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COMPARATIVE EVALUATION OF BONDING STRENGTH BETWEEN METAL CERAMIC AND ALL CERAMIC CROWN CEMENTED ON IMPLANT ABUTMENT LUTED WITH RESIN CEMENT

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Abstract
This in-vitro investigation was carried out at BSMMU's Department of Prosthodontics. Thirty specimens/crowns in all, made entirely of ceramic materials and with metal. In order to test bonding strength individually, a total of thirty crowns or specimens were luted with resin cement on implant abutments. These specimens' homogeneous outer layer thickness complied with American Dental Association (ADA) requirements. The two sets of crown specimens had the same inner hole diameter. Based on preset parameters, dental labs produced crowns for both groups. The Universal testing matching system at BUET's Biomedical Engineering Department was used to administer this test. The bonding strength (MPa) of luting cement between implant abutment and crown specimens was measured using a UTM test. The pre-tested semi-structured check list was utilized to record the specimens' bonding strength value. Software known as the Statistical Package for Social Sciences (SPSS) (version 24) for Windows was used to verify, amend, code, and analyze the collected data. To find the mean value and its standard deviation for each core material, the bonding strength values were subjected to a t-test analysis. Tables were utilized to display the results. The study's findings showed how the bond strength value (MPa) of resin cement, which was used as a luting agent in groups I (metal crowns) and II (all ceramic crowns), distributed over the thirty study samples in total (15 samples in each group). According to the study's findings, group-II (all ceramic crowns) had a mean bond strength value (MPa) of resin cement as a luting agent that is higher than group-I (metal crown). Furthermore, a statistically significant difference (p-value =.001) exists between the mean

and standard deviation of the bond strength value (MPa) of resin cement used as a luting agent in groups I (metal crown) and II (all ceramic crown). In conclusion, all ceramic crowns produced a stronger bonding strength than metal ceramic crowns cemented on implant abutments luted with resin cement.

Key words: metal ceramic crown, Implant, luting cement, ceramic crown

Introduction

In contemporary dentistry, implants are a common replacement for natural teeth. It is a tooth or tooth analog holder that is osseointegrated or osseofixed. In contemporary dentistry, restorations primarily aim to achieve optimal function and aesthetics (1). The advent of endosseous dental implants has significantly altered the alternatives available for repairing edentulous areas. Clinical considerations encompass not only implant type selection, but also abutment and cement type selection (2). Titanium is the most popular material for dental implants because of its excellent qualities, which include corrosion resistance and biocompatibility (3).

Following implant osseointegration, the dentist is in charge of maintaining a correctly fitting and constructed prosthesis (4). Clinical choices depend on a variety of factors, including prosthesis material in addition to implant type. A restoration is chosen to protrude from the tissues to mimic a natural tooth, regardless of the implant system (2). The pursuit of consistent long-term outcomes has prompted inquiries into the materials and procedures utilized in therapeutic practice. Ceramic or non-precious alloys can be used to create implant-supported restorations. In the current state of modern technology, titanium prosthesis may now be made because to advancements in casting techniques and the introduction of computer-aided design/computer-aided manufacturing (CAD/CAM). Patients allergic to other metal alloys should use titanium in particular (5).

At first, implant-supported prostheses were only held in place with screws; however, as new implant systems and rehabilitation methods have been developed, cement-retained prostheses have gained popularity as a form of treatment. Restorations for dental implants can be screw- or cement-retained, or they can be both. Some dentists prefer cemented prosthesis because screw-retained implant restorations are difficult to establish passive fit (7). Because there is a cement layer between the framework and the abutment, passive fit is ensured by cement-retained superstructures over the implant abutments. Additional benefits of cement-retained implant restorations include better load distribution, improved aesthetics, simple access, shortened fabrication times and costs, streamlined restorative processes, and optimal occlusion without screw access opening obstruction. Conversely, in cases where there is less interocclusal distance, the stability of a cement retained prosthesis is hampered because the abutment does not have the necessary height and taper for cement retention (8). For prosthetics held in place with cement, retention should be taken into account before removal for upkeep in the future. Additionally, retrievability acts as a safety feature that permits the prosthesis to be removed without endangering the implant superstructures underneath (9).

Retention undoubtedly affects both the longevity of implant prostheses and their absence of problems. The best kind of mechanism to improve the bonding of cemented restorations has been a topic of discussion among implant aided restoration practitioners over the years (1). The success of bonding between the prosthesis and metal contact determines the outcome of restorations supported by implants. The cement utilized, the implant abutment's surface preparation, and additional factors including the coping's internal surface features and the height and taper of the implant abutment all affect how long the crown lasts (9). Axial dislodgment forces should be used to investigate bonding or retentive strength in order to better simulate clinical situations (10). To the best of our knowledge, numerous research have examined the bonding strength of various luting agents on the retention of cement-retained prostheses. The purpose of this study is to assess and compare the bonding strength of all ceramic crowns cemented on implant abutments luted with resin cement vs metal ceramic crowns.

Materials and methods

From July 2023 to June 2024, this in-vitro study was conducted at Bangabandhu Sheikh Mujib University's Department of Prosthodontics. The study sample was chosen through the use of the purposeful sampling technique. The researcher's decision or their subjective assessment was used. Commercially pure, endoosseous, tapered, internal hex, non-coated titanium root from implant with straight platforms. Machined conventional commercial pure titanium abutment with 80 tapper was one of the inclusion criteria. Three types of crowns: custom built, CAD/CAM, and straight abutment.

Procedure

Acrylic resin blocks were used to embed implant analogs, and titanium abutments were torqued onto the analogs. To make mounting the specimen on the tensile strength testing apparatus easier, a 4 mm diameter hole was drilled in the end of the acrylic block. The torque applied to each abutment was 35 N/cm. The abutment is 7.4 mm in height, 4.2 mm in diameter, and has an 8 degree convergence angle. The samples were then split up into two groups. Group-A 16 samples: resin-luted implant abutments were used to cement metal ceramic crowns. The 16 ceramic crowns in Group B were all sealed using resin cement on implant abutments. An extension was created on each crown's occlusal surface, parallel to the implant's long axis, during the creation of the wax pattern for the crown. This extension served as a connector to the tensile strength testing apparatus. To make mounting the specimen on the tensile strength testing apparatus easier, a 4 mm diameter hole was drilled in the crown's center of extension.Ultimately, the wax designs were cast, cut, and completed. Furthermore, a CAD/CAM device was used to design and mill the entire ceramic crown. Ether alcohol was used to clean implant abutments before cementation, and they were left to dry for two minutes.

After mixing the cement per the manufacturer's instructions, it was poured into each crown, and each crown was seated using finger pressure on its corresponding abutment. A plastic scaler was used to get rid of extra cement. To guarantee full seating, the 5 kg weight was subsequently applied to each crown along the long axis. The cementing process was done at room temperature and left for a full day in storage. After that, for seven days, every specimen was submerged in distilled water at 370C and a pH of 7. Following seven days, the specimens were kept at 370C with 100% humidity for an hour, thermally cycled 100 times with a 10-second dwell period between 50 and 550 degrees Celsius, and then kept at 370C with 100% humidity for six days. To mimic thermal stressors and the aging process of the cemented crowns, thermocycling was used. The specimen was then fixed to a tensile strength testing apparatus. Tensile dislodgement stresses were applied to them at a cross head speed of 5 mm/min. The maximal force needed to remove the crown was identified as the retentive force, and it was measured in Newtons.

In order to ascertain the necessary force for the de-bonding of metal and ceramic crowns from the implant abutment, a Universal Testing Machine operating at a cross head speed of 1 mm/minute was utilized. The J-shaped hook was fastened to the machine's top jaw, while the reference model was positioned in its lower jaw. After that, as previously mentioned, this hook was secured to the U-shaped wire that was soldered to the crown samples. The pull-out test, in which the crown is dragged out in the occlusal direction, is the foundation upon which the machine operates.

Starting at zero, the applied force should be increased gradually. The prefabricated crown is loaded continuously until the implant abutment exhibits the first signs of dislodgement in the occlusal direction. Once the prefabricated crown indicates the first dislodgement, the machine is manually halted by pressing a button, and the readings are then recorded. Every reference model in each group underwent the same process. The force of debonding was measured in Newtons (N).

Measuring bond strength of luting material in Mega Pascal MPa =

$$\frac{\text{Maximum force required separating the band from the crown (N)}}{\text{Circumferential area of crown (mm}^2\text{) x crown Length (L) (mm)}}$$

Measuring of circumferential area of crown (mm^2) = π x D

Collected data was checked, edited, coded and analyzed by Statistical Package for Social Sciences (SPSS) software (version 24) for Windows. The bonding strength values were analyzed by t-test to determine the mean value with its standard deviation. To compare the bonding strength in between metal ceramic crown and all ceramic crown when p-value < 0.05 was considered as statistically significant.

Table 1: Distribution of the bond strength value (MPa) of resin cement as luting agent in group-I (metal crown) and group-II (all ceramic crown) (N=30)

Sample No.	Group-I (Resin cement + metal crown) (MPa) (n=15)	Group-II (Resin cement +all ceramic crown) (MPa) (n=15)
1	1.70	2.06
2	1.71	2.00
3	1.70	2.11
4	1.69	2.10
5	1.70	2.09
6	1.72	2.04
7	1.69	2.05
8	1.70	2.03
9	1.71	2.06
10	1.68	2.08
11	1.70	2.05
12	1.71	2.07
13	1.70	2.03
14	1.69	2.06
15	1.70	2.05

Table 2: Mean value of the bond strength value (MPa) of resin cement as luting agent in group-I (metal crown) and group-II (all ceramic crown)

Group Name	Number of samples (N)	Mean of the bond strength value (MPa) of resin cement	Standard. Deviation	Standard error	P-value
Metal Ceramic Crown	15	1.70	.010	.002	0.001
All Ceramic Crown	15	2.05	.028	.007	

Table 2 indicated that the mean value of the bond strength value (MPa) of resin cement as luting agent in group-II (all ceramic crown) is greater than group-I (metal crown). There is significant difference between mean value and standard deviation of the bond strength value (MPa) of resin cement as luting agent in group-I (metal crown) and group-II (all ceramic crown) (p-value =.001).

Discussion

When resin cement was used as a luting agent in group-II (all ceramic crown) as opposed to group-I (metal crown), the two types of crowns (metal ceramic and all ceramic crown) on which the implant was bonded with resin cement demonstrated superior bonding strength. Additionally, our investigation revealed a statistically significant difference in the bond strength value (MPa) of resin cement used as a luting agent in all ceramic crowns with implants compared to metal crowns with implants. In a similar vein, Abbo et al. (2) examined the adhesion ability of glass-ionomer and resin-based luting cements to zirconia in their systematic study and identified potential major influences on the bond strength outcomes to this substrate (2). They concluded that stronger adhesion may be anticipated following physicochemical conditioning of zirconia and MDP-based resin cements, as determined by macro- and micro-tensile tests, which yielded better results than those of other cement types (9).

Significant information regarding the cementing of all ceramic crowns on implants is not available due to new developments in the field of zirconia crowns and their implications in dentistry (3). To the best of our knowledge, a small number of experiments using self-adhesive resin cement have been published in the literature comparing the binding strengths of metal ceramic and all ceramic crowns. The bonding strengths of both of these types of crowns were only compared in one study, which was published by Ebert et al. (1); however, they employed resin and composite cements as luting cements. Additionally, they discovered that using resin cement on zirconia crowns produced the strongest bond (6). Additionally, they discovered that, regardless of the luting cement utilized, bands luted on zirconia crowns had a stronger bond than bands luted on stainless steel crowns. Three zirconia crowns that were being removed from their teeth during the band removal process were among the 15 samples of zirconia crowns that were banded with self-adhesive resin cement; nonetheless, this was one of the study's limitations. This could be because the self-adhesive resin luting cements produced an excessive binding strength between the zirconia and stainless steel crowns. After that, they changed the zirconia crowns on the teeth to carry out more research, but they were unable to come up with a valid explanation for the incident (9). Furthermore, no other pertinent study has described such an event. Therefore, in subsequent research, this phenomenon needs to be taken into account and examined with a bigger sample size. Moreover, they recommend that comparable in vivo investigations be carried out to examine the impact of saliva, gingival crevicular fluid, and masticatory stresses on the bond strengths of zirconia and stainless steel crowns (6).

Conclusion

All ceramic crowns produced a stronger bonding strength than metal ceramic crowns cemented on implant abutments luted with resin cement. Thus, the results of this study will support prosthodontic professionals in selecting zirconia or all ceramic for crown materials in order to maximize the benefits of cement-retained implant restorations, which include improved load direction and improved aesthetics.

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