: The study included 20 edentulous patients in the age range 45–65 years with a good general and oral health. In the first phase of the study, conventional CD were fabricated and delivered to each patient who participated in the study. A strain gauge transducer was used to analyze the maximum bite force and an agar test material was used to assess the masticatory performance using the sieve method. The existing lower denture was used to deliver a two-implant overdenture system and two implants were placed in the intermental–foraminal region of the mandible. One month after the delivery of implant-supported overdenture, the maximum bite force and masticatory performance were assessed as before.

Results: To test two independent variables, the data were analyzed statistically using an unpaired *t*-test. In comparison to the conventional upper and lower CD rehabilitations, the implant-supported lower denture and conventional upper CD rehabilitations resulted in statistically significant improvements in biting force and masticatory performance.

Conclusion: Study findings demonstrate that the completely edentulous patients can be rehabilitated with the upper CD and lower two-implant supported overdenture system that offers improved biting force and masticatory performance than conventional upper and lower dentures.

Clinical significance: Masticatory efficiency is one of the important indicators of functional state of stomatognathic system. Determination of individual masticatory performance has been used to ascertain the therapeutic effect of prosthetic device.

Keywords: Bite force, Complete dentures, Edentulism, Implant-supported overdentures, Masticatory performance.

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INTRODUCTION

Edentulism affects more than 30% of the world's population and is regarded as a disability of the elderly.¹ Although many edentulous patients are satisfied with their CDs, 10–30% of the patients have complaints. The longer the patients wear CDs, the more difficulties they encounter, as the alveolar ridges become increasingly atrophied. Conventional dentures lack stability, retention, compromised esthetics, and reduced masticatory efficiency. In addition, mucosal problems such as stomatitis and oral candidiasis may be frequent due to poor oral and denture hygiene, nutritional deficiency may lead the CD wearers to seek alternative therapy.² By providing the patients with vicious function, emotional well-being, and physical health, implant-supported overdentures furnish a solution to many of the problems encountered with conventional dentures. Many studies suggest that the implants supported by overdentures provide reliable retention and stability, with a median survival rate of about 95% after 5 years. Moreover, it offers a number of benefits over the conventional dentures, such as deterrence of prosthesis movements, reduced bone loss, great esthetics, better phonetics, an improved occlusal vertical dimension, and an enhanced outlook as well as the quality of life.^{3–5} By the York consensus in 2002 and McGill consensus in 2009, it has been established that implant-supported overdentures aggrandize the masticatory efficacy.^{6,7}

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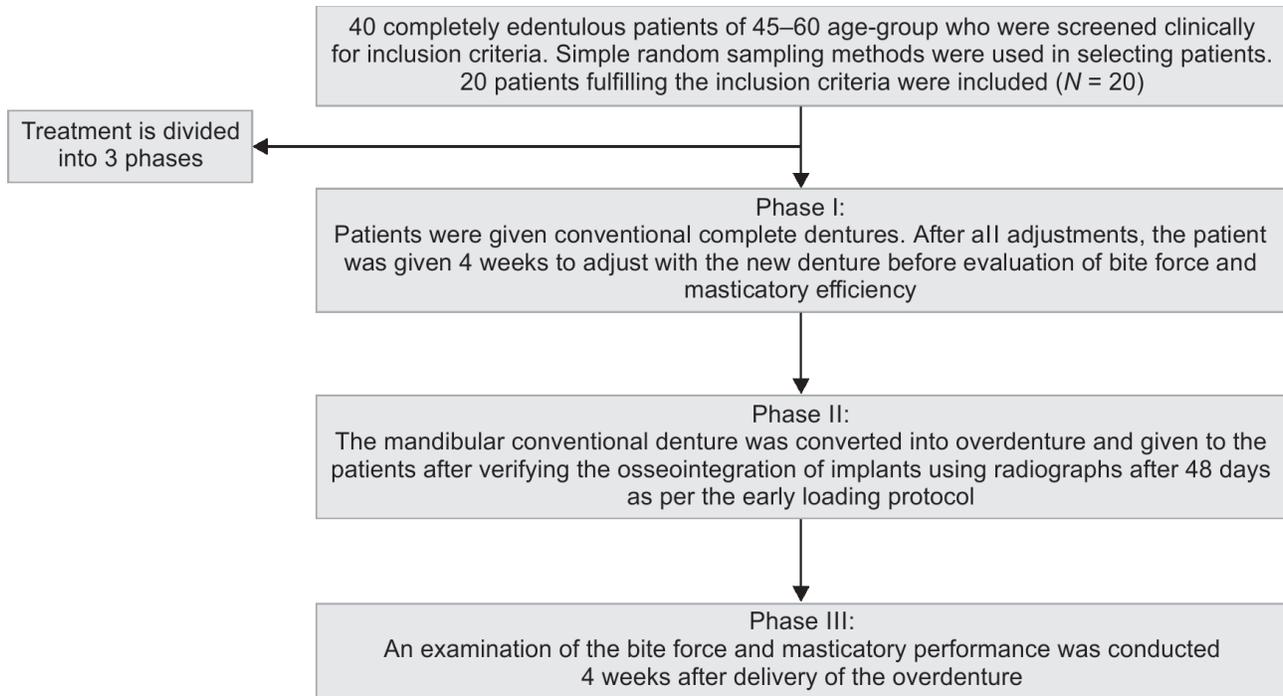
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One of the factors leading to the decrease in masticatory performance is the reduced bite force that denture wearers can develop owing to a lack of retention and stability of the denture. Masticatory performance is a cumulative contribution of various

Flowchart 1: Study protocol



factors such as bite force, severity of malocclusion, occlusal contact areas, loss of teeth, restorations from molar to canine, facial forms, and other motor activities; out of them, the bite force is one of the key factors that influences masticatory performance. The influence of bite force on the masticatory system is profound. It has been shown that the chewing efficiency will change up to 50% even with slightest changes in the bite force. The bite force measurements can be recorded directly by using a suitable transducer which is a convenient way of assessing the maximum voluntary bite force.⁸

The purpose of the study is to evaluate and compare the masticatory performance and bite force of same patients with conventional maxillary mandible CDs with mandibular implant supported overdentures opposing conventional maxillary dentures.

MATERIALS AND METHODS

Patient Selection

The study is an *in vivo* comparative study designed as a clinical trial among 40 completely edentulous patients of age-group 45–60 years who were screened clinically for inclusion and exclusion criteria. A total 20 patients who met the inclusion criteria and willing to participate in the study were included (Flowchart 1). Simple random sampling methods were used in selecting patients.

Inclusion Criteria

- Completely edentulous patients
- Patients with good general health without any systemic disease
- Patients without any oral mucosal disease
- Patients who are medically fit for oral surgical procedures

Exclusion Criteria

- Lack of inter-arch space
- History of any systemic disease jeopardizing osseointegration

- Cysts or tumors
- Recent history of radiation treatment to the head and neck region
- Active local infection
- Oral mucosal disease
- Chronic smokers and tobacco chewers
- Poor oral hygiene
- Patients with poor compliance or unrealistic expectations
- Psychiatric disorders

After obtaining the institutional ethical clearance, all participants were informed of the study and consented through written consent. After a detailed clinical examination, all edentulous patients received a panoramic radiographic examination (Fig. 1A) before beginning the treatment to assess the edentulous site for any pathology and to determine the bone height.

The study comprised of the following three phases:

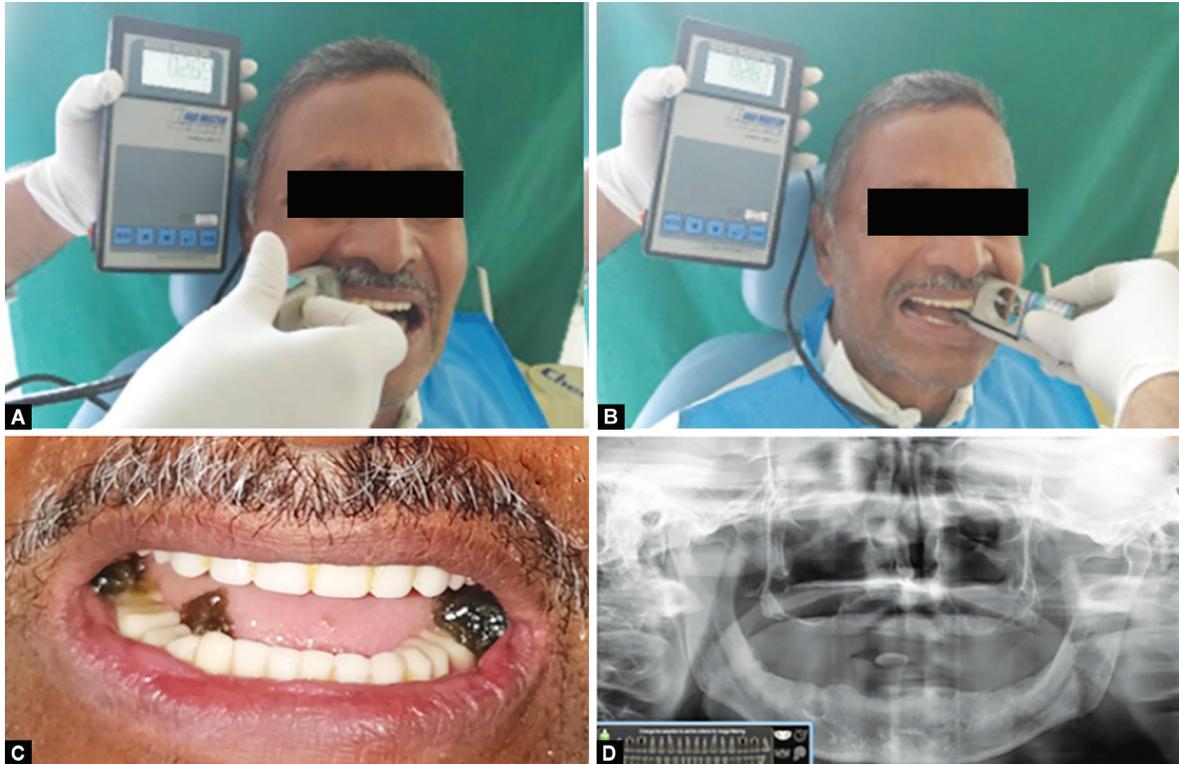
- **Phase I:** Upper and lower CD fabrication
- **Phase II:** Implant placement
- **Phase III:** Implant-supported overdenture fabrication

Phase I

Conventional upper and lower CDs were fabricated with bilateral balanced occlusion. Follow-up visits were done at seventh and 14th days to correct any problems with the conventional CD and was asked to use for 30 days to adjust to the dentures. The patient was asked to report back after 30 days for the evaluation of bite force and masticatory efficiency.

Evaluation of Bite Force

The bite force is the force applied by the masticatory muscles during dental occlusion, and it can be used to determine the efficiency of the masticatory system. The subjects were seated upright in a dental chair with their occlusal plane parallel to the floor. Using a strain gauge transducer, the maximum bite force was determined



Figs 1A to D: (A) Bite force measurement on right side with conventional CD, and left; (B) Bite force measurement on left side with conventional CD; (C) Chewing of agar bite block with CD; and (D) Preoperative radiograph

(Figs 1C and D). Strain gauge transducers are made from a metal plate or fork. During occlusal loading, metal plates deform, causing a change in resistance, which in turn results in a change in electrical potential that can be used to calibrate the applied occlusal load.⁹⁻¹¹ Each subject was instructed to bite on the device as forcefully as possible for 3–4 seconds without moving their heads. Each side's maximum bite force measurement was recorded as the highest bite force measurement. Between multiple recordings, a 30-second rest period was given to avoid masticatory muscle fatigue.¹²⁻¹⁷

Evaluation of Masticatory Performance

Masticatory performance can be described as the percentage dispersion of size of food particles when chewed for a specific number of strokes.¹⁸ As a test material, an agar hydrocolloid of 1 cm³ was used to measure masticatory performance using the sieve method (Fig. 1B). During this test, the subjects were asked to chew the test material for 10 and 20 strokes. The participants were asked to drink water after each chewing session so that they could rinse their mouth and expectorate the chewed particles, which were then placed into 0.5- and 3-mm mesh sieves, respectively. Those particles smaller than the meshes of the sieve were washed away in running tap water, and those larger particles were counted. For each subject, the following formula was applied to calculate the masticatory performance.¹⁹

$$\text{Masticatory performance} = B - (A/10)$$

where *A* is the number of particles collected in 10 strokes; *B* is the number of particles collected in 20 strokes.

Phase II

The existing mandibular CD was used as a template to place an implant (Hi-Tec, Israel) bilaterally with a diameter of 3.3 mm and

a length of 10 mm in the intermental–foraminal region of the mandible under local anesthesia (Figs 2A and B). To visualize the position of the implants, an orthopantomogram was taken post-operatively (Fig. 2C), patients were recalled after 48 days to assess osseointegration (Fig. 2D).

Phase III

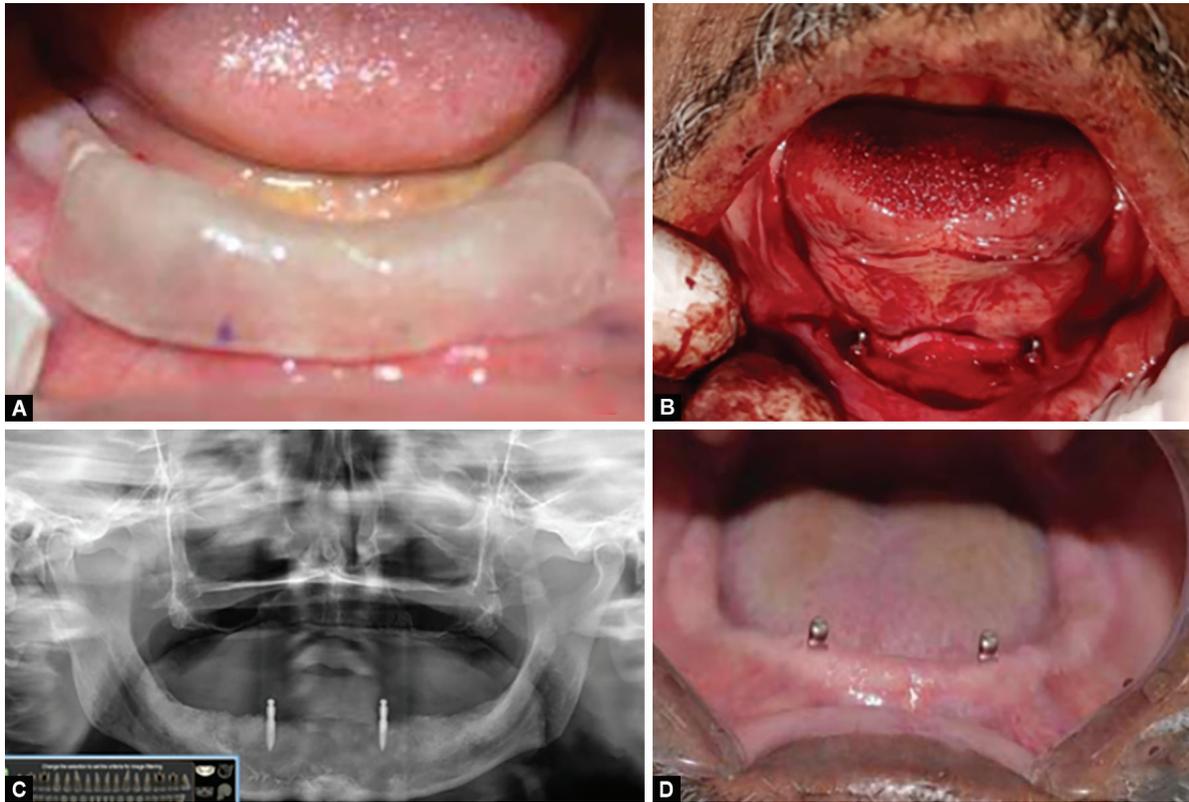
The patients were recalled after 48 days to assess osseointegration using radiographs and implants were loaded as per early loading protocol (48 days) (Fig. 3A), using the same mandibular conventional denture which was delivered in Phase I. Follow-up visits were done at seventh and 14th days to correct any problems with the denture and was asked to use for 30 days to adjust to the overdentures. After 30 days, the evaluation of bite force and masticatory performance was done (Figs 3B to D).

Statistical Analysis

The collected data were entered from the paper-based records into Microsoft Excel data sheet. The data were subjected to appropriate descriptive statistics and unpaired *t*-test using SPSS, version 22 (IBM corporation, Washington DC, United States).

RESULTS

The masticatory performance and bite force of the patients, who received CD followed by implant supported overdenture, were analyzed statistically by unpaired *t*-test. The mean bite force of conventional CDs on the right side is 3.5 ± 1.1 and on the left side is 3.3 ± 0.9. The mean bite force of implant supported overdentures on right side is 6.3 ± 1.5 and the left side is 6.4 ± 1.2. The maximum bite force of an implant-supported overdenture opposing a maxillary



Figs 2A to D: (A) Intraoral placement of surgical stent; (B) Implant placement done; (C) Postoperative radiograph; and (D) Implants after complete osseointegration with ball attachment



Figs 3A to D: (A) The implant-supported overdenture (ISOD) in patient oral cavity; Bite force measurement on right; (B) Bite force measurement on left side; (C) Chewing of agar bite block; and (D) with ISOD

Table 1: Comparison of maximum bite force between the CDs and an implant-supported overdenture opposing maxillary CD

Maximum bite force	Maxillary and mandibular CD (mean \pm SD)	Implant-supported overdenture opposing maxillary CD (mean \pm SD)	t-value	p-value
Right side	3.5 \pm 1.1	6.3 \pm 1.5	-6.6	0.0001*
Left side	3.3 \pm 0.9	6.4 \pm 1.2	-7.6	0.0001*

*p-value statistically significant

Table 2: Comparison of masticatory performance between the CDs and an implant-supported overdenture opposing maxillary CD

Masticatory performance	Maxillary and mandibular CD (mean \pm SD)	Implant-supported overdenture opposing maxillary CD (mean \pm SD)	t-value	p-value
With a 0.5-mm sieve	1.6 \pm 0.47	2.2 \pm 0.60	3.1	0.003*

*p-value statistically significant

Table 3: Comparison of masticatory performance of CD and ISOD by using 3-mm sieve

	CD Mean \pm SD	ISOD Mean \pm SD	t-value	p-value
Masticatory performance	0.93 \pm 0.12	1.6 \pm 0.18	13.1	0.0001*

*p-value statistically significant

CD was found to be higher than that of the maxillary CD opposing a mandibular CD, making the difference statistically significant ($p < 0.05$). There was no statistically significant difference in bite force between the right and left sides of conventional and implant supported overdentures (Table 1).

The mean masticatory performance (number of particles) with 0.5 mm sieve of CDs is 1.6 \pm 0.47 and for implant supported overdentures are 2.2 \pm 0.60 so there is increase in masticatory performance. The masticatory performance of an implant-supported overdenture opposing a maxillary CD was found to be superior to that of the maxillary CD opposing a mandibular CD with a statistically significant difference ($p < 0.05$) (Table 2).

The mean masticatory performance with 0.3 mm sieve of CDs is 0.93 \pm 0.12 and for implant supported overdentures are 1.6 \pm 0.18 so there is increase in masticatory performance (Table 3).

DISCUSSION

Edentulism may be defined as the loss of permanent teeth and is believed to be caused by dental caries, periodontal disease, trauma, and others. Edentulism affects the underlying nutritional deficiency, as the patient is not able to chew and digest food properly. These patients may also suffer from a range of age-related diseases, which may be further worsened by the patient's edentulism and thus effecting the quality of life. For over a century, only one kind of treatment is available for compromised dentition, that is, the conventional dentures. The field of prosthodontics has evolved as a new specialty with the advancement of dental implants which improves oral function and tackles the issue of instability of dentures. Depending on the particular clinical indication, the impact of each prosthodontic treatment modality varies, and the crucial gauging factors are masticatory performance, patient satisfaction, and improvement in quality of life.^{20,21} Dental implants have provided edentulous patients with multiple treatment options, primarily overdentures.²¹

Conventional CD wearers compensate for the lack of retention and stability of their prostheses by using the masticatory muscles, and this can result in a decreased bite force, as observed in this

study. In the patients with implant-supported overdentures, the masticatory muscles are only used for chewing and uniformizing the food material as they are not required to maintain the prosthesis in a resting position. Many studies have demonstrated that implant-supported overdenture users exhibit an improvement in masticatory performance since the implants strengthen and stabilize the mandibular prosthesis.²²⁻²⁷ This study provides a pioneering comparison of bite force and masticatory performance of upper-lower dentures with implant-supported overdentures opposing maxillary CDs that have never been done previously in the same patient. In 2020, a study was conducted by Possebon et al. to evaluate the bite force and masticatory performance of CD and mandibular overdenture in different patients using different methods and the results were more consistent with our study.²⁸ Our study had a valuable outcome in that we evaluated both treatment modalities on the same patient, enabling us to measure the patient's satisfaction after switching from CDs to implant-supported overdentures. A significant advantage of our study was that it was conducted for a target age-group of 45-65 years, which made evaluations of the parameters more precise.

According to the study by Rosa et al. the group treated with conventional upper dentures and two implants supported lower overdentures had an intermediate masticatory efficiency index that was approximately 50% higher than those treated with conventional CDs.²⁰ The results of our study are also in line with Rosa et al.

Mandibular jaw movement and action of muscles may lift the CD off the soft tissue causing difficulty in function and speech. Additionally, there is fourfold residual ridge resorption in the mandible than in the maxilla for edentulous patients. If this resorption continues, the current prosthesis may become inadequate both in terms of functionality and esthetic appearance, resulting in the need for a new denture, which is extremely challenging to make. All these problems can be solved by a mandibular overdenture supported on two implants. A study by Caloss et al. stated that the increased bite force and masticatory performance of implant-retained dentures can be explained by the greater stability of implant-retained dentures.^{29,30} A study by Batenburg et al. tested two groups using

different numbers of implants. The first group was treated with two implants in the mandible, and the second group was treated with four implants in the mandible, and while comparing the results of the second group to the first, they found only a slight improvement in retention, stability, and function of the lower overdenture regardless of implant number.³¹ Our study also confirmed that two implants can adequately support an overdenture in the lower arch, which negates the necessity to place more than two implants to achieve a secure fit for the overdenture.

A variety of studies demonstrate the sensitivity and validity of the sieve method for the assessment of masticatory performance, but the test foods such as peanuts and carrots pose a problem. This is due to the difficulty of controlling the size and texture of these test foods, which can lead to unexpected variation and lower reliability.¹⁴ This study, agar hydrocolloid was used as a test material that makes the masticatory performance test more reliable and faster. Unlike some other bite force transducers used in previous studies; we used a strain-gauge transducer for this study to measure bite force, which has high sensitivity and good repeatability.

With the possibility of oral rehabilitation with mandibular implant retained overdentures, the satisfaction level and masticatory function have been improved. In this study after stabilization of the mandibular denture with two osseointegrated implants the maximum bite force doubled, whereas the number of chewing cycles needed to comminute food particles to a certain size became half of that required before implant treatment limitations of this study include a limited sample size, a short study period, bite force and masticatory performance among genders were not evaluated.

CONCLUSION

Within the limitations of the study, we conclude that two implants supported mandibular overdenture opposing maxillary conventional CD is a better treatment option for edentulous patients as it possesses higher masticatory performance and bite force. The individuals who are edentulous will definitely benefit from this type of rehabilitation as it improves their nutritional intake, self-confidence, and satisfaction. Further studies can be conducted to fulfill the limitations of our study and improve the field of implant prosthodontics.

Clinical Significance

Success of any dental treatment primarily depends on the thorough knowledge of masticatory system. The masticatory efficiency is one of the important indicators of functional state of stomatognathic system. The determination of individual masticatory performance can be used to ascertain the therapeutic effect of prosthetic device.

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