Original Article

Comparative evaluation of failure mode for lithium disilicate crowns with four different cementation systems- An In Vitro Study.

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Abstract

AIM OF THE STUDY: This in vitro study was performed to compare the failure mode of pressable lithium disilicate crowns cemented with four different cementation systems.
METHODS: A sample size of eighty single rooted maxillary 1st premolars, was taken for the study. Mounting and preparation and crown fabrication of the sample was standardized for each tooth. The samples were randomly divided into 4 groups according to different cementation systems. Each upper block was pulled along the path of insertion of the crown with a crosshead speed of 1mm/min. Failure mode was classified as decementation or fracture. Failure modes were compared using Pearson's Chi-square test.
RESULTS: In samples luted with total etch resin cement (TE) and self adhesive resin cement (SA), fracture was found to be more common mode of failure in comparison to decementation. On the contrary, in self etch resin cement (SE) group, decementation was found to be more common mode of failure in comparison to fracture. Whereas, in glass ionomer cement (GIC) group there was equal percentage of fracture and decementation as a mode of failure in the samples.
CONCLUSION: Within the limitations of this in vitro study, self etch resin cement was found to be the cement of choice for luting lithium disilicate full coverage crowns.

KEYWORDS: Lithium disilicate, Self adhesive resin cement, Self etch resin cement, Total etch resin cement, Glass ionomer cement, Self cure acrylic resin.

INTRODUCTION

The options with the clinician have tremendously increased in designing the indirect restorations due to the variety of ceramic material available today in the market providing satisfactory esthetic value along with high mechanical strength for longevity ceramics.[1] Further, there has been a tremendous growth in the types of luting agents specially resin cements which are more user friendly and provide good bonding with the tooth structure.

Dental cements are joining medium which provides adhesion or micro-mechanical attachment to the surfaces to be joined,[2] like indirect restorations and tooth surface. They are very relevant in clinical dentistry since any restoration fabricated in the dental lab (metallic and non-metallic crowns and bridges) must be cemented with 'luting cement'.

The most important functions of the luting cements in fixed prosthodontics are; to be esthetic, provide an effective marginal seal, provide thermal insulation and mechanically lute the fabricated restoration in its desired place, so as to avoid any displacement while in function.[3]

For adequate luting, cement selection and manipulation is very critical. $ZnPO_4$, ZPC and GIC are water-based and require simple and user friendly steps for cementation. When used properly and where indicated, each can give excellent results. Usually they are used for luting indirect restorations fabrication of metal and PFM combination of metal with ceramic but not for restorations fabricated with all-ceramic material. The luting of indirect restoration to abutments is the final critical step in achieving proper performance of indirect restoration.[4]

Storage solutions are used to prevent the growth of microorganisms and dehydration of the teeth.[5] While bonding ceramic to tooth structure, two different interfaces need to be considered: the dentin/cement interface and the ceramic/cement interface. If the adhesive seal in the above interfaces fails, it results in micro leakage jeopardizing the clinical performance and longevity of the restorations, leading to staining, recurrent
caries, adverse pulpal response and postoperative sensitivity and finally the debonding of the restoration.[6] But not all the available luting cements are ideal for all situations.
Retention of all ceramic crowns has been found to change with different luting agents.[7] Retention form of a crown can be defined as a feature of a tooth preparation that resists dislodgment of a crown in a vertical direction or along the path of placement.[8] Frequent cause of failure of crowns and bridges was reported as lack of retention. The retention of a full coverage indirect restorations depends upon tooth preparation geometry, specifically axial taper, height, surface area and surface roughness which limit the paths of displacement of the restoration. Fracture and debonding are two major weaknesses of all-ceramic restorations and are particularly related to the cementation procedure. Adhesive cements improve the fracture resistance of a ceramic material by penetrating the flaws and irregularities of the restoration's internal surface and inhibiting crack propagation.[9]
Many factors are responsible for a successful prosthesis including preparation geometry, choice of material, method of fabrication and many more. However, key factor to success is the choice of a proper luting agent and the cementation procedure.[10]
Thus this in vitro study was taken up with the objective to compare the mode of failure for pressable Lithium Disilicate Ceramic crown with four different luting agents (glass ionomer cement, self etch resin cement, self adhesive resin cement and total etch resin cement)

METHODOLOGY

This experimental study was conducted at Department of Prosthodontic and Crown & Bridges, Inderprastha Dental College and Hospital, Uttar Pradesh, India, to compare the mode of failure for pressable lithium disilicate ceramic crown with four different luting cements. Recently extracted non carious maxillary 1st premolar teeth for orthodontic reasons were collected and kept in artificial saliva (WET MOUTH, ICPA). All extracted teeth were maxillary premolars. All extracted teeth were carefully checked for caries, any fracture lines and surface defects, if found, such teeth were eliminated. Cylindrical samples of acrylic block with dimension 40 mm X 14 mm were obtained from a master mould of stainless steel. The master metal mould was prepared in two halves, wherein one of the halves could be slided manually on a base to approximate the other half to enclose a cylindrical cavity of 40 mm X 14 mm (Figure-01).

Figure 01.

Care was taken to mount these teeth in the center of the jig. An aluminum jig was joined to the vertical limb (arm) of the surveyor. Aluminum jig consisted of two parts, one vertical cylinder which is aligned parallel to the vertical limb of surveyor (Marathon). A horizontal rectangular part was attached to the vertical aluminum cylinder by means of a screw. This horizontal rectangular part had an angulated housing to harbor the air rotor. A high-speed, high-torque air rotor hand piece (NSK Nakanishi Inc., Tochigi, Japan) was attached to the other end of the jig in such a manner that the bur always remained parallel to the vertical rod. Next, the airotor was oriented in such a way that the bur is aligned parallel to the anatomic contours of occlusal surface of the tooth. An ideal depth of 1.5 mm preparation all around the tooth structure was standardized. Finish line was radial chamfer with the inner line angles well rounded (or a chamfer at an angle of 10^0). A uniform width of 1.25 mm was maintained at the circumferential chamfer.

Following tooth preparation, 80 pressable all-ceramic monolithic crowns were prepared and were cemented with four different luting cements.

Group A: Glass ionomer cement

Group B: Self etch resin cement

Group C: Total etch resin cement

Group D: Self Adhesive resin cement

The cementation was done as per manufacturer's instructions. After cementation, the crowns were stored in water at 37°C for one week. Then they were embedded in an autopolymerizing acrylic resin block. At the top of this block, a screw base was incorporated with its long axis parallel to the long axis of the tooth. Each specimen as positioned in a metal holder with the long axis of the tooth parallel to the load direction. Each upper block was pulled along the path of insertion of the crown with a crosshead speed of 1 mm/min. Failure mode were recorded for each specimen. Failure mode was classified as decementation or fracture.

RESULTS

The data obtained was compiled systematically, transformed from a pre-coded proforma to a computer and a master table was prepared. The total data was distributed meaningfully and presented as individual tables along with graphs. Inferential statistical analysis was carried out in the present study. Results on continuous measurements are presented on Mean ± SD and results on categorical measurements are presented in Numbers (%). Significance is assessed at 5% level of significance. ANOVA test with post hoc Bonferroni for multiple comparison has been used to find the significance of study parameters on ordinal scale between more than two groups. The statistical software namely SPSS 19.0 was used for analysis of the data and Microsoft excel has been used to generate table (table 1) and graph (figure-02)

Table 1: Failure mode of lithium disilicate ceramic crowns according to different cementation systems.

Failure mode	Glass Ionomer Cement (GIC) (N = 20)		Total Etch Resin Cement (N = 20)		Self Adhesive Resin Cement (N = 20)		Self Etch Resin Cement (N = 20)	
	N	%	N	%	N	%	N	%
Decementation	10	50.00	05	25.00	07	35.00	12	60.00
Fracture	10	50.00	15	75.00	13	65.00	08	40.00
Total	20	100.00	20	100.00	20	100.00	20	100.00

Pearson Chi-Square = 5.934, df = 3, p – value = 0.115 (Not Significant)

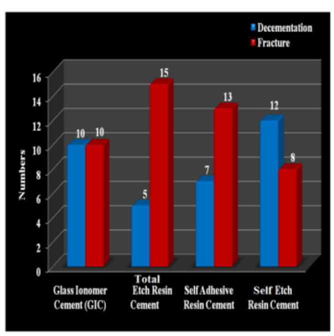

Figure 2: Failure mode of pressable lithium disilicate ceramic crowns luted with different luting agents.

DISCUSSION

In this study, extracted human premolars were chosen rather than acrylic teeth or metal dies for the assessment of the retention of pressable lithium disilicate ceramic crowns. This was done to simulate the clinical conditions as far as possible. In order to match the qualities of natural healthy teeth pertaining to their properties like modulus of elasticity, strength and bonding capacity to dental cements, human extracted teeth were an obvious choice.[11]

Standardized preparations were done with the help of a surveyor so that the axial walls during the preparation of the teeth got the corresponding tapering of the adjacent perpendicular bur as in several previous studies.[12]

Freshly extracted teeth must be stored in a storage solution after extraction for further experimental studies. For this experimental study extracted non carious maxillary 1st premolar teeth were collected and kept in artificial saliva for the following reasons. It can affect the mineral content of extracted teeth which can change the properties of adsorption, diffusion, and dissolution, and therefore possibly alter the physical properties of dentin and the conditions under which extracted teeth are stored are not standardized method.[13] It was also found that fresh teeth without contamination with microorganisms are required for the highest possible resin dentin bond strength.[14]

In this present study, the convergence angle between the axial walls of tooth preparation was standardized to 10 degrees with the help of a surveyor. It has been stated that maximal tensile retention occurred between 6° and 12° of total occlusal convergence. As the angle increases there is a higher chance of crown displacement when under masticatory forces.[15] The degree of displacement increases with increasing taper angles and it will lead to debonding of the indirect restoration.[16]

Lithium disilicate ceramic block is also available as IPS E max CAD which is used frequently because of its superior esthetics, excellent color stability, and its high resistance to wear.[17] The rise in the temperature during processing technique of monolithic lithium disilicate indirect restoration, results in a controlled growth of lithium disilicate crystals, producing a transformation of the microstructure that results in an increase of the final flexural strength. This flexural strength is approximately three to four times stronger than leucite-reinforced glass ceramics.[18]

The use of die spacer can reduce the hydraulic pressure between the cement and restoration; hence it allows better seating of an indirect restoration, decreases seating time and allows excess cement to escape.[19] In this experimental study die spacer of uniform thickness of 26 µm was applied on the prepared tooth surface. It has been proved that, a uniform thickness of cement between restoration and tooth provides more retention than a non-uniform thickness.[20] It was stated that all ceramic crowns displayed a greater fracture strength when the mean internal gap at the axial wall was < 73 um. A lower failure strength was reported when the mean internal gap was > 122µm without any significant improvement in seating.[21] Die spacer thickness of 25-40 µm was suggested for the optimum retention for all ceramic indirect restoration.[2]

Samples luted with self-adhesive resin cement (SARC) and total etch resin cement exhibited higher tensile strength and better bonding to the prepared tooth structure which yielded in higher retentive strength. Due to this reason most of the samples in these groups exhibited fracture as a mode of failure rather than decementation. Self adhesive resin cement may be used for cementing all ceramic crowns with high predictability of success, mainly if there is a large dentin surface available for bonding and no enamel at the finish line. Due to the same reason in the present study with 1.5 mm of circumferential chamfer finish line maximum tensile strength was observed with the SARC. Otherwise, conventional resin luting agent should be used for achieving an adequate bonding strength to enamel.[22]

The major disadvantage of total etch system is post-operative sensitivity.[23] Etching with phosphoric acid widens the dentinal tubule openings, and these may not be completely sealed by the adhesive resin. Thus, the unsealed microporous zone could then permit the shift of hydraulic dentin fluid results in post- operative sensitivity. Water is necessary to maintain collagen fibril expansion in etch and rinse for resin infiltration but on contrary it plays antagonist role in hybrid layer formation.[24]

In the present study, GIC group exhibited mixed type of failure mode (fracture and decementation) at cement dentin interface. The presence of mixed failures of GIC may indicate that the interfacial strength of the bond is actually higher than the inherent strength of the material.[25]

With GIC, When P/L ratio is reduced, there is a decrease in the ion release process and consequently, the cross links present lower strengths which can be reduced more rapidly. However, at high P/L ratios, unreacted particles can act as stress concentration points reduces the tensile strength.[26] Thus, slight variation in the mixing proportions of GIC might have resulted in such a mixed response towards the failure mode.

Amongst the samples exhibiting decementation as a mode of failure with self-adhesive resin cement most of them demonstrated adhesive failure between the resin cement and dentin. This can be explained due to the fact that SARC usually has high viscocity which prevents its penetration in the collagen matrix and leads to the formation of a weak union between the cement and tooth surface.[27]

The total etch system exhibited both types of failure mode, decementation (adhesive kind) as well as fracture. However, the fracture mode was more predominant. This can be explained due to increased bond strength of total etch systems with phosphoric acid.[28]

In the case of GIC, cohesive fracture of the cement was observed (part of the luting cement was visible on the prepared tooth as well on the intaglio surface of crown). It means that bond represent only the tensile bond strength of the cement rather than the strength of the tooth cement interface. It is because degradation process of glass ionomer cement with prolonged time was due to decreased material properties rather than to decrease bonding potential.[27] It was also stated that due to low resistance of GIC to early wear and the formation of glass ionomer matrix glass ionomer cement exhibits mix mode of failure. Therefore part of the glass ionomer remained attach to the tooth structure, while part was broken at the interface of GIC and tooth.[29]

Most of the fracture occurs at the cervical margin of the tooth structure because cervical margin is a thinnest area of the crown and most susceptible to fracture.[30] Further, the high cementation force or excess cement may induce unfavorable stress distribution which lead to fracture at cervical region.[31]

CONCLUSION

Within the limitations of this study, it can be concluded that with total etch resin cement (TE) and self adhesive resin cement (SA), fracture was found to be more common mode of failure in comparison to decementation. In self etch resin cement (SE) group, decementation was found to be more common mode of failure in comparison to fracture. However, glass ionomer cement (GIC) exhibited equal percentage of fracture and decementation as mode of failure with pressable lithium disilicate ceramic crowns. Therefore, self etch resin cement was found to be the choice of luting cement for monolithic lithium disilicate crowns.

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