RESEARCH ARTICLE

Survival of anterior metal ceramic and porcelain veneered zirconia cantilever resin bonded fixed dental prostheses

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Abstract

Objective: To compare the survival rates of anterior cantilever porcelain veneered zirconia and metal ceramic resin bonded bridges when used for the restoration of a missing maxillary central incisor.

Method: The quasi-experimental study was conducted at the de 'Montmorency College of Dentistry, Punjab Dental Hospital, Lahore, from July 4, 2022, to August 7, 2023, and comprised patients aged at least 14 years of either gender having a missing maxillary central incisor. They were divided into group A receiving anterior cantilever metal ceramic resin bonded bridges, and group B receiving anterior cantilever porcelain veneered zirconia resin bonded bridges. The restorations were clinically evaluated after cementation at baseline (one week) and then at 3, 6 and 12 months to determine the survival rate in terms of debonding, cracks/chipping/fracture, gingival health and plaque accumulation around restoration, postoperative hypersensitivity and aesthetic outcome with respect to staining of the restorations. Data was analysed using SPSS 25.

Results: Of the 30 patients, 15(50%) were in group A with mean age 22.1±5.9 years (range: 14-34 years), while 15(50%) were in group B with mean age 26.3±7.3 (range: 16-41 years) ($p>0.05$). No significant difference was found in debonding, cracks/chipping/fracture and postoperative hypersensitivity between the groups ($p>0.50$. Group B had superior gingival health and less plaque accumulation than group A ($p<0.001$). The survival of the restorations with regard to the aesthetic outcome was 15(100.0%) in both the groups.

Conclusion: Anterior cantilever porcelain veneered zirconia resin bonded bridges could be used as an aesthetic alternative to metal ceramic resin bonded bridges due to their excellent survival rates in terms of technical and biological outcomes.

Keywords: Zirconium, Dental porcelain, Dental prosthesis design, Resin cements, Aesthetics, Dental.

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Introduction

Replacement of a single missing anterior tooth in maxilla is a gruelling task for dentists around the world. The provision of implants or fixed partial dentures can become an onerous endeavour if the patient has an inadequate alveolar bone height and width, or if the patent refuses to accept the treatment option owing to its invasive nature or financial constraints. Moreover, the occurrence of secondary caries and endodontic complications are more convergently associated with traditional fixed partial dentures.[1] Anterior cantilever metal ceramic resin bonded bridges (RBBs) have been widely used as minimally invasive treatment alternative for the restoration of unitary edentulism, particularly in the maxilla. Despite their clinical success, debonding has been ascertained as the primary cause for the failure of these restorations. [2] Metal ceramic RBBs have faced criticism due to their considerable aesthetic limitations that are attributed to the undesirable display of the metal retainers in the interproximal area and the shine-through of metal lingual retainers through the abutment teeth. Moreover, dental casting alloys are associated with adverse tissue reactions and infrequent allergic complications.[3]

With rising aesthetic consciousness, all-ceramic cantilever RBBs were introduced as a desired alternative to address the aesthetic blemishes of metal lingual retainers. Yttria-stabilised tetragonal zirconia polycrystal (Y-TZP) has superior mechanical properties and fracture resistance compared to other conventional dental ceramics, which explains its use in dentistry. Zirconia ceramic has excellent biocompatibility with potentially low adhesion affinity for bacteria.[4] Porcelain veneered zirconia restorations display remarkable aesthetics, and precisely reproduce the chromaticity of adjacent natural teeth. Woefully, these bilayered restorations are markedly susceptible to chipping of the veneering porcelain.[5] The adhesive cementation of zirconia is technique-sensitive due to the absence of silica phase which renders it non-etchable against the conventional acid-etching treatments done with hydrofluoric acid.[6]

The current study was planned to comparatively evaluate the survival rates of anterior cantilever metal ceramic and porcelain veneered zirconia RBBs.

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Materials and Methods

The quasi-experimental study was conducted at the de 'Montmorency College of Dentistry, Punjab Dental Hospital, Lahore, from July 4, 2022, to August 7, 2023. After approval from the institutional ethics review board, the sample size was calculated using World Health Organisation (WHO) calculator[7] with 90% power, 5% level of significance, and assumed survival rate of 98.5% with metal ceramic RBB (resin bonded bridges) and 53.5% with porcelain veneered zirconia RBB.[8,9] The sample was raised using purposive sampling technique. Those included were patients aged at least 14 years of either gender having a missing maxillary central incisor with skeletal and incisal Class I and Class II (division 1) relationships with stable posterior contacts, sound or minimally restored maxillary central incisors as abutment teeth, and natural antagonists opposing the proposed RBBs. Patients were excluded if they exhibited parafunctional habits (e.g. bruxism), active periodontal or periapical pathology of abutment teeth, deep overbite, anterior crossbite, and documented metal hypersensitivity. After taking written informed consent from all the patients, they were divided into group A receiving anterior cantilever metal ceramic RBBs, and group B receiving anterior cantilever porcelain veneered zirconia RBBs.

Abutment teeth were minimally prepared on the lingual aspect with a supragingival finish line, and the preparation ended approximately 2mm below the incisal edge of the abutment tooth on the palatal side. A small proximal box of approximately 2mm length, 1mm width and 0.5mm depth was prepared. Impressions were taken and VITA tooth guide 3D Master (VITA Zahnfabrik, Bad Säckingen, Germany) was used to accurately determine the tooth shade in an ambient light.

The frameworks of metal ceramic resin bonded bridges were cast from the base metal alloy (Wirocast cobalt-chromium [Co-Cr] alloy, Bego, Bremen, Germany). The retainer wing had an overall thickness of 0.8mm. The frameworks of zirconia RBBs were designed using CAD/CAM technology. Exocad Dental CAD 3D design software (Exocad GmbH, Darmstadt, Germany) was used to produce a 3D digital model of the restoration which was then subsequently milled from pre-sintered Y-TZP zirconia blanks (Nobilium HT Zirconia, Nobilium, Albany, NY, USA)) using Arum 5X milling machine (Arum Dentistry Co., Ltd., Daejeon, South Korea). The thickness of the retainer wing was approximately 1mm.

Prior to insertion, the fitting surface of every restoration was air-abraded in Renfert micro abrasive sand blaster (Renfert GmbH, Hilzingen, Germany) using 50µm alumina

Figure-1: Preoperative and postoperative intraoral frontal view of patient rehabilitated with porcelain veneered zirconia resin bonded bridges (RBBs).

Figure-2: Occlusal view of cemented metal ceramic resin bonded bridge (RBB)a) and porcelain veneered zirconia RBB (b).

particles for 10 seconds, followed by ultrasonic cleaning in 96% alcohol for one minute. After the rubber dam isolation, the prepared abutment tooth was etched with 37% phosphoric acid for 30 seconds. Prime & Bond® NT adhesive (Dentsply Sirona, Konstanz, Germany) was applied on the enamel surface and light cured. The restorations were adhesively luted using Calibra® Universal Resin cement (Dentsply Sirona, Milford, DE, USA) (dual cure self-adhesive). Following cementation (Figure 1), occlusion was evaluated such that pontic was free of occlusal contacts in maximum intercuspation and dynamic excursions (Figure 2). The margin of the retainer was steered clear of occlusal contacts.

After the provision of restorations, they were clinically evaluated for one year. Restorations were evaluated at the baseline (one week), and at 3, 6 and 12 months. The restorations that had not debonded and were held in place intra-orally at the time of appointment was further assessed for other parameters of survival rate, including cracks/chipping / fracture, gingival health and plaque accumulation around restoration, postoperative hypersensitivity after cementation and aesthetic outcome of the restoration.

The presence of cracks/chipping/fracture of the restoration

was detected by objective visual examination, transillumination with a fibre optic illuminator (Ascentcare Dental Products, USA) and methylene blue staining. The presence of cracks, if any, was based on the pooling of methylene blue dye in that region.

Gingival health around the restorations was clinically assessed using the modified Gingival Index, with grade 0= normal healthy gingiva with no bleeding on probing, grade 1(a) = mild gingivitis but no bleeding on probing, grade 1(b) = mild gingivitis with delayed bleeding on probing, grade 2 = moderate gingivitis and immediate bleeding on probing, and grade 3 = severe gingivitis with spontaneous haemorrhage. Plaque accumulation around the restorations was detected by plaque disclosing tablets and evaluated by the Turesky modification of Quigley and Hein plaque index (TQHPI), with grade 0 = no plaque, grade 1 = separate flecks of plaque at the cervical margin, grade 2 = a thin continuous band (<1mm) at the cervical margin of the tooth, grade 3 = a band of plaque wider than 1mm but covering less than one-third of the crown of the tooth, grade 4 = plaque covering at least one-third but less than two-thirds of the crown of the tooth, and grade 5 = plaque covering two-thirds or more of the crown of the tooth. Postoperative hypersensitivity following the cementation of the restorations was detected with a cold test using an endo-ice spray and evaluated by the revised FDI World Dental Federation criteria.[10] Aesthetic outcome with respect to staining of a restoration was clinically evaluated by visual examination and photographic analysis.

Data was analysed using SPSS 25. Fisher's exact test was used to compare the debonding, cracks/chipping/fracture, gingival health, plaque accumulation, postoperative hypersensitivity and aesthetic outcome between the two groups across time points. The one-year survival rate of anterior cantilever metal ceramic RBBs and porcelain veneered zirconia RBBs for each variable was calculated by dividing the number of RBBs without failure by the total number of clinically examined bridges in each group. Therefore, descriptive statistics using frequencies and percentages were used to assess the cumulative survival rates of the two groups for each individual variable over a period of 12 months, considering the following failure criteria: debonding, cracks/chipping/fracture, bleeding on probing around the restoration, plaque covering one-third or more of the restoration surface, persistent postoperative hypersensitivity with irreversible pulpitis and moderate or severe surface staining of the restoration which cannot be corrected by porcelain polishing. Independent sample t-test was used where necessary. P<0.05 was considered significant.

Results

Of the 30 patients, 15(50%) were in group A with mean age 22.1±5.9 years (range: 14-34 years), while 15(50%) were in group B with mean age 26.3±7.3 (range: 16-41 years) (p=0.095). The overall sample comprised 16 (53.3%) males and 14 (46.7%) females. In group A, 10 (66.7%) were males and 5 (33.3%) were females. In group B, 6 (40.0%) were males and 9 (60.0%) were females.

At baseline, in group A, debonding was observed in 2(13.3%) patients, while in group B debonding was not observed in any patient. At 3 months, in group A, debonding was not observed in any patient, while in group B, debonding was observed in 1(6.7%) patient. At 6 months, in group A, debonding was not observed in any patient, while in group B, debonding was observed in 1(7.1%) patient. At 12 months, debonding was not observed in any patients in any of the two groups (p>0.05). The survival rate of the restorations in terms of debonding was 86.7% in both the groups.

No cracks/chipping/fracture was observed in any of the patients in groups A and B at the baseline, 3, 6 and 12 months. Hence, the survival rate of the restorations in terms of cracks/chipping/fracture was 15(100%) in both the groups.

No significant difference was observed in gingival health around the restorations between the groups at the baseline and 3 months. At 6 months, 4(30.8%) patients in group A had healthy gingiva and 6(46.2%) patients had bleeding on probing, whereas 10 (76.9%) patients in group B had healthy gingiva and 3(23.1%) patients had mild gingival inflammation but no bleeding on probing. At 12 months, 2(15.4%) patients in group A had healthy gingiva, whereas all 15(100%) patients in group B had healthy gingiva (p<0.05). Hence, the survival rate of the restorations when clinically evaluated for gingival health around restoration was 65.4% for group A and 94.5% for group B (Table 1).

At the baseline, 5(38.5%) patients in group A had plaque covering one-third of the restoration surface compared to none in group B. Group A patients had significantly higher grades of plaque accumulation around the restorations

Table-1: Comparison of gingival health between the study groups 12 months after restoration (n=30).

Gingival Health Around Restoration	Group A n (%)	Group B n (%)	*p*-value#
Grade 0	2 (15.4)	13 (100.0)	< 0.001*
Grade 1(a)	4 (30.8)	0 (0.0)	
Grade 1(b)	7 (53.8)	0 (0.0)	
Grade 2	0 (0.0)	0 (0.0)	
Grade 3	0 (0.0)	0 (0.0)	

#Fisher's Exact test *Significant

Table-2: Comparison of plaque accumulation between the study groups 12 months after the restoration.

Plaque Accumulation Around Restoration	Group A n (%)	Group B n (%)	*p*-value#
Grade 0	0 (0.0)	0 (0.0)	< 0.001*
Grade 1	0 (0.0)	5 (38.5)	
Grade 2	0 (0.0)	6 (46.2)	
Grade 3	5 (38.5)	2 (15.4)	
Grade 4	8 (61.5)	0 (0.0)	
Grade 5	0 (0.0)	0 (0.0)	

#Fisher's Exact test *Significant

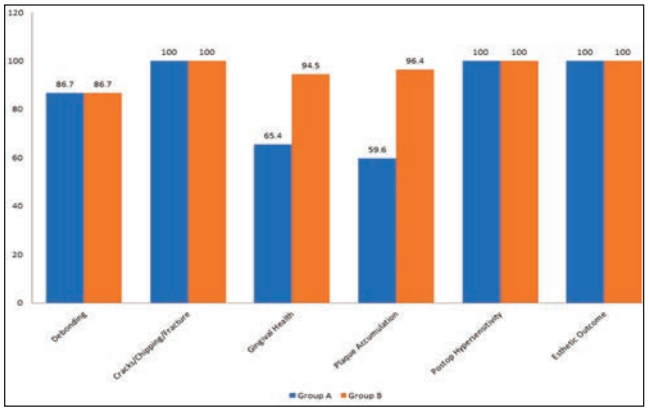

Figure-3: Comparison of the overall survival rate between the study groups in percentages.

compared to group B at 12 months (Table 2). Hence, the survival rate of the restorations in terms of plaque accumulation around restoration was 59.6% in group A and 96.4% in group B.

At the baseline, all the patients in both the groups exhibited postoperative hypersensitivity, but no postoperative hypersensitivity was reported at 3, 6 and 12 months. The survival rate of the restorations in terms of postoperative hypersensitivity was 15(100%) in both the groups.

None of the patients in either group exhibited moderate or severe staining of the restoration at the baseline, 3, 6 and 12 months. Hence, the survival of the restorations with regard to aesthetic outcomes was 15(100%) in both the groups. Overall survival rate between the two groups at 12 months was noted (Figure 3).

Discussion

The current in-vivo study revealed excellent survival rates for anterior cantilever porcelain veneered zirconia RBBs when contrasted with anterior cantilever metal ceramic RBBs. Survival rates are often evaluated in terms of debonding and fracture of the restorations. In the present study survival of the restorations was clinically evaluated for six variables; debonding, cracks/chipping/fracture, gingival health around restoration, plaque accumulation, postoperative hypersensitivity after cementation, and aesthetic outcome of the restoration.

The frequency of debonding was found to be same for both the current groups with a clinical retention rate of 86.7%. However, the incidence of debonding with respect to time was different for both the groups. Saker et al. reported a clinical retention rate of 95% for metal ceramic RBBs and 70% for all-ceramic RBBs after an evaluation period of 10 years.[11] In another study, 10-year clinical outcome of anterior cantilever zirconia ceramic RBBs was evaluated where the retention rate was found to be 95% and 3 out of 6 debondings were caused by traumatic accidents.[12] One of the metal ceramic restorations in the current study was debonded when the patient intended to forcefully bite sugarcane from his anterior teeth. Similarly, one patient with debonded zirconia ceramic restoration gave a history of aggressively rubbing Salvadora persica twigs on the labial and lingual surfaces of teeth for cleaning purposes. However, no appreciable cause was determined for other debonded restorations.

The restorations that remained bonded to the abutment tooth were further evaluated for other parameters in the current study. Not a single case of cracks/chipping/fracture was recorded. In a systematic review, porcelain chipping and fractures in metal ceramic RBBs were reported in 11 out of 15 studies, with the incidence of porcelain chipping ranging 0.8-8%.[13] A systematic review on porcelain veneered zirconia restorations revealed porcelain chipping to be as high as 20% over a period of 5 years with posterior restorations being affected the most.[14] Despite the excellent fracture resistance of zirconia, literature does not completely absolve it of these technical complications. In a study, 37 anterior cantilever zirconia RBBs were clinically evaluated for 3 years, with one fracture of the zirconia framework being reported after about 35 months.[15]

Bleeding on probing has been regarded as the classical indicator for the onset of gingivitis.[16] In the current study, the survival rate of the restorations when clinically evaluated for the abutment gingival health around restoration was 65.4% for group A and 94.5% for group B. Literature has been very vocal in highlighting the health implications of dental casting alloys primarily due to their inherent corrosive potential which can provoke an inflammatory reaction in the surrounding tissues. One study recorded elevated GI scores for the abutment teeth after the cementation of metal ceramic RBBs in 46 patients when compared to the controls at subsequent follow-up appointments.[17] Zirconia has been globally lauded as a promising dental biomaterial due to its non-cytotoxic nature and excellent corrosion resistance.[18] Five-year evaluations of gingival health of the abutment teeth

around 24 anterior cantilever zirconia RBBs revealed bleeding on probing in only one patient.[19] However, gingival bleeding on probing of the abutment teeth was observed in three patients of group B in the current study; one at the baseline and the other two after 3 months. The patient who exhibited bleeding on probing at the baseline demonstrated a significant improvement in gingival health, with no episode of bleeding on probing thereafter.

The survival rate with regard to plaque accumulation around the restorations was 59.6% for group A and 96.4% for group B in the current study. Suzuki et al established a positive correlation between the amount of plaque accumulation and the extent of gingival inflammation as evinced by bleeding on probing.[20] A strong concurrent validity existed between TQHPI and bleeding on probing.[21] This positive correlation between plaque accumulation and bleeding on probing was also witnessed in the metal ceramic restorations of the current study. No such concurrence was detected in porcelain veneered zirconia restorations of the current study, where the three patients who exhibited bleeding on probing aberrantly did not have high plaque scores recorded for the restorations or abutments. This is because zirconia exhibits low adhesion affinity for bacterial plaque attributed to its low surface energy and wettability.[22] Whereas dental casting alloys have been notorious for promoting bacterial adherence due to their high surface energies and greater affinity to bacteria for the electric charges on these alloys.

Literature has advocated the use of total-etch technique with self-adhesive resin cements to improve their bonding strength to enamel, especially for indirect bonded restorations with non-retentive preparation designs.[23] Despite concerns that the total-etch technique could lead to hypersensitivity, no cases of persistent postoperative hypersensitivity affecting the vitality of abutments was found in the current study. A study documented the devitalisation of two abutments post-cementation of 82 metal ceramic RBBs.[24] Another study reported normal pulp vitality responses of abutments post-cementation of 15 anterior cantilever zirconia RBBs.[25]

The literature is critical of the aesthetic limitations of metal-ceramic RBBs with metal lingual retainers even when using opaque resin cement.[26] This aesthetic deficiency was also witnessed in one of the patients of group A in the current study, where the grey metal shined through the translucent enamel of the abutment tooth, thereby jeopardising its aesthetic value. However, none of the patients in groups A and B exhibited moderate or severe staining of the restorations. Only one patient in group B exhibited slight surface staining on the lingual surface of restoration, which was corrected by porcelain polishing. This patient divulged his habit of betel nut chewing with smokeless tobacco. Although zirconia exhibits excellent staining resistance when exposed to acidic beverages and cigarette smoke, the impact of betel quid on zirconia's colour stability has not been documented in literature. [27] The current study suggests that zirconia is prone to develop betel stains despite its proclaimed colour stability.

The current study has limitations as it had a relatively small sample size and short duration. Moreover, patients in the study exhibited diverse oral hygiene habits, leading to variable plaque accumulation. Patient-related factors also contributed to debonding failures often due to poor dietary habits, like chewing sticky foods or biting hard items. These behaviours persisted despite post-cementation instructions and were difficult to control.

Conclusion

Anterior cantilever porcelain veneered zirconia RBBs delivered successful clinical outcomes when collated with metal ceramic RBBs. No appreciable difference in technical complications of debonding and cracks/chipping/fracture was registered between the two groups. However, there was an explicit demarcation in the survival rates with respect to the biological outcomes of gingival health and plaque accumulation between the groups. Moreover, no discernible difference was noted in the staining resistance of metal ceramic and porcelain veneered zirconia RBBs.

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Author Contribution:
SQ: Research concept and design.
MWUK: Critical revision and final approval.
MA: Data analysis and interpretation.