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CLINICAL EVALUATION OF BITE FORCE AND CHEWING EFFICIENCY OF MANDIBULAR OVERDENTURE WITH ZIRCONIA-PEEK OR CoCr-PEEK TELESCOPIC ATTACHMENT

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ABSTRACT

Objectives: to assess the maximum bite force and chewing efficiency of two implant-retained overdentures with telescoping crown attachments made of zirconia or Cobalt-chromium (CoCr) and secondary Poly-ether-ether-ketone (PEEK). **Subject and Methods:** A total of 8 patients aged between 45-65 years with full edentulism were chosen. After receiving two dental implants, each had an overdenture. overdentures were divided into two groups based on the telescopic attachment arrangement; Group I was made up of overdentures with a telescoping zirconia-PEEK attachment, whereas Group II was made up of overdentures held in place by a telescoping CoCr-PEEK connection. A bite force and chewing effectiveness were measured at three-time intervals of 1 week, 3 months, and 6 months. **Results:** The findings indicate that there were no significant differences in biting power and chewing efficiency when comparing overdentures maintained by both types of telescopic attachment. Chewing efficiency revealed a statistically significant decrease in chewing efficiency at the end of the first week in comparison to the measurements taken at 3 and 6 months. Loss in chewing efficiency was seen after 6 months. **Conclusion:** The telescopic attachment constructed of Zirconia-PEEK or CoCr-PEEK used to support implants-retained overdentures will not affect maximal biting force or masticatory efficiency.

KEYWORDS: Bite force, Chewing efficiency, Overdenture, PEEK, Telescopic attachment

INTRODUCTION

Due to insufficient bone structure, conventional dentures often don't fit well for many older edentulous patients, posing challenges in chewing and eating[1]. Denture instability leads to feelings of insecurity, inefficient chewing, and overall dissatisfaction with the prosthesis[2]. Therefore, the proper masticatory function is crucial because it affects both quality of life and food digestion[3].

Overdentures supported by implants have various benefits over conventional complete dentures, including increased chewing effectiveness, masticatory biting power, and general patient satisfaction[4]. A variety of splinted attachments, such as bars, or unsplinted connectors, such as telescopic copings, can be used to attach such overdentures to the implants[5]. Rigid crowns with telescopic attachments have a number of benefits that may encourage their use in implant-supported restorations[6]. Moreover, these dental prostheses not only ensure proper force distribution by linking the external crown with the abutment, but they also maintain suitable frictional resistance between the primary and secondary

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copings[7]. Additionally, the stress is administered vertically, which improves bone preservation and is well tolerated [6, 8].

A telescopic crown includes a primary telescopic crown securely attached to an abutment, and a secondary telescopic crown firmly connected to the denture[9]. Cobalt-chromium is an excellent material for the double crown technique because of its precise fit, high elastic modulus, and mechanical advantages[7]. A telescopic retainer for overdentures, which holds medical promise, is recently suggested to be fabricated using novel computer-aided design and computer-aided manufacturing (CAD-CAM) materials[10]. Among the materials, one possesses Zirconia is more aesthetically pleasing, biocompatible, resistant to wear, and has superior mechanical qualities than the basic thermoplastic high-performance polymer is modified by other materials, such as PEEK. It offers great biocompatibility and solubility, high thermal stability, high hardness, lower water absorption, and chemical inertness [11]. However, it's been noted that the shape and kind of overdenture support can significantly influence chewing efficiency by enhancing the maximum bite forces associated with larger masseter muscles[12]. Therefore, determining the maximum bite force and chewing effectiveness of two implant-retained overdentures with telescoping double crown attachments made of primary zirconia or CoCr crowns and secondary PEEK crowns was the goal of this clinical investigation.

SUBJECT AND METHODS

Eight healthy Egyptian patients between the ages of 40 and 65 who were completely edentulous, had a normal maxillo-mandibular relationship, sufficient inter-arch distance, and had received approval (EC. Res. No: 739/4953) from the Ethical Committee of the Faculty of Dental Medicine at Al-Azhar University (Boys, Cairo) for the randomized clinical trial.

Grouping

The involved patients were divided randomly (using sequentially numbered subjects in an opaque, sealed envelope) into two equal groups (n=4) based on the configuration of the telescopic attachments: Group I was made up of overdentures with a telescoping zirconia-PEEK attachment, and Group II was composed of overdentures with a telescoping CoCr-PEEK attachment.

Sample size

Based on the results of Sharma et al , for the evaluation of the effectiveness of the chewing efficiency. For this study, a sample size of 4 in each group was obtained using unpaired two sample two tail t-test. Using G*power version 3.0.10 to calculate sample size based on effect size =3.094, 2-tailed test, α error =0.05 and power =80%.

Clinical intervention

Each participant's residual bone ridge underwent radiographic evaluation using cone beam computed tomography (CBCT) to assess the quantity, quality, and height of the bone. Prior to implants, each participant received a brand-new complete denture that was made and delivered using the standard clinical approach for complete denture creation. [4]

1. Surgical phase:

The surgical operations were performed under local anesthesia [1, 4]. Every patient will be provided with a pair of dental implants,conical implant with 12 mm in length and 3 mm in breadth (Ref; k1n30130, lot no.1954482, oxyimplant, k1 line, Italy), which were surgically placed in the inter-foraminal (canine) areas,surgical guide was used to determine placed on both sides. The cover screw was inserted, and the flap sutured. The implant sites were gradually prepared using color-coded drills until the desired diameter was achieved. The two implant analogs were positioned orthogonally to the occlusal plane and aligned parallel to each other, confirmed by a pilot drill. The implant was manually inserted with a minimum torque of

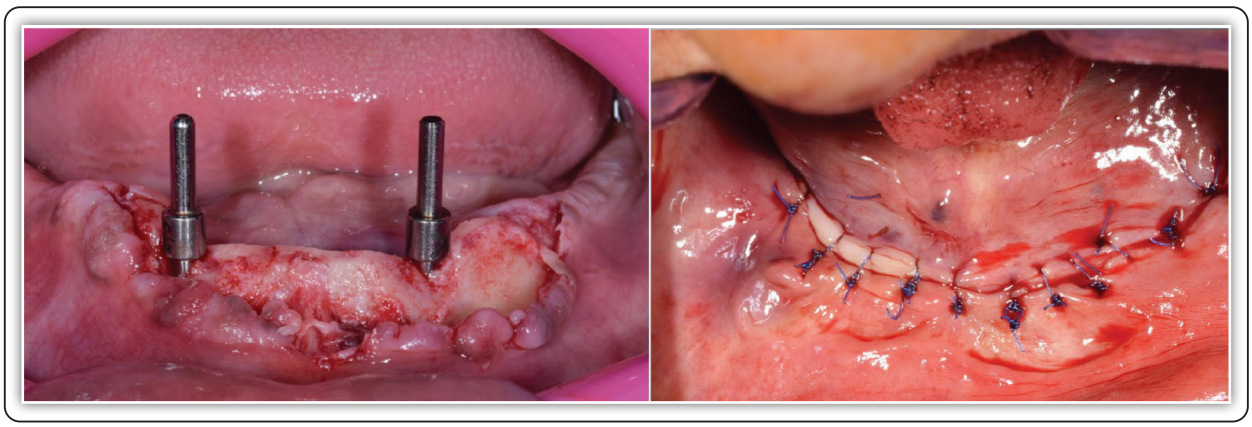

FIG (1) A photograph showing surgical and implant installation procedures.

40N.cm. In pliable consistency bone, the implant was directly inserted for stability and increased torque. Post-surgery, patients were prescribed painkillers(cetafen) and antibiotics(augmantine 1gm), advised to use chlorohexidine mouthwash, and instructed to consume a soft diet. [1, 4, 12]

2. Prosthetic phase:

After three months when all cases had proper osteointegration of implant placement, the implants were surgically exposed. Two 3mm high vertically oriented abutments were then screwed in for two weeks. The denture was fitted over the healing abutments and covered with a soft liner. After two weeks, the soft liner was removed from the denture's fitting surface, and the attached abutments were connected to the implants[4].

The previously installed abutment was scanned with an intra-oral scanner (Omnicam Scanner, UK) to gain a three-dimensional (3D) virtual image for designing the telescopic double crown attachments using CAD/CAM technology. A separate scan was performed for each implant abutment with an intra-oral scanner. The primary crowns (zirconia or CoCr) were CAD designed ensuring a common path of insertion. The following parameters were maintained for all groups; the primary crowns had the same insertion path and a 4.96 mm height (the gingival 3 mm was paralleled, the occlusal 2 mm was tapered 2 degrees), and the cement gap 0.02 mm occlusal to increase retention. All recorded and designed computer numeric control data were saved as STL files. The designed primary crown's STL file was imported into a 5-axis milling machine (MILL Box 2018 milling machine: ARUM, 400 Corea) to build the primary crown from zirconia blocks or CoCr metal blocks. The primary crowns were then cemented on an abutment using zinc polycarboxylate cement (Adhesoer Carbofine, Czech Republic). (**Fig. 2**)

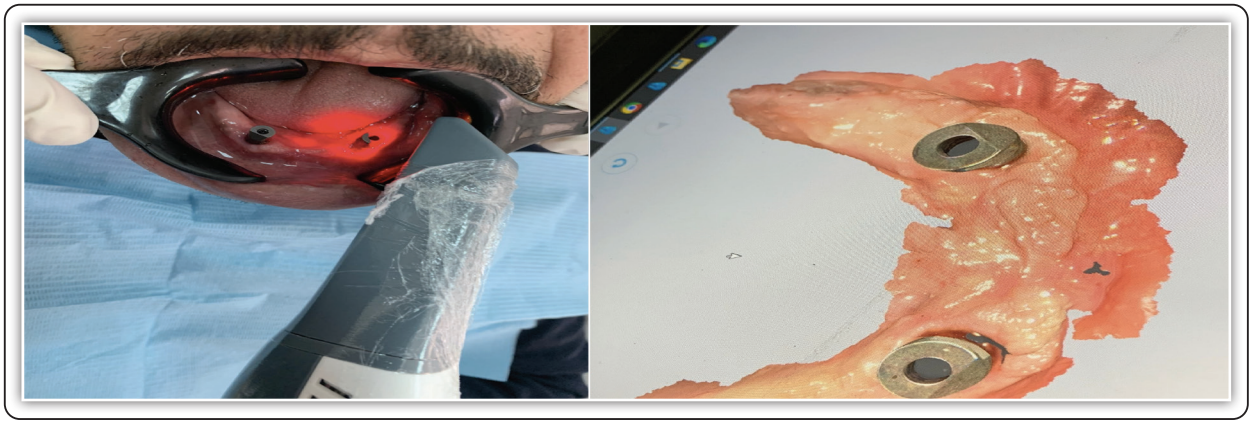

FIG (2) A photograph shows intra-oral scanning and a 3D virtual image of the telescopic crown.

Each primary crown was scanned separately with the same scanner. The secondary PEEK crowns were designed with the following parameters: parallel walls with a minimum thickness of 0.5 mm were employed for secondary crown design, and an occlusal space of 0.3 mm was created between primary and secondary crowns and milled from pre-polymerized PEEK blocks. Each secondary crown was given mechanical projections to aid in the mechanical interlocking of secondary copings with the overdenture base.

3. Construction of the new mandibular overdenture:

Secondary PEEK(CAD/CAM PEEK blocks, BioHPP, bredent,Germany) crowns were placed over the primary crowns made of either zirconia(CAD/CAM semi-sintered zirconia blocks, YETI Dental product, Gmbh, Germany) or Co-Cr(Co-Cr blocks, Heraenium pw, Heraeus-Kulzer Gmbh, Hanau,Germany), with a wax layer used as a spacer. A dual-phase selective impression was created using polyether impression material at the intermediate plant distance. The dental stone was then poured into the mold. After fabricating the wax rim, adjustments were made to the occlusal plane on the stone cast. Jaw relations were registered, and semi-anatomical acrylic resin teeth were arranged and trialed in the patient's mouth. The mandibular overdenture experiment underwent waxing up, flasking, curing, finishing, and polishing. Once the new mandibular overdenture was completed, secondary crowns were aligned with the primary crowns for proper insertion and then attached to the overdenture's intaglio surface. The dentures were tested for potential interference with the attachments and adjusted for optimal occlusal contacts. Border expansion of the denture was also modified to prevent pressure and discomfort. Participants wore their new dentures for three months to allow for neuromuscular accommodation.[5, 6].

Clinical evaluation:

1. Measurement of maximum bite force:

Biting force measurements were taken using an occlusal force-meter (GM10, Nagano Keiki co, Tokyo, Japan) with a capacity of 1000 Newtons (N), three months post-implant-supported overdenture placement. The device was set to zero and had registers for recording maximum force. Patients sat upright in the dental chair and bit down on the force meter fork, positioned at the first molars on both sides, three times for 3 seconds each with a 2-minute rest in between. The highest force value was displayed on the screen and selected from the three attempts. Readings were taken at both the left and right first molar areas, and the individual's maximum biting force was determined by averaging these values. Thus, three values were collected per patient [1, 4].

2. Measurement of chewing efficiency:

The glucose extraction method was used to objectively measure each patient's chewing efficiency at one week (T0), three months (T1), and six months (T2) after denture placement. The glucose concentration measured served as an indicator of masticatory efficiency. After chewing a commercially prepared gum-like sample, the extracted glucose was quantified. Patients were given a 10mm high gum-like specimen (Glucosensor Gummy, GC, Japan) with a 5% glucose concentration to chew for 20 seconds without swallowing. The chewed sample was then expelled into a receptacle with a plastic mesh filter to trap particles. The patient rinsed their mouth with 10ml of water and spit into the same receptacle. The glucose concentration (in mg/dl) in the filtered cup was determined using the Glucose Sensor Set[12].

Statistical analysis

The statistical analysis made use of SPSS statistical version 21. The Shapiro-Wilk test was used to determine whether the data was normal.

ANOVA and the student t-test were used to compare the two groups' normal quantitative data. For intergroup comparison Tukey's test was used. The significance threshold was set at p 0.05.

RESULTS

The normality assumption is assumed that the maximum bite force and chewing efficiency results of the Zirconia-PEEK group and Co/Cr-PEEK group are normally distributed (p-value >0.05). The independent t-test results revealed that Zirconia-PEEK telescopic attachment showed higher but not significant when compared to Co/Cr-PEEK telescopic attachment regarding maximum bite force and chewing efficiency at all follow-up periods. (**Table 1**)

Moreover, the one-way ANOVA test results of chewing efficiency regarding the follow-up period of Zirconia-PEEK and CoCr-PEEK telescopic attachment revealed that the difference between the sample average different follow-up periods is big enough to be statistically significant (p<0.001). The results revealed that both telescopic attachments showed higher and significant mean chewing efficiency at 3 months followed by 6 months and then after 1 week. The intergroup comparison revealed that the difference in the chewing efficiency between 1 week, 3 months, and 6 months is statistically significant (p<0.05). (**Table 2**)

TABLE (1) Comparing maximum bite force results of telescopic attachments:

Variable	**Mean**	**SD**	**t-value**	**p-value**
Zirconia-PEEK	168.58	6.13	0.41	0.683 ns
Co/Cr-PEEK	167.42	7.61		

**; significant at p < 0.05. ns= non-significant.*

TABLE (2) Comparing chewing efficiency results of telescopic attachments

Variable	**Zirconia-PEEK (Mean ± SD)**	**Co/Cr-PEEK (Mean ± SD)**	**t-value**	**p-value**
1-week (T0)	25.83± 2.32^{C}	24.17± 2.78^{C}	1.126	0.286 ns
3 months (T1)	76.50±4.64^{A}	75.83±6.08^{A}	0.21	0.835 ns
6 months (T2)	48.5±4.23^{B}	47.83±5.67^{B}	0.23	0.822 ns
p-value	<0.001*	<0.001*		

**; significant at p < 0.05. ns= non-significant.*

The different uppercase litters mean statistically signficant.

DISCUSSION

The telescopic crown was selected as an attachment system in this clinical trial because it was established that patients with full and partial edentulousness have employed telescopic crown attachments satisfactorily. Moreover, for the removable dental prosthesis, the telescopic crown of attachment offers retention, support, and stability along with the best possible hygiene [7, 13]. Therefore, the objective of this clinical trial was to compare the chewing efficiency, bite force, and electromyographic muscle activity of the masseter in two implants that retained complete mandibular overdentures between zirconia-PEEK and Co/Cr-PEEK telescopic attachments.

The participants that were chosen for this clinical investigation were still muscular and reasonably youthful (between 45 and 65 years). This is because as patients age, the canine region/inter-foraminal location was chosen for the insertion of the two implants in this clinical experiment[14,18]. Additionally, these areas lack any significant anatomical structures [18].

PEEK was chosen as the secondary crown in the current clinical investigation for both zirconia and CoCr primary crowns. This has to do with potential variations in the sliding characteristics of the various tested materials [19].

In this clinical trial, telescopic crown attachments were digitally created and precisely milled thanks to the development of CAD/CAM technology, ensuring a passive fit for the attachment pieces and maximum RDP functionality. Additionally, it generates correct prostheses and reduces the number of visits[7,20]. Furthermore, in this clinical investigation, a conventional taper angle of 2° was used to enable prosthesis implantation, give a modicum of resilience, and prevent excessive implant loading [7]. Moreover, Enaba [21] noticed that retention was rapidly lost when the taper angle of telescopic crowns surpassed 2°, which is why 2° was chosen.

To mitigate the potential discomfort arising from post-operative pain associated with implant insertion or the need for subsequent adjustments to new overdentures, the first measurements were initiated one week after the connection of the implants to the denture. The best period to gauge the improvement in masticatory performance was said to be at this time [12]. Additionally, the reorganization of the neuromuscular system, which needs a lot of time for functional improvement, may require three months of adaption [22]. Therefore, three months following denture placement, the maximum biting force test in this clinical experiment began.

Chewing gum was selected as the preferred method for assessing chewing efficiency in this clinical study, as compared to alternative comminution tests like the sieving technique. This choice was made due to the cohesive nature of the gum specimens, which pose challenges in terms of spreading evenly across the oral cavity and are less prone to aspiration or entrapment in the vestibule between the denture and the floor of the mouth [5, 12]. Moreover, chewing gum was employed to measure masticatory effectiveness since its volume loss from sweetener extraction is regarded as a reliable sign of improved masticatory effectiveness [12, 16].

The results of maximum bite force and masticatory efficiency comparison in this current clinical investigation showed non-statistically significant difference between both tested telescopic attachments. This could be related to the proper retention and stability of overdentures retained with both types of telescopic attachment with the same level due to increased neuromuscular adaptation is undoubtedly connected with better retention and function. As a result, patients were able to bite more forcefully and comfortably on the test specimens [4, 22]. Furthermore, it has been said that irrespective of the level of denture support, enhanced denture stability and retention contribute to the stabilization of occlusion, enable sufficient mastication, facilitate the axial transmission of masticatory load to the implants, and enhance the capacity to effectively crush food during the chewing process [23, 24].

However, the insignificant difference in chewing efficiency at the baseline for the both studied telescopic attachment systems could be attributed to the primary and secondary copings' apical tight fit, as well as the friction between them, which are what cause the initial maximum bite forces in both types of telescopic attachment due to increased retention and stability by restricting lateral movement [5, 24]. Furthermore, as compared to baseline, the chewing efficiency of both attachment systems studied in this clinical experiment showed a significant increase after 3 months. This might be related to

patients' sensory feedback pathways being restored to their current mandibular dentures over time as a result of neuromuscular adaptation in both studied groups[12,22]. Moreover, the results revealed considerable reduction in chewing efficiency after 6 months of follow-up. This could be attributed to the loss of retention between the primary and secondary crown combination could be the cause of the considerable reduction in chewing efficiency after 6 months of follow-up [25]. These findings support those of a recent study by Soldatovic et al., [25], and Priester et al.,[19].

CONCLUSION

The maximal biting force or masticatory efficiency is not affected significantly by the telescopic attachment combination. Moreover, in conjunction with main crowns constructed of zirconia or COCr, the production of secondary crowns using PEEK appears appropriate.

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