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Chewing efficiency and radiographic outcomes of (PEKK) framework for full-arch mandibular implant-supported fixed dental prostheses with All-on-four treatment concept

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Aim: Novel materials called polymers are employed in implant-supported prostheses. The purpose of this study was to evaluate polyetherketoneketone (PEKK) as a prosthetic framework material for fixed prostheses supported by implants in the mandible.
Materials and Methods: Four mandibular implants were placed in each of the sixteen totally edentulous patients, in accordance with the all-on-4 concept. Final repair; PMMA crowns and a screw-retained prosthesis with a PEKK framework were provided. After delivery, chewing efficiency (UF) with different number of chewing strokes was assessed at 6months(T6) 12 months (T12) and 18 months (T18), variations in marginal bone height were periodically observed at the same time intervals. SPSS software version 22 was used to analyze the data.
Results: For different chewing strokes, UF significantly decreased with advance of time. For 5, 20, and 50 strokes. There was a significant difference in UF between T6, and T18. There was a significant difference in vertical bone loss between implant positions at T6 (p=.032), T12 (p=.032), and T18 (p=.001) At all observations, posterior implants recorded significantly higher vertical bone loss than anterior implants
Conclusion: PEKK Framework showed improved chewing efficiency and low marginal bone loss after 18 months follow-up. PEKK polymer is suggested to be used as a framework material for full arch implant-supported prosthesis.

Keywords: All-on-four, Implant, PEKK, Screw retained prosthesis

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Introduction

Complete dentures as a treatment for patients who are completely edentulous may result in patient discomfort and soreness, which may lead to severe atrophy or bone resorption of the jaws.[1] The size of these changes has a significant influence on tooth replacement therapy, especially when implant-supported restorations are planned, and is crucial for comprehensive treatment planning and decision-making.[2]

Reducing treatment costs and patient morbidity while achieving the most satisfying treatment outcome for the patient is a recent paradigm shift in practice. Reasonable treatment planning, careful patient selection, fewer surgical procedures, and brief treatment intervals can all help achieve this. Attempting to meet these goals, the all-on-four treatment concept offers a comparatively easy (simple), predictable treatment option for edentulous patients' rehabilitation with a high quality of life outcome.[3]

Among the many benefits of hybrid prostheses are their high level of aesthetics and ability to decrease the impact force of dynamic occlusal loads.[4] An implant-supported hybrid prosthesis was extremely well received overall.[5]In comparison to implant overdentures and complete dentures, hybrid prostheses have also been suggested as the most reliable course of treatment for enhancing patient satisfaction in terms of oral pain and chewing functionality.[6]

Because the support for implant-hybrid prostheses comes from the implants, there is no need for a flange or extension of the denture bases.[7] Because prostheses do not restrict tongue movement, they do not affect phonetics and improve taste and temperature perception, leading to increased psychological comfort.[7]

High performance thermoplastic polymers known as polyaryletherketone (PEKK) can also be referred to as polyetherketoneketone (PEEK). compared to reinforced PEEK, PEKK offers 80% greater compressive strength and improved long-term fatigue characteristics.[8] Because of its low weight, ability to work with a variety of veneering materials, and industrial adaptability, PEKK has been gaining favor. In spite of this, a small number of studies have assessed its biological and therapeutic properties.[9]

Materials and Methods

Sample size calculation

Sixteen fully edentulous individuals, ranging in age from 50 to 70, were selected from the prosthodontic department's outpatient clinic in search of oral rehabilitation. Based on the outcomes of a prior clinical trial.[10]The sample size was established (effect size = 0.8, $\alpha = 0.05$, $\beta = 0.10$). There were sixteen samples computed. G*power 3.1.5, a computer program, was used to do the power analysis.

Study design: The preliminary research was conducted on sixteen individuals who were entirely edentulous and had unfavorable experiences with traditional mandibular dentures. Patients were progressively selected between (April 2022 and December 2023) and treated using all four concepts at the Faculty of Dentistry, The Local Ethics Committee (number A01100522) and ClinicalTrials.gov (Identifier NC06164990) both authorized the study. Following an explanation of the study procedures, every participant completed an informed consent form.

Patients' criteria

Inclusion criteria: (1) A preoperative CBCT scan demonstrates that they have enough bone volume (height and width) in their jaw to support two anterior implants oriented straight and two posterior implants angled distally, in accordance with the All-on-4 concept. (2) sufficient inter-arch space, as determined by preliminary jaw relations, to accommodate a fixed-detachable mandibular prosthesis.

Exclusion criteria: (1) People suffering from any kind of systemic sickness, including hemorrhage (2) Patients

receiving radiation therapy or immunosuppressive medication (3) People with parafunctional behaviors (4) Smokers, (5) people with uncontrolled diabetes mellitus, people with osteoporosis, and metabolic illnesses that may affect osseointegration.

Patients' examination

The patients' clinical and radiographic evaluations, as well as their medical and dental histories, were completed in order to meet the forenamed criteria. The patients received all on four implants then after 3months PEKK framework was delivered as shown by the flowchart in fig 1.

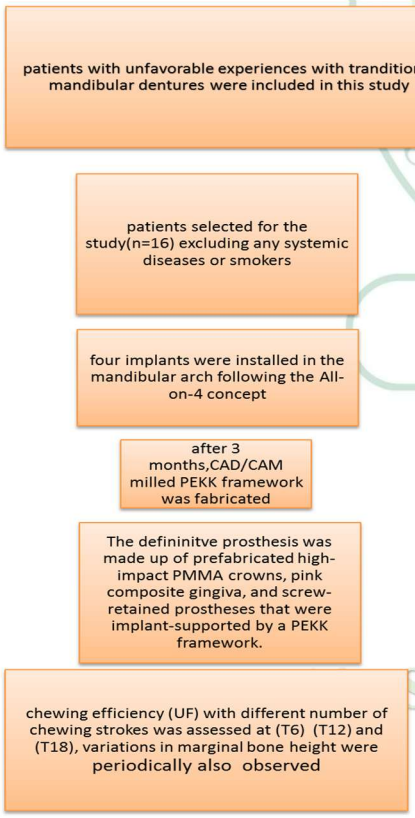

Figure 1: Patient examination Flowchart.

Each patient received a conventional denture, which acted as a temporary prosthesis while the occlusion was examined to guarantee the patients' neuromuscular accommodation and adaption. The denture was used in a dual scan CBCT procedure to create a surgical guide for guided implant insertion. First, the denture was placed intraorally, and gutta-percha radiopaque markers were created to serve as scan markers (radiographic stent).

Surgical Technique:

All patients were instructed to begin taking antibiotics (amoxicillin 875 mg plus clavulanic acid 125 mg) one week prior to surgery. According to the all-on-4 concept, each patient got two parallel implants in the anterior region (3.6x14mm, supraline II; Dentium) and two distally inclined implants in the premolar region (4.5x12mm, supraline II; Dentium), posteriorly angled by 30 degrees with respect to the occlusal plane. To reduce inflammation and surgical edema, corticosteroids (solupred 20 mg) were given postoperatively. After surgery, patients received 600 mg of the anti-inflammatory medication ibuprofen for five days. Relief was made in the denture above the implant locations.

Definitive prosthesis

Following three months of osseointegration, healing abutments were screwed for a duration of one week. Following this, two multiunit abutments, one angled for posterior implants and one straight for anterior implants, were torque-tightened (N=35). Duralay resin (Duralay; Reliance Dental Manufacturing, LLC.S) and ligature wire were used in the splinted-open tray imprint procedure after four long impression transfer copings were tightened to the multiunit abutments. A mandibular splinted open tray imprint was made utilizing light and putty vinyl siloxane material (ghenesyl; lascod). Four implant analogs were screwed into the modified stock tray, which was opened above the impression copings. After which the last cast was poured and a verification jig was made. The passivity of the verification jig was confirmed by one screw test and periapical radiography. A facial bow transfer and a centric jaw relation were captured using an occlusal wax created over

the definitive castings. Following that, the records were made using the semi-adjustable articulator (Denar combi II, Whip mix). a lab scanner (R900L,3shape) was used to scan the cast. A CAD-CAM machine (EMAR ed5x) was used to mill a resin pattern try-in after a virtual 3D CAD design for the prosthesis was completed using digital software (Exocad; America Inc.). This resin try-in was done to examine teeth position, esthetics, phonetics, and vertical and horizontal records. Next, CAD-CAM was used to digitally develop the (PEKK) framework. 1-2 mm retentive parts for the veneering material were made as an integral part of PEKK, and the dimensions of the CAD-CAM design were as described by Mourad et al., [11] With a minimum of 5 mm occluso-cervical height and 4 mm bucco-lingual width, the framework is thicker vertically buccally and lingually. It was attached to the abutments using DTK cement (DTK-Klebr; Bredent GmbH & Co.). Intraorally, the fit of the PEKK framework and the spacing between the dental crowns were verified. The dental crowns for the try-in were made using a high-impact polymethylmethacrylate (PMMA) material block (Novo.lign; Bredent GmbH & Co.)

Figure 2: PEKK framework try-in with PMMA crowns.

To mimic the soft tissue, a pink-hued light-polymerized nanofilled composite resin was utilized (Crea.lign; Bredent GmbH&Co.). For the patient, a lingualized occlusion scheme was employed. The implant-fixed prosthesis was screwed to 18 Ncm in accordance with the manufacturer's recommendations. The final prosthesis was made up of prefabricated high-impact PMMA crowns, pink composite gingiva, and screw-retained prostheses that were implant-supported and reinforced with titanium sleeves and a PEKK framework. follow-up visits were planned for the purpose of gathering data. All patients were asked to come in for check-ups every six months, Every patient received a complete set of periapical radiographs during their scheduled checkups in order to identify any changes in bone.

Patients' evaluation

Chewing efficiency: was assessed using two-color mixing ability test according to Schimmel, et al., [12] Patients were instructed to chew five samples with different number of chewing strokes (5, 10, 20, 30 and 50 chewing strokes respectively). Chewing samples were assessed in terms of measuring the unmixed chewing gum fraction (UF) The optoelectronic analysis was done by ViewGum software, the reciprocal values of the standard deviation of hue (SD Hue) of scanned samples were used to assess chewing efficiency

Radiographic evaluation: Using periapical x-rays taken at the time of prosthesis placement (base line T0), a periodic monitoring of the change in marginal bone height was carried out for each patient 6 months (T6), and 12 months (T12) and 18 months (T18) after delivery, standardized periapical radiographs were acquired using a modified Rinn (Dentsply Rinn) film holder and the paralleling technique.[13,14] The film holder was indexed on the implant to allow for the duplication of the film position. The assessor was blinded when taking the measures. With the aid of image analysis software (Image J, version 1.42, National Institutes of Health), the distance between the implant platform and the highest coronal bone level in contact with the implant surface was

determined. T0 was defined as the bone level coronal to the implant platform. The changes in bone level were calculated using the difference between the baseline value and the measurements at T6, T12 and T18. The mean of the measurements of the mesial and distal bone heights was applied to each implant. The average value of each participant's four implants was used for the analysis. Baseline is the location where the prosthesis first makes contact with the bone after delivery.

Statistical analysis

Comparison of UF of chewing samples between different chewing strokes (5, 10, 20, 30 and 50 strokes), and different observation times (T6, T12, T18) were performed using two-way repeated measures ANOVA followed by Bonferroni test for multiple comparisons and correction of p values. The data were analyzed using SPSS® software version 18 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at .05 for all analyses. Comparison between implant positions (anterior and posterior) for vertical bone loss was made using student t-test. To detect significant differences between observation times for Vertical bone loss repeated measures ANOVA followed by Bonferroni post hoc test was used. P-values <0.05 were considered to be significant

Results

Comparison of UF between observation times for different chewing strokes is presented in Table (1).

For 5 (p=.018), 20(p=.005), and 50 (p=.011) chewing strokes, there was a significant difference in UF between observations. However, for 10 and 30 chewing strokes, there was no significant difference between observation times

For different chewing strokes, UF significantly decreased with advance of time. For 5, 20, and 50 strokes. There was a significant difference in UF between T6, and T18. However, no significant difference in UF was noted between other observation times.

Descriptive statistics [mean± standard deviation] of vertical bone loss at different observation times for anterior and posterior implants are demonstrated in

Table 2 vertical bone loss significantly increased significantly with time from T6 to T18 for anterior (p<.001) and posterior (p<.001) implants. There was a significant difference in vertical bone loss between implant positions at T6 (p=.032), T12 (p=.032), and T18 (p=.001) At all observations, posterior implants recorded significantly higher vertical bone loss than anterior implants

Table 1: comparison of (UF) with different number of chewing strokes at different observation times.

	T6		T12		T18		Repeated measures ANOVA P value
	X	*SD*	*X*	*SD*	*X*	*SD*	
5 strokes	.7185A	.0476	.7059A	.0981	.5959A	.0438	.018*
10 strokes	.5814B	.1102	.4171B	.3246	.5074A	.0952	.066
20 strokes	.5993B	.0481	.4571B	.0256	.4472B	.0282	.005*
30 strokes	.4738C	.0199	.4468C	.0375	.3759C	.0422	.059
50 strokes	.2320D	.1049	.1857C	.1221	.0963D	.0452	.011*
Repeated measures ANOVA P value	<.001*		.038*		<.001*		

X; mean, SD; standard deviation. *p is significant at 5% level of significance. Different upper-case letters in the same column indicate significant differences between chewing strokes (Bonferroni, p<.05). Same upper-case letters in the same column indicate non-significant differences between chewing strokes (Bonferroni, p>.05).

Table 2: Comparison of vertical bone loss between different observation times and between implant positions

	T6 X±SD	T12 X±SD	T18	Repeated Measures ANOVA test (P value)
Anterior implants	.57±.082a	.78±.021b	1.05±.135c	<.001*
Posterior implants	.65±.079a	.85±.079b	1.21±.070c	<.001*
Independent samples t-test (P value	.032*	.032*	<.001*	

X; mean, SD; standard deviation * p is significant at 5% level. Different letters in the same raw indicates a significant difference between each 2-observation time (Bonferroni post hoc test, p<.05)

Discussion

This study was conducted to assess the effect of using CAD/CAM PEKK framework for implant supported screw retained prosthesis on the chewing efficiency of patients and the amount of bone loss around the implants by time.

The patient chewing efficiency while using CAD/CAM milled PEKK framework was improved by time at different number of chewing strokes. The significant improvement of masticatory efficiency was indicated by the significant decrease of the mean ratio of unmixed friction (UF) this could be explained by the cushioning effect of PEKK material on stress distribution in the peri-implant region. Patients had the ability to chew comfortably when CAD/CAM PEKK framework was used. Good stability and retention enhance oral perception skills when using CAD/CAM milled PEKK.

Peri-implant bone loss increased significantly from implant loading through the follow-up. The way bone heals and realigns itself in response to functional pressures may be the cause of this. Supporting data from other studies revealed that peri-implant bone loss accelerated with time in mandibular implant screw-retained prostheses.[15] After 18 months of follow-up, the mean Vertical bone loss (VBL) for anterior implants in this study was less than 1.05±.135, and for posterior implants, it was less than 1.21±.070. These findings meet the established requirements for implant success criteria and compare favorably to other studies that evaluated the peri-implant bone loss for full-arch restorations.[16] The reason for this is that PEKK polymer is a high-performance material with favorable mechanical properties, appropriate strength (65 MPa), acceptable fracture resistance, the ability to disperse stress, and the capacity to absorb shock. This is also consistent with a pilot study by Lee et al.[17] that compared the compressive stress-causing properties of PEKK, zirconia, and titanium materials for implant-supported restorations and found that the PEKK framework showed less stress to the implant and tissue. They did note that there are certain situations in which the shock-absorbing capabilities of a resilient implant-supported framework are limited. When compared to zirconia and titanium, another finite element analysis by Keilig et al.,[18] showed that there was a significant influence of equally distributed stress in the framework material of short span FPDs. The strain values in the bone surrounding the implants with PEKK framework were found to be below the critical value (3,000 με) at which microdamage would occur, according to Villifort et al.[19]. When comparing PEEK and PEKK materials, the implants, their corresponding connections, and screws showed the main differences in the mechanical behavior of the polymerics. The study found that after 18 months, there was clinically acceptable vertical bone loss around the implants as well as the improvement of the patient chewing efficiency by time. This phenomenon might be attributed to the PEKK's high shock-absorbance ability, mechanical sensitivity to shear stress, and compressive and tensile strength.

Study limitations

the study's limitations were the absence of a control group and the small sample size. However, once the prosthetic was delivered for five years, more follow-up appointments were set.

Conclusion

After 18 months of follow-up, the PEKK Framework material for complete arch screw-retained prostheses with PMMA teeth for edentulous arch rehabilitation revealed improvement in the chewing efficiency by time as well as clinically acceptable marginal bone loss around implants.

Clinical significance

chewing efficiency can be improved and bone preservation can be effectively

achieved by using PEKK material as framework for rehabilitation of edentulous patients with implant supported fixed prosthesis

List of abbreviation:
PEKK: Polyetherketonketone.
PEEK: Polyetheretherketone.
PMMA: Polymethylmethacrylate.
UF: unmixed fractions
VBL: Vertical bone loss.
CBCT: Cone beam computed tomography.
CAD/CAM: Computer added design/computer added manufacture.
SPSS: Statistical Package for the Social Sciences.
SD: Stander deviation.
FPDs: Fixed partial dentures.

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Declarations: Ethics approval and consent to participate: #A01100522
Competing interests: Authors declare no conflict of interest.

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