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Evaluation of Stability and Marginal Bone loss of Customized Posterior Hybrid PEEK Abutments Supported by Short Implants

Shahenda T. Elsaid

Mona H. Mandour

Roqaia M. Alassar

ORIGINAL STUDY

Evaluation of Stability and Marginal Bone Loss of Customized Posterior Hybrid Polyether Ether Ketone Abutments Supported by Short Implants

Shahenda T. Elsaid [a,*], Mona H. Mandour [a], Roqaia M. Alassar [b]

[a] Department of Crowns and Bridges, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt
[b] Department of Fixed Prosthodontics, Faculty of Dentistry, Pharos University, Alexandria, Egypt

Abstract

Purpose: To evaluate posterior screw-retained customized polyether ether ketone (PEEK) abutments/crowns on a Ti base and compare them to porcelain fused to metal crowns on ready-made abutments supported by short implants in terms of stability and marginal bone loss (MBL). **Patients and methods:** Twelve patients ($N = 12$) with missing posterior teeth indicated for short dental implants were selected based on the pre-established inclusion and exclusion criteria and randomly divided into two equal groups ($n = 6$) according to the type of implant superstructures. Group (1): customized PEEK abutment/crowns and group (2): prefabricated titanium abutment/porcelain fused to metal crowns. Patients were evaluated for stability and marginal bone level immediately after implant placement, immediately after loading, and then after 3, and 6 months. Accordingly, MBL was calculated. Data was collected, arranged, and tabulated for statistical analysis. **Results:** Group (2) recorded statistically insignificantly higher implant stability at primary and 0-month intervals than group (1), while at 3- and 6-month intervals group (1) recorded higher stability than group (2). The difference was statistically significant at the 6-month interval. Regarding MBL, group (1) recorded statistically significantly less bone loss than group (2) at different intervals. **Conclusion:** By time, customized posterior PEEK abutments supported by short implants have a significant positive effect on implant stability and MBL. The customized PEEK abutments constitute an effective alternative to titanium abutments.

Keywords: Customized abutment, Polyether ether ketone, Short implant, Stability

1. Introduction

Losing a tooth can have a significant impact on an adult's quality of life since it compromises oral health, lowers social status, and lowers self-esteem. All of these elements that have an impact on patients' quality of life can be restored through oral rehabilitation using implants.

The presence of adequate bone quality and quantity needs to be evaluated prior to surgical interventions for placing implants. Advanced surgical techniques include distraction osteogenesis, autogenous bone grafts, and sinus augmentation that aid in increasing bone height may be necessary for the atrophic jaw. Additionally, patients are prudent with these complex surgical techniques in terms of cost, donor site morbidity, and surgical treatment time. Short implants were developed to avoid these surgical procedures [1].

Polyether ether ketone (PEEK) can be used to replace metal in both fixed and removable restoration. The strength-to-weight ratio, corrosion resistance, biocompatibility, compatibility with medical imaging, low plaque affinity, and chemical stability of this material are only a few of its benefits. It also exhibits good mechanical behavior, creep resistance, wear resistance, and shock absorption. Due to these criteria, PEEK material is a useful alternative to metal for fixed implant-supported restorations. Additionally, PEEK is a very promising material with a low elastic modulus that enables it to function as a shock absorber [2].

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* Corresponding author at: Al-Azhar University, Faculty of Dental Medicine, Al-Azhar university Girl's branch, Nasr city, Cairo 11754, Egypt.
E-mail address: ShahendaAbuAmu.26@azhar.edu.eg (S.T. Elsaid).

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Even though the short implant resolved several clinical problems, it can sometimes be related to loss of osseointegration, which first manifests as peri-implantitis and marginal bone loss (MBL) due to an increased crown/implant ratio and decreased bone/implant contact. According to a recent meta-analysis, shorter implants failed 2.5 years earlier than regular ones, even with a similar long-term survival rate [3].

The function of implant-supported restorations, as well as adjacent soft tissue health and soft tissue stability, are all influenced by the chemical composition and surface properties of the abutment ground material, the geometry of the abutment in accordance with the natural roots and gingival margin, as well as the finish of the abutment.

Instead of using prefabricated abutments, customized abutments can be used to control all these qualities. Biocompatible materials can be used in the peri-mucosal area more easily with the help of customized abutments. This prompts the question as to whether there is a performance difference between prefabricated and custom abutments. There is insufficient information in the dental literature on whether making superstructure components supported by short implants from PEEK will enhance their performance.

Therefore, this study was directed toward evaluating stability and MBL of posterior customized PEEK abutments on Ti bases supported by short implants. The null hypothesis proposed for the present study was that the customized PEEK abutments do not affect stability and MBL of posterior Ti bases supported by short implants.

2. Patients and methods

2.1. Sample size calculation

A total sample size of 12 patients (six in each group) was sufficient to detect an effect size of 0.924, with a power (1-β error) of 0.8, using a two-sided hypothesis test and a significance level (α error) 0.05 for data. G power version 3.1.9.2 was used for sample size calculation [4].

2.2. Patients' selection is based on the established inclusion and exclusion criteria

The study was conducted on 12 patients with missing posterior teeth indicated for short implants, attending the outpatient clinic of the Crowns and Bridges department, Faculty of Dental Medicine for Girls, Al-Azhar University after obtaining the approval of the Research Ethics Committee (REC), under code: REC-CR-23-02. The patients were informed about the purpose of the investigation, the clinical procedures, and the advantages and risks of the applied materials and techniques. A written informed consent form was signed by patients before study initiation. The patients were selected based on the pre-established inclusion and exclusion criteria, as follows inclusion criteria [5], patients' ages range from 30 to 45 years old, with no gender prediction with the ability to read and sign informed consent, with missing posterior teeth who require short implant replacement due to anatomical limitations (near maxillary sinus or inferior alveolar nerve) or atrophic ridge. Opposing natural teeth should be present. The edentulous ridge should be free from any infection or remaining roots. The patient should be able to tolerate implant surgical procedures both physically and psychologically and should be willing to return for follow-up examination and evaluation. Exclusion criteria [5], patients with active periodontal diseases. Patients who lack motivation and have poor oral hygiene. Pregnant women. Patients with unrealistic expectations. Smokers and patients with parafunctional habits. Patients with systemic disease and those who are immunocompromised will not be surgically treated. Recent extraction or extraction socket with infection or remaining root.

2.3. Study design and follow-up strategy

Selected patients were randomly categorized using a coin toss and divided into two groups ($n = 6$) according to the type of implant superstructure. Group (1): customized PEEK abutment/crown on a Ti-base. Group (2): prefabricated titanium abutment/porcelain fused to metal (PFM) crown. After short implant placement and superstructure fabrication, patients were evaluated immediately after implant placement and at the following intervals; immediately after crown loading, and after 3- and 6-months follow-up periods.

2.4. Examination and implant planning

Preoperative periapical radiographs as well as cone-beam computed tomography were obtained for each patient. Clinical evaluation of the mesiodistal space, buccolingual space, and occlusogingival space was done with the help of study casts and cone-beam computed tomography. Implants with appropriate diameter and length were selected for each case according to the buccolingual width of bone (minimum 1 mm of bone was left buccally and lingually), the mesiodistal width of bone (minimum 2 mm of bone was left between the implant and adjacent teeth) and the length of the implant was selected (minimum 2 mm of bone was left between the implant and inferior alveolar canal).

2.5. Surgical procedures

After reflecting a full-thickness flap, precision drills (Oxy imp. Dent. System, Italy) were used to place the hole inside the bone, at a regular speed to avoid bone necrosis, then this hole was enlarged gradually by using successively wider drills (Oxy imp. Dent. System, Italy). The implant (Oxy imp. Dent. System, Italy) was placed into the hole with a torque-controlled wrench (Oxy imp. Dent. System, Italy) at the exact torque. A cover screw (Oxy imp. Dent. system, Italy) was placed to seal the implant orifice, the gingiva was adapted around the entire implant, and then the flap was closed with interrupted sutures. Three to six months of integrating time was allowed before the fabrication of the crowns. A subsequent surgical procedure was made to put a healing cap (Oxy imp. Dent. System, Italy).

2.6. Prosthetic procedures

Master impressions (Silagum. DMG, Germany) were taken using the open tray technique at the implant level. The long implant level impression transfer (Oxy imp. Dent. System, Italy) was screwed to the implant in the patient's mouth. The selected tray was perforated opposite the implant location to provide access for the transfer coping. Heavy consistency polyvinylsiloxane impression material (Silagum. DMG, Germany) was loaded into the selected impression tray and light consistency was meticulously syringed around the impression-transfer copings. After the impression material was set, the impression-transfer was unscrewed, and the impression was taken out of the patient's mouth with the transfer. The impression was inspected and then disinfected with sodium hypochlorite (1 : 10 dilution), followed by thorough rinsing under running water. The implant analogue (Oxy imp. Dent. System, Italy) was tightly screwed into the impression transfer and the gingival mask silicone (Bredent, comp. Germany) was injected around the implant analogue, which simulates gingival level. The impression was poured with type IV dental stone (Elite Rock, Zemack S.P.A. Bovazecchino, Italy) to create a master model.

2.7. Laboratory procedures for superstructures fabrication

2.7.1. Preparation of working casts for scanning

The working cast was fixed to the scanner tray (Smart optics ScanBox Gmbh, Germany) using specific clay. For group (1), a digital impression was captured for the cast with an implant scan body (Oxy imp. Dent. system, Italy). For group (2), the digital impression was taken after spraying the cast with implant abutment (Oxy imp. Dent. System, Italy) using a light-reflecting powder (Occlutec, Scan spray, Renfert GmbH, USA).

The captured impressions were saved in the occlusion catalogue of the software (Exocad Gmbh. German). The upper and lower casts were mounted on a semi-adjustable articulator. Hand articulation was used to achieve a highly accurate duplicate of tooth intercuspation because posterior teeth could stabilize occlusion by direct cast position. The articulator with casts was fixed to the scanner to take an optical impression of the casts in occlusion.

2.7.2. Fabrication of screw-retained customized PEEK abutment/crown

A custom abutment was designed on a Ti-base by Exocad software (exocad, GmbH, Germany). The breCAM.BioHPP blank (Bredent comp., Germany) was fixed to the Roland milling machine (Roland _Dwx-510_ Japan), and the preview window was activated to start the milling process. The milled PEEK abutment was cemented to the Ti-base and veneered with Crea.lign (Bredent comp. Germany). Then the screw-retained PEEK abutment/crown was finished by Visio.lign tool kit (Bredent comp. Germany) and polished by Abraso universal polishing paste (Bredent comp. Germany).

2.8. Fabrication of screw-retained prefabricated titanium abutment/PFM crown

The coping of the PFM crown was designed by Exocad software (exocad, GmbH, Germany) creating 2 mm space for veneering porcelain, and then three dimensional-printed using resin material (power resin comp, turkey) by a three dimensional printer (Epax mono 4 K, china).

The resin pattern was sprued, invested, burnout to fabricate a metal coping using the conventional lost-wax casting technique. The metal coping was veneered with porcelain (Kuraray Noritake Dental Inc. Japan) and fired according to the manufacturer's instructions. Finally, the screw-retained PFM crown was cemented to the prefabricated titanium abutment (Oxy imp. Dent. System, Italy).

2.9. Connecting the screw-retained crown of two groups to the implant

The healing abutment was unscrewed by anti-clockwise rotation using a manual screwdriver, then the screw-retained crown/abutment was screwed to the implant with a screwdriver through the hole of the crown and using a torque-controlled wrench to secure the crown/abutment to the crown. The screw of the crown/abutment was covered by Teflon paper, and the hole was closed by resin composite (3M, ESPE, US). Occlusion was checked by articulating paper. Even occlusal contact was tested by shimstock.

2.10. Evaluation of implant stability

AnyCheck device (DMS Co., Ltd, Korea) was used to determine implant stability and measure the degree of osseointegration through a unique tapping motion. This device combines the advantages of both tapping (Periotest) and Resonance Frequency Analysis method (Osstell) to provide a much safer and easier system. Primary stability was measured directly after implant insertion. Secondary stability was measured immediately (0), 3-, and 6- months after loading.

2.11. Radiographic evaluation to determine marginal bone loss (MBL)

Marginal bone level was evaluated through standardized reproducible periapical radiographs for each implant site directly after loading (baseline), three, and six months after loading. MBL was then calculated at 3- and 6- months. A direct digital image radiographic system, VISTA scan software (DURR DENTAL, Safwan, Germany) was used in this study to calculate bone loss. The image plate photostimulable phosphor (PSP) was mounted to a holder bite block. The bite block was inserted in the patient's mouth and assembled into the plastic aiming ring at the end of the long cone of the radiography tube. The image plate was exposed by the radiography machine (Runyes radiography machine, China) at 70 Kilovolt, 8 mA for 0.04 s. The exposure parameters were fixed for all patients and over the follow-up periods. The paralleling technique was used throughout the whole study period to standardize the radiographic images and allow accurate comparison of measurements. The image plate was inserted into the VISTA scan and the radiographic image was displayed within seconds on the computer screen and saved on the previously prepared active patient card.

For each radiograph, two horizontal lines (A and B) were drawn mesial and distal to the implants extending from the point of first bone/implant contact. A third line, (C), was drawn at the base of the implant (Fig. 1). The distances between lines A-C and B—C were recorded and compared at baseline, 3 and 6 months. The amount of bone loss was calculated as the respective differences between the two measurements (baseline/3 months and baseline/6 months). Mean bone loss of mesial and distal sides was then calculated and statistically analyzed.

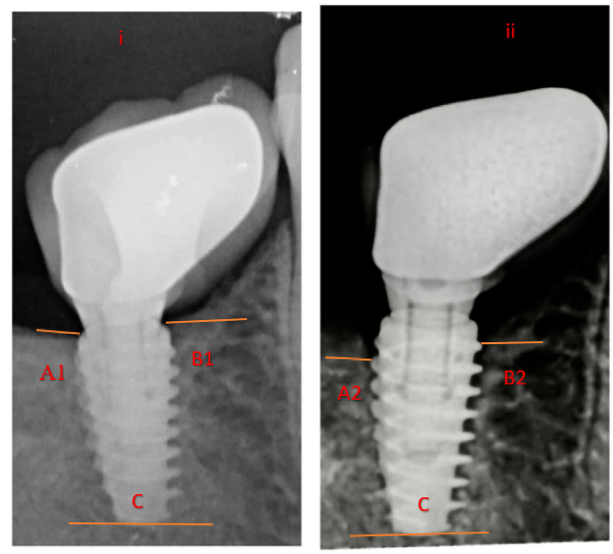

Fig. 1. Linear bone measurement, (i) bone level immediately after loading, (ii) bone level after 6 months of loading.

2.12. Statistical analysis

Data management and statistical analysis were performed using the Statistical Package for Social Sciences (SPSS) (version 20 IBM Co. USA). Numerical data were summarized using mean and standard deviation. Data were explored for normality by checking the data distribution and using Kolmogorov—Smirnov and Shapiro—Wilk tests. Comparisons between groups concerning normally distributed numeric variables were performed using independent *t*-test. Comparison between different observations within the same group was performed using repeated measures ANOVA. Comparisons between groups concerning nonparametric numeric variables (amount of difference in occlusal load) were performed using Mann—Whitney *U* test. The amount of difference was calculated by the formula: (Value after-value before). All *P* values are two-sided. *P* values less than or equal to 0.05 were considered significant.

3. Results

3.1. First: statistical analysis of implant stability

Group 2 recorded higher stability at primary (76.33 ± 1.51) and 0-month intervals (85.52 ± 1.30) than group 1 (76.17 ± 1.47 and 85.02 ± 1.06), respectively. However, the differences were statistically insignificant ($P = 0.85$), ($P = 0.776$). While group 1 recorded higher stability (85.08 ± 1.47 and 87.08 ± 1.36) than group 2 (84.07 ± 1.24 and 83.23 ±.97), respectively, at 3- and 6-month intervals. However, the difference was statistically insignificant at 3- ($P = 0.225$) and significant at 6-month intervals, ($P = 0.000$), Table 1.

Regarding the change in stability by time, group (1) showed a higher increase from primary stability to 0-, 3-, and 6-month intervals (9.55 ± 2.02, 8.92 ± 2.52, and 10.92 ± 2.11) than group (2) (9.18 ±.69, 7.73 ± 1.17, and 6.90 ± 1.2), respectively. However, the differences were statistically insignificant at 0- and 3-month intervals ($P = 0.683$, $P = 0.322$), and significant at 6-month intervals ($P = 0.002$), Table 2.

3.2. *Second: statistical analysis of marginal bone loss*

Regarding MBL during follow-up periods, group (1) showed a significantly less amount of bone loss from 0- to 3- and 6-month intervals (−0.08 ± 0.05 and −0.18 ± 0.08) than group (2), (−0.68 ± 0.17 and −1.02 ± 0.25), respectively, ($P = 0.000$) ($P = 0.000$), Table 3.

Table 1. Descriptive statistics and results for comparison between mean stability in two groups (independent t-test) and significance of change by time within each group (repeated measures ANOVA).

Stability	Group (1) Mean ± SD	Group (2) Mean ± SD	P value
Primary stability	76.17[c]±1.47	76.33[b] ± 1.51	0.85 ns
0 months	85.02[b] ± 1.06	85.52[a]±1.30	0.776 ns
3 months	85.08[b] ± 1.47	84.07[a]±1.24	0.225 ns
6 months	87.08[a]±1.36	83.23[a]±0.97	0.000*
P value	0.001*	0.000*	

Significance level ($P \leq 0.05$), *significant; ns; nonsignificant ($P > 0.05$).
Post hoc test: within the same column, means sharing the same superscript letter, are not significantly different.

Table 2. The amount of change in stability by time (independent t-test).

Difference in Stability	Group (1) Mean ± SD	Group (2) Mean ± SD	P value
Primary to 0 month	9.55 ± 2.02	9.18 ±.69	0.683 ns
Primary to 3 months	8.92 ± 2.52	7.73 ± 1.17	0.322 ns
Primary to 6 months	10.92 ± 2.11	6.90 ± 1.20	0.002*

Significance level ($P \leq 0.05$), *significant; ns; nonsignificant ($P > 0.05$).

Table 3. The amount of change in marginal bone loss by time (independent t-test).

Marginal bone loss	Group (1) Mean ± SD	Group (2) Mean ± SD	P value
0–3 months	−0.08 ± 0.05	−0.68 ± 0.17	0.000*
0–6 months	−0.18 ± 0.08	−1.02 ± 0.25	0.000*

Significance level ($P \leq 0.05$), *significant; ns; nonsignificant ($P > 0.05$).

4. Discussion

The use of short implants has several benefits, including simplicity in handling, less surgical invasiveness, and a minimal chance of damaging important anatomical structures, supporting the idea of 'stress-minimizing surgery'.

However, due to the increased crown-to-implant ratio and smaller bone-to-implant contact area compared with longer fixtures, short implants are not without dangers and difficulties. It can occasionally be linked to osseointegration loss, which first manifests as peri-implantitis and MBL [6].

Therefore, this study aimed to compare stability and MBL of posterior screw-retained customized PEEK abutments/crowns to prefabricated abutments/PFM crowns supported by short implants.

Titanium is the most preferred material for the fabrication of implant abutments despite its hypersensitivity and susceptibility to corrosion. However in cases where esthetic is in high demand, no completely satisfactory result is achieved with titanium implant-abutments. The titanium and its alloys change the color of marginal peri-implant tissue and show grayness through the gingiva [7]. With the introduction of ceramic-reinforced PEEK (Bio-HPP), it became possible to use PEEK as a definitive implant abutment [8].

As a result, PEEK was selected as the preferred material in the current study to fabricate implant superstructures since it has superior mechanical qualities and is lighter than traditional materials. PEEK material has an elastic modulus that is comparable to human bone tissue (14 GPa), which has the effect of dampening repairs and promoting stress shielding [9].In addition, the high mechanical property of PEEK makes it suitable for both abutment and prosthetic material. PEEK is an ideal abutment material as it meets all mechanical, biological, and esthetic expectations [7]. Therefore, it was important in this study to compare PEEK abutments with gold-standard prefabricated titanium ones.

In this study, all prefabricated titanium abutments used were straight abutments as prosthetic complications, such as screw loosening and abutment loosening, were more frequent after 1 year of follow-up, for implants supporting angulated abutments. The later were frequently associated with significantly more MBL than those supporting straight abutments [10].There was a study that reported increased abutment angulations result in the placement of a greater amount of stress on prostheses and the surrounding bone than that associated with straight abutments [11].

Moreover, screw-retained crowns were fabricated because screw-retained restorations clinically perform better than cement-retained ones in terms of their periodontal pocket depth and retention [12]. The major advantage of screw-retained restorations is retrievability, as the crowns could be easily removed to record implant stability at different follow-up intervals of the study.

In this study, a digital periapical radiograph was used to determine the MBL at the distal and mesial locations of implants. Two-dimensional radiographs may appear to have their limits, but it was still possible to distinguish between the effects of customized and prefabricated abutments on marginal bone levels. Periapical radiographs, which are one of the major weaknesses of the current investigation, are not the gold standard for evaluating marginal bone. However, it has been discovered that when standardization and regional distortion rates are controlled, digital periapical radiographs provide an efficient way to measure bone height [13].

At 3- and 6- month intervals, the results of the present study revealed the implant stability of customized PEEK abutments/crowns was higher than that of prefabricated titanium abutments/PFM crowns. The difference was insignificant at 3-, and significant at 6- month intervals, Table 1. Therefore, the 1st part of the study hypothesis was rejected. Regarding the change in implant stability over time, the customized PEEK abutments/crowns showed a significantly higher increase from primary stability to 6-month intervals than prefabricated abutments/PFM crowns, Table 2.

The insignificant difference between groups in primary stability may be related to the quality of bone and insertion torque. The density of the bone in all patients included in this study was type II or III to get the best result of primary stability and high insertion torque. These findings come in agreement with a study [14] which stated that the type of bone affected the primary and secondary stability of short dental implants. Implants placed in sites of poor bone showed the lowest primary and secondary stability.

The significantly higher secondary stability of customized PEEK abutments/crowns compared with titanium abutments/PFM crowns could be explained by the great relationship between implant stability and abutment material.

The material tested in the present study was PEEK which has a shock-absorbing effect. It was found that the choice of abutment material and design influences implant stability as reported in previous studies [15,16]. In 2022, a systematic review revealed that the material and geometric design of implant parts like abutments, screws, and threads affect how much stress is placed on the implant and the surrounding bone, which affects the stability of the implant over time. Therefore, attempts to improve stress distribution have been the subject of some research in this area [17].

In addition, the customized abutment has an excellent finishing line, thus avoiding sharp edges. Customized abutments also create a natural emergence profile between implants and crowns, allow for better hygiene and better alignment with angled implants, and provide a biological advantage as they support and interact with the soft tissues, unlike stock abutments, in which it is the crown that performs this function [18].

On the other hand, the results didn't agree with study that found no significant difference in Implant Stability Quotient (ISQ) values of titanium abutments and PEEK abutments with a slight increase in the ISQ value of PEEK abutments. This controversy may be due to the short time intervals of their study (initial, 1, and only 3 months) [19].

Regarding MBL, group (1) showed a decreased MBL by time, which was significantly lower than group (2), Table 3. Consequently, the second part of the study hypothesis was rejected.

These findings may be attributed to the high biocompatibility of PEEK which enhances the preservation of bone height and soft tissue stability. The results agree with previous studies in which PEEK abutment showed a significant less MBL over time [20−22].

This result was supported by another study [19] which discovered that PEEK abutment groups exhibited less MBL than titanium abutment groups and explained this discovery by the fact that PEEK material has an elastic modulus that is similar to bone. As a result, part of the forces applied to it are absorbed by it (shock absorber effect), reducing the strain on the bone and resulting in less bone resorption. Rigid structures promote bone resorption by directly transmitting loading onto the bone. However, a systemic review [23] reported that there were no significant differences in MBL when titanium abutments were compared with different abutment materials, they concluded that the abutment material had minimal impact on marginal bone levels.

Also, the results agree with studies [24,25] which revealed that PEEK abutment is considered a better alternative to titanium abutment about hard tissue response in addition to having a good role in occlusal force distribution, as the MBL was reduced with PEEK abutment than titanium abutment. This was explained by the PEEK material forms less biofilms on its surface than traditional Ti and ZrO_2 abutments. No proof of PEEK's mutagenic or cytotoxic action on human cells or organisms has been found in in vitro research. Additionally, studies on the in vitro cellular biocompatibility of carbon fiber-reinforced PEEK have also shown good performance. Furthermore, there was no toxic injury to fibroblasts or osteoblasts, according to *in vivo* investigations on bone and soft tissue biocompatibility [26].

In contrast there was a study that found no significant difference in tissue response between PEEK and titanium [27]. This may be related to the short follow-up period of this study (only 3 months). In addition, the research found a statistically significant difference regarding plaque accumulation between PEEK and titanium abutments (20.5% vs. 40.9%) at 2-week examination and this may cause tissue inflammation over time if the follow-up period was increased.

Similarly, another study showed a similar soft tissue response of PEEK superstructure compared with titanium, and histological data did not reveal early signs of elevated inflammation caused by PEEK abutments. Also, no change in radiographic pictures between PEEK and titanium abutments was found. Yet, this study conducted a short observation period and a small sample size [28].

Moreover, the abutments tested in the group (1) were customized. In addition to the natural emergence profile between implants and crowns which allows for better hygiene, it was reported that customized abutments are related to better interproximal papillae stability and marginal bone level than prefabricated ones [18,29,30]. Conversely, a study [31] and a systematic review [32] stated that no difference between customized and prefabricated abutments in probing depth and marginal bone level. This contradiction may be related to the different construction materials.

It was noted that the bone level varied between intervals, providing evidence of the occurrence of bone remodeling, which begins 1 month following functional loading. Additionally, group (2) lost much more bone than group (1), but the trend of bone loss itself was moderate, no rapid or massive loss was found for any period and there was no sign of failure in any group at any time interval.

The present study is not free from limitations, the main limitation was that MBL was assessed using a digital periapical radiograph, which is two-dimensional. However, it has been found that digital periapical radiographs are an effective method to evaluate bone height when standardization and regional distortion rates are controlled.

4.1. Conclusions

Within the limitations of this study, the following could be concluded:

(a) Customized posterior PEEK abutments/crowns supported by short implants have a significant favorable effect on stability over time.
(b) MBL around short implants supporting customized PEEK abutments/crown decreased over time indicating a favorable response.

4.2. Recommendations

More *in vivo* studies are needed on PEEK as an alternative material for existing titanium abutments to evaluate the clinical performance of PEEK, tissue reactions toward it for a long period of time, and patient satisfaction.

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Ethical statement

Approval of the Faculty of Dental Medicine for Girls, Al-Azhar University Research Ethics Committee (REC), under code: REC-CR-23-02.

Conflict of interest

There are no conflicts of interest.

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