



Comparative Evaluation of Porcelain Fused to Metal (PFM) Material used for Fixed Partial Prosthesis Placed on Vital & Non-vital Abutments on the Periodontal Status – A Two Year Retrospective Follow-up

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SS and KS designed the study, managed the literature searches and the analyses of the study and finalized the draft of the manuscript. Author OW was the chief coordinator of the study. Authors RT and JA were mainly responsible for data collection and writing the first draft of the manuscript. Author KHS performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Objective: Sound periodontal foundation of abutment teeth is essential for successful restorative therapy and also for long-term success of prosthodontic restorations. Porcelain fused to metal (PFM) has been a popular choice of novel esthetic material in fixed prosthodontics over the last few decades. The present study aimed to assess the long term effect and tissue responses of fixed partial prosthesis using PFM material on vital and non-vital abutments on the periodontal parameters both clinically and radiographically.

Methodology: Following ethical committee approval, the study group comprised of 86 abutment teeth in 41 systemically healthy patients (24 males and 17 females) aged between 18 – 45 years who had received 3 unit fixed prosthesis made of PFM, having equigingival margins using vital and non-vital abutments. The following parameters were assessed at baseline, phase 1, 3 and 4 (1 year follow up) – CAL, Probing depth, Distance between CEJ/ cervical crown margin and alveolar crest of the abutment teeth (radiograph).

Results: Statistical analysis carried out by SPSSV22 software revealed no significant changes in probing depth and CAL ($p>0.05$) and significant changes in radiographic bone levels ($p<0.05$) in vital abutments whereas significant changes in probing depth and CAL from baseline to the end of 2 years ($p<0.05$) with no changes in radiographic parameters ($p>0.05$) with non vital abutments. However, significant differences were observed between vital and non vital abutments with regard to probing depth at the end of 2years, CAL and radiographic bone levels at 6months, 1 year and 2 years ($p<0.05$)

Conclusion: The response of the periodontal tissues to the PFM material used on fixed prosthesis on both vital and non vital abutment teeth although favorable, were marginally better in vital abutments.

Keywords: Non-vital abutment; periodontal status; porcelain fused to metal; vital abutment.

1. INTRODUCTION

The knowledge of the responses of periodontal tissues to fixed partial dentures is crucial in the development of treatment plan with predictable prognosis. Several studies have in the past indicated that poor marginal adaptation [1] sub-gingival margin placement [2] and over-contoured crowns [3] can contribute to localized periodontal inflammation. These studies have forced clinicians and researchers to focus on the qualities of FPDs and crowns in order to reduce the periodontal inflammation and ensure long term prognosis of the prosthesis as periodontal health governs FPD survival to a large extent. PFM crowns have been popular FPD materials for a long time and have been considered the gold standard for the repair of damaged teeth. PFM crowns have good mechanical properties, satisfactory esthetic results, and an acceptable biological quality needed for periodontal health [4]. However, PFM crowns have some limitations that may limit their use. For example, the esthetic of PFM crowns is limited by the metal framework and the layer of opaque porcelain needed for masking the underlying metal grayish shade [5]. Recently the cost of precious metals has risen markedly making PFM relatively unattractive from an economic standpoint [6]

Historically, resin-based crowns were the first metal-free crowns to be used, but they were abandoned because of their low fracture resistance [7] Newer metal-free crowns are increasingly being used in dental practice; these crowns are made from different ceramic materials such as lithium disilicate, zirconia, leucite-reinforced glass, and glass-infiltrated alumina [8].

All-ceramic crowns have been used over the last four decades as an alternative for PFM crowns to overcome their esthetic limitations [9] and can be made from different types of ceramic materials such as lithium disilicate, zirconia, leucite-reinforced glass, and glass-infiltrated alumina, and such newer metal-free crowns are increasingly being used in dental practice [10]. In spite of the increase in the use of all-ceramic fixed partial dentures (FPDs), metal-ceramic systems continue to be used due to their clinical longevity and biocompatibility. This kind of prosthesis is used mainly when a large number of teeth should be replaced. Advantages of metal-ceramic FPDs lie on their predictable structural performance, versatility and cost [11].

Although manufacturers routinely advertise all-ceramic systems as a viable option for anterior and posterior FPDs, there are few clinical studies to support these claims. Olsson, et al.16 (2003) have reported that 91% and 83% of In-Ceram alumina short-span FPDs had survived after 5 years and 10 years, respectively, and that 6.7% fractures in a group of sixty had occurred within 12 months for Empress® 2 three-unit anterior and posterior FPDs.[9] On the other hand, for metal ceramic FPDs the survival rates found by Karlsson (1986) revealed a 93% success rate in a 10-year period [12], while Palmqvist and Swartz (1993) reported a 79% success rate over an 18- 23-year period [13]. In a review of FPDs failures on the past 50 years, Goodacre, et al (2003) found that the porcelain fracture was the main factor for failure. The decrease in FPD survival rate after 10 years may be a result of

material fatigue and/or a combination of biologic and biomechanical factors [14].

The interactions between restorative dentistry and periodontal health have been well-documented both clinically and histologically. Periodontal health at the restorative gingival interface continues to represent one of the most difficult challenges for the restorative dentist. Emphasis must be placed on the control of bacterial plaque, the coronal contour of a restoration, alloy sensitivity and the margin location of a restoration. Only about 30% of those patients with a known nickel allergy develop a reaction to an intraoral nickel chromium dental alloy [15]

Endodontically treated teeth are commonly required to serve as abutments for crowns, fixed partial dentures, or removable partial dentures. Many clinicians are of the opinion that endodontically treated teeth do not serve as well as vital teeth [16]. However some researchers believe that with appropriate preparation designs, endodontically treated teeth can serve well as abutments for crowns. Wegner et al [17] concluded that the endodontically treated teeth restored with endodontic posts and crowns had a good survival rate (92.7%) when observed for a 5 year period. In some fixed partial denture designs, the use of endodontically treated teeth may be contraindicated.

Since most of the relevant studies were carried out in different European countries because of the lack of such studies from other parts of the world, it would be interesting to investigate in other populations with different cultural, ethnic and dietary backgrounds. Thus, the aim of the present cross sectional study was to assess the periodontal conditions in a group of Saudi adults who had received regular oral prophylaxis following the insertion of FPDs made up of PFM.

2. MATERIALS AND METHODS

Following approval from the institutional Ethical Committee at ISNC, nearly 200 patients treated with 3 unit FPDs in the period between January 2017 and August 2018 were screened. Of these

$$\frac{\text{Actual distance between two points (grid)}}{\text{Measured distance between two points (grid)}} = \frac{\text{Actual distance between two points (anatomic)}}{\text{Measured distance between two points (anatomic)}}$$

The distance measured was between 2 points - cement-enamel junction/ crown margin to alveolar crest.

The patients were given appropriate oral hygiene instructions to ensure maintenance of low plaque scores throughout the duration of the study.

41 patients were selected for the study based on the following inclusion criteria:

- Adults who were systemically healthy, non-smokers, and who had 3 unit FPDs made of PFM for the last 2 years and
- Abutment teeth that had equigingival margins with plaque and gingival indices less than 10%.
- Clinical and radiographic measurements were made on the abutment teeth in the various phases of treatment:

Phase 1 – 4 weeks after baseline

Phase 3 (restorative phase) – 4-6 weeks after phase 1

Phase 4 – at 1 year and at 2 years following phase 3.

The following measurements were made clinically on the abutment teeth at baseline and end of phase 1, phase 3 and phase 4 with a UNC 15 periodontal probe.(company name)

- Probing depth(facial and lingual)
- Clinical attachment level(CAL) (facial and lingual)

A total of 6 measurements, 3 each on the facial and lingual surfaces and an average of these was used as a final value.

The following measurements were made on the radiographs on the abutment teeth at baseline and end of phase 3 and phase 4 using grids.

- Distance from CEJ to alveolar crest. (baseline)
- Distance from cervical margin of crown to alveolar crest. (phase 3 and 4)

Care was taken to ensure that the radiographic techniques and the radiographs were standardized to maintain homogeneity in measurements.

The linear distances in two dimensions were measured using the following mathematical formula:

3. RESULTS

Statistical analysis was carried out using SPSSV22 software. Since the data was normal, a parametric 't' test was applied and 'p' value of less than 0.05 was considered significant.

3.1 PFM Material on Vital Abutment: (Table 1 A & B)

The vital abutment teeth receiving PFM material crowns revealed no significant reduction in probing depth and clinical attachment levels(CAL) from time of placement to post 2 year follow up period.(P>0.05). However, significant changes were observed in the bone levels seen in the radiographs in the 2 year period (p<0.05).

3.2 PFM Material on Non-Vital Abutment: (Table 2 A & B)

On the other hand, the non-vital abutment teeth receiving PFM material crowns revealed a statistically significant reduction in probing depth and CAL from time of placement to post 2 year follow up period.(P<0.005). However, no

significant changes were observed in the bone levels seen in the radiographs in the 2 year period.(P>0.05)

3.3 PFM –vital v/s Non-Vital: (Table 3)

Significant differences were observed with regard to probing depth at the end of 2 years, CAL and radiographic bone levels at 6 months, 1 year and 2 years (p<0.05) between vital and non vital abutments. However, no differences were found with probing depths at 6 months and 1 year. (p>0.05).

4. DISCUSSION

Comprehensive dental therapy is founded on team work. Of all disciplines within modern dentistry, periodontics and prosthodontics have the strongest and the most intimate connections. Great efforts through research and clinical trials have been made to achieve the goal of a healthy coexistence between restorations and surrounding periodontal structures. Over the years, many concepts and techniques have evolved and were discarded or modified as they were met with varying degrees of success or failure.

Table 1. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PD P-3	1.9500	60	.61658	.07960
	PD P-4	1.9817	60	.74162	.09574
Pair 2	CAL P3	1.8117	60	1.41566	.18276
	CAL P4	1.8050	60	1.21842	.15730
Pair 3	RBL P3	1.9983	60	.82595	.10663
	RBL P4	2.3400	60	.84436	.10901

a. The correlation and t cannot be computed because the standard error of the difference is 0. P-3 at the time of bridge cementation, P-4 at the end of 2 years

		Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pair 1	PD P-3 - PD P-4	-.03167	.40316	.05205	-.608	59	.545
Pair 2	CAL P 3 – CAL P 4	.00667	.77741	.10036	.066	59	.947
Pair 3	RBL P 3 – RBL P 4	-.34167	.37384	.04826	-7.079	59	.000

Table 2. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PD P3	1.6923	26	.42607	.08356
	PD P4	1.4038	26	.34696	.06805
Pair 2	CAL P3	1.1923	26	.78838	.15461
	CAL P4	.8269	26	.64718	.12692
Pair 3	RBL P3	1.3077	26	.61769	.12114
	RBL P4	1.3654	26	.50115	.09828

P-3 at the time of bridge cementation, P-4 at the end of 2 years

		Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pair 1	PD P3 PD P 4	.28846	.45107	.08846	3.261	25	.003
Pair 2	CAL P 3 CAL P4	.36538	.36215	.07102	5.145	25	.000
Pair 3	RBL P 3 – RBL P4	-.05769	.32640	.06401	-.901	25	.376

Table 3. Parametric test – independent t-test vital v/s non-vital

	t	df	Sig. (2-tailed)	Mean Difference
PDbaseline	2.291	84	.024	.3332
PD – 6months	.711	84	.479	.0923
PD-1year	1.938	84	.056	.2577
PD – 2years	3.804	84	.000*	.5793
CALbaseline	.823	84	.413	.2131
CAL – 6 months	1.514	84	.036*	.3542
CAL – 1 year	2.088	84	.040*	.6189
CAL – 2 years	3.861	84	.000*	.9786
RBLbaseline	3.697	84	.000*	.6511
RBL- 6 months	3.830	84	.000*	.6921
RBL – 1year	5.485	84	.000*	.9761
RBL – 2 years	4.616	84	.000*	.77247

A healthy periodontium, in which the free gingival margin is in a stable relationship to the tooth is essential to the success of a restoration. This healthy periodontium must exist prior to the fabrication of a crown and must be maintained after the crown has been placed. Despite the long-standing use of alloys and ceramics as fixed and removable restoration materials, there are still questions about their behavior in the oral environment. These materials come into close and prolonged contact with gingival and oral mucosa and have been claimed to cause inflammation of these tissues [18].

The need for this study had arisen from the growing popularity of the newer esthetically and biologically compatible materials used in fixed partial dentures today although PFM has been a popular choice for a long time and has always been the gold standard for FPD. However, newer esthetic materials such as IPS empress and zirconia which are comparatively expensive, are gradually replacing it. This study was designed to assess the periodontal status of a group of Saudi adult patients following the insertion of FPDs using PFM. Such an assessment is considered valuable since the FPD is still a very common replacement option for edentulous ridges and PFM a very economical and viable option. It therefore seems essential to adequately understand its effects on the oral health status of such patients in order to establish effective maintenance programs.

It was decided to include only bridges in which the crown margins of the abutment teeth were equigingival. Only 3 unit bridges were included in

order to standardize the occlusal load on the abutments and keep it uniform. Bridges with multiple units would have further led to variations in clinical and radiographic parameters owing to variations in the load bearing capacity of the abutments. This made it easier to standardize the study population and perform appropriate measurements both clinically and radiographically as the landmarks could be easily determined for linear measurements. There is a great deal of evidence surrounding the suitability of endodontic teeth as abutments with an equal number of them supporting and against their use as suitable abutments. Hence it was also decided to comparatively assess the periodontal health of both vital and non-vital abutments used in the PFM prostheses.

Biocompatibility and chemical durability are highly important properties in dental materials. De Baker reported that irrespective of margin configuration, it is the baseline periodontal health that determines the long term periodontal success of a fixed restoration.[19] Weishaupt et al concluded in their study that galvanoceramic crowns may accumulate less plaque as compared to metal ceramic crowns. They attributed certain stabilizing effect of this particular material for a favorable gingival response.[6] Only about 30% of those patients with a known nickel allergy may be influenced by the physical properties of the alloys, cost, and biocompatibility. [20] Dental casting alloys vary differently in composition and some of them contain toxic elements, such as nickel, cobalt, lead, cadmium, and beryllium. Certain dental

alloys tend to cause gingival and periodontal inflammation and if not identified early, they can lead to periodontal breakdown and further material failure. Despite the long-standing use of alloys and ceramic as fixed and removable restoration materials, there still are open questions about their behavior in the biological environment. [21]

Metal ceramic systems combine both the exceptional esthetic properties of ceramics and the extraordinary mechanical properties of metals. Some metals used as restorative materials in dentistry may constitute a problem for some patients. The drawbacks, as well as the search for more esthetic materials by patients and dentists, have stimulated research and development of metal-free ceramic systems.[22] Since alloys used in dentistry come into close and prolonged contact with the gingiva and oral mucosa, prosthodontic and periodontal research must involve cellular and molecular biological approaches to assess the host's immune status and chronic inflammatory responses to the materials in contact with the oral tissues. Weishaupt et al [6] presented an interesting theory. According to their findings, particular alloy type may have a stabilizing effect on gingival health irrespective of level of margin placement. Contrary to this claim, Reitemeier et al [23] did not find any effect of the type of alloy on gingival health and reported that type of alloy did not affect the level of plaque accumulation and gingival health was similar around any alloy. Christensen in a comparison of zirconium to metal fused to porcelain crowns also made similar conclusions [24] as were also observed by several other authors [25,26] However, Alsinaidi et al [27] indicated that in subjects with fixed partial dentures, the abutment teeth are more prone to periodontal inflammation than the non-abutment teeth. Additionally, the individual's age, duration of insertion of fixed partial dentures and location of the crown margins may affect the periodontal health of the abutments.

On the basis of such varying evidences, it was decided to assess the effects of PFM material used in fixed prosthesis on the periodontal status by evaluating the clinical and radiographic status. The alloy used in the metal component of the PFM bridge in our study was nickel-chromium and no allergies were reported by any of the study participants.

Although the clinical parameters did not show significant differences from the time of placement

of prostheses to the 2 years post insertion in case of vital abutments receiving PFM prostheses, the radiographic bone levels showed a significant increase in bone levels in the 2 year period thereby indicating a positive response of the periodontal tissues. However, these findings are in contrast to the findings of Mishary et al, who concluded that within the limits of this study, ceramic fused to metal crowns appear to be associated with more periodontal breakdown and consequently more bone loss [10] but the authors have not specified the vitality of the abutment teeth in their study.

However, with regard to non vital abutments receiving PFM it was observed that only the clinical parameters showed significant improvement and not the radiographic bone levels. There has been a lot of conflicting evidence with regard to endodontically treated teeth as abutments. De Backer et al (2007) suggested that there was no difference between complete crowns on vital abutments versus endodontically treated ones or post and core treated abutments [19]. Speilman et al [28] concluded that one of the factors associated with restorative success for endodontically treated teeth was good periodontal health thus suggesting that the type of material used may not be relevant. A study carried out by our team, found not much differences between vital and non vital abutments irrespective of the esthetic materials used which were IPS empress, PFM and zirconia [29,30].

Comparison of the abutments with regard to clinical and radiographic parameters revealed better improvement in the periodontal health of vital abutments compared to non vital abutments at the end of 1 and 2 year follow up period. Although the baseline PPD and CAL values were significantly high; at the end of phase 1 therapy and the subsequent 2 year period, all the values had reduced significantly indicating good periodontal health.

Studies have reported increased gingival inflammation due to distortion of the metal substructure that occurs during thermal cycling, mesiodistal opening of margins and leaching of metal ions when in contact with marginal gingiva especially those containing nickel-chromium-molybdenum alloy [1,31-35].

However, our study reported no such observation probably because of the smaller sample size which was also one of the limitations of our study.

5. CONCLUSION

Within the limitations of the study, although it is unclear which parameter; the type of FPD material or the status of the abutment, may have an influence on the long term periodontal status; our study found vital abutments receiving PFM crowns showed better response of the periodontal tissues.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

Informed consents were obtained from the enrolled subjects after explaining the nature of the study and possible risks involved.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval from the institutional Ethical Committee at ISNC has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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