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CLINICAL EVALUATION OF PLATFORM SWITCHING IMPLANT ABUTMENTS RESTORED BY TWO METAL FREE RESTORATIONS (IN-VIVO STUDY)

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ABSTRACT

Objective: The objective of this study was to evaluate the clinical effect of two abutment materials with two different types of superstructure metal-free restorations on platform switched implant. **Subjects and Methods**: Twenty human patients with a missing maxillary central incisor were selected for implant placement and divided randomly into two groups according to abutment type; Titanium abutment and PEEK abutment (n= 10 each). Each group was subdivided into two subgroups according to type of superstructure crown (PEEK and VITA ENAMIC crowns, n=5). All groups were evaluated clinically through measuring implant stability, determining screw loosening and color stability at base line, 3, 6 and 12 months. **Results**: regarding implant stability, there was no significant difference between the four subgroups, Ti PEEK, Ti VIT, PEEK PEEK and PEEK VIT (73.40 ± 3.44, 73.80±2.17, 76.0±1.87, 73.40 ± 2.30). There was no screw loosening of all tested groups. PEEK VIT group showed the highest color change among all groups but the change is not significant. **Conclusion**: PEEK abutment with PEEK crown gives better results, however, implant stability is comparable with other groups. No screw loosening occurred in all groups. Color stability was better when a titanium abutment was used, however the difference between all groups was non-significant. VITA ENAMIC crowns with PEEK abutments showed the highest color change, still the difference was not significant.

KEYWORDS: Implant stability, abutment, PEEK, color stability, VITA ENAMIC

INTRODUCTION

Dental implants are one of the most exciting treatments in modern dentistry. Unlike crowns, bridges or veneers, which attach to existing teeth, dental implants replace lost or damaged teeth entirely by connecting a fixture directly into the jawbone by osteointegration, then attaching a fully functional, esthetic tooth-like restoration [(1)].

Titanium (Ti) and its alloys have been used as dental implants since Brånemark introduced them at the end of the 1960s [(2)]. Titanium materials possess good physicochemical characteristics, mechanical properties, biocompatibility, and high resistance to fatigue stress and corrosion [(3,4)]. However, Ti materials have an elastic modulus significantly higher than that of bone (titanium: 110 GPa; cortical bone: 14 GPa), and the difference may result in inadequate stress shielding, bone resorption, and implant fracture [(5,6)]. In addition, certain studies have shown that titanium is an allergen that can cause allergic reaction to some patients [(7)].

Poly ether ether ketone (PEEK) has some clinical advantages as a dental implant material compared to

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Ti. Firstly, it causes fewer hypersensitive and allergic reactions. Secondly, it is radiolucent and causes fewer artifacts on magnetic resonance imaging[5,8]. Thirdly, it does not have a metallic color; it is beige with a touch of gray, and has a more aesthetic appearance than Ti especially in the anterior zone. Fourthly, PEEK is a versatile foundation material that can be tailored to a particular purpose by changing its bulk or surface properties. PEEK can be applied as an implant material in the implant body, abutment, and superstructure [8].

Vita Enamic is a member of the hybrid ceramics group. The ceramic part consists of an aluminum oxide-enriched, fine-structure feldspar matrix (86wt.%) infused by a polymer material consisting of (14wt.%) urethane dimethacrylate and triethylene glycol dimethacrylate. It has flexural strength of 151 MPa.[9] Both advantages of ceramic and resin materials are combined in ceramic/polymer materials such as less brittleness, excellent machinability and edge stability.[9]

The concept of platform-switching (PS) is based on the placement of a narrow diameter abutment on a wider diameter implant. Implants placed according to this concept have implant abutment junction placed closer to the center of the implant [10].

Stability of dental implant is considered a fundamental prerequisite for implant success at the time of insertion and following loading of the implant. To evaluate the initial bone quality and the degree of osseointegration, various methods have been proposed [11], including histology and histomorphometry [12,13], removal torque analysis [14], pull and push through tests [15] and X-ray examination [16]. However, due to problems of invasiveness and inaccuracy, these methods are not suitable for long-term clinical assessment. To overcome these problems, a non invasive device to evaluate the conditions of implant bone interface in vivo, a new device OsstellTM (W&H group Gothenburg, Sweden) based on Resonance Frequency Analysis (RFA) was developed [11]. The use of transducer probe that can be directly attached to an implant body or to the abutment on the implant represent RFA values which have been correlated with changes in implant stability during osseous healing, failure of implants, and the supracrestal dimensions of the implant and given a wide range of values [17].

Vita Easyshade Compact (Vita Zahnfabrik, Germany) is a cordless, small, portable, cost efficient, battery operated, contact type spectrophotometer that provides shade information to help aid in the color analysis process. Different measurement modes are possible with Easyshade Compact: tooth single mode, tooth area mode (cervical, middle and incisal shades), restoration color verification (includes lightness, chroma and hue comparison) and shade tab mode (practice/training mode) [18,19].

Therefore, the hyposis of this study is that the type of implant abutment with two superstructure metal free restoration (crowns) has an effect on implant stability, screw loosening and color change of the restoration.

SUBJECTS AND METHODS

This study included twenty systemically healthy patients (12 females and 8 males, ranged in age from 20-50 years with mean age of 35.5 years) with a missing anterior maxillary central incisor requesting (3.75*11) implant placement. All patients were selected from those attending at the Out-Patient Clinic, Oral Medicine and Periodontology Department, Faculty of Dental Medicine, Al-Azhar University.

Inclusion criteria: Patients' being free from any systemic disease, of both sexes, absence of any infection or periodontitis in the area that will receive the implant**.**

Exclusion criteria: Patient without any major or minor systemic diseases, Pregnancy, Patients with parafunctional habits, Poor oral hygiene, lack of motivation, and Smokers.

Ethical Consideration: Patients enrolled in this study signed in written consent form and acceptance from the ethical committee with the reference number 533/1604.

Patients are randomly classified into 2 groups (n=10) according to the material type of the platform switched abutment:

1st group: Titanium abutment (Ti) (Flotecno implant system, Itay).

2nd group: Polyetheretherketone abutment (PEEK) (Bredent, Germany)

Each group will be subdivided into two subgroups (n=5) according to superstructure crown materials into:

(A) PEEK superstructure (Bredent, Germany) crown groups with titanium and peek abutment (Ti PEEK, PEEK PEEK)

(B) VITA ENAMIC superstructure (VITA Zahnfabrik, Germany) crown groups titanium and PEEK abutment (Ti VIT,PEEK VIT).

Pre-surgical Evaluation:

Preoperative Computed Tomogram Scanner (Siemens SOMATOM Scope 16-Slice computed tomogram Scanner® Siemens, Erlangen, Germany) was carried out to the patients before the intervention to assess bone quality, quantity and density, to quantify the ridge height and width of the supporting bone. Oral hygiene measurements, instructions and reinforcement were performed at the end of the appointment.

Surgical procedures:

The preoperative medications included the patient rinsed with Chlorhexidine gluconate 0.1% to reduce the bacterial load. Local anesthesia was administrated as following; the surgical site was anesthetized using Mepecaine®-L 2% (Alexandria Co.For Pharmaceuticals, Alexandria, Egypt). A surgical stent was used as a surgical guide during sequences of drilling, and full thickness flap reflection of the labial and palatal mucoperiosteal flap was done, Pilot drilling for the most correct anatomical positioning of the planned dental implants. Preparation of the implant site continued with the continuous drilling until final drill, then insert the fixture of the implant 3.75*11 mm. Standard implant is placed in the site, the implant shoulder to be located at the bony level and reevaluate by periapical radiograph .The final wound closure performed by interrupted 0/3 non resorbable sutures. Sutures were removed between 10 and 14 days after surgery. 3 months later, which represents the healing period, patients were called back for the second stage surgery. Healing abutments were tightened for 15 days. Afterwards the final abutment was placed and checked to evaluate the need to use angled abutments or not in addition to evaluation of implant abutment connection. Closed tray impression technique was done using additional silicone material (Elite HD, Zhermack, Badia Polesine, Italy), through impression post and analog to transfer the hard and soft tissue relationship to the laboratory technician for fabrication of superstructure crowns.

The final crown (PEEK or VITA ENAMIC) for each case was examined intraorally, both clinically and radigraphically. Clinical evaluation was to check the seating of the crown margin, occlusion, anatomical features, contours, and color matching. Radiographic evaluation was done to check marginal adaption between abutment finish line and margin of the restoration, and removal of excess cement after cementation of final crown. Cementation of the final crown was done using a long term provisional cement Provitemp (Itena, France).

Implant stability was assessed using Osstell ™ (W&H group Gothenburg, Sweden). Measurements were taken twice in the buccolingul direction as well as in the mesiodistal direction. The mean of all measurements was rounded to the nearest whole number and was regarded as representative of the ISQ. This step is repeated at each follow up at the base line, 3, 6, and 12 months.

FIG (1) Upper right central incisor with VIT ENAMIC crown

FIG (2) Upper left central incisor with PEEK crown

Screw loosening determination:

The connection screw was determined clinically with the use of the screw driver and checking for any loosens at each follow up periods.

Color stability:

Before doing any color measurements, each crown in each of the twenty patients participating in the study was polished to remove any accumulated extrinsic stain. An intraoral spectrophotometer VITA Easyshade® Advance 4.0 (VITA Zahnfabrik, Germany) was used to capture CIELAB color coordinates. Color quantification was based on CIE Lab values. Colour differences (DE) were calculated using the formula:

$$DE = \sqrt{((L1 - L2)2) + (a1 - a2)2 + (b1 - b2)2}.$$

Statistical analysis:

Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level.

RESULT

Implant Stability

Regarding Ti PEEK, mean stability was at baseline 68.60±3.21, at 3 months 69.80±3.27, at 6 months was 71.40±2.88, and at 12 months was 73.40±3.44. The difference was statistically significant. Mean stability increased significantly from baseline to 12 months.

Regarding Ti VIT, mean stability at baseline was 68.40 ± 1.82, at 3 months 69.60 ± 2.07, at 6 months 71.20±1.79, and at 12 months 73.80 ± 2.17. The difference was statistically significant. Mean stability increased significantly from baseline to 12 months.

Regarding PEEK PEEK, mean stability was at baseline 70.60±1.52 at 3 months 71.80±1.64, at 6 months was 73.60±1.82, and at 12 months was 76.0±1.87. The difference was statistically significant. Mean stability increased significantly from baseline to 12 months.

Regarding PEEK VIT, mean stability was at baseline 68.60±2.51 at 3 months 68.60±2.51, at 6 months was 71.20±2.39, and at 12 months was 73.40±2.30. The difference was statistically significant. Mean stability increased significantly between from baseline to 12 months, however, at baseline to 12 months, the difference was statistically non-significant in all groups. Table (1) and Figure (3).

TABLE (1) Comparison between the four studied groups according to stability

	Ti PEEK (n = 5)	Ti VIT (n = 5)	PEEK PEEK (n = 5)	PEEK VIT (n = 5)	F	p
Stability						
Baseline	68.60 ± 3.21	68.40 ± 1.82	70.60 ± 1.52	68.60 ± 2.51	0.970	0.431
3 months	69.80 ± 3.27	69.60 ± 2.07	71.80 ± 1.64	69.40 ± 2.41	1.052	0.397
6 months	71.40 ± 2.88	71.20 ± 1.79	73.60 ± 1.82	71.20 ± 2.39	1.337	0.298
12 months	73.40 ± 3.44	73.80 ± 2.17	76.0 ± 1.87	73.40 ± 2.30	1.231	0.331

Data was expressed by using **Mean ± SD.** **F*: F for ANOVA test***

p: p value for comparing between the studied groups

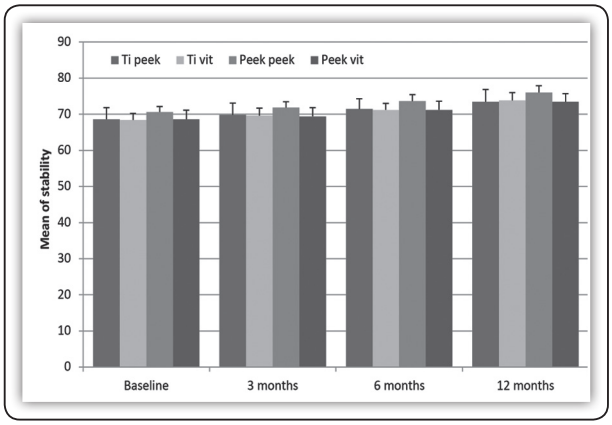

FIG (3) Comparison between the four studied groups according to stability

Color stability

Regarding Ti PEEK, mean 3–6 months DE was 1.81±0.55, and 3–12 months DE was 2.10 ± 0.51. the difference was statistically non-significant. Regarding Ti VIT, mean 3–6 months DE was 1.37±0.56, and 3 – 12 months DE was 2.14 ± 0.87. the difference was statistically non-significant. Regarding PEEK PEEK, mean 3–6 months DE was 1.99 ± 0.80, and 3 – 12 months DE was 2.27 ± 0.38. the difference was statistically non-significant. Regarding PEEK VIT, mean 3–6 months DE was 2.44 ± 0.33 , and 3 – 12 months DE was 2.84 ± 0.74. the difference was statistically non-significant. So, At 3-6 months DE the difference was statistically non-significant and at 3-12 months DE, the difference was statistically non-significant. Tab (2) Fig (4)

TABLE (2): Comparison between the four studied groups according to color change

Color change	Ti PEEK (n = 5)	Ti VIT (n = 5)	PEEK PEEK (n = 5)	PEEK VIT (n = 5)	F	P
3-6 months delta E	1.81 ± 0.55	1.37 ± 0.56	1.99 ± 0.80	2.44 ± 0.33	2.928	0.066
3-12 months delta E	2.10 ± 0.51	2.14 ± 0.87	2.27 ± 0.38	2.84 ± 0.74	1.390	0.282

Data was expressed by using **Mean ± SD.** **F*: F for ANOVA test***

p: p value for comparing between the studied groups

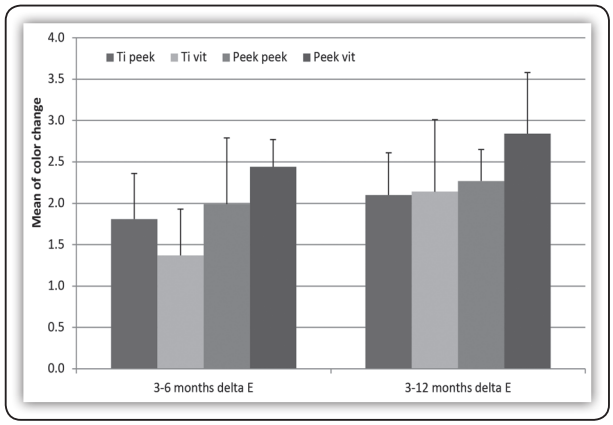

FIG (4) Comparison between the four studied groups according to color change

DISCUSSION

The occlusal forces are transmitted to the prosthesis, implant, and the bone around the implant, respectively. Therefore, the direction and amount of the load; the prosthetic material; the design of the prosthesis; the implant material; the design of the implant; the number of implants; and the mechanism of bone implant interface, bone type, and bone characteristics can be listed as factors affecting the load on the bone [20,21]. Prosthetic design and material selection affect the distribution of stress on prosthetic structures, implants, and bones. These stresses can lead to bone resorption around the implant and loss of implants [20, 22].

One of the most important features of PEEK material is low elastic modulus like the bone. Due to this feature, the material is considered to be used in fixed prosthetic treatments [23]. PEEK is a very light[24] flexible, and hard to break material. The PEEK material's cost efficiency and its feature of easy to be processed in the mouth also support its use [25]. In our study two different types of abutments were used, Ti and PEEK abutments, on which two different resilient crown materials (PEEK and VIT ENAMIC) were cemented. All tested groups showed no significant difference of the implant stability during follow up periods as from baseline to 12 months, however the PEEK PEEK group was recorded the highest value of implant stability during follow up period. This may be due to the closeness of the modulus of elasticity of PEEK to that of bone which play an important role of favorable occlusal force distribution in addition to it act as shock absorbent.

Tekin et al approved the use of PEEK crowns to reduce the stress on the implant itself and abutments. When a PEEK crown was used on titanium abutments, the stress on screw was decreased and when it was used on PEEK abutment, the stress was increased. It was known that the use of PEEK material reduced the stresses resulting from the applied forces on itself. Because of its low solubility in water and low reactivity with other substances, PEEK may also be suitable for patients with metal allergy or susceptibility to metallic taste [26].

One of the problems that face hybrid ceramics is its questionable long term color stability. Its discoloration may be endogenous or exogenous [27]. This is also recorded with the final result of our study that the crowns of VITA ENAMIC either with titanium or peek abutment, had a higher color change than PEEK crowns within the follow up period, but the difference was statistically non-significant. However these change of color located within clinical acceptance range as stated by Johnston WM established $\Delta E=3.7$[28].

In a previous study, VITA ENAMIC was reported to be a good choice for anterior restorations that closely matched neutral tooth color [29]. In Enamic, the ceramic network material is infiltrated with urethane dimethacrylates (UDMA) and triethylene glycol dimethacrylate (TEGDMA) mixture [30]. Because TEGDMA has higher water absorption, staining agents penetrate more easily the resin matrix. Therefore, the stainability of VITA ENAMIC may be due to the TEGDMA content [31].

Regarding screw loosening, there was no cases recorded in this study with looseness of the screw. This may be due to the use of platform switch implant with internal hex and tighten the screw with adequate torque according to manufacture

instructions. So, the hypothesis of the this study was the implant stability screw loosening and color change will be affected by PEEK or titanium abutment was rejected.

The limitation of the present study is that short follow up period and color measurement was done with limited standardization. So the future study needed longer follow up period and may use more than two type of abutments and crowns.

CONCLUSION

Within the limitation of this study it can concluded that PEEK abutment with PEEK crown gives better result but in general implant stability, however, it was still comparable with other groups. No screw loosening occurred in all groups. Color stability was better when titanium abutments were used, however the difference between all groups was non-significant. VITA ENAMIC crown with PEEK abutment showed the highest color change, however the difference was still non-significant.

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