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ORIGINAL RESEARCH

Evaluation of the biting power and chewing efficiency of the all-on-four treatment concept in comparison to those of other treatment methods in people who are completely edentulous

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ABSTRACT

Comparison and evaluation of the biting power and chewing efficiency of the all-on-four treatment concept, an implant-supported overdenture, and a traditional full denture are the objectives of this abstract study.

Materials and the Methods: The study had a total of 15 individuals who were missing all of their teeth and conventional full dentures were created for each of them. Patients were separated into their own respective groups. In Group 1, patients had their full dentures replaced with an implant-supported overdenture. In Group 2, patients had their full dentures replaced with a hybrid denture that was supported by the all-on-four treatment approach. When chewing three meals of varying consistencies, the biting force was measured with a bite force sensor, and electromyographic recordings of the masticatory muscles were produced using an electromyogram.

Statistical Analysis Carried Out The statistical analysis of the data was carried out by utilizing SPSS version 22.0 software. The paired t-test was used for comparing the data within each group, while the unpaired t-test was utilized to compare the data between groups.

Results showed that there was a statistically significant difference between the overdenture and total denture groups in terms of biting power and chewing efficiency for the all-on-four treatment concept. The all-on-four treatment idea was seen to have the highest biting force and chewing efficiency, followed by the implant-supported overdenture treatment concept, and then the full denture treatment concept.

According to the findings of the study, persons who are entirely toothless and have atrophic posterior alveolar ridges can be successfully rehabilitated with better biting power and chewing efficiency by using the All-on-four therapy approach.

All-on-four treatment idea, biting force, chewing efficiency, total denture, and overdenture

INTRODUCTION

The loss of teeth not only impairs oral function, such as mastication, swallowing, and communication, but it also has a negative impact on an individual's self-esteem since it ruins

their esthetics. This is because missing teeth are unsightly.[1] In the past, persons who were entirely edentulous had only one choice for rehabilitation: a full denture. However, throughout the course of time, many therapeutic approaches have emerged.

No matter how well the rehabilitation of people who wear traditional full dentures was carried out, it was never going to be able to alleviate all of those people's difficulties, whether they were functional or psychological. Comparatively, those who wear complete dentures have a reduced capacity for efficient chewing when compared to dentate controls. [2] The same functional impairment applies to maximal biting force, which was stated to be 5–6 times lower than the dentate controls. This is in comparison to the fact that the dentate controls have teeth. [3] People who wore complete dentures expressed dissatisfaction with the decreased retention, decreased enjoyment, lower masticatory efficiency, and increased risk of prosthesis instability. [4] The area of prosthodontics has been completely transformed as a result of the advent of dental implants as well as the ongoing development of dental advancement procedures. The oral function as a whole has been enhanced, and the issue of denture instability has been resolved as a result. It has offered a variety of choices for the treatment of edentulous patients, ranging from detachable prosthesis to fixed prosthesis, including implant-supported overdentures and either ceramometal or hybrid prostheses, respectively.

A more recent approach known as "All-on-Four" has been developed by Malo et al. for use in heavily resorbed ridges in cases where there is ample bone available in the intraforaminal area of the mandible and in the premaxillary region of the maxilla.

[5,6] This all-on-four treatment strategy comprises the placement of two axially straight implants in the front of the mouth and two tilted implants in the back of the mouth at an angle ranging from 30 degrees to 45 degrees in order to keep a full-arch fixed prosthesis. [5,6]

Each therapy technique has its own unique clinical indication, which can lead to a variety of varied outcomes and prognoses. The masticatory performance, the efficiency with which the patient chews, the patient's contentment, and the increase in quality of life are what determine the outcomes. [7,8,9,10] The effectiveness of the masticatory system may be evaluated using a number of different approaches, the most common of which is the assessment of bite force and masticatory efficiency. [11] A linear link between electromyographic activity potentials and direct biting force measurements was shown to exist as a consequence of the findings of a number of experiments that were conducted in the past. [12]

TO VIEW THE MATERIALS AND METHODS

This clinical research was carried out inthe department of Dental Sciences' Department of Prosthodontics, Crown and Bridge and Implantology. The university's ethics committee gave its stamp of approval before allowing the project to move forward.

PATIENT SELECTION

Following the inclusion and exclusion criteria, a total of 15 patients were chosen at random for the research so that full dentures could be fabricated for them. This selection was made without regard to the patients' gender, caste, religion, or creed. There were six patients chosen for each group, with Group 1 consisting of edentulous individuals with ridges and Group 2 consisting of edentulous patients with bone loss in the posterior area. Both the premaxilla area of the maxilla and the intraforaminal region of the mandible have appropriate bone density. Edentulous patients in the Group 1 therapy were first rehabilitated with complete dentures as the baseline treatment. After one month, biting force and electromyographic recordings were evaluated, and then complete dentures were replaced with implant-supported overdentures (2 implants are placed in the B and D region of the mandible, opposing complete denture in the maxillary arch). In the second group, patients first had rehabilitation with a conventional denture as the baseline therapy. After one month, the biting force and electromyographic recordings were

evaluated, and then, subsequently, complete dentures were replaced with all-on-four treatment. The average age of people in Group 1 was 54 whereas the average age of people in Group 2 was 51.

CRITERIA FOR SELECTION OF CASES

Inclusion criteria are shown in Table 1.

Table 1: Inclusion criteria

Overdenture	All-on-four
Completely edentulous patient	Completely edentulous patient
Absence of local infection	Absence of local infection
Absence of oral mucosal disease	Absence of oral mucosal disease
Medical fitness for surgery	Medical fitness for surgery
Controlled diabetes, no systemic disease	Controlled diabetes, no systemic disease
Written consent	Written consent
	Atrophic ridges posteriorly with adequate bone present in premaxillary region of maxilla and intraforaminal region of mandible

EXCLUSION CRITERIA

1. History of metabolic or systemic disease affecting the osseointegration
2. Recent history of irradiation in the head and neck region
3. Smokers
4. Active infection, cyst, or tumor
5. Psychiatric disorders or unrealistic expectations.

METHODOLOGY

A signed informed consent form was collected from every patient after they were each given a thorough explanation. Initial evaluation of biting force and electromyographic records were performed on all patients using conventional full dentures that had bilateral balanced occlusion as the prosthesis. This was done in accordance with a normal procedure. Implants were placed with regard to the canine area bilaterally in the mandibular arch of the participants in Group 1, and implant-supported overdentures were implanted as the final prosthesis. The masticatory muscle activity was recorded using electromyography, and the biting force was evaluated with the use of a bite force sensor. In the second group, implant insertion was carried out in accordance with the all-on-four treatment approach, and a hybrid denture served as the definitive final prosthesis. The electromyographic readings and biting forces were recorded for the final prosthesis, which was an overdenture in Group 1 and a hybrid denture in Group 2.

The biting force was determined with the assistance of an electromechanical device that is based on the Wheatstone bridge concept and measures strain gauges. Display unit and sensing probe are the two components that make up the device. The sensor is wired to the display unit, which presents the numeric readings in a format determined by the manufacturer (Newtons, kilograms, or pounds, for example). When sensing probes are positioned between the occluding surfaces of dentition, the display unit receives readings from the sensor in the form of deflections between the sensing probes. These readings are shown in mathematical units (Newton, Kg or lbs). The instrument has a measuring range of 0–2500 Newtons' worth of force. The biting force sensor that was utilized has an accuracy of within 0.05% of its rated capability.

An electromyographic research was used to determine how well the chewing was done. The electromyographic research was carried out on both the right and left sides of the body, focusing on the masseter, temporalis, and anterior digastric muscles respectively. The participants were given food with several consistencies, including foods with a soft

consistency, foods with a medium consistency, and foods with a hard consistency, such as bananas, apples, and peanuts, respectively. This electromyography (EMG) equipment has one display unit, three electrodes, and two electrodes that are placed directly on the skin of the muscle in question. The reference electrode, which is the third electrode, is positioned on the person's forehead. Recordings are shown on the display device in waveform format.

BITE FORCE MEASUREMENT

It was recommended that the patient sit in an upright position without using a headrest. After wrapping a disposable sheet around the sensing probes, which were then covered with a sponge sheet measuring 1 mm thick and secured with double-sided adhesive tape, the patient was given instructions to bite both the right and left sides three times with as much force as they could muster at regular intervals of two minutes. After inserting probes into the spaces between the occluding surfaces of the patient's maxillary and mandibular molars, the biting force was measured by asking the patient to bite voluntarily with as much force as possible. On the display unit, the amount of biting power was shown in Newton. The biting force was measured bilaterally, that is, individually for the right side and the left side of the mouth. After an interval of two minutes, three readings were taken, and the average of those values was computed.

RECORDINGS MADE WITH ELECTROMYOGRAPHY

Surface electromyography was utilized in the recording of the EMG (Synergy EMG-System, Arena medical care private limited, New Delhi, India).

It was recommended that the patient sit in an upright position without using a headrest. The EMG recording was carried out in an environment that was serene and devoid of noise. In order to do an electromyographic investigation on the surface of the masseter, temporalis, and anterior digastric muscles, an electromyogram was employed. In order to lower the resistance that existed between the patient's skin and the electrode, 70% alcohol was used to clean the patient's skin. Before putting the electrodes on the skin and securing them there using white tape, the electrode gel was applied to the electrodes themselves. The use of the three electrodes took place. Along the length of the muscle, the two electrodes were positioned two to three millimeters apart from one another. The surface electrodes were arranged such that they faced in the direction of the muscle fiber bundles of the masseter, the temporalis, and the anterior digastric. The patient's forehead served as the location for the reference electrode, which was the third electrode. The patient was provided with food supplies, including bananas (a meal with a soft consistency), apples (a food with a medium consistency), and peanuts (a food with a firm consistency). The right and left masseter, temporalis, and digastric muscles were utilized, respectively, in order to create the recordings. A waveform representation of the recordings was shown on the monitor. After measuring the number of microvolt peaks, we were able to determine the maximum amplitude.

Statistical analysis was performed on each and every piece of data that was gathered by employing version 22.0 of the Statistical Package for the Social Sciences. The paired t-test was utilized to conduct an intragroup comparison of biting force and chewing efficiency of masticatory muscles for the right and left side in Group 1 (individuals with complete dentures and overdentures) and Group 2 (individuals with complete dentures and all-on-fours). The unpaired t-test was utilized to do an intergroup comparison of biting force and chewing efficiency of masticatory muscles for the right and left side between Group 1 (individuals with complete dentures and overdentures) and Group 2 (individuals with complete dentures and all-on-four).

RESULTS AND OBSERVATIONS

The biting force of hybrid denture supported by all-on-four treatment concept was significantly highest followed by overdenture and complete denture, respectively.

Table 2: Intragroup comparison of biting force within Group 1

Side	Prosthesis	Mean±SD (Newton)	*P*
Right	Complete denture	24.80±12.02	0.001
	Overdenture	77.20±11.11	
Left	Complete denture	23.13±11.22	0.001
	Overdenture	81.60±22.78	

SD: Standard deviation

Table 4: Intergroup comparison of biting force for Group 1 and Group 2

Side	Prosthesis	Mean±SD (Newton)	*P*
Right	Overdenture	76.33±22.15	0.014
	All-on-four	222.36±117.25	
Left	Overdenture	81.40±21.66	0.004
	All-on-four	210.23±83.55	

SD: Standard deviation

Table 3: Intragroup comparison of biting force within Group 2

Side	Prosthesis	Mean±SD (Newton)	*P*
Right	Complete denture	50.27±21.27	0.001
	All-on-four	222.13±110.25	
Left	Complete denture	54.47±27.16	0.001
	All-on-four	207.23±82.80	

The chewing efficiency of the hybrid denture supported by the all-on-four treatment approach was much higher than that of the overdenture and the full denture, respectively. According to the findings of the study, the masseter muscles have the maximum chewing efficiency when compared to the temporalis and digastric muscles. Food with a firm consistency was shown to require the least amount of chewing effort when compared to food with a medium or soft consistency.

DISCUSSION

The purpose of the current study was to compare and assess the biting force and chewing efficiency of full dentures, all-on-four treatments, and overdentures. An exhaustive review of the relevant literature revealed that a study of this kind had never been carried out in the past. As a result, the current investigation is a groundbreaking comparison of the biting force and electromyographic activity of masticatory muscles in patients who had been rehabilitated using all-on-four treatment, implant-supported overdentures, and complete dentures.

Studies that were done in the past made use of a variety of techniques to record bite force and masticatory efficiency. These studies measured masticatory forces, the amount of time needed to pulverize a specific food, the number of strokes used to pulverize the food, the electrical activity of the masticatory muscles, and the size of the particles produced after a specific amount of pulverization. In the current investigation, an electromyogram and a bite force sensor were utilized, respectively, to assess the activity level of the masticatory muscles and the biting force. Age, craniofacial morphology, gender, periodontal support of teeth, signs and symptoms of temporomandibular disorders and pain, the tooth loss and type of restoration, malocclusion, total area of teeth in contact, oral motor function, and salivary glands function are some of the various factors that influence bite force. Other factors include malocclusion, total area of teeth in contact, oral motor function, and the function of salivary glands. In addition to these biological factors, the mechanical determinants such as using

acrylic splints and opening the mouth wide also have an impact on the biting force measurement. These mechanical determinants include different recording devices, the position of recording devices in the dental arch, unilateral or bilateral measurements, and using different recording devices. [13] The current study took three separate measurements of bite force in the molar and incisor areas, and then took the average of those three measurements to determine bite force. Despite the fact that the accuracy of the biting force sensor that was utilized in this investigation was just 0.05%. Previous research found that a strain gauge device that recorded a broad spectrum of force may provide accurate results (10 N) and high levels of precision (80%). (50–800 N). [14] Biting on the harsh metal surfaces of the strain gauge transducers produces discomfort in addition to the concern of breaking the edges of teeth and restorations, as stated by Lyons et al. Although the protective coverings have alleviated some of the discomfort and worry, the accompanying problem has not been solved entirely. [15] The transducers have been covered with a variety of materials, including gauze, gutta percha, polyvinyl chloride, and acrylic resin, amongst others. [16] In the current research, the metal surfaces of the sensing probes were protected from the risk of tooth edge fracture by being wrapped in a disposable sheet and coated with a sponge sheet that measured 2 millimeters thick. The adhesive tape used was double-sided. The thickness of the sensor in its whole was roughly 16 millimeters. According to the findings of Paphangkorakit and Osborn's research, the optimal opening for bite force measurement occurs when the distance between the incisors is between 14 and 28 millimeters. [17,18]

The current research shown that the all-on-four idea produced a biting power that was much greater than that of an overdenture, which was followed by a full denture. Previous research has shown that the amount of biting force exerted by an implant-supported overdenture is more than that exerted by a complete set of dentures, and that the amount of bite force exerted has a positive correlation to the amount of muscle [19,20,21] Carlsson and Lindquist carried out a research on ten edentulous patients, each of whom was first fitted with a full denture and then given a fixed implant-retained prosthesis. The biting force is now substantially higher, having grown from 80 N to 240 N. [22] In a study that evaluated the biting force and masticatory performance of complete dentures and implant-supported mandibular overdentures, van der Bilt et al. found that both types of prostheses showed a statistically significant increase in biting force, going from 116 N to 200 N for complete dentures and from 116 N to 200 N for overdentures, respectively. [23]

In order to examine the masticatory activity of the masseter, temporalis, and anterior digastric muscles, surface EMG recordings were taken. An electromyogram is a piece of medical equipment that captures signals by detecting the electrical activity that occurs during the contraction of a muscle. It is a device that measures the activity of the muscles. A few studies showed that there is a linear connection between EMG activity potentials and direct biting force measurements. This association was found to be significant. [24] The electromyogram (EMG) is used to evaluate the electrical activity of a particular muscle. Therefore, using EMG, one can identify how the muscles work during chewing and the role of a particular muscle in terms of the degree to which it contributes to mastication (i.e., which muscle play what role to what extent).

Chewing efficiency was significantly different among participants in Group 1 (complete dentures and implant-supported overdentures) and Group 2 (complete dentures and hybrid dentures supported by all-on-four treatment concept) according to the findings of our research, which revealed a statistically significant difference between the two groups. When compared to the performance of typical full dentures, overdentures showed dramatically improved chewing efficiency. In a similar vein, the chewing effectiveness of hybrid dentures was noticeably higher than that of full dentures.

In addition, a comparison between the two groups—overdentures and all-on-fours—showed that there was a statistically significant difference in the efficiency with which they chewed, with very few exceptions. When chewing meals of varying consistencies, the hybrid denture supported by the all-on-four treatment concept provided the maximum level of effectiveness for all three masticatory muscles. This was followed by the implant-supported overdenture and the full denture. When chewing food with a medium consistency, there was not a significant difference between the chewing efficiency of hybrid dentures and overdentures in the left masseter and right and left digastric muscles. However, there was a significant difference in the chewing efficiency of overdentures in the left digastric muscle when chewing food with a soft consistency. In comparison to other muscles, the masseter muscles were shown to have a greater EMG activity in the most recent study. According to the findings of this study, EMG activity was highest for foods with a firm consistency, followed by foods with medium and soft consistencies.

However, Feine et al. found in a cross-over research that there was no statistically significant difference in patients' perceptions of implant-retained fixed prostheses and implant-retained overdentures in terms of electromyographic activity.

[25,26,27,28] Overdentures and fixed implant-retained prostheses were shown to have functionally identical performance by Ferrario et al., who also revealed similar results in their research. After conducting an electromyographic investigation of the masticatory muscles, they came to the conclusion that implant-supported overdentures and fixed implant-supported prostheses both had equal levels of efficiency. [29] Apolinário et al. carried out a randomized controlled experiment to compare the masticatory performance of implant-supported dentures to that of full dentures (fixed and overdenture). [30] Their research demonstrated that there is a statistically significant gap in masticatory efficiency between conventional complete dentures and implant-supported dentures (both fixed and removable overdentures). On the other hand, there was not a statistically significant gap in masticatory efficiency between implant-supported overdentures and implant-retained fixed prostheses. [30]

In order to demonstrate contradictory findings, Heydecke et al. carried out a crossover experiment in which they compared a maxillary implant-retained fixed prosthesis to an implant-supported overdenture against the backdrop of a mandibular implant-supported overdenture. According to the findings of the study, detachable overdentures provide much greater levels of chewing ability and overall pleasure than permanent prostheses. [31]

The EMG activity of the masseter muscles was shown to be higher than that of the temporalis muscles, according to previous investigations. Because it applies greater force during the process of mastication, the masseter is often regarded as the most powerful muscle. The study included foods with a range of consistencies, categorizing bananas as soft, apples without peels as medium, and peanuts as hard. [32]

The research's drawbacks include a limited sample size, a short time span, random patient distribution across groups, and a lack of modern tools for bite force assessment and masticatory muscle activity recordings. The study was also conducted in a random manner among patients. Participants in the research who had full-mouth conventional implant fixed prostheses were excluded from the analysis.

In order to improve the quality of life of people who are missing all of their teeth, further research and studies need to be carried out once the current study's flaws have been addressed and removed.

CONCLUSION

The current study that we did concludes that biting force and chewing efficiency increases with the all-on-four treatment concept when compared to implant-supported overdenture and traditional full denture. The limitations of the study are discussed in the previous paragraph.

The participants who had all-on-four implants had the highest biting power and chewing efficiency, followed by those who had implant-supported overdentures, and then those who had traditional full dentures. In comparison to the temporalis and anterior digastric muscles, the electromyographic activity of the masseter muscle has been shown to be much greater. The electromyographic activity of the muscles used to chew hard foods was shown to be greater than that of foods of other consistencies.

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