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Brief Report

A Comparison of the Effect of Zirconia Crown on Periodontal Tissues: A Nonrandomized Clinical Trial

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Abstract

Background: Dental crowns are effective on the gingival tissue around the teeth. However, using zirconia as crowns due to the method and type of material can effectively improve this effect.

Methods: This is a pre-post clinical trial conducted on 35 teeth with metal-ceramic crowns and 35 teeth with zirconia crowns. Teeth were prepared for fabricating metal-ceramic and zirconia crowns. Plaque index (PI), modified gingival index (MGI), pocket probing depth (PPD), papilla bleeding index (PBI), and gingival level (GL) were measured before and six months after getting the dental crown. The data were analyzed using the Mann–Whitney test.

Results: In both groups, the GL remained the same after six months of crown placement ($P>0.05$). In the metal-ceramic group, the PI decreased significantly ($P=0.000$), but MGI and PBI significantly increased ($P=0.000$ and $P=0.000$, respectively) six months after crown placement. Based on the results, PPD increased significantly only on the midlingual surface ($P=0.02$). The PI significantly decreased in the zirconia group ($P=0.000$). Nevertheless, PPD represented no change ($P>0.050$). The comparison between the two groups six months after crown placement indicated that the PI, MGI, and PBI were significantly higher in the metal-ceramic group ($P=0.010$, $P=0.011$, and $P=0.044$, respectively). The metal-ceramic group showed a significantly greater increase in PPD on the midlingual surface ($P=0.043$).

Conclusion: Both crown types on teeth could significantly increase the incidence of gingivitis, and compared with zirconia crowns, metal-ceramic crowns demonstrated significantly more inflammation.

Keywords: Periodontal Index, Crown, Zirconia, Metal-Ceramic

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Background

Teeth restoration has various types, two of which are metal-ceramic or all-ceramic crowns. However, the success rate of such treatments requires compliance with a set of principles and therapeutic methods (1).

The ultimate goal of a dentist should be to perform proper restoration without causing damage to healthy periodontal tissues (2). Hygiene is one of the most important conditions for proper restoration and positively draws the attention of patients (3). Several factors, including nutrition, hygiene, tooth morphology and contour, finish line, and type of restoration materials, change the biomechanical behavior of the tooth and plaque accumulation (4). Therefore, proper restoration design helps in the survival of periodontal tissues. These factors naturally accumulate biofilms and microorganisms if not properly considered, forming microbial plaques, periodontitis, periodontal degradation, and marginal caries (5).

In fabricating dental crowns, utilizing materials that reduce the accumulation of biofilms and plaque is an essential factor in preventing periodontal disease (6). Metal-ceramic crowns are extensively used to repair damaged teeth because they have good mechanical properties and acceptable biological quality to ensure periodontal health (7). However, metal-ceramic crowns have limitations that may restrict their use. For example, the metal framework and the opaque porcelain layer required to mask the underlying metal shade lower the esthetic appeal of metal-ceramic crowns (8).

Zirconium dioxide (ZrO_2) has been employed in dentistry since 1960, although yttria-stabilized tetragonal zirconia (Y-TZP) was previously utilized in medicine for hip implants, given its excellent mechanical performance and biocompatibility (9, 10). In dentistry, Y-TZP ceramic was prescribed as a framework material for crowns and large fixed partial dentures (FPDs) in the anterior and posterior regions of the mouth (11). Nonetheless, treatment failure for Y-TZP crowns can be due to secondary caries, loss of retention, and chipping of porcelain veneers (12,13).

Bremer et al compared biofilm formation (dental plaque) in 5 different types of dental ceramics and concluded that zirconia crowns exhibit the least plaque accumulation. Zirconia has high strength and is an appropriate material for different periodontal indications (14).

Sjögren et al reported no plaque accumulation in all-ceramic crowns (15). Bindl and Mörmann indicated that although there was no difference between plaque accumulation on monolithic and layered ceramics, much less plaque has been observed in ceramics compared to control teeth (16). Al-Wahadni et al observed a lower plaque level in control (healthy) teeth than in all IPS Empress-type ceramics (17). Cehreli et al found no plaque in the all-ceramic crowns of In-Ceram and CeraCon-Z types after six months and two years of follow-up (18). According to Demarco et al, the prevalence of gingival bleeding and dental calculus around the restoration is higher when the number of restored surfaces and posterior restoration is higher (19).

Given the results of different studies and today's widespread application of metal-ceramic and zirconia crowns, this study aimed to evaluate the effects of metal-ceramic and zirconia crowns on periodontal tissues in a 6-month follow-up assessment. The null hypothesis was that gingival indices in teeth crowned with metal-ceramic and zirconia were the same.

Materials and Methods

This clinical trial was conducted in vivo on patients' teeth before prosthesis delivery and six months after cementing crowns temporarily. Using Minitab software for determining the sample size, Jalalian et al considered alpha 5% and beta 0.2, the minimum significant difference in envelope depth of 0.5 mm, and the average standard deviation of 1, along with estimating the minimum sample size of the study groups. The same approach was adopted in this study. The study's sample size was 70 teeth (maxillary first molar) of patients aged 20–60. Of these, 35 teeth that needed metal-ceramic crowns and 35 teeth that needed all-ceramic crowns (zirconia) were randomly selected. The inclusion criteria were good physical (the absence of severe systemic disease) and mental health, a lack of being under any medication that increases gum volume, and good periodontal health (no severe swelling, bleeding, periodontitis, or tooth mobility). The other inclusion criteria included pocket depth ≤ 3 mm and the existence of at least 3 mm of keratinized gingival tissue. On the other hand, teeth with prior pain or sensitivity, endodontic failures, or thin biotype periodontium were excluded from the study. The causes of dental caries and oral diseases were explained to all patients. Additionally, ways for observing hygiene standards, such as brushing teeth and using dental floss, were taught. For each patient, the plaque index (PI) of a mandibular incisor tooth was measured during the entire time of the study to evaluate personal hygiene care and standardize the analysis method. In a blind experiment, PI, modified gingival index (MGI), pocket probing depth (PPD), papilla bleeding index (PBI), and gingival level (GL) were examined in the patients' mouths and then recorded in an information form. Before being prepared for crowns, the tooth surfaces were dried using air power, and several periodontal assessments were performed as follows:

Modified Gingival Index

MGI was utilized to investigate gingival inflammation. Four mesial, distal, facial, and lingual tooth areas were observed clinically. Diab defined four scores for MGI, assigned numbers 1–4 to them based on the inflammation severity, and calculated the average score for each tooth (20).

Plaque Index

PI was assessed by the Silness-Löe PI method using an explorer at four facial, lingual, mesiofacial, and distofacial surfaces of the tooth (21).

Pocket Probing Depth

PPD, the distance between the gingival margin and the base of the pocket, was measured at six points (mesiobuccal, buccal, distobuccal, distolingual, lingual, and mesiolingual) of each tooth using the Williams Graded Probe (Sklar Instruments Inc., West Chester, PA, USA).

Papilla Bleeding Index

The periodontal probe was moved from the base of the pocket to the top of the papillae in the mesial and distal papilla.

GL, the distance between the gingival margin and cementoenamel junction, was estimated at six points (mesiobuccal, buccal, distobuccal, distolingual, lingual, and mesiolingual) of each tooth using the Wiliams Probe (in mm).

Each patient's data were recorded, and an experienced prosthetic specialist gave prosthetic treatments. Tooth were prepared for fabricating metal-ceramic and all-ceramic zirconia crowns 0.3 mm below the gingival margin using standard methods. To prepare the tooth for metal-ceramic crowns, the occlusal surface was reduced (1.5-mm functional and 1-mm non-functional cusps), and a functional cusp bevel was made. The lingual surface was prepared to create a Chamfer finishing line (with a

convergence angle of 6°) using a Torpedo bur (Kerr, California, USA). The labial surface was more deeply prepared to create the metal and porcelain frame using a shoulder bur and a 0.3-mm bevel at the buccal surface.

A depth of 1.2–1.4 mm at the labial surface was considered to prepare the tooth for zirconia restoration. A flat-end tapered diamond bur was used for all preparations, except for the lingual surface, for which a small diamond-coated wheel bur was utilized. The shoulder finish line, which was at least 1 mm wide, was also prepared with the lateral part of this bur.

All the metal-ceramic and zirconia crowns were fabricated in the same laboratory. Waxed-up copings of metal-ceramic were invested and cast, followed by applying porcelain (Argedent Euro; the Argen Corporation and IPS d.SIGN; In-Line Porcelain; Ivoclar-Vivadent). The zirconia crowns were fabricated using milling technology (Wieland Mini-mill; Wieland Dental). Self-colored zirconia blocks (Zenostar; Wieland Dental) were milled in the green state and then sintered according to the manufacturer's recommendations. Afterward, the porcelain was used to cover the framework.

Finally, after fabricating the same crowns (in terms of the type and thickness of alloy and ceramic) and glazing, they were cemented using temporary cement (Temp-Bond NE, Kerr, CA, USA), and the excess cement was removed from the gingival sulcus.

The non-standard crowns (over contour, open proximal contacts, and margins above or more than 0.5 mm below the gingival margin) were excluded from the study. The margins were examined using a sharp explorer and diagnosed by a dentist's direct observation. Samples with marginal gaps over 50 µm, whose amounts were determined by a fit checker (Fit Checker Advanced; GC Corporation), or samples with improper clinical margins were excluded from the study.

After six months, when patients returned, all periodontal indices were re-investigated, and the data were recorded in the related forms, which were later evaluated and compared. After data collection, the Wilcoxon test in SPSS software (IBM SPSS Statistics v25.0; IBM Corporation, USA) was utilized to compare the PI and MGI of all groups. The *t* test and the Mann–Whitney test were used to investigate the PPD, gingival level, and PBI and to measure indices between metal-ceramic and zirconia crowns, respectively.

Results

There were 16 male and 19 female patients with a mean age of 39.37 ± 8.92 years in the metal-ceramic group, as well as 17 male and 18 female patients with a mean age of 41.53 ± 9.96 years in the zirconia group.

Based on the results of the Wilcoxon test, the PI of mandibular incisor teeth in all patients showed no significant difference after six months of crown placement.

The results of the Wilcoxon test in the metal-ceramic group are presented in Table 1. The gingival level was the same after six months of crown placement ($P > 0.050$). The PI decreased significantly ($P = 0.000$), but MGI and PBI significantly increased ($P = 0.000$ and $P = 0.000$, respectively). The PPD increased significantly only on the midlingual surface ($P = 0.020$), whereas it did not change significantly on the other surfaces ($P > 0.050$) (Table 1). In the zirconia group (Table 2), although the gingival level did not change significantly ($P > 0.050$) after six months of crown placement, the PI represented a significant decrease ($P = 0.000$). However, MGI and PBI significantly increased ($P = 0.000$ and $P = 0.000$, respectively), and the PPD changed on none of the surfaces of the zirconia crowns ($P > 0.050$, Table 2).

Table 1. Mean of Indices and Pocket Probing Depth in the Metal-ceramic Restoration Group

Index	PBI	MGI	PI (%)	Ppd in Distobuccal (mm)	Ppd in Midbuccal (mm)	Ppd in Mesiobuccal (mm)	Ppd in Distolingual (mm)	Ppd in Midlingual (mm)	Ppd in Mesiolingual (mm)
Before tooth preparation	0.96 ± 0.47	1.21 ± 0.34	1.08 ± 0.28	2.44 ± 0.55	1.91 ± 0.88	2.54 ± 0.65	2.52 ± 0.61	1.90 ± 0.66	2.36 ± 0.58
Six months after crown placement	1.64 ± 0.41	1.93 ± 0.35	0.65 ± 0/22	2.51 ± 0.56	2.03 ± 0.82	2.60 ± 0.60	2.68 ± 0.52	2.50 ± 0.63	2.43 ± 0.55
Test results	$P = 0.000$*	$P = 0.000$*	$P = 0.000$*	$P = 0.102$ns	$P = 0.056$ns	$P = 0.157$ns	$P = 0.064$ns	$P = 0.020$*	$P = 0.102$ns

Abbreviations: Ns, Non-significant; PBI, Papilla bleeding index; MGI, Modified gingival index; PI, Plaque index.
* Significant differences

Table 2. Mean of Indices and Pocket Probing Depth in the Zirconia Restoration Group

Index	PBI	MGI	PI (%)	Ppd in Distobuccal (mm)	Ppd in Midbuccal (mm)	Ppd in Mesiobuccal (mm)	Ppd in Distolingual (mm)	Ppd in Midlingual (mm)	Ppd in Mesiolingual (mm)
Before tooth preparation	0.92 ± 0.55	1.31 ± 0.30	1.16 ± 0.30	2.62 ± 0.61	2.14 ± 0.79	2.30 ± 0.66	2.42 ± 0.60	1.81 ± 0.74	2.28 ± 0.61
Six months after crown placement	1.41 ± 0.53	1.82 ± 0.33	0.53 ± 0.29	2.69 ± 0.57	2.19 ± 0.82	2.36 ± 0.59	2.55 ± 0.50	1.97 ± 0.65	2.39 ± 0.49
Test results	$P = 0.000$*	$P = 0.000$*	$P = 0.000$*	$P = 0.102$ns	$P = 0.317$ns	$P = 0.317$ns	$P = 0.052$ns	$P = 0.064$ns	$P = 0.146$ns

Abbreviations: Ns, Non-significant; PBI, Papilla bleeding index; MGI, Modified gingival index; PI, Plaque index.
* Significant differences.

The comparison between the two groups after six months of crown placement using the Mann–Whitney test revealed that the PI, MGI, and PBI were significantly higher in the metal-ceramic group ($P=0.010$, $P=0.011$, and $P=0.044$, respectively, Table 3). In addition, the difference in PPD between the two groups after six months of crown placement was significant only in the midlingual area. The increase in the PPD in this area was significantly greater in the metal-ceramic group ($P=0.043$, Table 3).

Discussion

Based on the results obtained from this clinical trial, PI, MGI, and PBI indices in zirconia crowns were lower than in metal-ceramic ones. In the zirconia group, the pocket depth did not change significantly, and in the metal-ceramic group, the pocket depth increased significantly only on the midlingual surface.

The findings of the present study demonstrated that there was a statistically significant decrease in PI scores of metal ceramics compared to zirconia crowns, indicating that metal-ceramic crowns have more negative effects on periodontium compared to zirconia crowns. Gingival inflammation was significantly higher around the crowned teeth than in those without crowns. Similarly, gingival inflammation was significantly higher around teeth crowned with metal-ceramic than those crowned with zirconia. The PI of crowned teeth was significantly less than that of teeth without crowns. Compared with zirconia crowns, the PI of metal-ceramic crowns was significantly higher. This is in agreement with the results of Mishari et al, indicating that metal-ceramic crowns appear to be associated with periodontal breakdown more than all-ceramic crowns (20). Additionally, Al-Wahadni et al reported that all-ceramic crowns attract less plaque accumulation than metal-ceramic crowns (17). According to Weishaupt et al, ceramic crowns accumulate less plaque than metal-ceramic ones, which can be attributed to a favorable gingival response (22). This is in agreement with the findings of the study by Chan and Weber, focusing on PI in 150 zirconia, metal-ceramic, cast gold, and acrylic resin crowns (23). They showed that the PI of zirconia and metal-ceramic crowns was less than that of teeth without crowns.

Further, according to Koidis et al, the metal and coarse surfaces represented the greatest rate of bacterial accumulation in the laboratory environment, and lingual crown surfaces were the same because of a metal collar. This rate was, on average, less than that for teeth without crowns, given that other surfaces were coated with ceramic (24). This result is in line with our results, where a significant difference was observed between plaque accumulation at the lingual and buccal surfaces. Moreover, Al-Wahadni et al investigated PI, GI, and PPD indices in 82 IPS Empress crowns, suggesting that teeth with IPS Empress crowns had lower gingival health than those without crowns (17), which conforms to our results.

The MGI of crowned teeth was significantly less than that of teeth without crowns, and the MGI was significantly lower in zirconia than in metal-ceramic crowns. Weishaupt et al evaluated the clinical and inflammatory effects of galvano-ceramic and metal-ceramic crowns on periodontal tissues by measuring GI, PI, and gingival crevicular fluid (GCF). The PI rate of natural teeth was higher than that of metal-ceramic crowns, whose amount was greater than that of galvano-ceramic crowns (22). The findings of this study demonstrated that MGI increased more in metal-ceramic crowns than in galvano-ceramic crowns, which is consistent with the results of the present study.

Ababnaeh et al explored the relationship between the type and material of dental crowns and periodontal health, showing that crowns and bridge abutments had the highest gingival and high probing depth but a low PI. Porcelain had the lowest PI and clinical attachment level, while non-precious alloy castings exhibited the highest gingival index and clinical attachment level (25). These results corroborate our study's findings, except for PPD, which represented a significant increase only on the midlingual surface of the metal-ceramic group in our study. This difference could be due to different materials and different follow-up durations.

Furthermore, in a study by Jalalian et al, PI and MGI were investigated in 120 teeth with metal-ceramic and all-ceramic crowns. Consistent with our study findings, the PI was significantly lower, but the MGI was significantly higher around crowned teeth than those without crowns. However, PI and MGI were significantly lower around all-ceramic than metal-ceramic crowns (26). The reason for increased MGI despite the lower PI in teeth with crowns can be attributed to factors such as the existence of previous periodontal problems and a lack of appropriate treatment before the onset of restorative therapy. The

Table 3. Comparison of PI, $PI_{control}$, MGI, PBI Indices, and Pocket Probing Depth Between the Metal-ceramic and Zirconia Restoration Groups After Six Months of Crown Placement

Index	PI6 (%)	MGI6	PBI6	Ppd in Distobuccal (mm)	Ppd in Midbuccal (mm)	Ppd in Mesiobuccal (mm)	Ppd in Distolingual (mm)	Ppd in Midlingual (mm)	Ppd in Mesiolingual (mm)	Ppd in Mesiolingual (mm)
Metal-ceramic	0.65	1.93	1.64	2.51	2.03	2.60	2.68	2.50	2.43	2.43
Zirconia	0.53	1.82	1.41	2.69	2.19	2.36	2.55	1.97	2.39	2.39
P value	0.010*	0.011*	0.044*	0.183ns	0.372ns	0.101ns	0.320ns	0.043*	0.670ns	0.670ns

Abbreviations: Ns, Non-significant; PBI, Papilla bleeding index; MGI, Modified gingival index; PI, Plaque index.
* Significant differences.

other factors were injury to periodontal tissues during prosthetic fabrication stages, damage to the biological width, non-compliance with the correct structural principles of the fixed prosthesis, and lack of patient referral during the maintenance period (22).

Kınay Taran and Kaya compared the effects of prefabricated stainless steel crowns (SSC) and zirconia crowns on PI and GI, arguing that teeth restored using zirconia showed lower GI and PI than those restored by SSC and the control group (27). The researchers attributed it to the smoother surface and higher biocompatibility of zirconia than SSC.

The results of this study indicated that in the metal-ceramic group, the pocket depth increased significantly only on the midlingual surface, but it did not change significantly in the zirconia group. In another study conducted by Moeintaghavi et al, MGI, PI, PD, and the width of the keratinized gingiva around crowned teeth were compared with those of natural teeth. The results demonstrated that MGI and PD around crowns were greater than those around natural teeth, but keratinized gingiva and PI around crowns were lower than those around natural teeth (28). However, our results revealed that the difference in PPD was significant only in the midlingual area. Additionally, the statistical results in the current study showed that plaque accumulation on metal-ceramic crowns on the lingual side, with the metal surface, was greater than on the buccal side, with the ceramic surface, which can explain the increased pocket depth on the lingual surface. In a 3-year follow-up study performed by Schmitt et al on 27 zirconia posterior-FDPs, the periodontal criteria (GI, PI, sulcus bleeding index, and PD) between the control and test groups were almost the same (29). The present study assessed these indices before getting a dental crown and six months after cementing prostheses. Nonetheless, in the above-mentioned studies, the indices were investigated in the crowned tooth compared to the natural tooth; thus, the difference between the results of this study and those of the above-mentioned study can be justified. Likewise, Schmitt et al evaluated FDPs, and the follow-up duration was longer than that of the present study.

Our findings confirmed that PBI was significantly higher around the crowned teeth than teeth without crowns and was significantly higher around teeth crowned with metal-ceramic than with zirconia. According to Emily et al, who investigated GCF and bleeding on probing (BoP) in 32 metal-ceramic, lithium disilicate, and monolithic zirconia crowns, the mean volume of GCF and BoP showed no difference between different types of crowns, between control groups and groups under treatment, or over time. Although a slight increase in the GCF volume was observed for the lingual surfaces of untreated teeth, it was not statistically significant (30). This inconsistency in results compared to our study findings could be attributed to the smaller sample size in the above-mentioned study and the different designs of these two studies.

Limitations of the Study

One of the limitations of this study was its short-term follow-up sessions. Furthermore, zirconia-related biofilms may differ from metal-ceramic ones, which could alter recorded inflammatory responses. In addition, the biofilms were not compared in this study, and long-term scientific research is needed to evaluate such differences.

Conclusion

The findings demonstrated that, regardless of other factors related to the metal-ceramic restoration quality, compared to zirconia crowns, the existence of metal-ceramic crowns on teeth leads to a significantly increased incidence of gingivitis.

Authors' Contribution

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Competing Interests

The authors declare no conflict of interests.

Ethical Approval

All patients were provided with written informed consent, and the Ethics Committee of Shahed University approved the study (No. 4/318547).

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