International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 8; Issue 07 (C); July 2019; Page No.19540-19546
DOI: http://dx.doi.org/10.24327/ijcar.2019.19546.3779

Research Article

CLINICAL OUTCOME OF TWO IMPLANTS RETAINED COMPLETE MANDIBULAR OVERDENTURE WITH ZIRCONIA-PEEK TELESCOPIC ATTACHMENT

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A R T I C L E I N F O

Article History:
Received 4th April, 2019
Received in revised form 25th May, 2019
Accepted 18th June, 2019
Published online 28th July, 2019

Key words:
Implants retained overdenture, Zirconia-PEEK telescopic attachment, Per-implant tissue health.

A B S T R A C T

This clinical study was conducted to evaluate peri-implant soft tissue health of two implants retained complete mandibular overdenture with Zirconia-PEEK telescopic attachment. Six completely edentulous patients of both sexes and average age of 60 years old were selected for this study. Each patient received two implants in the mandibular canine regions. Maxillary conventional complete dentures were constructed against mandibular implant retained over dentures for all patients. Zirconia-PEEK telescopic attachments were fabricated to retain the over dentures where primary crowns were made of zirconia and secondary ones were made of PEEK. Peri-implant soft tissue health (modified gingival index, modified plaque index and probing depth)was evaluated at the time of over denture insertion (T0), three months (T3) and six months later (T6).Results of this study revealed that, after 6 months of overdenture use, no statistically significant difference was found in all measured peri-abutment soft tissue health parameters. Within limitations of this study, it could be concluded that: zirconia-PEEK telescopic attachment may be considered as a biologically promising attachment system regarding preservation of peri-implant soft tissue health of implant retained overdentures.

INTRODUCTION

Conventional complete denture wearers experience a number of problems on a daily basis, such as instability of their mandibular dentures, inability to comminute foods , decreased self-confidence, decreased quality of life and decreased social contact and satisfaction(Emami, Heydecke *et al*. 2009). The use of implant-supported overdentures has improved outcomes for edentuolous patients compared to conventional dentures. These include, reduced residual ridge resorption and improved retention and support of prostheses that resulted in better quality of life, function, and general health (Abraham, Koka *et al*. 2010),(Abrahamsson, Wennström *et al*. 2017).

Previous studies recommended the use of removable prostheses with telescopic attachments fastened to natural teeth and/or implants for prosthetic restoration(Von Wowern and Gotfredsen 2001). These attachments allow for easy access for oral hygiene around the abutments as well as easy handling of the overdenture. The comparatively high retention obtained with them leads to good masticatory performance and phonetics. Therefore, they offer more advantages than other types of attachments(Hoffmann, Beaumont *et al*. 2006). While metal alloys are currently commonly used for telescopic crowns, their clinical use is limited to patients without metal allergies.

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In addition, some drawbacks and problems appeared when metal restorations were combined with other metals in the oral cavity as galvanic corrosion (Manicone, Iommetti *et al*. 2007).None of the problems associated with metal alloys was observed when the primary telescopic crowns were fabricated with a new tooth-colored CAD-CAM material like zirconia, the issue that became possible by the improvement in manufacturing techniques(Uludag, Sahin *et al*. 2008) .Its high biocompatibility, tooth color, and resistance to wear have promoted its usage in recent years (Beuer, Edelhoff *et al*. 2010, Engels, Schubert *et al*. 2013,Quinn, Studart *et al*. 2010, Choi, Kim *et al*. 2012, Chaar, Witkowski *et al*. 2013)

Rinke *et al*, (Rinke, Buergers *et al*. 2015) reported a successful function, high survival rates and rare biological complications of implant retained overdentures with telescopic zirconia primary copings and electroplated secondry copings over a prolonged period of time.

Another promising tooth-colored CAD-CAM material is polyetheretherketone (PEEK) which is a high performance thermoplastic polymer that consists of an aromatic backbone molecular chain, interconnected by ketone and ether functional groups. Its structure confers outstanding physical properties, biocompatibility and chemical resistance (Hoffmann, Beaumont *et al*. 2006). Recent studies concluded that PEEK is a suitable material for fabrication of double crown attachments(Stock, Schmidlin *et al*. 2016).

A new concept could be the combination of these two biocompatible materials, i.e., zirconia and PEEK in order to produce metal-free restoration such as telescopic crowns (Merk, Wagner *et al*. 2016)(Emera , Elgamal *et al*, 2019, Emera, Abdelkhalek *et al*, 2019, , Merk, Wagner *et al*. 2016, Emera, Altonbary *et al*, 2019, Schubert, Reitmaier *et al*. 2019). Reviewing the literature, very rare data is available about the clinical performance of telescopic attachments with these two materials. Consequently, the aim of this study was to evaluate peri-implant soft tissue changes of two implants retained complete mandibular overdenture when using Zirconia –PEEK telescopic attachment.

MATERIAL AND METHODS

Six healthy completely edentulous patients of age ranging from 40 to 60 years of both sexes were selected for this study from the out patients 'clinic, Faculty of Dentistry, Mansoura University. Inclusion criteria were adequate residual alveolar bone quantity and quality as verified by cone beam CT, suitable restorative space, and normal maxilla-mandibular relationship (Angle's class I). Exclusion criteria were local inflammation or or systemic diseases that interfere with surgical implant procedures, bone metabolic disorders e.g. uncontrolled diabetes or osteoporosis, history of chemotherapy or radiotherapy to the head and neck region and history of parafunctional habits. This research protocol was approved by the Faculty Ethical Committee.

Pre-surgical procedures

- Conventional maxillary and mandibular dentures were constructed for each patient.
- Stereolithographic surgical guide template was constructed using dual scan technique as follows :(Fig1).

Fig 1 CAD-CAM generated Stereo lithographic surgical guide for implant placement.

1. The mandibular denture was prepared for the cone beam CT scan by attaching guttapercha, radiopaque markers, to act as reference points and extraoral scanning was done.
2. Each patient was exposed to cone beam CT scan wearing his/her denture while biting in centric relation.
3. The two scans were merged to obtain software 3D image.

The bone height and thickness were measured for accurate planning of implant location, diameter and angulation. Universal surgical kit with successive drill diameter sleeves and horizontal indicators was supplied with the stent.

Surgical and prosthetic procedures

For each patient, intraoral fixation of the surgical guide template was done and two implants (DentiumSuperline, Dentium, Co. Ltd., Korea) (3.5mm diameter and 12 mm height) were inserted in the mandibular canine area bilaterally. After 3 months of oseointegration period, covering screws were exposed and replaced by healing abutments for more two weeks.

Mandibular acrylic resin custom tray was constructed with two holes corresponding to each implant site. Zinc oxide eugenol-free impression was done for recording residual alveolar ridges. Two long transfer copings were secured to the implants and splinted with orthodontics wire and light cured flowable composite. Light body rubber base material (Speedex, Coltene/WhaledentInc, Cuyahoga Falls, OH, USA) was injected to record the peri-implant soft tissues (Fig. 2). Implant analogues were fixed to the transfer coping and impression was poured (Fig. 3).

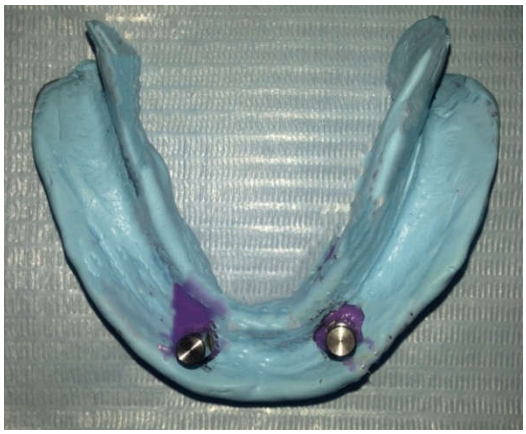

Fig 2 Implant analogues that screwed to the impression copings within the impression.

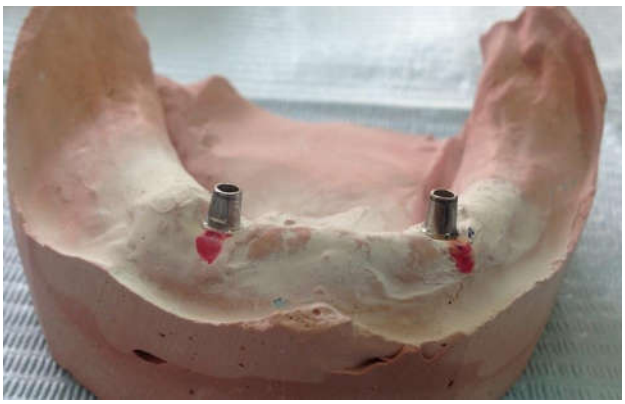

Fig 3 Master cast with screwed implant abutments.

Attachment construction

A-Primary telescopic crown construction

The model containing the two implants abutments was scanned to gain 3D virtual image for designing a resilient telescopic attachment using CAD/CAM technology. The same parameters for designing primary copings were maintained for all patients concerning 5mm height (2mm gingival height was paralleled and the occlusal 3mm was occlusaly tapered 4˚) (fig 4). The computer numeric control (CNC) data were

transmitted to the milling machine and connected to the CAD system (Sheraeco_scan3 Germany) to mill primary copings from semi-sintered zirconia (Zirconia Katan)

Fig 4 Planning the design of the primary copings based on the common path of insertion

B-Secondary telescopic crown construction

Scanning of primary copings was done after trying them intraoral for designing the secondary copings on their 3D image. Parameters used for designing secondary copings were minimal wall thickness of 0.5 mm and an occlusal space (0.3mm) was preserved between the primary and secondary copings (Fig 5). Projections were added to secondary copings design to enhance their mechanical retention to the over denture fitting surface according to Emera, 2016. Data were finally transferred to the CAM program for milling of the secondary crowns from PEEK (ceramic filled Bio HPP).

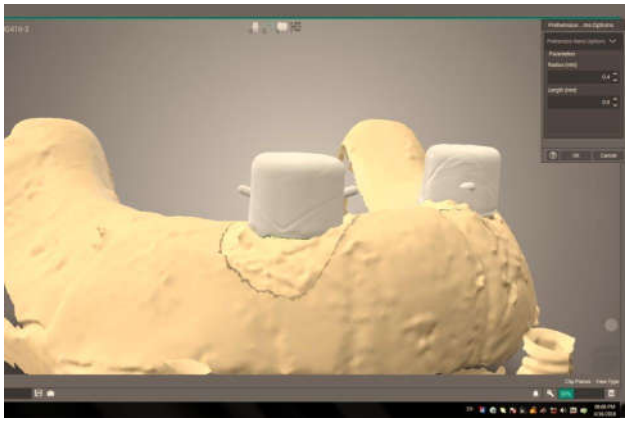

Fig 5 Planning the design of the secondary copings with mesial and distal projections

Fabrication of mandibular over dentures

Duplication was done to the model while the secondary telescopic crowns were secured over the primary ones on each abutment. Duplication of the conventional mandibular denture polished and occlusal surfaces was done using a silicone index (Coltoflax; ColteneAG, Altstatten, Switzerland). Identical acrylic teeth were positioned in their respective places in the mold. The index was repositioned against the duplicate stone model. The mold cavity was filled with molten base plate wax followed by flasking procedures.

Pick up procedures of secondary crowns:

Primary copings were cemented to the implants abutments. Venting holes were prepared through the lingual flanges of mandibular over dentures. Secondary crowns were positioned over primary ones in the correct path of insertion then were picked up to the over dentures fitting surfaces, under light biting force, using an auto polymerized acrylic resin (Fig 6). The excess material of auto-polymerized acrylic resin was removed using diamond bur.

Fig 6 Direct pick-up of secondary PEEK copings to the overdenture fitting surface

Evaluation of peri-abutment soft tissue health

Implants were examined at four sites per implant regarding modified gingival index, modified plaque index and probing depth. All measurements were rounded up to the nearest millimeter and mean value of the four sites of each implant was recorded. Evaluation was done at the time of overdenture insertion (T0), three months (T3) and six months (T6)later.

Modified Gingival index (GI)

Modified gingival index was scored 0 to 3 according to the following criteria:

Score 0: normal peri-implant mucosa (no redness, no swelling and no bleeding).
Score 1: mild inflammation (slight change in colour and slight oedema)
Score 2; moderate inflammation (redness, oedema and glazing)
Score 3, severe inflammation (marked redness, oedema and ulceration).

Modified plaque index (MPI)

Peri-implant plaqe was assessed using a pressure sensitive plastic periodontal probe by modified plaqe index scores 0 to 3 as follows:

Score 0: no plaque detected.
Score 1: plaque recognized only by running a probe across a smoothmarginal surface of the implant abutment.
Score 2: plaque can be seen by naked eye.
Score 3: abundance of soft matter.

Probing depth (PD)

By using a pressure sensitive plastic periodontal probe, the probing depth was measured (Fig 7).

Statistical Analysis

Data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (Standard version 21). The normality of data was first tested with Shapiro test. Variables were presented as median (min-max) for non-parametric data and Wilcoxon signed rank test was used to compare paired data.

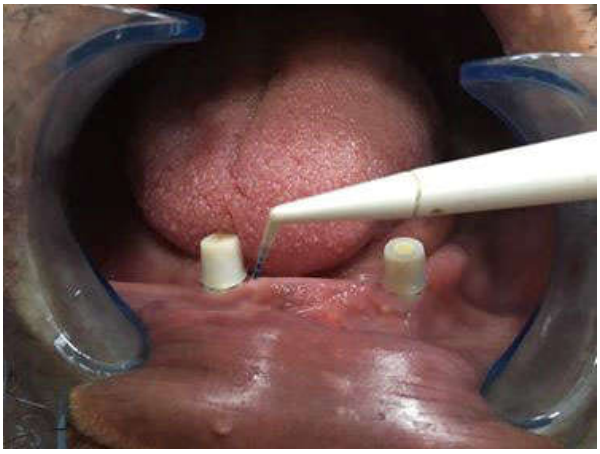

Fig 7 showing measuring peri-implant tissue health using Williams Probe

RESULTS

- **Table (1)** demonstrates comparison of modified gingival index of all surfaces (T0, T3 and T6) around the two implants.
- The lingual surface is the only surface that shows significance difference (0.046) at P3 after 6 mounths.
- The other surfaces show no significant changes.

Table 1 Comparison of Modified Gingival index at different follow up periods:

Gingival index	T0	T3	T6	P1	P2	P3
Buccal	0 (0-0)	0 (0-1.0)	0 (0-1.0)	0.025	0.083	0.480
Lingual	0 (0-1.0)	0 (0-1.0)	0 (0-0)	0.414	0.157	0.046*
Mesial	0 (0-0)	0 (0-1.0)	0 (0-0)	0.083	1.00	0.083
Distal	0 (0-0)	0 (0-1.0)	0 (0-0)	0.157	1.00	0.157

*significant p <0.05
T0: zerotime of denture insertion
T3: after 3 month of denture insertion
T6: after six months of denture insertion
P1: comparison between T0-T3
P2: comparison between T0-T6
P3: comparison between T3-T6

Table (2) illustrates comparison of modified plaque index of all implants surfaces.

- Both Buccal&Distal surfaces show slight increase from P1 to P3 with insignificant difference.
- The interaction between the observation times was insignificant.

Table 2 Comparison of Modified Plaque index at different follow upperiods

	T0	T3	T6	P1	P2	P3
Buccal	0 (0-2.0)	0 (0-2.0)	0 (0-1.0)	0.317	0.317	0.564
Lingual	0 (0-2.0)	0 (0-2.0)	0 (0-1.0)	0.317	0.180	0.157
Mesial	0 (0-2.0)	0 (0-1.0)	0 (0-0)	0.083	0.102	0.157
Distal	0 (0-2.0)	0 (0-2.0)	0 (0-1.0)	0.157	0.257	0.564

T0: zerotime of denture insertion
T3: after 3 month of denture insertion
T6: after six months of denture insertion
P1: comparison between T0-T3
P2: comparison between T0-T6
P3: comparison between T3-T6.

Table (3) shows comparison of probing depth of all implants surfaces:

- Comparison of the probing depth of all surfaces at different follow up periods revealed non statically significant change.

Table 3 Comparison of probing depth at different follow up (total) (T0, T3 and T6) around two implant retained mandibular telescopic overdenture

Probing depth	T0	T3	T6	P1	P2	P3
Buccal	0 (0-1.0)	0.25 (0-1.0)	0 (0-1.0)	0.453	0.516	0.160
Lingual	0 (0-0.50)	0 (0-1.0)	0 (0-1.0)	0.098	0.084	0.931
Mesial	0.50 (0-1.0)	0 (0-1.0)	0.50 (0-1.0)	0.792	1.000	0.655
Distal	0 (0-1.0)	0 (0-1.0)	0 (0-0.50)	0.317	0.739	0.380

T0: zerotime of denture insertion
T3: after 3 month of denture insertion
T6: after six months of denture insertion
P1: comparison between T0-T3
P2: comparison between T0-T6
P3: comparison between T3-T6.

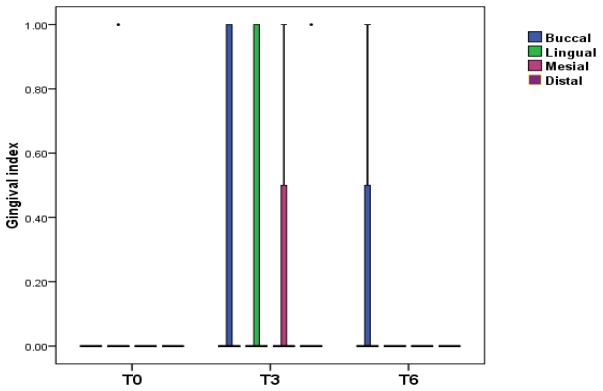

Figure 8 Box plot for median Gingival indexat different follow up periods (T0,T3 and T6) around the two implants.

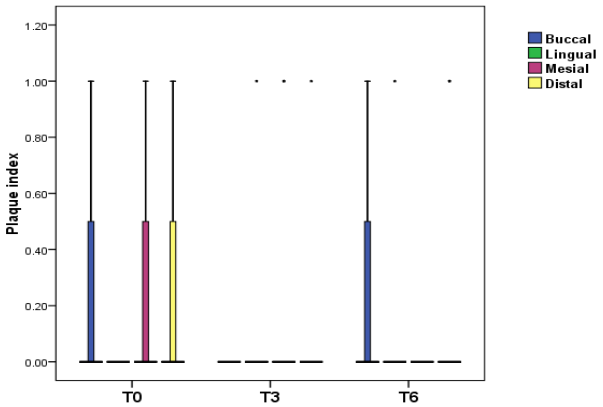

Figure 9 Box plot for median Plaque index at different follow up periods (T0,T3 and T6) around the two implants.

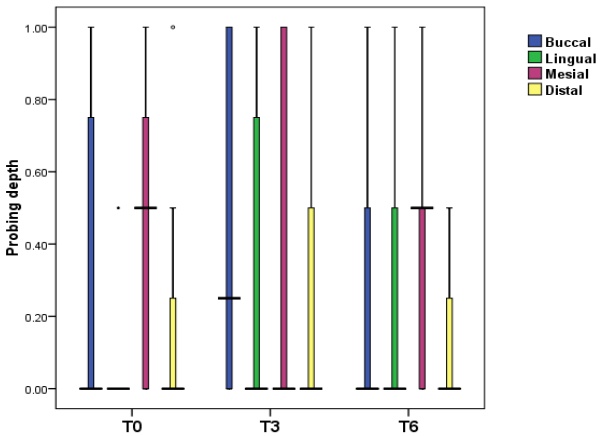

Figure 10 Box plot for median Probing depth at different follow up (T0,T3 and T6) around the two implants.

DISCUSSION

The introduction of zirconium dioxide (zirconia) and PEEK as tooth-colored biocompatible materials in restorative dentistry with their superior physical properties and the ongoing development of CAD/CAM technology led to manufacturing of Zirconia-PEEK telescopic attachment in this study.

One of the prosthetic options in combining the use of PEEK restorations with zirconia is the load cushioning capacity (Parmigiani-Izquierdo, Cabaña-Muñoz *et al*, 2017). It was proven that the use of hard and wear resistant material for primary crowns against a less hard material for secondary crowns may be advantageous. Minimum changes will occur in the primary crown, which is designed according to the treatment plan of the dentist, and the adaptation between both crowns will be achieved by the changes in the secondary crown (Baye, Zuziakr *et al*, 2011).

A statistically insignificant difference was observed in all measured peri-abutment soft tissue parameters (modified gingival index, modified plaque index and probing depth) after the 6 months of follow-up period. This result is in agreement with the few studies that have evaluated overdentures retained on natural abutments or implants using zirconia for fabrication of primary telescopic copings and/or implant abutments(Bae, Han *et al*. 2008, Kerstein and Radke 2008, Kollar, Huber *et al*. 2008, Uludag, Sahin *et al*. 2008, Emera 2016)**.**

A study by Zafiropoulos *et al*, (Zafiropoulos, Rebbe *et al*. 2010) where the primary coping was constructed of Zirconia and the secondary copings were made of electroformed goldconcluded that all teeth and implants survived during the entire observational period, and no mechanical or biological complications occurred. The periodontal and peri-implant parameters were overall very positive. Low plaque accumulation and low bleeding on probing were also observed. The probing depth of the periodontal or peri-implant areas was stable and no gingival recessions were seen.

This result is also in consistence with the study of Emera (Emera, 2016) who evaluated the clinical outcome of all-zirconia double crown retained complete mandibular overdenture on a two natural abutments regarding peri-abutment soft tissue health and periodontal microbiota. The results revealed that, after 12 weeks of over denture use, no statistically significant difference was observed in all measured peri-abutment soft tissue parameters (gingival index, plaque index and probing depth), no loss of clinical attachment was detected and also periodontal microbiota related to abutment teeth was not significantly changed.

The results of this study showed that the average probing depths was less than 3 mm in all follow-up periods of the study. This result is in agreement with Mombelli(Mombelli 2002) who claimed that successful implants generally allow a probe penetration of approximately 3 mm. The author added that if there are pockets deeper than 3 mm, an inflammatory process may take place at the bottom of the defect. This study showed also no significant increase of pocket probing depths. This result is compatible with a clinical study by van Brakel *et al*,, (van Brakel, Cune *et al*. 2011, van Brakel, Noordmans *et al*. 2011) that revealed decreased pocket probing depth around zirconia abutments, compared to titanium ones.

Insignificant difference was observed in modified plaque index after six months at all assessed implant surfaces. The insignificant change of plaque scores with time agreed with a study by Krennmair *et al*(Krennmair, Weinländer *et al*. 2006) who found low mean plaque scores for implant supported mandibular overdentures retained with ball or telescopic crown attachments in a 3-year prospective follow up.

Microbial adhesion and the accumulation of pathogenic biofilms are considered to play major roles in the pathogenesis of peri-implantitis and implant loss(Elter, Heuer *et al*. 2008). Previous studies regarding biofilm formation on abutment materials predominantly addressed the impact of titanium surface roughness on biofilm formation rather than the impact of the abutment material itself (Quirynen, Van der Mei *et al*. 1993, Elter, Heuer *et al*. 2008) However, with regard to the formation of biofilms on alloys and ceramics, several studies have demonstrated that differences in biofilm formation occur on these materials, with alloys featuring thick biofilms with low survival rate and ceramic materials featuring thin biofilms with high survival rate(Busscher, Rinastiti *et al*. 2010).

The composition and surface characteristics of the different substrates used for abutment components may directly influence the adhesion and maintaining of oral biofilm and, consequently, facilitate or hinder the colonization and growth of microbial species found in the oral cavity(Teughels, Van Assche *et al*. 2006) Zirconium was proved to its low affinity to plaque(Nascimento, Pita *et al*. 2014) in addition to its biocompatibility.

A study of Bremer *et al*, 2011 (Bremer, Grade *et al*. 2011) who investigated the formation of oral biofilm on various dental ceramics and found that biofilm formation on different types of dental ceramics differed significantly; in particular, zirconia exhibited low plaque accumulation. They also concluded that, in addition to its high strength, low plaque accumulation makes zirconia a promising material for various indications including implant abutments and telescopic crowns that previously were met only with metal-based materials.

In addition, A study by Hanhel *et al*,(Hahnel, Wieser *et al*. 2015) revealed lower biofilm formation on the surface of PEEK than on the conventionally applied titanium abutment , which hints that from a microbiological point of view, PEEK features favorable properties as definite abutment material.

The observed significant difference in modified gingival index of the implants lingual surface after 6 months may be countered to difficulty in accessibility for cleaning. Therefore adherence of microflora and microorganisms to this inaccessible site may cause gingival hyperplasia with increased probing depth(Mombelli 2002, Chen and Darby 2003). While the insignificant difference observed at buccal, mesial and distal sides of both implants in the present study may be related to the better accessibility for brushing and restricted oral hygiene measures followed by the patient.

The Insignificant difference in modified gingival index after six months may be also related to highly polished surfaces of telescopic attachment crowns that reduce accumulationof microorganisms and relatively minimize the bacterial invasion into the mucosal barrier around the implants.

The reduction of bacterial invasion may decrease peri-implant sulcular inflammation and consequently reduce bleeding on probing. The peri- implant mucosal seal may be less effective

barrier to bacterial plaque than the periodontium around a natural tooth. There is less vasculature in the gingival tissue surrounding dental implants compared to natural teeth, this reduced vascularity concomitant with parallel-oriented collagen fibers adjacent to the body of any dental implant make dental implants more vulnerable to bacterial insult(Greenstein and Cavallaro 2011). Consequently, special care should be taken in the choice of the materials used for attachment fabrication especially primary crowns in case of telescopic attachments.

Two investigations (Degidi, Artese *et al*. 2006, Welander, Abrahamsson *et al*. 2008)have shown fewer inflammatory cells in the peri-implant soft tissue of zirconia in comparison to titanium or other metals. Moreover, many studies have reported that zirconia shows a lower bacterial colonization potential than titanium in vivo. It has been further reported that this material can help to stabilize soft tissues against inflammation (Rimondini, Cerroni *et al*. 2002, Scarano, Piattelli *et al*. 2004, Degidi, Artese *et al*. 2006, Balmer and Mericske-Stern 2009).

CONCLUSION

Within limitations of this study, it could be concluded that: Zirconia-PEEK telescopic attachment system may be considered as a biologically promising attachment system regarding preservation of peri-implant soft tissue health of implant retained over dentures.

Recommendations

Randomized long-term studies should be directed towards:

1. Long term serviceability of zirconia-PEEK telescopic attachment for implant retained overdentures.
2. Evaluation of peri-implant marginal bone loss accompanied by zirconia-PEEK telescopic attachment.
3. Replacement of different metal attachment designs with zirconia and PEEK as more biocompatible alternatives.

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