An in vitro Comparative Evaluation of Micro Tensile Bond Strength of Two metal bonding Resin Cements bonded to Cobalt Chromium alloy

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ABSTRACT

Background: The purpose of this study was to evaluate and compare the micro tensile bond strength of two metal bonding resin cements to sandblasted cobalt chromium alloy.

Materials & Methods: Eight, Cobalt chromium alloy blocks of dimensions 10x5x5 mm were cast, finished and polished. One of the faces of each alloy block measuring 5x5mm was sandblasted with 50 µm grit alumina particles. The alloy blocks were then cleaned in an ultrasonic cleaner for 1 min and then air dried with an air stream. The Sandblasted surfaces of the two alloy blocks were bonded together with 2 different metal bonding resin systems (Panavia F Kuraray and DTK Kleber – Bredent). The samples were divided into 2 groups (n=4). Group 1- Two Co-Cr blocks were luted with Panavia cement. Group 2- Two Co-Cr blocks were luted with DTK Kleber-Bredent cement. The bonded samples were cut with a diamond saw to prepare Microtensile bars of approximately 1mm x 1mm x 6mm. Thirty bars from each group were randomly separated into 2 subgroups (n=15) and left for 3hrs (baseline) as per manufacturer's instructions while the other group was aged for 24hrs in 37^{0}C water, prior to loading to failure under tension at a cross head speed of 1mm/min. Failure modes were determined by means of stereomicroscopy (sm). Statistical analysis was performed through one way – ANOVA.

Results: Significant variation in micro-tensile bond strength was observed between the two metal bonding resin systems.

Conclusion: DTK showed higher mean bond strength values than Panavia F cement both at baseline and after aging.

Key Words: alloy, bonding, casting.

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Introduction

The Co-Cr alloys were introduced into dentistry in 1929 and since that time they have come into wide use as an alternative material to gold base alloys for partial denture castings. In addition to lower cost, Co-Cr alloys are much stronger, harder and possess relatively high elastic modulus and low density, which allow the base metal frameworks to be thinner, lighter and stiffer. Besides being used as partial denture alloys, cobalt-chrome alloys can be utilised as crown and bridge alloys for ceramic veneering and in making dental implant supra-structures and frameworks. When used for ceramo-metal prosthesis, the Co-Cr alloy structure needs to be bonded onto the tooth structure. The bond strength between the teeth and the Co-Cr prosthesis is well documented and is satisfactory. But there are also many clinical and laboratory procedures like connecting attachments to crowns or partial denture frameworks, passive cementation of full arch implant prosthesis, etc where metal- metal bonding is needed.

Metal to metal bonding has not been well accepted generally due to what has been perceived as an insufficient ability to bond metal to metal. Several resin cement systems have been developed over the last two decades in order to improve the bond strength of metal to metal.

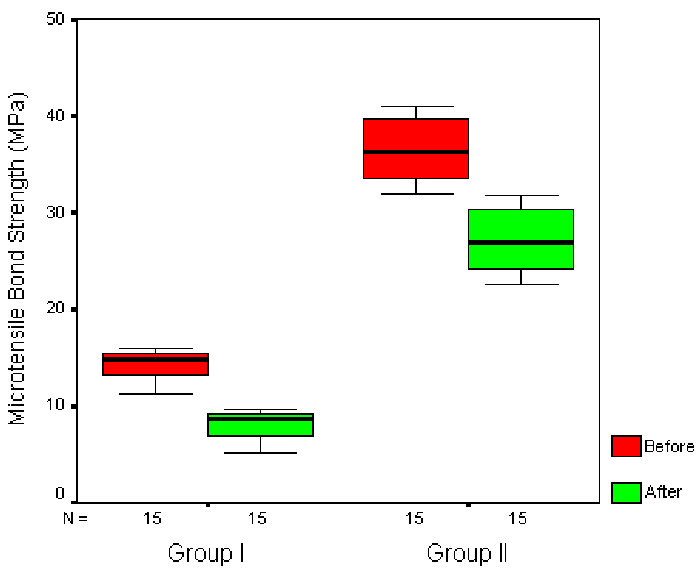
Few adhesive systems are indicated, to fix dental attachments to crowns and bridges, implant bars and removable partial dentures. Among these, Panavia cement is considered as a gold standard and the recently introduced DTK cement claims to provide higher flexural and adhesive strength. This study was therefore undertaken to evaluate the micro tensile bond strength of this newly introduced cement to Co-Cr alloy pre and post aging. The bond strength was determined by micro-tensile testing and failure mode analysis was performed by stereomicroscopy to investigate potential weak links in the resin metal-metal interface.

Materials and Methods

For the present study 10mmx5mmx5mm cobalt chromium blocks were casted (n=8). These blocks were finished and polished. The upper side of the blocks received sand blasting with 50um grain – sized alumina using a grit blaster for 30s at a distance of 1.5cm. After sand blasting the samples were cleaned for 1 min in a ultrasonic cleaner and air dried in air stream before getting bonded by the following cements (Figure 1).

Panavia F (Kurrary) : application of two layers of metal primer (allowed to dry for 30s between layers) , application of thin layer of Panavia F cement and allowed to set for 6mins under 25 lbs pressure (Figure 2).

DTK (Kleber – Bredent) : application of two layers of metal primer (allowed to dry for 30s between two



Graph 1: Graphic representation of the two groups before and after aging

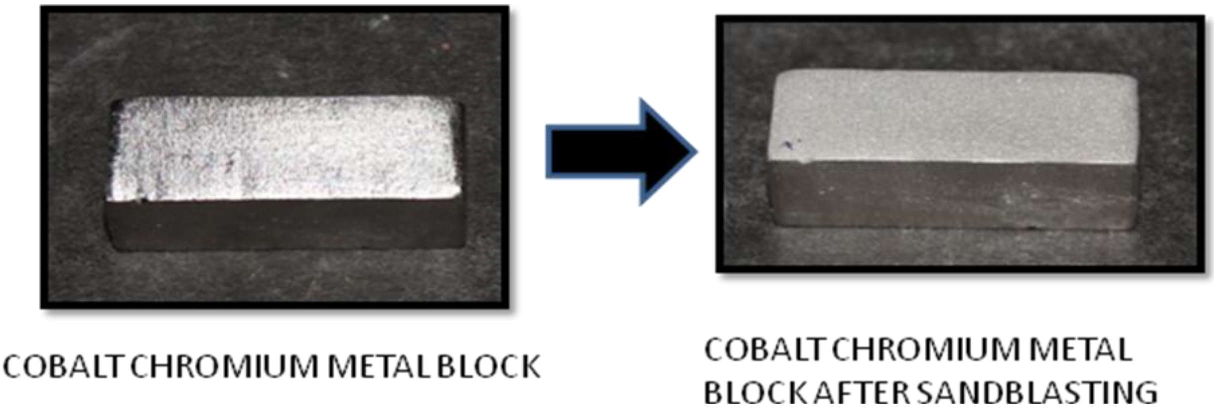


Fig. 1: Chrome cobalt test blocks before and after sand blasting.

layers) application of thin layer of DTK cement and allowed to set for 6mins under 25lbs pressure.

The specimens were cross sectioned perpendicular to the cobalt chromium block interface with a diamond wafering blade (buehler series 20HC N0 11-4215) mounted on an IsoMet low speed diamond saw (buehler , lake bluff , IL,USA) under copious water , to produce a series of rectangular beams with a mean cross sectional area of 0.85mm2, according to the "non-trimming" technique for micro-tensile bond strength testing (Figure 3). After exclusion of the beams from the peripheral areas , 30 bars were randomly selected from each group of two bonded blocks and then divided into two sub groups for each material (n=15). Sub group 1 was tested for micro tensile bond strength (micro TBS) at baseline (3 hrs). Subgroup 2 was aged in distilled water at 37^0C for 24 hrs before bond strength testing.

Each group had a cross sectional area measured with a digital calliper (mitutoyo,Tokyo, japan). Beams were individually attached to the flat grips of the universal testing machine using cyano-acrylate adhesive. The bars were loaded under tension at a cross head speed of 1.0mm/min using the universal testing machine (Figure 5). The bond strength data were converted to MPa and analysed by one-way ANOVA (n=2). Multiple comparisons between groups were evaluated by wicker's plot graph at a 95% level of significance. Graph 1.

The mode of failure of each specimen was determined by a stereomicroscope. The fracture modes were classified according to the following categories (Figure 6):

1. Adhesive failure
2. Cohesive failure
3. Mixed failure.

Results

The results summary for the µTBS of the two cements

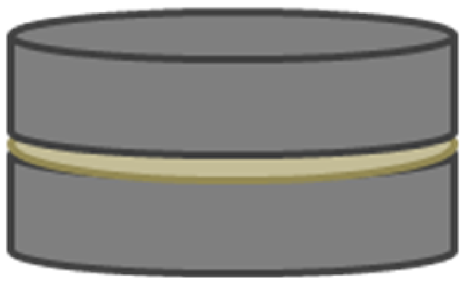


Fig. 2: Schematic representation of the two blocks after bonding.

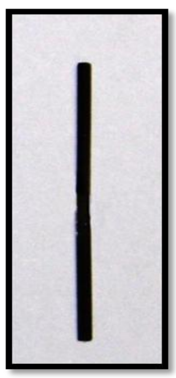


Fig. 3: Bonded Sample of 0.81mm square.

under various storage conditions are presented in table 1.

One – way ANOVA showed significant differences among μTBS values for the two resin systems (Figure 4) and storage conditions. When comparing the two systems at baseline, DTK group showed the highest mean μTBS values compared to Panavia F cement (p< 0.001).Table 1

The stereomicroscopy of the metal side of the fractured specimens showed that DTK group had cohesive fracture (type 2) in all the specimens in both the subgroups observed and Panavia had adhesive fracture (type 2) in all the specimens in all the sub groups observed.

Table 1: Comparitive values of micro tensile bond strength of Chrome cobalt alloy with DTK and Panavia cement before and after aging.

Microtensile Bond Strength (MPa) Mean ± SD	Baseline (3hrs)	Ageing after 24hrs in distilled water	P-value
Group I (n=15)	14.2 ± 1.9	7.9 ± 1.7	0.001 (Significant)
Group II (n=15)	36.5 ± 3.9	27.2 ± 3.6	0.001 (Significant)

Regarding the influence of storage condition, the resin systems were affected differently. After 24hrs storage in distilled water at 37^0C (sub group 2), micro TBS values of DTK and Panavia F were significantly reduced (p<0.001) compared to their bond strength at baseline. But the mean micro TBS of DTK was still higher than that of Panavia F cement.

Discussion

There are many attachments on the market and just as many techniques and corresponding parts that are incorporated into the prosthesis, in order for them to function effectively. Some of them are rather difficult and technique sensitive with many complicated parts

Fig. 4: Cements- used DTK and Panavia.

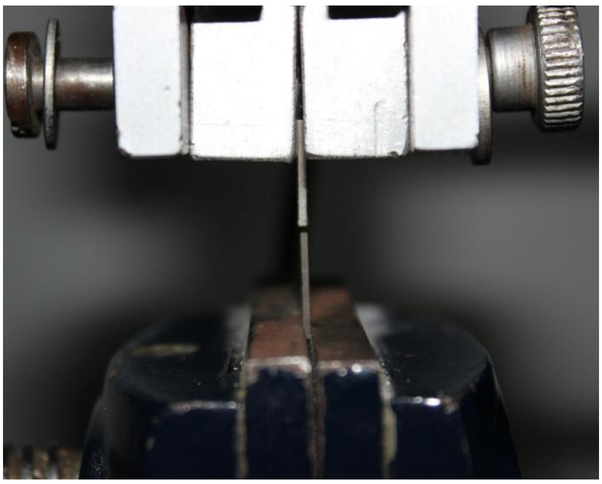


Fig. 5: Samples undergoing testing.

that are tricky at best, to assemble and complete. Instead of soldering and LASER welding the dental attachments to the prosthesis an adhesive option is given. Some of these advantages with this adhesive option are that the negative hurdles in "casting onto" are eliminated and minor inaccuracies are compensated for thereby assuring superior precision in the path of insertion and a larger choice of gold or base metal alloys, some of which may have a greater melting temperature than the attachment. Finally there is no change to the physical properties of the attachment by thermal heating which occurs by soldering or by casting. Within the last few years, implant component systems have been introduced that allow prosthetic crowns to be cemented directly to the implant abutment. The rapid rise in the popularity of cementable implant prostheses has been attributed to several factors. They can be less costly and utilize fewer prosthetic components. The cemented concept eliminates the need for a prosthetic screw and its occlusal screw access channel through the restoration, thereby improving esthetics, optimizing occlusal loading, and also limiting the incidence of loose screws and associated maintenance.

Passivity of full arch screw retained implant prosthesis is important. Making it cement retained, at the same time using the screws for retrievability of the prosthesis is newer acceptable trend.DTK resin cement has been used successfully for this kind of metal- metal bonding.

The purpose of this study was to evaluate the micro tensile bond strength of this new resin system to Co-Cr alloy and compare it with the existing resin system before and after aging.

To improve the bond of resin compounds to metallic alloys, several techniques have been developed in an attempt to achieve a stable bond. Sandblasting the metallic alloys with aluminum oxide is commonly employed for surface cleaning and a proper retentive topography, with a consequent increase in the adhesive bond. The same protocol has been followed in this study.

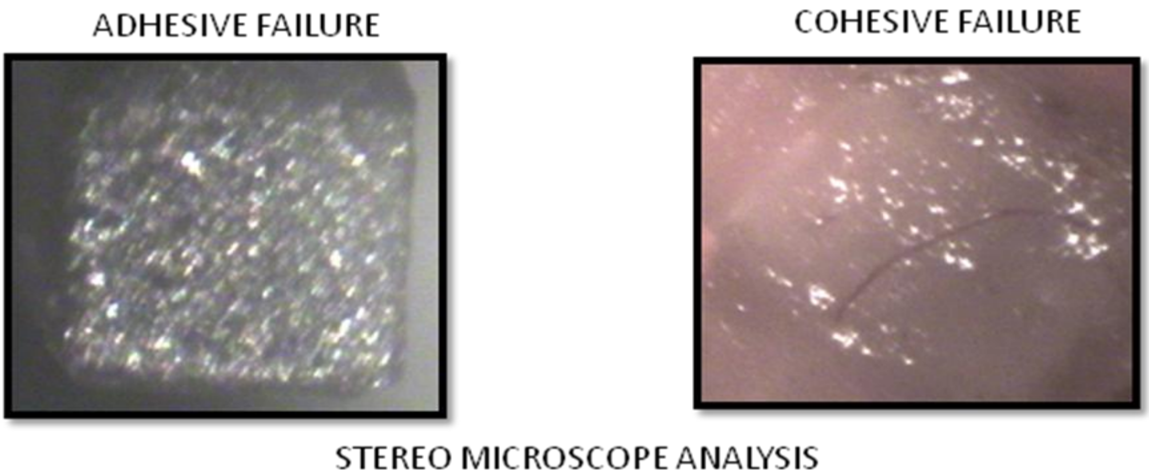


Fig. 6: SEM Figures showing adhesive failure for Panavia and cohesive failure for DTK cement.

The stability and durability of certain adhesive systems under aging conditions may have an important influence on the absolute bond values. *In vitro* procedures for aging simulation of adhesive bonds may be applied, such as thermo-cycling, before bond strength testing. Whereas some authors observed that the adhesive bond between metallic alloy and resin cement is not affected after thermo cycling, others found a decreased bond after aging of the specimens. With the widespread utilization of different luting cements, the influence of thermo cycling on the bond durability of resin cements to Cobalt-Chromium alloy becomes fundamental.

The current study evaluated two different adhesive systems to enhance metal bonding to cobalt chromium alloy. The μ tensile bond strength tests showed that the baseline of DTK (Kleber – Bredent) exhibited bond strength values that ranged from 36 – 40 MPa level whereas Panavia F cement exhibited bond strength values ranging from 14- 16 MPa (table 1). After subjecting it to water storage the bond strength of the cements dropped ranging from 27-30 MPa and 7-10 MPa respectively. This depicted that the bond strength was significantly affected after water storage i.e. 40 % in case of Panavia F and 20% reduction in case of DTK (Kleber – Bredent) in case of water storage after 24 hrs.

Although shear testing is the most commonly used method to asses metal-metal bond strength, several studies suggest it can produce misleading results.[1,2,3,4,5] Tensile strength tests and in particular the microtensile testing method, has been considered to be more appropriate for bond strength evaluation since it allows a more uniform distribution for the stresses , a reduction in cohesive failure, and more realistic measurement of bond strength of the adhesive interface.[1,2,6,7,8,9]

The present *in vitro* work suggests that adhesive system DTK (Kleber- Bredent) would be acceptable for achieving clinically high and stable bond strength to cobalt chromium alloy , surpassing the minimum level of 20 MPa for resisting masticatory forces[2]. The adhesive system was not significantly affected by water aging and may represent a viable alternative for metal-metal restoration on cobalt chromium with regard to adhesion. However, it should be noted that in vivo long term bond stability of metal – metal has not yet been determined and further clinical research should be undertaken to investigate these materials.

Conclusion

Within the limitation of this experiment, the following conclusions could be made:

The resin bonding systems exhibited significantly different bond strengths to cobalt chromium alloy. Both the systems showed high initial bond strength and water aging had an adverse affect on both the systems. However, DTK showed better results than Panavia-F.

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