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Original Article

Effects of abutment materials on the tissues surrounding dental implants immediately after loading: An in vivo study

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Abstract

Aim: The aim of this study was to evaluate the effect of PEEK abutments, an alternative to titanium abutments, with temporary acrylic restorations using immediate loading protocol on the marginal bone loss and peri-implant tissues.

Methodology: This study was performed with temporary restorations using 32 titanium and PEEK abutments (14 titanium and 18 PEEK) on 32 implants performed on 21 patients (13 females, 8 males). Before surgical placement of the implants, intraoral and radiographic examinations were performed. The patients were divided into two groups as titanium abutment group (Grup Ti) and PEEK abutment group (Grup PEEK). In both groups, all implants were placed according to the manufacturer's recommendations. After surgery, impressions were taken using polyvinyl siloxane impression material and closed tray impression technique. The gingiva, which is thought to be formed on the model, was scraped and screwed onto the appropriate titanium or PEEK abutment analogue according to the groups and temporary restoration was prepared and applied on the implant.

Results: The results of the statistical analysis show that abutment types have no significant effect on ISQ values ($p>0.05$), but the diameter of the implant significantly affected ISQ values independently from abutment type ($p<0.05$). Less marginal bone loss was observed in the PEEK abutment group compared to the titanium abutment group ($p<005$), and similar results were obtained in both groups in terms of periodontal scores ($p>0.05$).

Conclusion: Within the limitations of this study, there was less bone loss in the PEEK abutment group ($p<0.05$). There was no difference between PEEK and titanium abutments in terms of ISQ values and clinical evaluations ($p>0.05$).

Keywords: immediate loading, PEEK, titanium, abutment.

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Introduction

Advances in implant technology enable patients' esthetic and functional expectations to be fulfilled by allowing same-day implantation using immediate-loading protocols and temporary prostheses. Immediate loading is defined as the provision of rehabilitation with a temporary prosthesis within 48 hours of implantation. However, imprecise immediate loading can lead to implant failure (1-3).

The design and material of the prosthesis influence the stress distribution by affecting the forces transferred to the implant and bone. Such stresses can

lead to bone resorption and implant loss (4). Successful implant treatment can be achieved by ensuring the optimal biomechanical conditions (5). Several manufacturers offer abutment options and materials designed for various indications. The mechanical resistance, esthetic features, and biological characteristics that affect the bone and soft tissue surrounding implants are important features of abutment materials (6-9). Titanium (Ti) has long been used for abutments and has seen high success rates. Until recently, Ti was the gold standard abutment material because of its clinical durability, excellent stability, distortion resistance, and success in long-term clinical trials (8). However, Ti abutments are esthetically insufficient because they generate a grayish reflection in the mucosa (10). For this reason, polyether ether ketone (PEEK) abutments are increasingly used. Due to its biocompatibility, white color, and mechanical features comparable with bone, PEEK can be used for the infrastructure or superstructure of crown and bridge restorations, implants, and mobile prosthetic restorations (10-12). The PEEK material is a synthetic polymer with high mechanical performance (11,13).

Although the mechanical features of PEEK have been investigated, few studies have evaluated its effect on peri-implant tissues. We investigated the effect of PEEK abutments on peri-implant tissue using an immediate loading protocol. The null hypothesis was that there is no significant difference in bone loss and the periodontal index value between PEEK and Ti abutments for implants applied using an immediate-loading protocol.

Materials and Methods

This study involved patients who presented with partial tooth loss to the Faculty of Dentistry, Hatay Mustafa Kemal University from 2018 to 2019 years (approval# 2018/160). Table 1 shows the inclusion criteria. The patients were randomly assigned to the titanium (Ti) and PEEK (PEEK) abutment groups (Fig. 1).

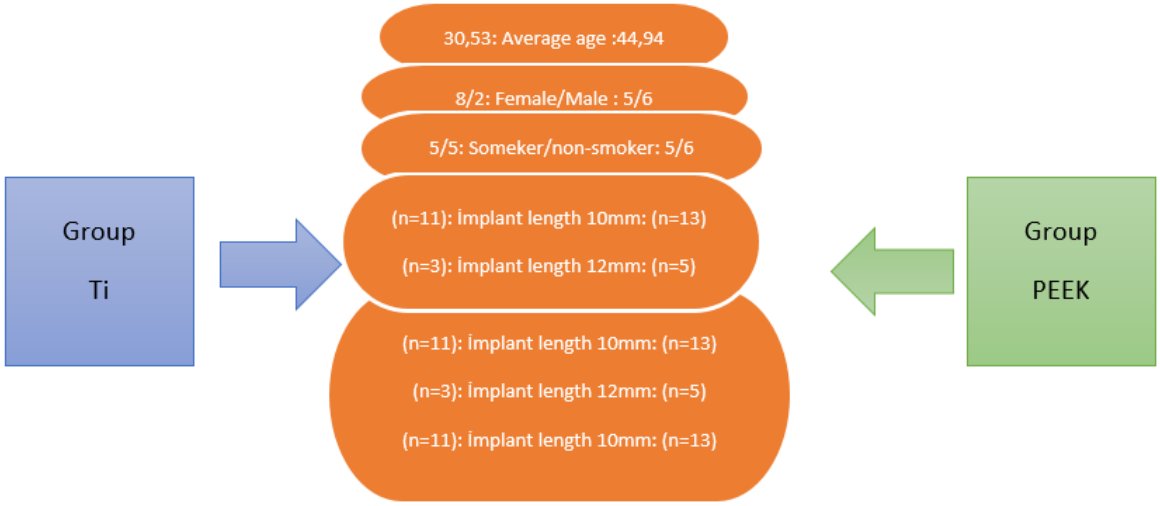

Figure 1: Distribution of patients included in the study.

A surgical stent was prepared on diagnostic models based on measurements obtained from the patients. Implant sockets were prepared by normal saline irrigation with the aid of a surgical stent, in line with the manufacturer's recommendations. Implants were placed in prepared sockets under aseptic conditions. Implant Stability Quotient (ISQ) values were recorded by measuring the resonance frequency analysis (RFA) after adapting a multi-Tipeg intermediate material using a force of 4-6 N/cm^2. The RFA was measured on four surfaces of each implant, and the mean value was used as a reference. A non-functional immediate loading protocol was applied with the patients' consent because there was sufficient primary stabilization at an insertion torque of >35 N and an ISQ value of ≥ 65. On the day of surgery, the healing cap covering the implant was removed, and analogs were placed over the implant. Measurements were performed at the level of the implant by the closed-tray-and-putty-wash technique using C-type silicone impression material (Zetaflow Intro Kit: Zetaflow Putty, Zetaflow Light, and Zetaflow Catalyst, Zhermack; Rovigo Italy). Temporary restorations were inserted over Ti and PEEK abutments on the same day. Non-contact was achieved in centric occlusion and contacts during lateral movements were eliminated. Temporary crown implants were screwed onto the implants. Screw gaps were covered with a polytetrafluoroethylene band and coated with temporary crown acrylic. The patients were provided with instructions regarding nutrition and chewing.

Medical treatment was prescribed, and a control visit was scheduled after 1 week. During the control visit, sutures were removed, and the effect of the temporary crown on gingival tissue was assessed. Frequent control visits were scheduled, during which oral hygiene, mobility, occlusion, and gingival recovery were evaluated. ISQ values were recorded on day 1 and at months 1 and 3. In both groups, permanent prostheses were scheduled to be placed 3 months after the temporary prosthesis. Thereafter, permanent prostheses were placed. To assess vertical bone loss around implants, standard periapical radiographs were obtained by the parallel acquisition technique immediately after temporary loading and at months 1 and 3. The radiographs were transferred to digital media. Peri-implant bone resorption was measured separately on the implant mesial and distal surfaces by using a software (DBSWIN imaging software, DÜRR DENTAL SE; Bietigheim-Bissingen, Germany). On radiographs, implant size and the distance from the implant to bone contact were measured. Implant size ratio was calculated, and the bone level was measured. The amount of peri-implant bone resorption was calculated by measuring the mesial and distal bone levels around the implant on radiographs obtained at baseline and at months 1 and 3. Peri-implant parameters were assessed at baseline and at months 1 and 3. The peri-implant parameters were probing depth, gingival bleeding index, modified plaque index, gingival index, and keratinized gingiva width. All measurements were performed by a single, experienced researcher (IG).

Statistical analysis

Analysis of the data was carried out with SPSS software version 22 (IBM SPSS Inc., Armonk, NY, USA). The normality of the data distribution was assessed at a significance level of 0.05 by the Shapiro-Wilk test. Bone loss and ISQ values and the factors affecting these parameters were assessed at a significance level of 0.05 by analysis of variance (ANOVA) for repeated measurements and Bonferroni correction with the Tukey post hoc honestly significant difference test. Relationships between qualitative parameters were assessed at a significance level of 0.05 by Pearson correlation analysis. A power analysis was performed using a type 1 error rate of 5% (alpha, 0.05) and 32 samples using G*Power v. 3.1.9.2 (G*Power, Kiel, Germany).

Results

Abutment type had no significant effect on the ISQ value ($p>0.05$). Also, the ISQ values were significantly correlated with time and implant diameter ($p<0.05$) but no other parameter ($p>0.05$). The ISQ values decreased over time in both groups (Table 1).

Table 1: Averages of ISQ values between groups over time.

ISQ VALUE			
	Initial	1. month	3. month
Group Ti	$67,86+3,35^{Aa}$	$62,4+4,32^{Ab}$	$64,46+3,85^{Ac}$
Group PEEK	$68,55+3,09^{Aa}$	$62,88+3,52^{Ab}$	$65,33+3,37^{Ac}$

Different upper-case characters show the statistical significance in the columns. Different lower case upper characters show the statistical significance in the lines. ($p<0.05$)

In group Ti, the mean ISQ value was 67.86 at baseline, 62.4 at month 1, and 64.46 at month 3. In group PEEK, the mean ISQ value was 68.55 at baseline, 62.88 at month 1, and 65.33 at month 3 (Table 2). Bone loss (total and at months 1 and 3) was significantly affected by abutment type independently of other factors ($p<0.05$), and bone loss was lower in group PEEK.

In group Ti, the mean bone resorption was 0.83 and 0.96 mm on the mesial and distal surfaces, respectively, at month 3. In group PEEK, the mean bone resorption was 0.46 and 0.58 mm on the mesial and distal surfaces, respectively (Table 2).

No significant correlation was observed between abutment type and probing depth ($p>0.05$). The mean probing depth at month 3 was 3.70 mm in group Ti and 3.31 mm in group PEEK (Table 2). There was no significant relationship between the gingival index score and abutment type ($p>0.05$). The mean gingival index score at month 3 was 1.26 in group Ti and 1.16 in group PEEK ($p<0.05$). There was a significant correlation between the plaque index value and abutment type ($p<0.05$). The mean plaque index value at month 3 was 0.86 in group Ti and 1.11 in group PEEK ($p>0.05$). There was no significant correlation between the keratinized gingiva width and abutment type ($p>0.05$). At month 3, the mean keratinized gingiva width was 5.86 mm in group Ti and 4.62 mm in group PEEK (Table 3).

Table 2: Marginal bone loss amounts between groups. (mm)

	MARGINAL BONE LOSS					
	Mesial 0-1.mounth	Distal 0-1.mounth	Mesial 1-3.mounth	Distal 1-3.mounth	Mesial Total	Distal Total
Group Ti	*0,663*	*0,804*	*0,182*	*0,174*	*0,833*	*0,967*
Group PEEK	0,373	0,436	0,09	0,146	0,464	0,582

Table 3: Time-dependent change of periodontal values.

		Group Ti			Group PEEK		
		Min	Max	Mean	Min	Max	Mean
Probing depth	Initial	1,5	3,25	2,31	1,5	2,75	2,13
	Month 1	2	3,25	2,8	2	3,25	2,68
	Month 3	3	4,75	3,7	2,25	4,25	3,31
Gingival index	Initial	0	2	0,8	0	1	0,72
	Month 1	0	2	0,93	0	2	1,11
	Month 3	0	2	1,26	0	2	1,16
Modified plaque index	Initial	0	2	0,86	0	1	0,66
	Month 1	0	2	0,8	0	2	0,94
	Month 3	0	2	0,86	0	2	1,11
Keratinized gingiva width	Initial	2,66	8,66	5,66	3	6,33	4,53
	Month 1	2,66	8,66	5,84	3	6,33	4,59
	Month 3	3	8,66	5,86	3	6,33	4,62

Discussion

There was less marginal bone loss around PEEK abutments ($p<0.05$), resulting in rejection of the null hypothesis of no significant difference between Ti and PEEK abutments.

The mean ISQ value at baseline was 67.86 in group Ti and 68.55 in group PEEK and was 64.46 and 65.33, respectively, at month 3 ($p<0.05$). The decreased ISQ value in both groups can be attributed to peri-implant remodeling and resorption. In addition, in a study of SLA implants (10 and 12 mm in length), Barewal et al. assessed ISQ changes and showed that implant length had no significant effect on stability over time and that implant design had a lesser effect on primary stability than did bone quality (14). The lack of a difference in ISQ values was attributed to the use of implants of length ≥ 10 mm. Similarly, in a multicenter study, Buser et al. assessed the long-term success of 2,359 non-embedded implants. There was no significant difference in the cumulative success rate between 10 and 12mm implants at year 8 (15).

In an animal study, Bergluth et al. analyzed changes in the marginal bone level following implantation, abutment attachment, and functional loading. The maximum bone loss occurred after implantation, and abutment attachment, and almost no bone loss occurred during 10 months of functional loading (16). Clinical studies also indicate that marginal bone loss occurs early after implantation and is more prominent than during the implantation period, when the implant becomes functional (16, 17). Copper et al. reported no significant difference in marginal bone loss between week 6 and month 12 (18). Donati et al. reported that the greatest marginal bone loss occurred within 3 months after implantation (17). Therefore, we assessed marginal bone loss within the first 3 months. Bone loss at month 3 was higher in group Ti than in group PEEK ($p<0.05$). PEEK enhances bone remodeling;

therefore, PEEK abutments are suitable alternatives to Ti abutments (12). PEEK material has an elastic modulus similar to bone. Therefore, it will absorb some of the forces applied on it, minimizing the pressure on the bone, causing less bone resorption has been considered. Rigid structures promote bone resorption by directly transmitting loading onto the bone. Zoidish et al. suggested that PEEK material reduces bone resorption by absorbing stresses (13). In a finite element analysis, Sarot et al. found no significant difference in stress distribution between Ti and PEEK implants (19). In addition, Lee et al. compared stress on prosthesis components caused by different infrastructure materials. Materials with a low elastic modulus, such as PEEK, resulted in the highest stress on peri-implant tissue (20). By contrast, Scwitalla et al. compared stress alterations in peri-implant bone by finite element stress analysis for a Ti abutment on a Ti implant and a PEEK abutment on a PEEK implant. In contrast to our results, the stress value was higher in the PEEK abutment on the PEEK implant (2). Also, the finite element analysis by Tekin et al. showed that the stress on bone was lower in a model using a PEEK compared to a Ti crown. Therefore, there is less stress accumulation in the bone surrounding a PEEK abutment, which may explain the lesser bone loss (21).

In this study, there was no significant correlation between abutment type and plaque score or periodontal index value ($p>0.05$). Moreover, there was no significant correlation between peri-implant bone loss and plaque score or gingival index value. Between plaque scores and gingival index scores, and the amount of bone loss around the implant, no statistically significant relationship was observed. The absence of high plaque and bleeding indices in the measurements can be considered as evidence that the patients are well motivated in terms of oral hygiene habits, and therefore the peri-implant tissues are healthy. This result may indicate that patient-related complications can be minimized by increasing patient-physician relationships and patient cooperation in implant applications. It is not always possible to include the necessary patient groups in clinical trials. Performance of implant procedures in patients of different ages and at different sites is a limitation of this study. Further studies should investigate the effects of other materials on implant osseointegration and peri-implant tissues.

Conclusions

Marginal bone loss was significantly lower for the PEEK abutment compared to the Ti abutment ($p<0.05$). There was no significant difference in plaque score and periodontal index value according to abutment material ($p>0.05$), and implant diameter, but not implant length, had a significant positive association with the ISQ value ($p<0.05$).

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Ethical Approval: Ethics committee approval was received for this study from Hatay Mustafa Kemal University in accordance the World Medical Association Declaration of Helsinki, with the approval number: 2018/160.

Peer-review: Externally peer-reviewed.

Author Contributions: Conception – İ.G.; Design –M.Z.; Supervision – C.Ö.; Materials – İ.G.; Data Collection and/or Processing – M.Z.; Analysis and/or Interpretation – C.Ö.; Literature Review – İ.G.; Writer – M.Z.; Critical Review – C.Ö.

Conflict of Interest: No conflict of interest was declared by the authors.

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