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ZIRCONIA VERSUS METAL CAD/CAM EXTRACORONAL ATTACHMENTS FOR THE BILATERAL DISTAL EXTENSION REMOVABLE PARTIAL DENTURE

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ABSTRACT

Objectives: To compare between the effect of zirconia and metal CAD/CAM fabricated attachments on alveolar bone height of the residual ridge and periodontal health of abutment teeth in cases with bilateral distal extension base.

Materials and Methods: Seven Kennedy class I patients were selected for this study. In a split-mouth manner, one side of the arch received metal attachment together with porcelain fused to metal fixed partial denture, while the other side received zirconia attachment connected to zirconia fixed restoration. Alveolar bone loss, bleeding on probing (BOP) and pocket depths (PD) were measured for each side at the time of delivery and at 6 and 12 months post-insertion.

Results: There was no statistically significant difference between the two attachments regarding bone loss in the residual ridge in all follow-up appointments. There was also no significant bone loss for each attachment by the end of the follow-up period. There was no significant difference in BOP and PD at 6 months, but there was a significant increase in BOP and PD for both attachments at 12 months post-insertion. However, the difference between the two attachments was not statistically significant at any follow-up appointment.

Conclusions: Zirconia attachment yields comparable clinical and radiographic results as metal attachments for distal extension cases within a follow-up period of one year.

INTRODUCTION

The bilateral distal extension removable partial denture has always presented a myriad of problems to the dental practitioner. The absence of a posterior abutment compromises the support, retention and stabilization of the removable partial denture (RPD) due to the disparity of support between the edentulous ridge and the supporting abutment teeth[1]. Problems such as resorption of the edentulous alveolar ridge and excessive loading of abutment teeth are common with distal extension RPDs. Furthermore, conventional clasp-retained RPDs have been associated with increased plaque

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accumulation, higher caries susceptibility and periodontal disease of abutments. Metal clasp display is also objectionable to a lot of patients[2–5]. The placement of dental implants has managed to solve a lot of the problems associated with RPDs. However, patient factors, bone factors as well as economic factors prevent the use of dental implants in all clinical situations[6].

Extracoronal attachments are other means of mechanical retention that provide support and retention for RPDs, especially in bilateral distal extension cases. They are available in a wide range of sizes, designs, heights as well as different retentive matrix materials. Generally, extracoronal attachments consist of a patrix connected to splinted abutments, and a retentive matrix which is embedded in the denture base. They provide retention without the need for clasp retainers, thereby enhancing denture esthetics[7–9]. Resilient extracoronal attachments have been indicated for distal extension base cases to prevent torque of abutments and to distribute load favorably between abutments and the edentulous ridge[9–11].

Extracoronal attachments are either precision or semi-precision. Precision attachments come in a ready-made metal form that is directly connected to implants or soldered to the fixed partial denture (FPD) splinting the abutments. Semi-precision attachments are made of a burn-out material that is cast along with the FPD. Attachments also differ in the material of the engaging components. Some attachments involve metal-to-metal contact while others attachments have a metal- to-polymer contact [7,8].

One of the most commonly used materials for casting semi-precision attachments is nickel chromium alloy. Nickel chromium has shown good clinical results when used with attachments and porcelain fused to metal FPDs due to its high modulus of elasticity, hardness, relatively low cost and convenient laboratory procedures[12–15]. Porcelain fused to Metal (PFM) restorations are considered the gold standard for fixed restorations with up to 95.9% survival rate after 10 years of function[16] .However, the esthetics of PFM restorations can become unsatisfactory due to the metallic discoloration that occurs at the gingival margin as well as the opacity of the restoration resulting from the underlying metal[17,18]. In addition, the conventional technical procedures for casting metal alloys are known for the numerous variables involved which make room for error and render the procedure highly technique sensitive[19]. There are also some cases, albeit rare, of allergic reactions to metallic restorations[20].

Metal-free, all-ceramic FPDs have gained popularity in recent years due to their superior esthetic properties and enamel-like translucency that resemble natural teeth. When they were first introduced, feldspathic ceramics were limited to anterior restorations as they have not been able to match the superior mechanical properties of PFM restorations. This was due to their brittleness and low resistance to tension resulting in crack propagation and subsequent fracture[21]. Studies comparing all-ceramic to metal ceramic FPDs confirmed that FPDs made of glass or glass-infiltrated ceramics had lower survival rates and higher rates of technical complications than PFM restorations[22,23].

On the other hand, high-strength ceramics including Zirconia have been developed as an alternative to PFM restorations with superior mechanical properties to glass-ceramic restorations. Zirconia has a fracture toughness and flexural strength that is twice as high as those of feldspathic ceramics, making it suitable for use in posterior restorations[24,25]. Sailer et al[17,26] demonstrated that zirconia FPDs exhibited comparable survival rates as well as biological and technical outcomes as PFM after 3 and 5 years of function with a survival rate of 97.8%. In a prospective 4-year study by Palaez et al[27], survival rates were 95% and 100% for zirconia-based FPDs and PFM restorations respectively. Furthermore, no significant difference was found regarding plaque index, gingival index and pocket depth between the two restorations, which reveal that gingival tissues respond favorably to zirconia FPDs.

The recent, rapidly developing advances in computer aided design and computer aided manufacturing (CAD/CAM) has facilitated the use of zirconia for various dental applications. Zirconia restorations may be fabricated by milling with CAD/CAM controlled milling machines. CAD/CAM technology has revolutionized laboratory procedures owing to the elimination of the various steps and errors resulting from the conventional casting procedures[19]. This is of great importance when fabricating attachments as the lack of accurate fit between the attachment components could have an adverse effect on wear of the components and the retention of the prosthesis. This in turn would result in unfavorable loading of the supporting structures[8,28].

Despite its biocompatibility, good esthetics, high hardness and wear resistance, the use of zirconia in fabricating attachments for removable prosthesis is scarce in the literature. This study was conducted to compare between CAD/CAM zirconia attachments and metal attachments fabricated from CAD/CAM wax patterns with respect to hard and soft tissue changes.

MATERIALS AND METHODS

Seven partially edentulous patients were enrolled in this study. They all possessed a Kennedy class I edentulous mandible, with premolars or canines as last standing abutments. The opposing arch was either fully dentate or restored with fixed restorations. All patients had good oral hygiene and sufficient inter-arch space in the edentulous areas. Exclusion criteria included patients with gingival or periodontal disease, diabetic patients, smokers, or those with any other systematic condition that could affect periodontal status.

This was a split-mouth study, where each patient received an attachment-retained RPD, with one side of the arch harboring a metal attachment together with a porcelain-fused-to-metal FPD, while the other side having a zirconia attachment and zirconia FPD.

Primary framework construction and design (FPD)

Fixed partial denture (two splinted crowns) construction was started by the reduction of the principle abutments. Each abutment was prepared with a deep chamfer finish line to accommodate PFM and Zirconia restorations. Retraction cords were placed and a final impression using polyvinyl siloxane (PVS) rubber base was made. These impressions were poured and dyes were created.

The casts were then scanned* in the laboratory for construction of CAD/CAM fixed partial dentures. Digital software** was used to design the splinted crowns with an extra-coronal attachment*** attached to the FPDs. Mesial rest seats for support and stabilization and a lingual ledge to accommodate a reciprocal arm for bracing and reciprocation were included in the design of the FPDs to accommodate the RPD (fig.1).

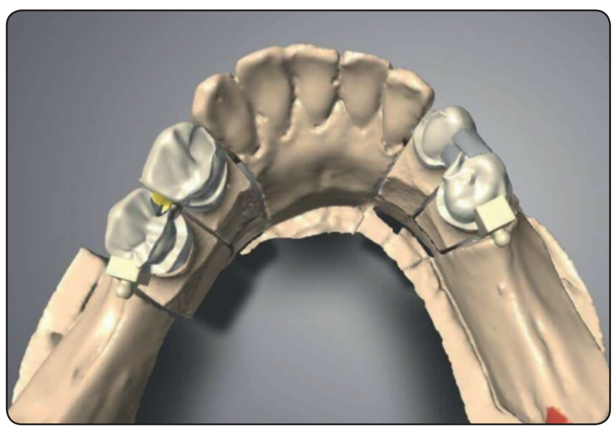

Fig (1). Design of the fixed RPDs and attachments using digital software

* Shera eco-scan 7, Werkstoff-Technologie GmbH & Co. KG,Germany
** Dental Wings software, Dental wings Inc, Montreal H1V 2N9, Canada
*** VKS-SG, Xpdent Corp, Miami, Florida 33186

Next, a castable pattern for the metal attachment and PFM restoration was milled from burn-out resin blocks* using a CAM-controlled milling machine**. The patterns were then cast in nickel chromium*** in the conventional manner. Zirconia**** blocks were used for milling the zirconia restoration for the other side of the arch.

After finishing, the splinted crowns were tried in the patient's mouth and were checked for marginal fitness and seating on both sides. The splinted crowns were later finished and polished and the metallic crowns were veneered with porcelain (fig 2,3).

Secondary Framework Construction and Design (RPD)

The splinted crowns were cemented using temporary cement in the patient's mouth, and an overall impression was made using PVS impression material in a special tray to pick up the splinted crowns.

A new cast was poured, on which the RPD was constructed. The RPD was designed as follows; mesial occlusal rests and bracing arms on the principle abutments, combination denture bases, and a lingual bar major connector. The steps of partial denture construction were continued, including metal try-in, jaw relations and final insertion.

Patients were given an oral hygiene regimen and were recalled frequently for hygiene maintenance. Radiographic and clinical assessments were done at the time of prosthesis insertion, and at 6 and 12 months post-insertion.

Radiographic Assessment

Using paralleling technique with digital radiography, the patients were followed up at the time of insertion, 6 and 12 months post insertion. For reasons of standardization, an acrylic template was constructed to place the radiographic sensor in the exact position at each measurement. Bone levels at the area of the residual ridge on both sides were measured by linear measurements using the Digora software***** from the extracoronal attachment to the crest of the ridge (fig. 4). The amount of bone loss in millimeters was calculated by subtracting the measured distance at 6 and 12 months from the original distance measured at the time of denture insertion.

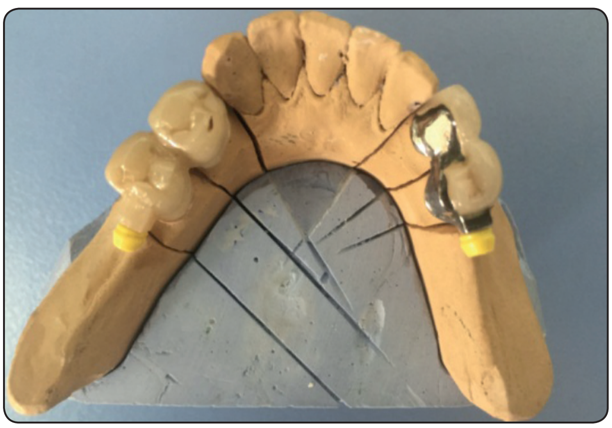

Fig. (2) PFM and zirconia attachments and FPDs

Fig. (3) Mirror-image of PFM and zirconia attachments and FPDs in the patient's mouth

* Copraplex pmma blocks for casting, Whitepeaks Dental Solutions GmbH & Co. KG, Germany
** Shera eco-mill 5x, Werkstoff-Technologie GmbH & Co. KG,Germany
*** Ecolloy CS, dent-e-con, Germany
**** Noritake multilayer Zirconia blocks, Kuraray Noritake Dental Inc.,
***** DIGORA® for Windows. Soredex, Finland

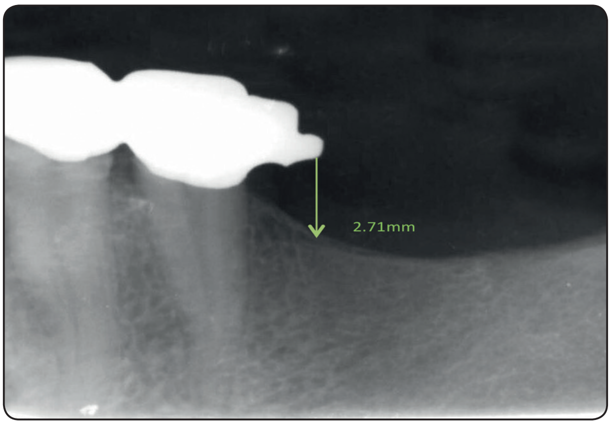

Fig. (4) Radiographic assessment using Digora software

Clinical Assessment

The periodontal status of the abutments was evaluated by measuring BOP and PD at the three follow-up appointments; at time of insertion and at 6 and 12 months post-insertion. BOP was measured as described by Lang et al[29]. BOP was assessed at four surfaces for each abutment tooth; buccaly, mesiobuccally, distobuccally and lingually. PDs were measured with a graduated periodontal probe to the nearest millimeter on 6 surfaces of each abutment; mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, disto-lingual and mid-lingual. The periodontal probe was held parallel to the long axis of the tooth and pocket depth was measured from the gingival margin to the bottom of the pocket using gentle pressure. Mean values were calculated and the results were tabulated and statistically analyzed.

Statistical Analysis

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data showed normal distribution (Parametric). Independent sample t-test was used to compare between two groups in non-related samples. Repeated measure was used to compare between more than two groups in related samples. Paired sample t-test was used to compare between two groups in related samples. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

RESULTS

Bone Level Changes

The mean value of bone loss in the metal attachment group was 0.123 ± 0.085 mm after 6 months and 0.333 ± 0.045 mm after 12 months of insertion. The mean value of bone loss between 6 and 12 months was 0.21 ± 0.069 mm. This loss in bone levels was not statistically significant at 6 or 12 months pos-insertion. As for the Zirconia attachment group, the mean value of bone loss was 0.113 ± 0.07 mm after 6 months and 0.27 ± 0.082mm at 12 months post insertion. The mean value of bone loss between 6 and 12 months post insertion was 0.157 ± 0.025mm. There was also no significant difference regarding bone loss within the zirconia attachment group at all appointments. On comparing the two groups, there was no significant difference in bone loss between metal and zirconia attachments after 6 or 12 months of insertion (table 1, fig 5).

Results of Clinical Assessment

Bleeding on Probing (BOP)

Regarding the metal attachment group, the results show that there was no statistically significant difference in BOP at 6 months post-insertion. However, there was a statistically significant increase in BOP at 12 months post-insertion. The increase in BOP between 6 and 12 months was also statistically significant. The highest mean value of BOP was 0.339 ± 0.119 found at 12 months post-insertion while the lowest mean value of BOP was 0.143± 0.086 found at the time of insertion. As for the zirconia attachment group, the increase in BOP was also insignificant at 6 months but it was significant at 12 months post-insertion. There was no significant difference in BOP between the two groups at 6 or 12 months post-insertion (table 2, fig 6).

Pocket Depths (PD)

The change in PD in the metal attachment group was insignificant at 6 months. The was a significant increase in PD between 6 and 12 months and between time of insertion and 12 months post-insertion. The highest mean value of PD was 2.70 ± 0.20 found after 12 months, and the lowest mean value was 1.80 ± 0.26 at time of insertion. As for the zirconia attachment group, there was no significant increase in PD at 6 months but the increase between 6 and 12 months was found to be statistically significant. The increase between time of insertion and 12 months post-insertion was also significant. The highest mean value of PD was 2.567 ± 0.15 found at 12 months followed while the lowest mean value of PD was 1.70 ± 0.20 found at time of insertion. On comparing the two groups, there was no significant difference between the two groups at 6 or 12 months post-insertion (table 3, fig 7).

TABLE (1): The mean, standard deviation (SD) values of bone loss in both groups

Variables	Bone loss				p-value
	Metal attachment		Zirconia attachment		
	Mean	SD	Mean	SD	
At 6 months	0.123	0.085	0.113	0.070	0.883ns
Between 6 and 12 months	0.210	0.069	0.157	0.025	0.306ns
At 12 months	0.333	0.045	0.270	0.082	0.278ns
p-value	0.131ns		0.058ns		

significant (p≤ 0.05) ns; non-significant (p>0.05),

TABLE (2) The mean, standard deviation (SD) values of BOP in both groups.

Variables	BOP				*p-value*
	Metal attachment		Zirconia attachment		
	Mean	SD	Mean	SD	
At time of insertion	0.143 ^{aA}	0.086	0.125 ^{aA}	0.102	**0.730ns**
After 6 months	0.179 ^{aA}	0.067	0.143 ^{aA}	0.086	**0.403ns**
After 12 months	0.339 ^{bA}	0.119	0.321 ^{bA}	0.142	**0.803ns**
p-value	**0.001***		**0.003***		

Superscripts with different small letters indicate statistically significance difference within the same column. Superscripts with different capital letters indicate statistically significance difference within the same row. *; significant (p≤ 0.05) ns; non-significant (p>0.05),

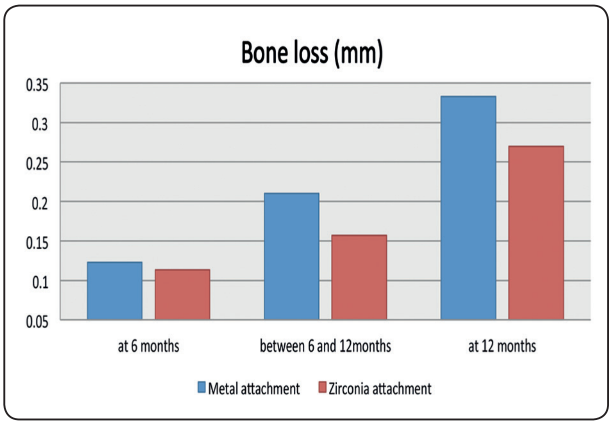

Fig (5) amount of bone loss in mm in both groups between all appointments

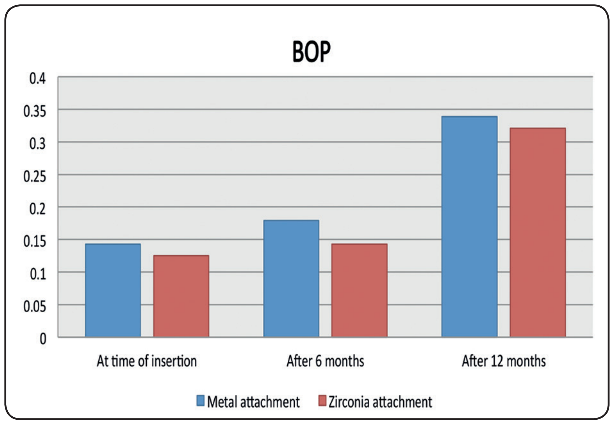

Fig (6) changes in BOP in both groups at the three follow-up appointments

TABLE (3) The mean, standard deviation (SD) values of PD in both groups.

Variables	PD				*p-value*
	Metal attachment		Zirconia attachment		
	Mean	SD	Mean	SD	
At time of insertion	1.800 ^{aA}	0.265	1.700 ^{aA}	0.200	**0.629ns**
After 6 months	2.000 ^{aA}	0.100	1.997 ^{aA}	0.105	**0.970ns**
After 12 months	2.700 ^{bA}	0.200	2.567 ^{bA}	0.153	**0.411ns**
p-value	**0.006***		**0.013***		

Superscripts with different small letters indicate statistically significance difference within the same column. Superscripts with different capital letters indicate statistically significance difference within the same row. *; significant (p≤ 0.05) ns; non-significant (p>0.05)

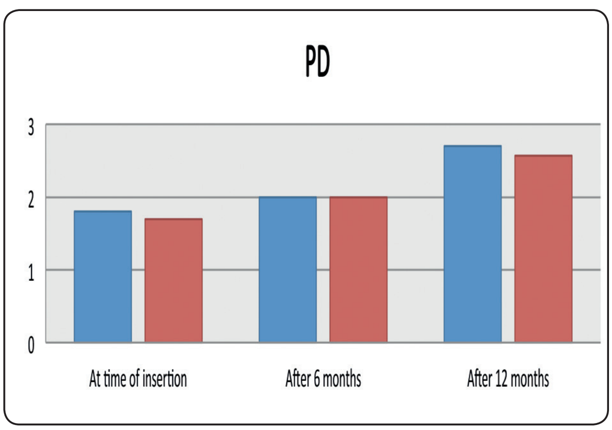

Fig. (7) Changes in PD in both groups at the three follow-up appointments

DISCUSSION

Preservation of the remaining supporting structures has always been one of the primary objectives of any restoration. In cases where support is shared between abutment teeth and the residual ridge, it becomes essential to understand the effect a particular restoration can have on the health of these tissues. Digital radiography was used to measure the amount of bone loss at the residual ridge for both types of attachments. The radiographic assessment revealed that bone loss occurring with the two attachments was not statistically significant at 6 or 12 months after insertion. There was also no significant difference between the two attachments regarding bone loss. This lack of difference could be due to the use of nylon caps as a retentive matrix in the denture base of the RPD, thereby offering the same resiliency and stress breaking effect for both attachments. It could also be attributed to the relatively short follow-up period of only one year which was not long enough to cause significant bone loss beneath the RPD. However, since a degree of bone loss is inevitable in all cases where the residual ridge plays a role in denture support, the fact that the amount of bone loss was not significant after one year in addition to being less than that of metal attachment is a good indication of the performance of the zirconia attachment.

The abutments were evaluated clinically by assessing BOP and PDs. BOP and PD were significantly higher in both groups at the end of the follow-up period, although there was no significant difference between the two groups regarding both parameters. However, the mean pocket depth for each group was less than 3mm, which remains within the normal range for healthy periodontium[30]. This slight decline in periodontal condition is probably a normal consequence of the presence of fixed restoration on the abutment teeth. The finish line has an effect on plaque accumulation and subsequent gingival irritation[27]. The lack of significance between the two restorations regarding BOP and PD comes in accordance with a number of studies that compared soft tissue reaction between zirconia and PFM fixed restorations over longer follow-up periods[17,22,27,31].

Zirconia currently possesses the highest mechanical and esthetic properties in the market with respect to ceramic restorations. Its high survival rates and pleasing esthetics make it a viable alternative to PFM restorations regardless of the tooth/teeth to be restored. Although Zirconia is still a novel material when it comes to attachment fabrication, its clinical and radiographic performance was comparable to the gold standard metal attachments after one year of function. Nevertheless, these promising results do not negate the need for more long-term clinical studies on zirconia attachments.

CONCLUSION

Zirconia extracoronal attachments can be used with distal extension base cases as they yield comparable clinical and radiographic results to metal attachments after one year of function.

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