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Influence of different separating mediums applied on the immediate dentin sealing in the tensile strength of temporary restorations

Influência de diferentes agentes isolantes aplicados sobre o selamento dentinário imediato na resistência à tração de restaurações provisórias

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ABSTRACT

Objective: To evaluate the ability of different separating mediums to prevent adhesion between provisional restorations and hybridized dentin surfaces when used with the Immediate Dentin Sealing technique (IDS). **Material and Methods:** 120 extracted human teeth — 40 premolars and 80 molars — were selected to integrate acrylics samples separated into 4 different groups (n=10) according to the separating medium used for IDS protection. Forty samples were made of three teeth mounted in a self-cure acrylic resin block (Jet, Classic, São Paulo, Brazil) arranged side by side, simulating the positioning and proximal contacts present in the dental arch between the second premolar, first molar and second molar. A standard dental preparation for ultra-thin occlusal veneer was performed and complete occlusal dentin exposure was achieved by selective removal of the occlusal enamel with a high-speed conical round burr (Code: 1801.4138 FG, KG Sorensen, Medical Burs Ind. e Com. de Pontas e Brocas Cirúrgicas Ltda, São Paulo, Brazil). Dentin hybridization were performed on the control group and 3 different groups of separating mediums (n=10): PC—commercial provisional separating agent (Pro-V Coat, Bisco, Schaumburg, USA); GG—glycerin gel (K-Y Gel; Johnson & Johnson Industry and Commerce LTDA, São Paulo, Brazil); PJ—petroleum jelly (Rioquímica, São Paulo, Brazil). Provisionalization were manufactured on the prepared teeth. After 2 weeks, the tensile test was performed, and the analysis of the failure pattern was performed by 3D laser confocal microscopy and Scanning Electron Microscopy (SEM). The data were analyzed with the 1-way ANOVA and the Tukey test ($\alpha = 0.05$). **Results:** Significantly lower tensile strength values were found for the commercial provisional separating agent (30.39 ± 10.01 N) compared to others ($p < 0.05$). **Conclusion:** The commercial provisional separating agent showed greater effectiveness on protecting hybridized dentin against the provisional restorations.

KEYWORDS

Dental bonding agent; Dental restoration temporary; Immediate dentin sealing.

RESUMO

Objetivo: Avaliar a capacidade de diferentes agentes isolantes em prevenir a adesão entre as restaurações provisórias e a superfícies de dentina hibridizadas quando usados com a técnica do Selamento Dentinário Imediato (IDS). **Material e Métodos:** 120 dentes humanos extraídos - 40 pré-molares e 80 molares - foram selecionados para integrar as amostras de acrílico divididas em 4 grupos diferentes (n = 10) de acordo com o meio de separação usado para proteção IDS. Foram confeccionadas 40 amostras de três dentes montados em um bloco de resina acrílica autopolimerizável (Jet, Classic, São Paulo, Brasil) dispostos lado a lado, simulando o posicionamento e os contatos proximais presentes na arcada dentária entre o segundo pré-molar, primeiro molar e segundo molar. Um preparo dentário padrão para laminado oclusal ultrafino foi realizado e a exposição completa da dentina oclusal foi obtida pela remoção seletiva do esmalte oclusal com uma broca cônica arredondada de alta rotação

(Código: 1801.4138 FG, KG Sorensen, Medical Burs Ind. E Com. de Pontas e Brocas Cirúrgicas Ltda, São Paulo, Brasil). A hibridização da dentina foi realizada no grupo controle e em 3 grupos diferentes de agentes isolantes (n = 10): PC - agente de separação provisório comercial (Pro-V Coat, Bisco, Schaumburg, EUA); GG — gel de glicerina (K-Y Gel; Johnson & Johnson Industry and Commerce LTDA, São Paulo, Brasil); PJ — vaselina (Rioquímica, São Paulo, Brasil). As restaurações provisórias foram fabricadas nos dentes preparados. Após 2 semanas, foi realizado o teste de tração, e a análise do padrão de falha foi realizada por microscopia confocal a laser 3D e Microscopia Eletrônica de Varredura (MEV). Os dados foram analisados com a ANOVA de 1 fator e o teste de Tukey ($\alpha = 0,05$). **Resultados:** Valores de resistência à tração significativamente menores foram encontrados para o agente separador provisório comercial (30,39 ± 10,01 N) em comparação com os demais ($p < 0,05$). **Conclusão:** O agente separador provisório comercial mostrou maior eficácia para a proteção da dentina hibridizada contra as restaurações provisórias.

PALAVRAS-CHAVE

Adesivo dentário; Restauração dentaria temporária; Selamento dentinário imediato.

INTRODUCTION

Aesthetic indirect restorations are widely used in contemporary dentistry for the restoration of permanent human teeth [1]. Unfortunately, cavity preparation is always needed to allow the adaptation of these restorations to the prepared teeth, often leading to exposure of dentin tissue [2]. In cases of severe dental erosion, dentin exposure already exists naturally and, due to the absence of interocclusal space, even minimally invasive preparations may increase the area of exposed dentin [3].

In the adhesive technique, dentin is the most critical dental tissue because it has lower adhesion values and is more sensitive to acid etching and hybridization than enamel [4,5]. Previous studies have also revealed that dentin can be contaminated during the provisionalization phase, leading to post-operative sensitivity due to bacterial infiltration and reduced potential of dentin adhesion [6,7]. In addition, during the clinical dentin hybridization procedure, there is an imminent risk of the hybrid layer collapsing before it is polymerized [8].

Immediate dentin sealing (IDS) has been proposed to overcome these problems. IDS is characterized by hybridization of the exposed dentin with a conventional or self-etching adhesive system immediately after dental preparation and prior to the impression and provisionalization [6]. Adhesive pre-polymerization on freshly prepared dentin prior to impression, confection and cementation of the permanent restoration results in increased bond strength [9,10], as the bond develops progressively over time due to the complete copolymerization process involving different monomers [11]. The IDS technique, besides sealing dentin, offers improved dentin-pulp complex protection, prevention of bacterial infiltration during the provisionalization and impression phases and, consequently, reduced postoperative sensitivity and limited need for anesthesia during insertion of the definitive restoration [3,6,12-14]. However, during the provisionalization, the exposure of the prepolymerized adhesive layer to oral fluids can bring on water sorption and compromised adhesion between the adhesive coating and the indirect restoration [13,15]. In addition, it is possible to attach the adhesive coating to the resin-based provisional materials during the fabrication or even in the removal phase of the provisional restoration [12]. Therefore, the IDS technique protocol recommended the use of a separating medium on the immediate-sealed dentin to avoid bonding to provisional material [12,16-20]. Studies have used a thick layer of petroleum jelly as a separating medium [12,13,20], glycerin gel and [19-22], more recently, a commercial provisional separating agent manufactured expressly for use with the IDS technique [17,21,23].

To date, few studies have reported the effect of different separating mediums in preventing adhesion between the resin coating and the provisional restoration in the IDS technique.

The aim of this study was to evaluate the isolation capacity of different separating mediums applied to sealed dentin in the IDS technique from adhesion of provisional restorations by measuring the tensile bond strength (TBS) required to remove the provisional restoration from the tooth and subsequently, analyze the dentin surface failure pattern. The hypothesis tested was that the

commercial provisional separating agent would provide more efficient protection to immediate sealed dentin.

MATERIALS AND METHOD

After approval by the Federal University of Rio de Janeiro and the Fluminense Federal University Ethics Committees (protocols: 94156418.2.0000.5257 and 94156418.2.3001.5243), 120 extracted human teeth — 40 premolars and 80 molars — were selected to integrate the acrylics samples. This samples were separated into 4 different groups (n = 10): 3 groups according to the separating medium used for IDS protection and 1 group for control. The extracted teeth were refrigerated with 0.5% aqueous chloramine solution for microbial disinfection for 7 days. Subsequently, the teeth were washed and stored in distilled water. Forty samples were made of three teeth mounted in a self-cure acrylic resin block (Jet, Classic, São Paulo, Brazil) arranged side by side, simulating the positioning and proximal contacts present in the dental arch between the second premolar, first molar and second molar (Figure 1). A preselection was performed considering the shape and proximal contour of the teeth for group formation.

The samples were blindly sorted into test groups by a second researcher according to the planned treatment: PC—commercial provisional separating agent (Pro-V Coat, Bisco, Schaumburg, USA); GG—glycerin gel (K-Y Gel; Johnson & Johnson Industry and Commerce LTDA, São Paulo, Brazil); PJ—petroleum jelly (Rioquímica, São Paulo, Brazil), PJ; and the control group, processed as other groups but without a separating medium.

Dental preparation

An impression with a hard, high-precision polydimethylsiloxane was made prior to the preparation by impressing the teeth embedded in the resin blocks to obtain an index that would be used on the provisionalization stage (Zetalabor, Zhermack Incorporated, Michigan,USA). Then, a standard dental preparation for ultra-thin occlusal veneer was performed only on the first molars to simulate advanced dental erosion on the occlusal surface. Adjacent teeth remained intact to maintain proximal contact. Complete occlusal dentin exposure was achieved by selective removal of the occlusal enamel with a high-speed conical round burr (Code: 1801.4138 FG, KG Sorensen, Medical Burs Ind. e Com. de Pontas e Brocas Cirúrgicas Ltda, São Paulo, Brazil). New burs were used every five-teeth preparation, and all the drillings are performed under water irrigation [23, 24]. The buccal and lingual margins were kept approximately 5.0 mm from the cementum-enamel junction, and 2.3-2.6 mm below the central sulcus, keeping the cuspal inclination as constant as possible [17,25] (Figure 2).

Dentin hybridization and isolation technique

Then, the IDS technique was performed with a conventional 3-step adhesive system (OptiBond™ FL, Kerr Corporation, CA, USA) used according to the manufacturing instructions: dentin etching for 15 seconds with 37.5% phosphoric acid (Ultra-etch; Ultradent Products, Inc., Utah, USA), profusely rinsed, gently air dried for 5 seconds, primer applied with a brush with a light scrubbing motion for 30 seconds (OptiBond™ FL Prime, Kerr Corporation, CA,

Figure 1 - Preparation for ultra-thin occlusal veneers with full dentin exposure.

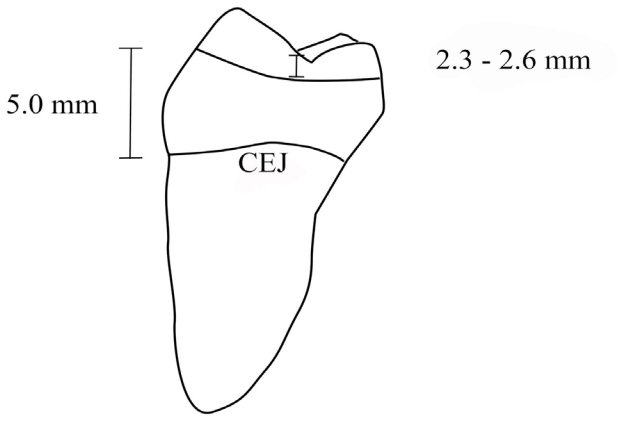

Figure 2 - Dental preparation dimensions. The occlusal preparation followed the cusps convergence CEJ: cemento-enamel junction.

USA), gently air dried for 5 seconds, adhesive resin applied by brush with a light scrubbing motion for 15 seconds (OptiBond™ FL Adhesive) and gently air jetted for 3 seconds to thin the adhesive layer. The adhesive was light cured for 20 seconds at 1000mW/cm^2 (Valo, Ultradent Products Inc., Utah, USA), followed by the application of an air barrier (glycerin gel) and 10 seconds of additional light-curing with the same light-curing unit to polymerize the oxygen inhibition layer [26], and finally a new wash was performed.

Due to the non-retentive characteristics of tooth preparation, a selective adhesive protocol was used through spot-etching with 37.5% phosphoric acid the occlusal prepared enamel margins, two spots on buccal side and other two on lingual side, to increase primary stability of the provisional restoration without impairing the integrity of the dentin sealing [17]. Then, the prepared molar was abundantly rinsed and softly air dried for 5 seconds. Thereafter, the PC, GG and PJ groups received the application of their respective separating mediums with a brush applicator on the sealed dentin to prevent adhesion to the self-curing acrylic resin used in the fabrication of provisional restorations. In PC group, the isolation technique was made as the fabricant recommendation and the control group did not receive any separating medium.

Provisionalization

Provisional restorations were made by using the impression index manufactured on prior stage loaded with a self-cure acrylic resin (Refine Bright; Kota Imp., São Paulo, Brazil) and positioned over the prepared tooth Not retrieving the provisional restoration from the prepared tooth during fabrication (the "shrink-fit method"), which included 3 minutes waiting for polymerization of the acrylic resin and left a small amount of excess resin in the cervical embrasures, provided additional stability to the provisional restoration [25,27]. The rough excess acrylic resin was removed from the free faces and interproximal areas with scalpel blade No. 12 (Swann-Morton Limited). No temporary cement was used. It has been related that immediate sealed dentin contamination with provisional cement results on reductions in bond strength [12]. Then, the teeth blocks were stored in distilled water at 37 °C for 14 days.

Tensile test

After the storage period, the provisional restorations had their occlusal surfaces gently roughened with a Maxicut burr (Code: 510836; Edenta, Au, Switzerland) to promote retention to the tensile testing device. The stain steel tensile testing device, made with a 3.5 mm diameter cylindrical end, was attached to the provisional restoration with cyanoacrylate-based adhesive (793; Tekbond Saint-Gobain, Mumbai, India). Then, acrylic resin was applied over the tensile testing device/provisional restoration junction with the bead-brush technique, setting them together. The tensile testing display was reset, and the specimen was attached to the universal testing machine base (DL 2000, EMIC, Paraná, Brazil) and any force resulting from the polymerization contraction of the cyanoacrylate-based adhesive was zeroed out. The tensile test was performed with a 50 Kg/F load cell at a crosshead speed of 0.5mm/min until failure. The tensile bond strength (TBS) results were expressed in N/mm^2.

Failure pattern analysis

Immediate sealed dentin surfaces were observed with a 5x objective lens through a 3D measuring laser microscope (LEXT OLS4100, Olympus, Tokyo, Japan) to perform a qualitative failure pattern analysis, and were classified as: 1, adhesive along the IDS layer/acrylic resin interface; 2, cohesive within the acrylic resin; and 3, mixed, if different regions were involved. Some specimens were randomly selected for analysis in the scanning electron microscope (SEM) for illustrative purposes.

Statistical analysis

A Shapiro-Wilk normality test, 1-way ANOVA and the Tukey post hoc test (α=.05) were performed with statistical software (Statgraphics Plus 5.1; StatPoint Technologies, Warrenton, VA, USA) to determinate the effect of three different separating mediums on the TBS of provisional restorations fabricated according to IDS technique guidance. The control group (n = 10) was used to verify and confirm the adhesion of provisional restorations on the IDS layer when not isolated with a separating medium, as well to validate the isolation effect of the experimental groups on the tensile bond strength test [12,16-20].

RESULTS

The TBS means and standard deviations are presented in Table I. Statistical analysis revealed a significant statistical difference between experimental groups ($p < 0.0000$). The results revealed that TBS values in PC were significantly lower compared to GG and PJ, which did not show a statistically significant difference between them. The control group presented a TBS mean and standard deviation of 139.92 ± 41.45 (N/mm^2), significantly higher than the experimental groups.

Table I - Mean and standard deviations of the tensile strength (N) of experimental groups

Separating medium groups (n = 10)	Mean ± SD
PC	30.39±(10.01)^A
GG	73.05±(22.93)^B
PJ	61.99±(18.95)^B
Control	139.92±(41.45)^c

PC: commercial provisional separating agent (Pro-V Coat); GG: glycerin gel; PJ: petroleum jelly.

The failure patterns analysis revealed mixed failure in all experimental groups – acrylic resin over hybridized dentin surface. The SEM images illustrate the failure patterns according to the different separating mediums (Figure 3).

DISCUSSION

The results of the present study confirm the hypothesis that the commercial provisional separating agent has a higher efficiency protection of immediate sealed dentin and promotes significantly lower TBS values than other products,

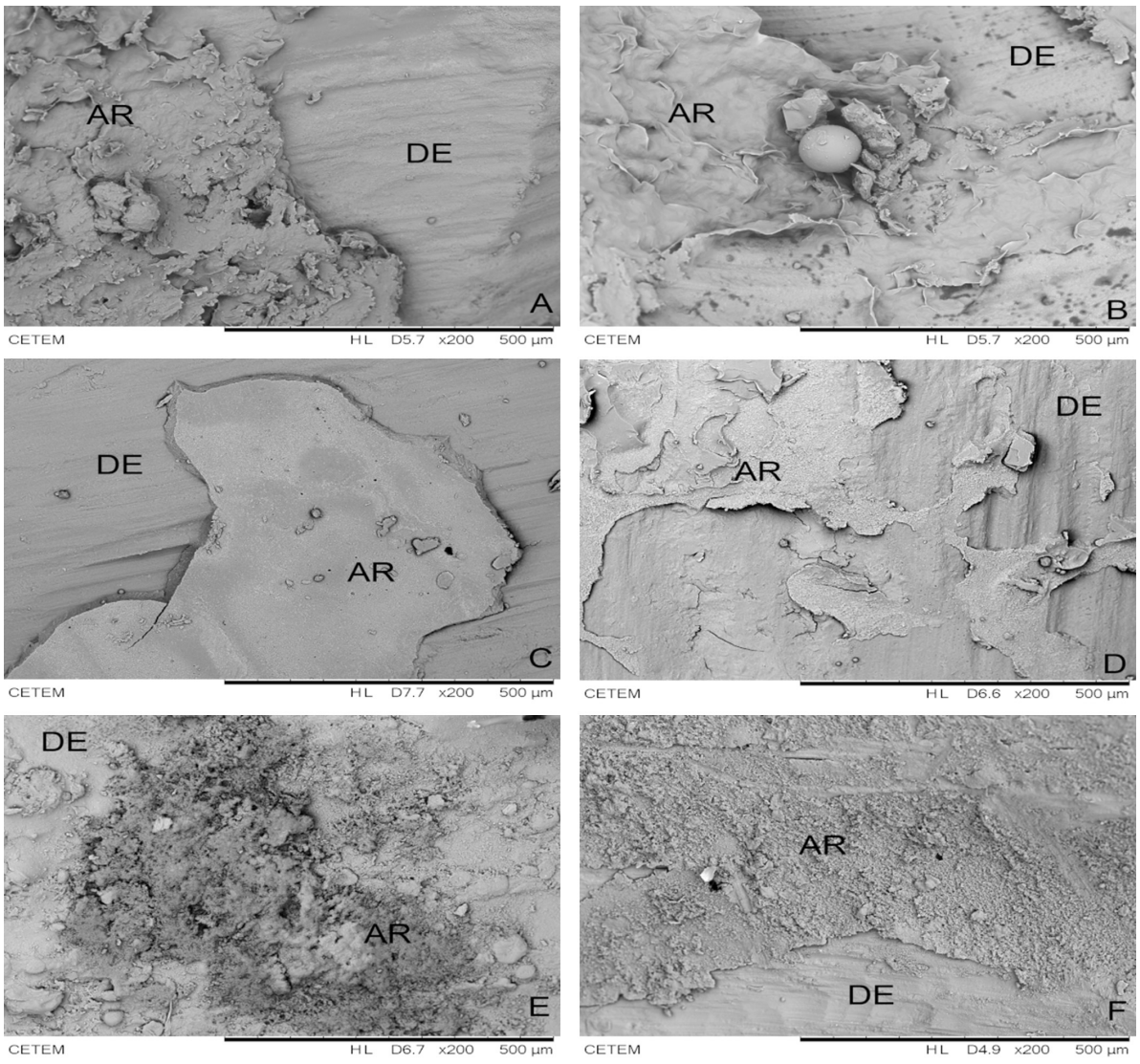

Figure 3 - Scanning electron photomicrographs of tensile specimens. AR: Acrylic resin; DE: Dentin. (A and B: PJ - mixed pattern; C and D: GG - mixed pattern; E and F: PC - mixed pattern. B, C and D micrographs were obtained from different samples of A, B and C).

which indicates a lower interaction between the prepolymerized adhesive and the methacrylate-based resin used in the provisionalization phase. However, each separating medium was able to reduce this interaction, demonstrating achievement, to a certain extent, of the IDS protection aim [12,20].

As expected, the control group shown a statistically significance TBS values compared to the experimental groups, confirming the need to use separating mediums to perform the IDS technique [12,13,20,26]. To date, previous studies have not directly compared the results of different separating mediums used in the IDS technique against methacrylate-based provisional restoration adhesion.

Glycerin gel and commercial provisional separating agents have as an advantage their water solubility property that allows easier removal. In contrast, petroleum jelly is an oily substance, which makes cleaning the immediate sealed dentin surface more difficult [22].

In the IDS technique, after the dentin hybridization, an application of glycerin gel with 10 s additional light exposure (air-blocking) is recommended to prevent oxygen-inhibited layer (OIL) formation [10,12,13,26]. However, it has been reported that air-blocking is not sufficient and a thin OIL remains, allowing minor interactions with impression and provisional restorative materials [16,19,28]. Other studies have reported that creating an air-blocking barrier with glycerin gel could prevent this interaction [8,12,13,16].

The presence of an OIL could allow interaction between the free functional methyl methacrylate groups of resin adhesive and the methyl methacrylate free monomers of acrylic resin provisional restorations. This interaction could explain the adhesion of the provisional restoration on the IDS layer observed at surface dentin analysis and illustrated by SEM images of mixed failures. The absence of adhesive and cohesive failures may be explained by the protective action of separating mediums, though such protection does not appear to be sufficient. In addition, it has been reported that when using the IDS technique, a mild difficulty in removing provisional restorations that were isolated with the commercial provisional separating agent was noticed . Despite the isolation protocol was not described, that difficulty was justified to a probable insufficient material application [21].

The lower TBS values in the PC group suggest that the commercial provisional separating agent is the most efficient for the IDS technique. This material suffers volatilization after the air jet, as indicated in its instructions for use, which brings on an apparent change of viscosity to a thin dry film. Glycerin gel and petroleum jelly maintain the same viscosity and film thickness. It has been speculated that, in the case of a provisional restoration fabrication with the silicone index, the provisional restorative material might have compressed the glycerin gel and the petroleum jelly, inducing shear stress that may have induced flowage of the separating mediums and consequently, provided an irregular protective surface [29].

Limitations of the present study include the small size variation of human teeth, the small sample size, and the *in vitro* nature of this study. Additional studies are necessary to evaluate the efficiency of separating mediums used in the IDS technique.

CONCLUSIONS

Within the limitations of this *in vitro* study, were concluded that:

1. The application of separating mediums on the hybridized dentin in the IDS technique is fundamental for protecting the hybridized dentin during the provisionalization phase;
2. The commercial provisional separating agent presented more efficient protection compared to glycerin gel and petroleum jelly.

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Authors' Contributions

IINS: Conceptualization, Methodology, Software, Formal Analysis, Investigation, Writing – Original Draft Preparation. KRR: Conceptualization, Validation, Writing – Review & Editing, Supervision, Project Administration.

Conflict of Interest

No conflicts of interest declared concerning the publication of this article.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of: Federal University of Rio de Janeiro and the Fluminense Federal University Ethics Committees. The approval codes for this study are: 94156418.2.0000.5257 and 94156418.2.3001.5243.

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