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In-vitro assessment of the effect of various self-adhesive resins on the fracture resistance of zirconia crowns

Shaima Tyor[1], Amal Abdelsamad Sakrana[2]and Walid Al-Zordk[3]
[1] *Teaching lecturer, Fixed Prosthodontics Department, Faculty of Dentistry, Mansoura University, Egypt*
[2] *Professor, Fixed Prosthodontics Department, Faculty of Dentistry, Mansoura University, Egypt*
[3]*Associate professor, Department of Fixed Prosthodontics, Mansoura University, Mansoura, Dkahlia, Egypt*

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ABSTRACT:
Purpose:to study the effect of different self-adhesive cements (Panavia SA, RelyxU200 and Calibra universal) on translucent zirconia (KATANA) crowns resistance to fracture.
Material and methods: Thirty human premolars were selected with approximated dimensions. Then, selected teeth were prepared and KATANA zirconia crowns were fabricated by the aid of CAD/CAM. Then, each crown was cemented with its corresponding cement after pre-conditioning each zirconia crown with zirconia primer (Clearfil Ceramic Primer). The specimens were subjected to aging (thermo-cycling and cyclic loading) equal to one year of clinical use. One-way ANOVA test was used to compare the mean fracture load of the groups. After that, post-hoc Tukey test had been used to detect any significance between groups.
Results: showed a statistically significant difference between P-CA, P-RE and P-PA ($P<0.001$) as regard to fracture load. The highest fracture load value was for P-RE (2446.9±126.72N).
Conclusion:different self-adhesive cements affect the fracture load of translucent zirconia crowns.
KEYWORDS:self-adhesive, Resin-cements, zirconia crowns, fracture resistance.

I- INTRODUCTION

In the early 1990s, Zirconia was introduced into dentistry and was used as a key material to support more esthetic ceramic materials with sufficient mechanical properties.[1]Subsequent generations of dental zirconia have been invented since then. [2]First generation contained 3 mol% yttria exhibiting exceptional high mechanical properties but, optically opaque.[3]Different strategies such as reducing the amount of alumina and grain size were applied to diminish light scattering by impurities and grain boundaries.[4]The demand for a more translucent zirconia was evolved as the second-generation of zirconia was still insufficient.[5]The third way to improve zirconia translucency was achieved by increasing yttria content, which results in a greater cubic phase quantity.[6] Cubic phase has a coarser particle size and is optically isotropic which dramatically reduce light scattering and improve translucency.[7]The flexural strength of cubic translucent zirconia ranging from 600 – 800 MPa, while that of conventional tetragonal zirconia was1000 to1200 MPa.[8]

Resin cements exhibit good characteristics, lower solubility, better mechanical properties and binding ability; for these reasons, resin cements have become more reliable for zirconia cementation.[9]Adhesion between the restorations and the teeth is a critical factor for getting a successful, long-lasting indirect restoration.[10]Sustainable bond with different substrates, adequate compression and tensile strengths, wettability and resistance to dissolution in the oral cavity must be given by an ideal cement.[11]

Resin cements are classified into three categories: traditional resin cements (total-etch or self-etch) and self-adhesive resin cements.[12]Self-adhesive resin cements are referred to as all in one adhesive cements since they are true adhesive that provide the benefits of single step protocols.[11]The first product of self-adhesive resin cements launched in 2002 Rely-X Unicem as a dual-cured self-adhesive resin cement.[13]Thanks to recent advances in chemistry, Phosphate ester monomer has been grafted into self-adhesive resin cement without chemically interfering with other components.[14]Those phosphate ester monomers has been reported to chemically interact with zirconia and hydroxyapatite in tooth structure.[15]

Functional monomers may be carboxylic monomer such as 4-META or phosphorylated methacrylate monomer such as 10-MDP.[16]A number of other systems have since been released based on the incorporation of different phosphoric acid monomer such as GPDM (glycerol di-

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methacrylate dihydrogen phosphate) in MaxCem, PENTA (dipentaerytritolpentacrylate phosphoric acid) in SmartCem2 and 10-MDP in Panavia SA.[17],[18] However, self-adhesive cements have a low PH, the acidic groups join with calcium hydroxyapatite to form a stable bond between the methacrylate network and tooth .[19]

The type of luting cement has been shown to influence the distribution of stress generated on the tooth and crown complex.[20] It has been reported that resin cements play an important role through resin infiltration that sealed tiny-cracks at the material surface and reduced the flaws.[21],[22]The fracture strength of a prosthetic crown is influenced by the supporting structures, loading force, and cementation procedure.[23]It is also critical to remember that the foundation substrate onto which these materials are bonded has a significant impact on the mechanical behaviour of these restorations.[24]

The purpose of this in vitro study was to evaluate the fracture resistance of zirconia restorations cemented using different self-adhesive cements. The null hypothesis was that the cements had no effect on zirconia crowns fracture resistance.

II- MATERIALS AND METHODS

Thirtyfreshly extracted human maxillary premolars were collected from Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Mansoura University for Orthodontics purposes. The selected teeth were debrided and cleaned of any superficial stains.The teeth were stored in distilled water at room temperature through all testing period.The selected teeth were divided randomly into 3 groups (n=10) according to the type of cement used: group P-PA: crowns cemented by primer/PanaviaSA plus,group P-RE: crowns cemented byprimer/RelyxU200 and P-CA: crowns cemented by primer/Calibra Universal.

The roots of the selected teeth were dipped into the molten wax at 2 mm away from cement-enamel junction. This result in layer of 0.2 mm of wax that simulate the periodontal ligament.[25] The roots of each selected tooth were embedded within acrylic resin blocks to simulate the bone. The roots and the acrylic mold were cleaned carefully by hot water. After that, PVS light body (Ghenesyl light body, LASCOD, Italy) was injected using a gun into the acrylic resin mould.[26, 27]

Silicon index was prepared by using hydrophilic poly vinyl siloxane putty addition silicon impression material (Ghenesyl putty soft, LASCOD, Italy).The preparations were performed using dental surveyor(Marathon-103 surveyor, Saeyang company, Korea). The preparation parameters were 6 degree tapered angles, 1mm for non-functional cusp, 1.5 mm for functional cusp and 0.5 mm chamfer finishline.[28]

Each tooth was scanned by the optical scanner (Identicahyprid, MEDIT corp, Korea). The software (DentalDB 2.2 Valletta, exocad GmbH, Darmstadt, Germany) was used for crowns designing. Each design file was submitted to the milling machine (CORiTEC 250i touch, imes-icore, Germany).The firing tray loaded with milled zirconia restorations was placed inside the sintering furnace (Tabeo-1/M/Zirkon-100, MIHM-VOGT, Germany). A thin glaze liquid layer was applied to the crowns with a clean brush (CERABIEN ZR Kuarary Noritake, Japan). Then,crowns delivered into (Multimat Cube press, Dentsply Sirona, Germany) furnace.

A device (Basic classic fine sandblasting unit, Renfert, Germany), all zirconia restorations were abraded by airborne alumina particles of 50µm at 2 bar air pressure for 10 seconds with the tip of sandblaster 10 mm away from the crowns.[29]

Each zirconia crown was pretreated with primer (Clearfill Ceramic Primer) for 60 secondswith rubbing during application. After that every crown was cemented with its corresponding cement according to their manufacture instructions.

All specimens were subjected to 10000 cycles of varying temperatures between 5°C and 55°C to simulate approximately one year of clinical activity using a thermal cycling apparatus (Thermo Scientific, Thermo Fisher Scientific Inc., Waltham, MA, USA).[21] They were then exposed to 240000 load cycles using a chewing simulator.[25]

All specimens were fractured under static compressive axial load using universal testing machine (Instron Universal testing machine, 3345, USA, Universal bluehill software) at a crosshead speed 1mm/min, 5 mm diameter stainless steel ball-shaped loading piston. The fracture load value of each specimen was recorded(N).

One-way ANOVA test was used to compare the mean fracture load (N) between three independent groups of numerical data followed by Post-hoc Tukey test to detect any significance between groups.

III- RESULTS

One-way ANOVA test showed that there was a statistically significant difference between the studied groups as regard to the mean fracture load. While Post Hoc Tukey test that showed statistically significant difference between P-CA, P-RE and P-PA($P<0.001$).The highest fracture load value was for P-RE (2446.9±126.72), followed by P-PA (2124.54±181.59) and finally the lowest was P-CA (1803.01±133.18). There was a statistically significant difference between P-CA and P-RE(p<0.001), P-CA and P-PA(p<0.001) and between P-PA and P-RE (p<0.001).

	P-CA	P-RE	P-PA	Test of significance
fracture load/N	1803.01±133.18	2446.9±126.72	2124.54±181.59	F=33.56 P<0.001*
Comparison with P-CA		p<0.001*	p<0.001*	
Comparison with P-RE			p<0.001*	

F: One Way ANOVA test,Similar superscripted letters denote significant difference between groups by Post Hoc Tukey test.

IV- DISCUSSION

The null hypothesis was that the cements had no effect on zirconia crowns fracture resistance was rejected since there was a statistically significant difference between P-CA, P-RE and P-PA groups(P<0.001).

Translucent zirconia was chosen for its enhanced aesthetic properties, as well as the benefit of avoiding chipping possibilities with a smart biocompatiblebehaviour.[1]Self-adhesive resin cements were chosen for this investigation due to their ease of use, superior mechanical performance, and aesthetics, as well as their simple application approach.[30] Fracture resistance test is widely used to check the effectiveness of a material and type of restoration as a realistic alternative in clinical scenarios.[31]

The support provided by the underlying components, the cement and the underlying dentin, affects the development of cracks in the ceramic crown.[20] This research utilized natural teeth rather than resin dies but, teeth standardization is challenging due to age, anatomy, size, shape, storage duration after extraction, and tooth fracture under loading due to the variations in the elastic modulus that happen after extraction.[32] Airborne-particle abrasion was used in this investigation because it cleans the bonding surface while increasing roughness, surface area, and surface energy, and hence the wettability of zirconia surfaces. This in vitro study utilized accelerated ageing based on a combination of both thermo-cycling and dynamic loading of samples which appears to better match the circumstances in the oral cavity.[33]

There is a higher risk of failure due to stresses at the adhesive interface, tendency to degradation and uneven load distribution on the set.[34] Resin cement's flexural strength and modulus of elasticity are both dramatically reduced by water absorption, as the absorbed water acts as a plasticizer in cements, causing unsupported areas beneath the restoration and increasing the risk of fracture due to mastication stresses.[35]

A previous study demonstrated that the elastic modulus of the cement had an effect on the structural integrity of the restored tooth-crown complex.[20]SmartCem2, the previous version of calibra universal, had the lowest bond strength performance when compared to RelyX, explained that this could be owing to ineffective micromechanical interlocking and chemical bonding.[36]These findings possibly explain why the P-CA group has the lowest fracture load

According to previous studies, the binding energy of PENTA was lower than that of 10-MDP, studies reported the lower chemical affinity of PENTA for hydroxy-appetite compared to 10-MDP.[37] This may explain the lower fracture load of P-CA group and higher fracture load of P-SA group.

A steady water sorption process accounts for persistent hydrophilicity triggering hygroscopic expansion that is strongly correlated to the longevity of bonded restorations.[38]RelyX has been found to have superior pH-neutralization, low sorption, and solubility qualities. Because increased hydrophilicity of self-adhesive resin cements resulted in greater hygroscopic expansion stress, the hygroscopic expansion strains induced by RelyX cement were negligible. This could explain the higher fracture load of the P-RE group.[39]

Researchers had been proposed that different behavior of resin cements can improve fracture resistance by sealing defects in ceramic restorations.[40]**Tsuyuki et al.[9]** reported that cementing monolithic zirconia crowns with resin cement increased fracture load by integrating the restoration and abutment. They believed that such difference was likely to have contributed to differences in compressive strength between the cements.

On the other hand,**sakrana et al.[21]** The cement type has no benefit on the fracture resistance of monolithic zirconia restorations. Also, **Lim et al.[41]** concluded that the self-adhesive resin cement had only a minor impact on the fracture resistance of Y-TZP. The fracture resistance of zirconia did not considerably improve after adhesive luting.

V- CONCLUSIONS:

1. Different self-adhesive cements affect the fracture load of translucent zirconia crowns.
2. Panaviasa and Rely-X U200 cemented zirconia crowns showed higher fracture load values than those cemented byCalibra Universal.

LIMITATIONS

The fact that only one type of zirconia was employed in this study means that the results cannot be generalized to othertypes. Natural teeth standardization was nearly impossible. Limited simulation to the oral changing conditions.

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