



Original Research Article

Comparison of the influence of different cements on the compressive strength of Nickel chromium coping and Zirconium oxide coping- An invitro study

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ABSTRACT

Strength and biocompatibility of any restoration is an important criterion for success and function of any prosthesis. Despite the high fracture resistance of traditional metal ceramic crowns, limitations are imposed by esthetic concerns. The objective of this study is to determine whether zirconium dioxide or nickel chromium copings had better strength when used with two resin based luting cements namely RelyX U100 and Variolink II.

Materials and Methods: A total of 40 copings were fabricated, of which 20 were zirconium oxide copings made using CAD/CAM technology. The remaining 20 were nickel-chromium copings obtained using Lost Wax technique. Two resin cements were selected i.e, RelyX U100 universal selfadhesive resin luting cement (RelyXTM U100, 3M ESPE, Sumaré, SP, Brazil) and Variolink II resin luting cement (Ivoclar Vivadent, Schann, Liechtenstein). These cements were mixed and luted on the copings. The copings were seated onto the steel die using finger pressure for 1 minute and placed under a 2.2 kg standard load for 15 minutes. A compressive load was applied through a 1/8-inch diameter hardened steel sphere attached to the moving head of universal testing machine (LR 50K, Lloyds instruments, UK). Load was applied at a crosshead speed of 0.5 mm per minute until fracture occurred.

Results: It was found that Nickel-Chromium yielded a higher fracture load compared to Zirconia and the difference in mean fracture load between them was found to be statistically significant ($P < 0.001$). The Copings are found to be a significant factor influencing fracture load. No statistically significant difference was observed between RelyX and Variolink II cements ($P > 0.05$). Slightly higher mean fracture load was recorded in Variolink II compared to RelyX.

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1. Introduction

Despite the success of porcelain fused to metal restorations the need for better esthetics and biocompatibility remains the driving force for the development of all-ceramic core materials.¹ The need for an extremely esthetic and natural restoration has become predominant in recent years. In such situations it is important that these restorations provide a predictable long clinical lifespan. Success of any indirect dental restorations depends on many factors and one such factor is cementation procedure.² The behaviour of the cement and bonding systems is complex and

partially depends on the properties and quality of the component parts of each system.³ The dental cement must act as a barrier against microleakage, holding the tooth and restoration together mechanically and/or chemically. Clinical trials conducted on All-ceramic crowns suggest that the All-ceramic crowns should be internally etched and bonded into place with resin cement. Bonding these restorations result in greater strength which should translate into improved clinical services. Therefore these resin cements are critical for the success of the restorations. The majority of failures of all-ceramic crowns are initiated at the inner surface of crown where it is subjected to maximum tensile stress and this is intensified by the presence of flaws

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and cracks.³In this study steel dies were used to study the compressive strength testing of copings as they include standardised preparation and identical physical quality of materials. Therefore the aim of this study was to compare the difference in compressive strength between zirconium-dioxide coping and nickel-chromium copings when luted with resin cements namely RelyX U100⁴ and Variolink II.⁴

2. Materials and Methods

A total of 40 copings were fabricated, of which 20 were zirconium oxide copings, made using CAD/CAM Cercon (Degudent, Germany) technology. The remaining 20 were nickel-chromium copings obtained using Lost Wax technique (Figure 1)

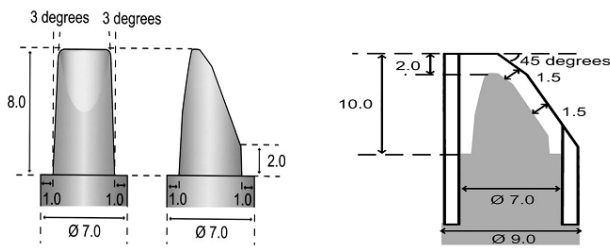


Fig. 1: Schematic diagram of the Metal Die

These Ni-Cr copings were fabricated on the metal dies which were made from locally made hardened steel.⁵ To further eliminate any variation, all these 40 master dies were milled from a single block of steel. All 40 dies were duplicated using Vinyl polysiloxane putty which was relined with Vinyl polysiloxane light viscosity material to record all fine detail. Later impressions were poured in type IV dental stone. 40 copings were directly fabricated on these dies. The zirconia copings were fabricated using Cercon (Degudent, Germany) CAD/CAM machined zirconia blocks. For nickel-chromium coping, Inlay wax (Bego, Germany) was kept at recommended temperature of 160°F or 100-150°C, in an electrically controlled wax bath (Delta). The molten marginal wax was poured initially into the sleeve to fill only the cervical portion. Next, the crown molten wax was flowed into the assembly mold till the top edge of the die (not the sleeve). Later wax was poured slightly above the top edge of the sleeve. The sleeve fitted tightly and did not allow molten wax to flow beyond the gingival margin of the die. This assembly was then compressed with a glass slide until wax solidified. The top edge was carved flush with the open end of the sleeve with a sharp lecron's carver. Then the sleeve was removed and groove was extended on the wax pattern for orientation. Wax patterns were invested immediately to avoid distortion. All the castings were done in an induction casting machine (DUCATRON series – 3, France) wound $2\frac{1}{2}$ turns using Ni-Cr base metal alloy (Wiralloy, Bego, Germany). The cements used were RelyX U100 (3M ESPE, Seefeld,

Germany) which is a resin based luting cement (Figures 2 and 3).



Fig. 2: Metal dies with zirconium-oxide copings luted with RelyX U100



Fig. 3: Metal dies with nickel chromium copings luted using RelyX U100

The required amount of cement is dispensed onto a mixing pad and mixed using an agate spatula. The second cement used was Variolink II resin luting cement (Ivoclar Vivadent, Schann, Liechtenstein) (Figures 4 and 5).

These cements were supplied as base and catalyst paste. The materials were mixed according to the manufacturer's instructions and luted on the copings. The copings were seated onto the steel die using finger pressure for 1 minute and placed under a 2.2 kg standard load for 15 minutes. The excess cement was removed from the die using curved explorer. A compressive load was applied through a 1/8-inch diameter hardened steel sphere attached to the moving head of universal testing machine (LR 50K, Lloyds instruments, UK). Load was applied at a crosshead speed of 0.5 mm per minute until fracture occurred. (Figure 6)

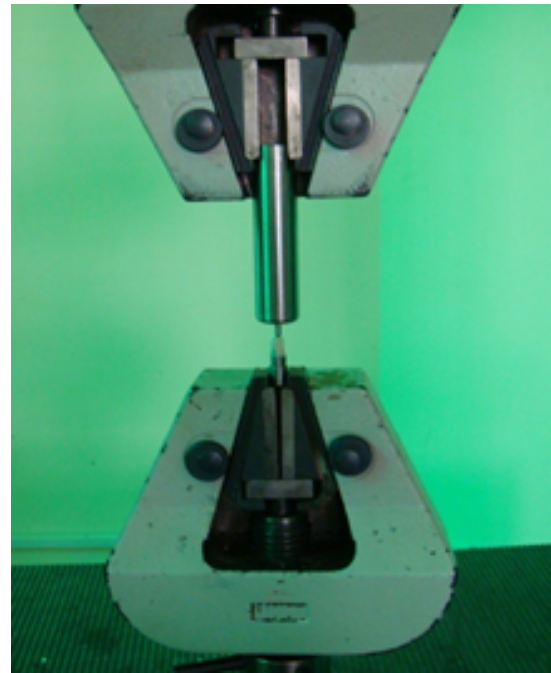
Table 1: Mean fracture load (Newton) recorded in the two copings with different cements:

Coping	Cement	n	Mean	Std dev	Min	Median	Max
Nickel	RelyX	10	1257.10	293.10	779.90	1133.00	1727.00
Chromium	Variolink II	10	1297.00	335.00	780.00	1317.00	1702.00
Zirconia	RelyX	9	431.20	100.70	267.10	437.10	565.70
	Variolink II	9	410.30	54.60	297.00	424.90	463.10

**Fig. 4:** Metal dies with zirconium oxide copings luted with Variolink II**Fig. 5:** Metal dies with nickel-chromium copings luted with Variolink II

3. Results

The test were carried out and the comparison was done for the compressive strength for nickel chromium and zirconium oxide copings using Variolink II and RelyX U100 (Table 1). Tests were also conducted for the compressive strength of nickel chromium and zirconium oxide (Table 2) and fracture loads of luting cements (Table 3). It was observed that there is a significant difference between the two different types of coping ($P < 0.001$). It was noticed that there is no significant

**Fig. 6:** Specimen mounted on Universal testing machine

difference between the two types of cement ($P > 0.05$). Also, the interaction (joint effect) of coping and cement on fracture load (Newton) is not found to be significant ($P > 0.05$). It was also noticed that Nickel-Chromium yielded a higher fracture load (Newtons) compared to Zirconia and the difference in mean fracture load between them was found to be statistically significant ($P < 0.001$). The Copings were found to be a significant factor influencing fracture load (Newtons). No statistically significant difference was observed between RelyX U100 and Variolink II cements ($P > 0.05$). Slightly higher mean fracture load (Newtons) was recorded in Variolink II compared to RelyX U100. An observation was made that Nickel-Chromium yields a higher mean fracture load (Newtons) compared to zirconia when used with either RelyX U100 or Variolink II cements. Maximum fracture load (Newtons) is recorded in Nickel-Chromium coping when used with Variolink II cement. Lowest fracture load (Newtons) was recorded in zirconia coping with Variolink II cement. In zirconia coping, slightly higher mean fracture load (Newtons) is recorded in RelyX U100 compared to Variolink II cement (table 4).

Table 2: Mean fracture load (Newtons) recorded in different copings:

Coping	n	Mean	Std dev	Min	Median	Max
Nickel-Chromium	20	1277.10	307.30	779.90	1150.50	1727.00
Zirconia	18	420.80	79.30	267.10	425.60	565.70

Table 3: Mean fracture load (Newtons) recorded in different cements:

Cement	n	Mean	Std dev	Min	Median	Max
Rely X	19	866.00	476.00	267.00	780.00	1727.00
Variolink II	19	877.00	514.00	297.00	780.00	1702.00

Table 4: ANOVA table:

Source	df	Sum of Squares (SS)	Mean SS	F	P-Value
Coping	1	6946459	6946459	124.900	<0.001*
Cement	1	1178	862	0.020	0.902
Coping*Cement	1	8757	8757	0.160	0.694
Error	34	1890948	55616	—	—
Total	37	8847343	—	—	—

4. Discussion

The study was done to compare the compressive strength of nickel-chromium and zirconium-oxide copings using RelyX U100 and Variolink II luting cements. The behaviour of the cement and bonding systems is complex and partly depends on the properties and quality of the component parts of each system.⁴ Adhesive resin cement must have the ability to bond to the tooth structure and restoration, otherwise, poor bond quality at either the ceramic-cement or dentin-cement interface can significantly reduce the fracture resistance.⁶ Self-etching techniques rely on etching the dentin using non rinse acidic monomers that simultaneously condition and prime, in one step, incorporating the smear layer within the hybrid layer so that it becomes one single layer. RelyX U100 (3M ESPE, Seefeld, Germany) the self-adhesive, universal resin cement without surface pretreatment had been introduced. It was based on a novel initiation technology using new monomer and filler. The organic matrix consists of newly developed multifunctional phosphoric acid methacrylate, which, can react with the basic fillers in the luting cement and the hydroxyapatite of the hard tooth tissue. This cement quickly neutralizes during the curing process, to switch from a hydrophilic to a hydrophobic state. This unique switch allows the material to adapt to the tooth structure while in the hydrophilic state, yet provide for ongoing dimensional stability with the restoration after converting to the hydrophobic matrix.⁷ The present investigation was designed to allow the concomitant investigation of 2 variables: the type of coping and type of luting agent. Each of these factors was thought to significantly influence ultimate load-to-fracture strengths of crowns. The first variable studied was type of coping and its effect on load-to-fracture strength. As seen in Table 1, utilizing RelyX U100 luting cement Nickel-Chromium yielded a higher fracture load compared to zirconia and the

difference in mean fracture load between them was found to be statistically significant ($P < 0.001$). The Cercon copings failed by splitting due to radial cracking, which originated at the core-resin interface instead of by cone cracking which is seen in veneering ceramic.¹ The global residual stresses in the veneer layer are responsible for the delamination and chipping of the veneer material, which may explain this frequently occurring failure mode observed in the Cercon system.⁷ The copings are found to be a significant factor influencing fracture load. Several authors have reported that annealing at 900 °C for 1hr or relatively short heat treatments in the temperature range 900–1000 °C for one minute induces the reverse transformation from monoclinic to tetragonal. This phenomenon was accompanied by the relaxation of the compressive stresses at the surface and a decrease in strength. The firing of veneering porcelain during the fabrication of dental restorations is therefore likely to promote the reverse transformation with the consequences listed above.⁶ The second variable studied was the luting agent and its effect on final load-to-fracture strength of the two types of copings. No statistically significant difference was observed between RelyX U 100 and Variolink II cements ($P > 0.05$). Slightly higher mean fracture load was recorded in Variolink II compared to RelyX U 100. The bonding systems used were dual cured cements, their polymerisation reaction is both photo and chemically-initiated. This leads to higher conversion rate of curing, leading to better mechanical properties, i.e. the force will be distributed over a large area, as the whole assembly: the crown, the adhesive, and the tooth structure would act as one unit.⁸

5. Limitations of the present study

The present study is an in-vitro study and has some limitations. The first could be the type of testing used. A

single cycle to failure was used for compressive testing, which does not represent the intraoral condition in which teeth undergo cyclic loading at varying velocities and magnitudes while being immersed in a wet environment that is subject to chemical and thermal changes. Prepared teeth made of steel or resins do not reproduce the real force distribution that occurs on crowns cemented on natural teeth. Dentin has a lower elastic modulus than steel; therefore the inner surface of crown shows a greater shear stress every time the tooth is subjected to deformation.⁹

6. Clinical implications

The mechanical properties of zirconia are highest ever reported for any dental ceramic. This may allow for posterior fixed partial dentures and permit substantial reduction in core thickness. Esthetically zirconia has superior properties over nickel-chromium coping, hence it is recommended for anterior teeth. Nickel-chromium copings can be recommended for posterior teeth where esthetics and cost is not a prime concern.

7. Conclusion

From this study, it can be concluded that Compressive strength of nickel-chromium copings is greater than zirconium di-oxide copings when used with either RelyX or Variolink II luting cements. Slightly higher mean fracture load was recorded in Variolink II compared to RelyX. Despite the various advantages of zirconia, the main drawback of zirconia coping is high cost which many patients may not afford.

8. Source of Funding

None.

9. Conflict of Interest

None.

References

1. Aboushelib MN, de Jager N, Kleverlaan CJ, Feilzer AJ. Effect of loading method on the fracture mechanics of two layered all-ceramic restorative systems. *Dent Mater* . 2007;23(8):952–9.
2. Rosenstiel SF, Land MF, Fujimoto J. Contemporary fixed prosthodontics. Mosby-Year Book: St Louis; 2006.
3. Guindy JFE, Mostafa DH, Agroudi MAE. Margin assessment and fracture resistance of adhesively luted ceramic crowns. *J Am Sci*. 2010;6(11):264–73.
4. Diaz-Arnold AM, Vargas MA, Haselton DR. Current status of luting agents for fixed prosthodontics. *J Prosthet Dent*. 1999;81(2):135–41.
5. Shiratsuchi H, Komine F, Kakehashi Y, Matsumura H. Influence of finish line design on marginal adaptation of electroformed metal-ceramic crowns. *J Prosthet Dent* . 2006;95(3):237–42.
6. Denry I, Kelly JR. State of the art of zirconia for dental applications. *Dent Mater* . 2008;24:299–307.
7. Rodrigues RF, Ramos CM, Francisconi PAS, Borges AFS. The shear bond strength of self-adhesive resin cements to dentin and enamel: An in vitro study. *J Prosthet Dent* . 2015;113(3):220–7.
8. Braga RR, Cesar PF, Gonzaga CC. Mechanical properties of resin cements with different activation modes. *J Oral Rehab* . 2002;29(3):257–62.
9. Potiket N, Chiche G, Finger IM. In-vitro fracture strength of teeth restored with different all-ceramic crown systems. *J Prosthet Dent*. 2004;92:491–496.

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