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Influence of the Internal Conditioning of Indirect Restorations of Resin Composite in Relation to Microleakage Using LEDs and QTH Units

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Clinical Relevance

An efficient polymerization of resin composite inlays associated with treatment of the surface and luting with dual resinous cement and flowable resin composites presents better longevity of restorations.

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SUMMARY

The current study evaluated *in-vitro* microleakage of indirect composite inlays fixed with flowable composite and resinous cement and cured by LEDs and QTH units, thus modifying the internal conditioning of the inlays. Thirty-two non-carious teeth were selected and 64 cavity preparations were performed in both enamel and cementum. These teeth were divided into four groups: I—Elipar FreeLight appliance and Filtek Flowable composite; II—Ultralux appliance and Filtek Flowable composite; III—Elipar FreeLight appliance and RelyX cement and IV—Ultralux appliance and RelyX cement. The inlays were internally sandblasted with aluminum oxide, etched with 37% phosphoric acid, washed and silanized. The dental etching was carried out with 37% phosphoric acid for 15 seconds in

dentin and 30 seconds in enamel. After being washed and dried, Single Bond dentinal adhesive was then applied, and the inlays were fixed with their respective luting agents, cured in close contact with their surfaces for 60 seconds, thermocycled and immersed in 0.5% basic fuchsine solution. The teeth were then washed and sectioned through the center of the restoration in order for the microleakage readings to be performed using the Image Tool Software. Then, ANOVA and Tukey's statistical tests were applied. In enamel, there was no significant difference for both groups with regard to microleakage; in cementum, the significant difference was 5% (p>0.005). In agreement with the results, the inlays can be fixed with RelyX and Filtek Flowable resins.

INTRODUCTION

The use of porcelain and resin composite inlays has been evaluated under several aspects, including microleakage and physical properties, such as thermal diffusiveness and electrical conductivity, as well as the ability to simulate natural tooth esthetics.

The tireless search for indirect resinous materials by both professionals and patients has brought a preoccupation with regard to its adaptation not only for enhanced esthetical properties, but also for microleakage and fixation. Taking this into consideration, the evolution of adhesive systems and resinous cements, which are released daily into the market, the aim is to improve retentive and adhesive qualities and decrease microleakage.[1] Techniques to measure and evaluate microleakage have been developed by means of electron microscopy and assessment with the Image Tools 2.00 Software. This technique enables the measurement of liquid leakage, which, in turn, facilitates the assessment of tooth/restoration interface properties and provides for a more accurate measurement.

Retention mechanisms of a restoration toward a previously prepared dental structure can be divided into three different categories. These categories include mechanic bonding, micromechanics and molecular adherence. Cements must feature properties, such as biocompatibility, adhesion, pellicle thickness, low solubility, bond strength, handling facility and low microleakage.

The materials that have been used to fix esthetic restorations were developed to help ease the difficulties resulting from conventional cements. Adhesion to the dentin surface is obtained by resin penetration through dentin etched with acids. Adhesives that produce a micromechanical tagging with the partially demineralized dentin form a hybrid layer zone and provide stronger retention of the composite to the dental substrate.

In the literature, it is possible to verify the use of material associations in order to improve fixation and esthetic restorations, such as flowable composite (low viscosity), that can also be used in inlay fixation and be activated by different light sources (for example, alternative curing techniques feature better results). In the beginning, it was believed that these materials absorbed mastication efforts under resin composite direct restorations, mainly those of high density that facilitated this absorption. The setting of a more resilient material could help the assimilation of these deformations, and the presence of load would narrow the groove caused during the polymerization procedure, thus reducing liquid leakage into the tooth/restoration interface.

As a result, it was observed that the activation of these resinous materials had also been going through modifications in regards to both polymerization appliances and techniques. In addition, light-curing appliances have influenced the final result of the restorations, since ultraviolet lights, halogen lamps and now LEDs have become available. Studies in the literature have demonstrated satisfactory results, considering that the speed involved in converting resin composite photoinitiators is more effective[2] when the light emission spectrum ranges from 460 nm to 488 nm and reaching a maximum emission peak at 470 nm. This coincides with the peak of camphorquinone conversion,[3-4] resulting in a longer lifespan and the absence of heat when it is activated.[5]

METHODS AND MATERIALS

Thirty-two non-decayed human maxillary third molars were used. The teeth were divided into four groups of eight molars each, where 16 box-type preparations were performed for each group. Eight preparations were made in enamel and eight were made in dentin 1 mm above (Figure 1) and below the cementoenamel junction (Figure 2). The material and the appliances used to polymerize the inlays in their respective groups (n=8) for fixation with Filtek Flowable composite (3M ESPE, St Paul, MN, USA) were as follows: Group I–polymerized with Elipar FreeLight (3M ESPE) and Filtek Flowable composite (3M ESPE); Group II–with Ultralux (Dabi Atlante, Preto, SP, Brazil) and Filtek Flowable composite (3M ESPE); Group III–with Elipar FreeLight (3M ESPE) and RelyX (3M ESPE) resinous cement; Group IV–with Ultralux (Dabi Atlante) and RelyX resinous cement.

The teeth were cleaned and checked for the presence of cracks. Retrograde fillings with amalgam were performed in the root apices, which were then luted with Duralay acrylic resin (Dental Mfg Co, Worth, IL, USA).

Using a digital caliper rule (Mitutoyo, Kanagawa, Japan), the cavity preparations were standardized in

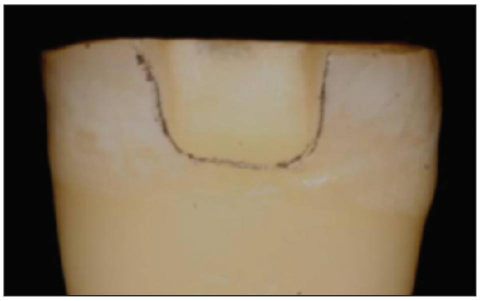
Figure 1


Figure 2

4 mm occlusal-gingival length, 2.5 mm buccal-lingual width in the gingival region and 1.5 mm axial-proximal depth in the gingival wall. The preparations were carried out with a #721 diamond (KG Sorensen Indústria e Comércio Ltda, Alphaville-Barueri, Brazil) and #7642 and #7664 multi-laminated (Beavers jet burs, Division of Sybron Canada Ltd, Morrisburg, Ontario, Canada) burs, featuring the following characteristics: a) proximal boxes 1 mm before the cementoenamel junction; b) distal box 1 mm beyond the cementoenamel junction; c) buccal and lingual boxes divergent toward the occlusal aspect; d) axial wall convergent towards the occlusal aspect and plane in the buccal-lingual direction; e) chamfered ending and f) buccal and lingual walls divergent toward the axial-proximal direction.

After the preparations were completed, the teeth were separated into their groups for the impression step, which was performed with condensation silicon. The impression material was used in two steps, putty and light body. After the impressions were taken, the molds were poured with type IV gypsum at a ratio of 19 ml of water by 100 grams of gypsum. All the materials were used according to the manufacturers' instructions. The dies were then trimmed for excess removal and the preparation margins were assessed with a 4x magnifying glass (Equipamentos Odontológicos Ltda, São Carlos, SP, Brazil), while the peripheral limits of the cavity were outlined with a demographic pencil. In the dies, the "jacket spacer" apparatus (Kuraray Co Ltd, Osaka, Japan) was applied to obtain a fixation release with 40 µm on average,[6] observing the limit of 1 mm before the cavosurface angle. The "margin sep" device (Kuraray Co Ltd) was applied to the internal surface of both the bottom and surrounding walls.

Cesead II composite (Kuraray Co Ltd) shade A2 was applied all over the dies in layers with the same color, then it was light cured with the UniXS polymerization appliance (Heraeus Kulzer GmbH, Hanau, Germany) for 180 seconds. The inlays were then removed from the dies and adapted to the prepared teeth.

An aluminum oxide blast with 100 µm was applied to the internal surfaces of the inlays and then applied over the internal surfaces of the inlays for five seconds at 40 Bar of pressure. These surfaces were then etched with 37% phosphoric acid for 60 seconds, rinsed and dried. During the luting procedure of each inlay and its respective preparation, the silane agent (Silano Primer, 3M ESPE) was applied over the internal surfaces of the inlays and, after 30 seconds, the inlays were dried with an air jet for 10 seconds. The cavities were etched with 37% phosphoric acid for 15 seconds, washed with air/water spray for 15 seconds and dried with absorbent paper. The adhesive agent Single Bond (3M ESPE) was then applied all over the cavity preparation and inlay surfaces. The excess was removed with a light air jet.[7] The inlays were then set aside for later fixation with Filtek Flowable composite (DA2 shade–dentin, 3M ESPE, Lot #1BH2004-09 [BIS-GMA,GMA, UEDMA, BIS-EMA]) and applied along the cavity surface and RelyX resinous cement (A2 shade, 3M ESPE, Lot CTCT–03-05) on a paper block for spatulation. The inlays were fixed in their respective preparations with light digital pressure[8] and, after the excess composite and resinous cement were removed, the inlays were polymerized for 60 seconds in close contact with the inlay surface according to their respective groups.

The light-curing appliances were gauged as follows: Ultralux (Dabi Atlante) potency between 350 mw/cm^2 and 500 mw/cm^2, thermal filter that controls light temperature, light filter that produces a wave length ranging between 400 nm and 500 nm; LED Elipar FreeLight appliance (3M ESPE), constant light intensity throughout the entire exposition time, light intensity measurer coupled (radiometer) and the exponential mode of light exposition ("Hamp" mode), LED (light emission diode) with a light intensity between 270 mW/cm^3 and 370 mW/cm^3.

The specimens were coated with nail varnish and submitted to 1,000 thermal cycles, varying the temperature between 5°C (± 1°C) and 55°C (± 1°C) for 15 seconds each. The specimens were immersed in 0.5% basic fuchsine solution for 12 hours and thoroughly washed and eliminated. The specimens were then taken to the ISOMET 1000 cutting machine, sectioned across the center of the restorations and the reading was carried out via scanning and measuring using Image Tool Software (University of Texas Health Science Center in San Antonio, San Antonio, TX, USA). The measurement consisted of capturing the image in a microscope, later storing the image in the computer and then measuring the interface as to where the microleakage occurred. The program allows for calibration in several measures. For this, it was gauged in millimeters. After measuring the microleakage in the interface, it was automatically transformed into millimeters to provide data for the statistical assessment.

RESULTS

The original data for enamel leakage was submitted to both ANOVA and Tukey's tests (0.47328), where the microleakage results were non-significant. When cement was present with the application of the Kruskal-Wallis' multiple comparison test, there was significance in microleakage between the appliances Ellipar with Filtek composite and Ellipar with RelyX cement, as well as between Ellipar with RelyX cement and Ultralux with Filtek composite. This was non-significant in the rest of the groups (Table 1, Figure 3). After the test application in enamel and cementum, several groups and cements were compared, and the ANOVA and Tukey's complementary tests were performed (0.34154), where the non-significant result was obtained for marginal microleakage for both preparation endings.

DISCUSSION

Resinous esthetic materials to fabricate inlays have arisen that combine esthetics, higher levels of hardness, handling facility and durability. These properties are also featured in conventional porcelain and restore harmony and function to the stomatognathic system.

Resin composites for indirect restorations are rather promising; however, only results from long-term clinical and laboratory experiments may demonstrate the effectiveness and durability of these new materials in the future.[9] This justifies the current study on the *in-vitro* evaluation of microleakage using dual-cure cements and flowable composites polymerized immediately after their fixation using different light sources, as demonstrated in clinical trials.[9] Satisfactory results were obtained with the Elipar FreeLight appliance[10] and by using its own bonding agents,[11] where these fixation agents feature high Knoop hardness, low solubility, little wear, dimensional stability, biocompatibility and fracture resistance.[12]

The internal conditioning with an aluminum oxide blast and the internal etching of the restorations has shown satisfactory results in accordance with the current study. According to the literature,[6,13] the aim of the current study was to improve retention between the restoration and the fixation resinous agent. This study used internal conditioning of the inlays using an aluminum oxide blast of 100 µm at 40 Bar of pressure associated with 37% phosphoric acid etching and silanization. The internal blast of the indirect composites featured better results in adhesion to dental structure,[13-14] which has combined dental structure etching and the use of bonding agents.

Considering the technique used during the fixation procedure and the strength exerted for the adaptation of the inlays, digital pressure has been selected according to a study by Chieffi and others.[8] Even though the techniques for the application of the fixation agents have influenced the final results when indirect composites are used, dual-cure cements featured a polymerization (physical-chemical) that provides more safety in the curing depth of indirect restorations. Nevertheless, the restoration thickness may prevent light from reaching the different areas and, therefore, the appliance's effectiveness, according to its parameters, allows for polymerization to reach a sufficient cure depth for this material,[3-5,15-20] breaking carbon chains and reducing polymerization contraction.

The possibility of using a flowable composite as cement with adhesive properties, without using adhesive systems, is limited.[14] A reduced bonding strength

Table 1: *Means and Standard Deviations of Microleakage*

Limits	Cements and Curing Units			
	RelyX Ultralux	RelyX Elipar	Filtek Ultralux	Filtek Elipar
Cementum	0.12 (0.11)ABa	0.09 (0.23)Ba	0.24 (0.14)Aa	0.33 (0.29)Aa
Enamel	0.13 (0.08)Aa	0.01 (0.03)Aa	0.06 (0.07)Aa	0.15 (0.27)Aa

Capital letters in row and lower case letters in column denote no significant differences (p≤0.05). Standard deviations are shown between parentheses.

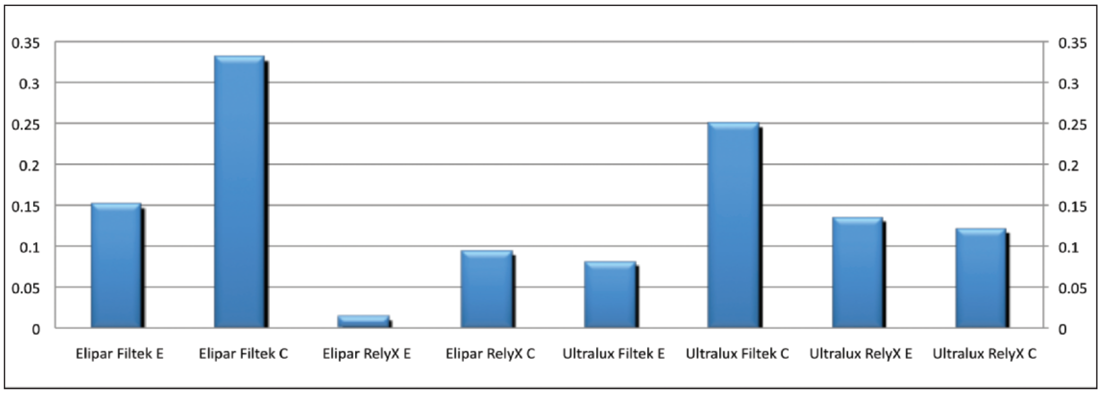

Figure 3

was observed, which indicated that the flowable composite that was used is more effective when associated with adhesive systems, according to Frankenberger and others.[14] Hence, composite load may decrease the occurrence of marginal grooves and the consequential liquid leakage through this interface. However, when using a flowable composite,[21] there was no decrease in microleakage when the preparation ending was in cementum. On the other hand, it was reduced when the preparation ending was in enamel and, according to the literature, when techniques of fixation and light curing were used.[11,21-22]

The fixation techniques that were used showed effectiveness and simplicity for daily clinical use, since it was clear that resinous cement is effective for this purpose. When the use of flowable composite was proposed, it was verified that the load portion of these materials could reduce the stress formed during their polymerization, thus providing a better marginal seal.

The evolution of polymerization systems, both gradual and incremental, has improved the grooves in the tooth/restorative material interface in direct composite restoration techniques, thus decreasing microleakage. Therefore, contraction in the cements can create grooves in this interface with an auto polymerization system, for cements feature a continuous reaction after their manipulation. The use of light in their immediate activation accelerates the curing procedure, providing the professional with greater safety.[23] However, physical-chemical polymerization is only effective when the incidence of light features a wavelength between 400 nm and 500 nm; whereas, the activation of these cements by LEDs and halogen lamps may reduce this contraction. Moreover, the use of LEDs reduced this contraction as much as the effectiveness of the appliances increased when the photoinitiator is camphorquinone,[2] while polymerization combined with dual cement features an improvement in the overall results[17] of material hardness.

LEDs are more likely to be re-configured and used in new light-curing units due to their superior conversion speed, their narrow range of light spectral emission and their ease of handling. These factors influenced an evaluation of the possible use of these appliances as an alternative for inlay polymerization, varying the types of fixation cements and their effectiveness in regard to microleakage.

The types of preparations and techniques of inlay fabrication, the internal etching of restorations, the dentinal surface treatment and the use of bonding agents with polymerization techniques using LED-based light sources compared to the halogen lamp, brings new tendencies. Polymerization by LEDs features better effectiveness, considering that the new appliances are being manufactured with satisfactory configuration parameters and that composite conversion becomes more efficient, because its light spectra are closer to the conversion peak of camphorquinone due to the fact that this device features a longer lifespan and produces no heat, thus reducing composite polymerization contraction.

Nevertheless, the current study verified the need for further investigation related to the hardness of these cements and flow composites, which was evaluated after polymerization by LEDs and a halogen lamp in order to prove their effectiveness. This was clear in studies carried out by means of the transdental technique.

CONCLUSIONS

Inlay fixation using resinous cement and flowable composite on enamel has no significant microleakage, and on cementum, it has a featured significance when both appliances were used. A modification in the treatment of the inlay surface may have caused stronger retention, thus reducing this microleakage. The presence of load in the flowable composite may have caused a smaller polymerization contraction and, consequently, less microleakage. According to the literature and the material and methods used, the fixation of resin composite inlays can be indicated.

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