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CLINICAL AND RADIOGRAPHIC OUTCOMES ON SUPPORTING TISSUES OF TWO IMPLANTS RETAINED COMPLETE MANDIBULAR OVERDENTURE WITH ZIRCON- PEEK VERSUS COBALT CHROMIUM -PEEK TELESCOPIC ATTACHMENTS

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ABSTRACT

Objectives: The aim of the present study was to evaluate outcomes on supporting tissues of two implant retained complete mandibular overdenture with zircon-PEEK versus cobalt-chromium- PEEK telescopic attachments. **Subjects and Methods:** Twelve completely edentulous patients were randomly put into two groups: Group **I:** patients with zirconia as primar3y copings and PEEK as secondary copings in telescopic attachments. **Group II:** patients with cobalt-chromium as primary copings and PEEK as secondary copings in telescopic attachments. Peri-implant bone level changes and mandibular alveolar bone height changes around implants were examined at four sites (mesial, distal, buccal, and lingual) regarding the modified gingival index. **Results:** In both the cobalt and zirconia groups, there was a statistically significant increase in bone loss at the mesial and distal surfaces of right and left implants ($p \leq 0.05$).On the right side at (T0: immediate, T6: 6th month, and T12: 12th month), there was a statistically significant difference between the two studied groups according to bone loss at mesial and distal surfaces ($p \leq 0.05$). The zirconia group showed lower bone loss than the cobalt group. On the left side at (T6: 6th month), the zirconia group showed lower bone loss than the cobalt group. At T12: 12th month, there was a statistically significant difference between the two studied groups according to bone loss at mesial and distal surfaces ($p \leq 0.05$), with the zirconia group showing lower bone loss than the cobalt group. There was a statistically significant difference in gingival index at buccal, lingual, mesial, and distal surfaces of right and left implants ($p \leq 0.05$). **Conclusion:** Implant overdentures can be retained by zirconia-PEEK telescopic attachments, which can reduce the stress on the implants by utilizing the stress-breaking ability of PEEK.

KEYWORDS: Bone loss, modified gingival index, retention.

INTRODUCTION

Many completely edentulous patients have difficulty wearing conventional complete dentures due to poor support and retention. These problems may lead to a reduction in quality of life by adversely affecting both oral and general health.

Implant-supported mandibular overdentures offer many advantages over conventional dentures for edentulous patients, such as reduced bone loss, better prosthesis retention and support, and improved quality of life, function, chewing, nutrition, and overall health [(1)]. Different types of attachments can

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be used to connect the implants and the prosthesis, such as studs, bars, magnets, and telescopic crowns. These attachments influence the retention, stability, and function of the prosthesis [2–4].

Telescopic crowns consist of inner and outer copings that can be made of various materials, such as cobalt-chromium (CoCr), zirconia, and PEEK[5]. CoCr is a precise, strong, and elastic material suitable for double crowns[6]. Zirconia copings can provide retention for telescopic crowns and exhibit good mechanical properties in fixed restorations. CAD/CAM technology has improved the quality of zirconia copings[7]. PEEK is a suitable material for removable prostheses and telescopic crowns placed on zirconia copings. It can be used in CAD/CAM systems and has better mechanical properties than acrylic[8].

The aim of the present study was to evaluate the clinical and radiographic outcomes on supporting tissues of two-implant retained complete mandibular overdentures with zirconia-PEEK versus cobalt-chromium–PEEK telescopic attachments.

SUBJECTS AND METHODS

Study design and setting

An interventional study (controlled clinical trial) was conducted on twelve completely edentulous patients who were randomly selected from the Outpatient Clinic, Department of Removable Prosthodontics, Faculty of Dental Medicine, Al-Azhar University (Boys, Cairo), according to the following criteria:

Eligibility criteria of population

Inclusion criteria:

The patients were selected according to the following criteria:

They had completely edentulous ridges, free from any systemic diseases that may affect bone resorption. The mandibular residual alveolar ridge had suitable height and width, and was covered with healthy, firm mucosa. Patients had sufficient inter-arch space. They had Angle Class I maxillo-mandibular skeletal relation.

Exclusion criteria:

Patients with local or systemic diseases that interfere with implant placement and osseointegration. Patients with a history of drug therapy that interferes with bone resorption or deposition. Immunocompromised patients and those currently undergoing chemotherapy or radiotherapy. Patients with abnormal jaw relationships. Patients with parafunctional habits. Patients with inadequate inter-arch space. Patients unable or unwilling to return for follow-up visits. Patients with an infection or disease in the area where the implant would be placed, either currently or in the past.

Patient approval

All participants signed a written consent form after being informed in detail about the treatment plan. The ethical committee of the Faculty of Oral and Dental Medicine at Al-Azhar University approved the study protocol under code no. (738/4362).

A) Prosthodontic phase of treatment:

Each patient received an acrylic complete upper and lower denture. The denture was inserted into the patient's mouth after finishing and polishing. Esthetics, retention, stability, occlusion, high spots, and any potential sources of pain, such as sharp edges or overextensions, were checked.

B) Surgical phase of treatment:

Patients were instructed to rinse their mouths with 0.25 mg/ml Chlorhexidine for about 1 minute. Intraoral and extra oral scrubbing was performed using gauze soaked in Povidone-Iodine solution, followed by draping with sterile surgical drapes. Bi-mental nerve block and lingual infiltration anesthesia (Articaine hydrochloride 4% with epinephrine 1:100,000) was administered. After

achieving profound anesthesia, a crestal incision was made using a no. 15 scalpel on the crest of the ridge at the canine–premolar region for all patients (Fig. 1a). A periosteal elevator was used to elevate the periosteum and reflect the flap (Fig. 1b). Drilling was performed using an electric motor under continuous saline irrigation. The first step of bone osteotomy involved using a small pilot drill (1.5 mm diameter), followed by a second drill (2.3 mm diameter). The drilling sequence was performed according to the manufacturer's instructions.

The final drilling was done with the surgical drill that matched the selected implant. The diameter, direction, and angulation of the drill were verified by x-ray and paralleling pin. The implant (Oxy Implant System, Italy) was taken out of the sterile vial and inserted under aseptic conditions. It was slowly threaded with a torque wrench until it was slightly below the ridge crest, with an insertion torque of 35–45 N/cm (Fig. 1c). Cover screws were placed on the implant fixtures (Fig. 1d), and the flap was repositioned and sutured (Fig. 1e).

Prosthetic phase

Mandibular overdenture construction:

Three months after implant installation, two small incisions were made at the site of the implants to expose the fixtures. The cover screws were unscrewed, and 2 mm-height healing abutments were screwed into the fixtures using a Hex Key (Fig. 1f).

The participants were given the following oral hygiene instructions: use a soft brush to gently clean the healing abutments, rinse the mouth with mouthwash, and carefully remove any plaque from the mucosa around the implants to prevent plaque buildup on the healing abutments.

After 10 to 14 days, the healing abutments were removed, and scan bodies were placed directly on the implants to perform a digital impression using an intraoral scanner.

Patient grouping:

After two weeks, the patients were randomly allocated into two groups according to the line of treatment (6 patients for each group):

- **Group I:** Patients with zirconia as primary copings and PEEK as secondary coping telescopic attachments.
- **Group II:** Patients with cobalt chromium as primary copings and PEEK as secondary coping telescopic attachments.

Primary Telescopic Crown Construction:

The primary crowns were designed with a common path of insertion using special software. The design parameters included a 6 mm height (2 mm parallel gingival height and 4 mm occlusal taper of 4°). The design data were sent to a milling machine connected to the CAD system to mill the primary crowns from semi-sintered zirconia (Zirconia Katana) in Group I and cobalt chromium in Group II, as shown in Fig. 1g & h. The line angles of the primary crowns were rounded and polished to eliminate edges and sharp corners. A special polishing paste (Spofa Dental, Kerr Company) was used to polish the primary crowns.

Secondary Telescopic Crown Construction:

The primary copings were checked intraorally and sprayed with a thin layer of scan spray on the outer surface. The cast and each primary coping were scanned separately to improve the data quality. The secondary crowns were designed with parallel walls and minimal wall thickness.

Mechanical projections were added to the design of the secondary crowns to facilitate mechanical interlocking with the denture base material. The design data were sent to the milling machine to mill the secondary crowns from PEEK (Predent PEEK, Germany).

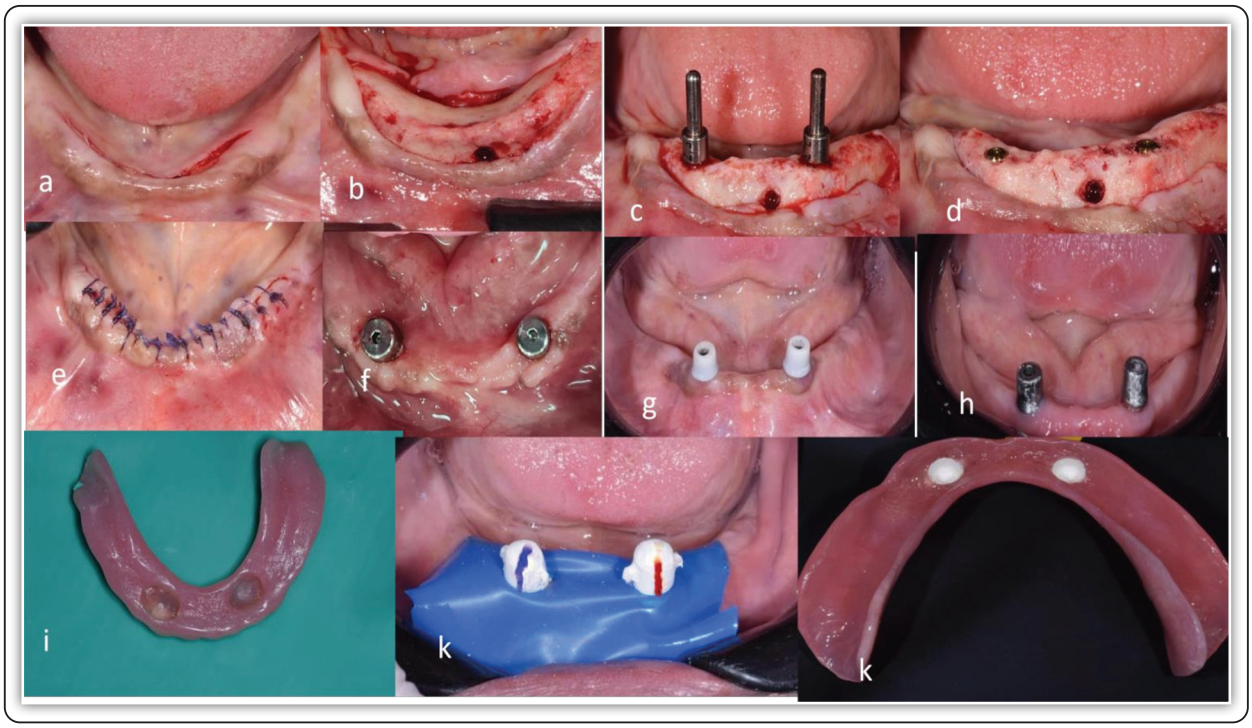

FIG (1) a, A crestal incision by a scalpel number 15, b, Reflection of the flap, c, Paralleling pin to check angulation of implants, d, Cover screw, e, Flab repositioned and sutured, f, Healing abutments attachments Construction, g, Zirconia primary crowns, h, Cobalt chromium primary crowns, i Venting holes were prepared in the fitting surface. j, Secondary copings over primary one in correct path of insertion before pick up procedure. (Pen color indicates the side and orientation of each coping), k, Direct incorporation of outer PEEK copings in the overdenture.

Pick-up of secondary crowns procedures:

Primary copings were cemented to the abutments and screwed into the implant fixtures. Venting holes were made in the fitting surface of the mandibular overdentures through the lingual flanges (Fig. 1i). The secondary crowns were fitted over the primary ones along the correct path of insertion (Fig. 1j) and attached to the fitting surfaces of the overdenture with auto-polymerized acrylic resin (Fig. 1k). The excess acrylic resin was removed with a diamond bur and polished.

Evaluation

Peri-implant bone level changes, mesial and distal vertical bone loss around implant and Implants were examined at four sites (mesial, distal, buccal& lingual) regarding modified gingival index.

Statistical analysis

Data were analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Quantitative data were summarized using range, mean and standard deviation. ANOVA with repeated measures and Post Hoc Test (adjusted Bonferroni) were used to compare different periods. Independent t test was used to compare groups. *: $p \leq 0.05$ was considered statistically significant.

RESULTS

Bone loss

TABLE (1) Comparison between the different time periods of cobalt group according to Bone loss at Right and left implant

Bone loss		T0		T6		T12		p	P1	P2	P3
		Mean	±SD	Mean	±SD	Mean	±SD				
Right implant	**Mesial**	0.20	0.21	0.55	0.05	1.15	0.38	0.001*	0.097	0.001*	0.003*
	Distal	0.45	0.38	0.80	0.21	1.20	0.10	0.001*	0.107	0.001*	0.056
Left implant	**Mesial**	0.15	0.05	0.30	0.10	1.25	0.05	0.001*	0.013*	0.001*	0.001*
	Distal	0.25	0.05	0.75	0.16	1.19	0.40	0.001*	0.001*	0.001*	0.001*

*p: p value for Post Hoc Test (***adjusted Bonferroni***) for ANOVA with repeated measures for comparing between different periods.*

T0: **Immediate** *T6:* **6th month** *T12:* **12th month**

p1: p value for comparing between **Immediate** *and* **6th month.** *p2: p value for comparing between* **Immediate and 12th month.** *p3: p value for comparing between* **6th month** *and* **12th month.**

**: Statistically significant at p ≤ 0.05*

TABLE (2) Comparison between the different time periods of zircon group according to Bone loss at Right and left implant

Bone loss		T0		T6		T12		p	P1	P2	P3
		Mean	±SD	Mean	±SD	Mean	±SD				
Right implant	**Mesial**	0.10	0.08	0.53	0.13	0.96	0.13	0.001*	0.001*	0.001*	0.001*
	Distal	0.20	0.15	0.36	0.22	0.60	0.23	0.016*	0.561	0.014*	0.216
Left implant	**Mesial**	0.16	0.13	0.33	0.13	0.83	0.20	0.001*	0.292	0.001*	0.001*
	Distal	0.16	0.18	0.36	0.05	0.73	0.05	0.001*	0.027	0.001*	0.001*

*p: p value for Post Hoc Test (***adjusted Bonferroni***) for ANOVA with repeated measures for comparing between different periods.*

T0: **Immediate** *T6:* **6th month** *T12:* **12th month**

p1: p value for comparing between **Immediate** *and* **6th month.** *p2: p value for comparing between* **Immediate and 12th month.** *p3: p value for comparing between* **6th month** *and* **12th month.**

**: Statistically significant at p ≤ 0.05*

TABLE (3) Comparison between the two studied groups according to Bone loss at Right implant

Bone loss	Right implant								P1	P2
	Cobalt				Zircon					
	Mesial		Distal		Mesial		Distal			
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD		
T0	0.20	0.21	0.45	0.38	0.10	0.08	0.20	0.15	0.325	0.169
T6	0.55	0.05	0.80	0.21	0.53	0.13	0.36	0.22	0.787	0.007*
T12	1.15	0.38	1.20	0.10	0.96	0.13	0.60	0.23	0.296	0.001*

Independent t test *for comparing between groups. T0:* **Immediate**

T6: **6th month**

T12: **12th month**

p1: p value for comparing **Mesial** *and* **Mesial.**

p2: p value for comparing **Distal and Distal.**

**: Statistically significant at p ≤ 0.05*

TABLE (4) Comparison between the two studied groups according to Bone loss at LEFT implant

Bone loss	Left implant								P1	P2
	Cobalt				Zircon					
	Mesial		Distal		Mesial		Distal			
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD		
T0	0.15	0.05	0.25	0.05	0.16	0.13	0.16	0.18	0.787	0.318
T6	0.30	0.10	0.75	0.16	0.33	0.13	0.36	0.05	0.651	0.001*
T12	1.25	0.05	1.19	0.40	0.83	0.20	0.73	0.05	0.001*	0.001*

Independent t test for comparing between groups. T0: **Immediate**

T6: **6th month**

T12: **12th month**

p1: p value for comparing **Mesial** and **Mesial.**

p2: p value for comparing **Distal and Distal.**

*: Statistically significant at p ≤ 0.05

Gingival index

TABLE (5) Comparison between the different time periods of cobalt group according to gingival index at Right and left implant

Gingival index		T0		T6		T12		p	P1	P2	P3
		Mean	±SD	Mean	±SD	Mean	±SD				
Right implant	Buccal	0.00	0.00	1.00	0.00	1.50	0.54	0.000*	0.000*	0.000*	0.046*
	Lingual	0.00	0.00	1.00	0.00	1.50	0.54	0.000*	0.000*	0.000*	0.046*
	Mesial	0.00	0.00	0.00	0.00	1.50	0.54	0.000*	1.000	0.000*	0.000*
	Distal	0.50	0.54	0.50	0.54	1.00	0.00	0.116	1.000	0.216	0.216
Left implant	Buccal	0.00	0.00	0.50	0.54	1.00	0.00	0.000*	0.046*	0.000*	0.046*
	Lingual	0.00	0.00	0.50	0.54	2.00	0.00	0.000*	0.046*	0.000*	0.000*
	Mesial	0.00	0.00	0.00	0.00	1.50	0.54	0.000*	1.000	0.000*	0.000*
	Distal	0.00	0.00	1.00	0.00	2.00	0.00	0.000*	0.000*	0.000*	0.000*

*p: p value for Post Hoc Test (***adjusted Bonferroni***) for ANOVA with repeated measures for comparing between different periods.*

T0: **Immediate** *T6:* **6th month** *T12:* **12th month**

p1: p value for comparing between **Immediate** *and* **6th month.** *p2: p value for comparing between* **Immediate and 12th month.** *p3: p value for comparing between* **6th month** *and* **12th month.**

**: Statistically significant at p ≤ 0.05*

TABLE (6) Comparison between the different time periods of zircon group according to gingival index at Right and left implant

Gingival index		T0		T6		T12		p	P1	P2	P3
		Mean	±SD	Mean	±SD	Mean	±SD				
Right implant	Buccal	0.00	0.00	0.00	0.00	0.33	0.52	0.116	1.000	0.216	0.216
	Lingual	0.00	0.00	0.33	0.52	0.66	0.52	0.048*	0.573	0.046*	0.573
	Mesial	0.00	0.00	0.66	0.52	0.66	0.52	0.022*	0.046*	0.046*	1.000
	Distal	0.00	0.00	0.00	0.00	0.33	0.52	0.116	1.000	0.216	0.216
Left implant	Buccal	0.00	0.00	0.33	0.52	0.33	0.52	0.315	0.573	0.573	1.000
	Lingual	0.00	0.00	0.00	0.00	0.33	0.52	0.116	1.000	0.216	0.216
	Mesial	0.00	0.00	0.00	0.00	0.66	0.52	0.002*	1.000	0.005*	0.005*
	Distal	0.00	0.00	0.00	0.00	0.33	0.52	0.116	1.000	0.216	0.216

*p: p value for Post Hoc Test (***adjusted Bonferroni***) for ANOVA with repeated measures for comparing between different periods. *: Statistically significant at p ≤ 0.05*

T0: **Immediate**

T6: **6th month**

T12: **12th month**

p1: p value for comparing between **Immediate** *and* **6th month.** *p2: p value for comparing between* **Immediate and 12th month.** *p3: p value for comparing between* **6th month** *and* **12th month.**

DISCUSSION

Peri-implant bone level is a key indicator of dental implant success; as pathological bone loss may compromise implant stability [9]. To maintain a stable marginal bone level, it is important to choose a well-documented implant design, control plaque, and avoid implant "overload." Good planning and proper case selection are essential [10]. Excessive forces on implant-supported prostheses can cause peri-implant bone loss if the host tissues cannot tolerate them. The stress is transferred from the prostheses to the implant-bone interface at the crestal level, resulting in the loss of osseointegration and/or crestal bone loss [11]. Two-implant-retained overdentures can create a bending moment on the implants due to the denture saddles, depending on the attachment system. The attachment design can significantly affect the stress/strain levels around implants. Therefore, a detailed analysis of attachment systems is important [12, 13].

The telescopic attachment-retained overdentures showed more vertical bone loss, which may be due to the height of the telescopic attachments, increasing the vertical cantilever and the stress on the implant. This is consistent with Heckmann et al. [14], who found that telescopic attachments experienced horizontal forces due to the forward movement of the mandibular overdenture under occlusal load. These forces could be higher in cases with resorbed residual ridges, leading to greater moment loads on the implants.

In the present study, a comparison between the two studied groups regarding bone loss at the right implant at 6 and 12 months showed a statistically significant difference at the mesial and distal surfaces ($p \leq 0.05$). The zirconia group showed lower bone loss than the cobalt group.

A study by Emera et al.[15] evaluated peri-implant bone level changes in two-implant-retained mandibular overdentures with zirconia-PEEK telescopic attachments. They found a significant vertical bone loss around the implants after 6 and 12 months of overdenture use, but it remained within the normal range for successful implants. They also found that the highest stresses on the framework materials were observed in the all-zirconia group, followed by the all-PEEK group, and then the zirconia-PEEK group.

Another study by Elshahawy et al. [16] compared the strain distribution of single-implant mandibular overdentures reinforced with cobalt-chromium or PEEK bars. They found that both materials reduced the strain on the implant and surrounding bone compared to non-reinforced overdentures.

They also found that the PEEK bar showed less strain than the cobalt-chromium bar, indicating better stress distribution and shock absorption.

This result may be due to the load-cushioning capacity of PEEK when combined with zirconia or cobalt-chromium [17]. The authors suggested that a combination of a hard and wear-resistant material for the first coping and a softer material for the second coping could improve performance. The first coping would undergo minimal changes, and the fit between the two copings would depend on changes in the second coping [18]. PEEK has a much lower elastic modulus (4 GPa) than zirconia (210 GPa), allowing PEEK restorations to behave like natural teeth by absorbing occlusal forces and wear. The normal range of marginal bone loss for successful implants in the first year is 1.5 mm. The median values of vertical bone loss around implants in this study varied from 0.10 mm to 0.35 mm, which is within the normal range [19, 20].

In the present study, a comparison between different time periods in the zirconia and cobalt groups according to the gingival index at right and left implants revealed a statistically significant difference in gingival index at the lingual and mesial surfaces ($p \leq 0.05$). The cobalt group showed more inflammation than the zirconia group after 6 and 12 months, which could be due to faster plaque

accumulation in the cobalt group, causing gingival inflammation. This was supported by the fact that there was no significant increase in gingival inflammation in the zirconia group from T6 to T12, but a significant increase occurred in the cobalt group during this period.

This may be related to the properties of zirconia, which has a smooth surface that makes it less prone to bacterial adhesion than cobalt-chromium (Co-Cr), which has a rough, hydrophobic, and highly charged surface that attracts bacteria. This was explained by Elsayed et al. [21], who suggested that zirconia copings could help maintain better oral hygiene than Co-Cr copings.

Previous studies also showed lower inflammation around implants and natural teeth and healthier gingival tissues with zirconia copings (22, 23). Other studies confirmed that zirconia has a lower tendency for bacterial colonization than other materials under investigation [21-24].

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