The effect of dentine pre-treatment using bioglass and/or polyacrylic acid on the interfacial characteristics of resin-modified glass ionomer cements

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\begin{abstract}
Objective: To evaluate the effect of load-cycle aging and/or 6 months artificial saliva (AS) storage on bond durability and interfacial ultramorphology of resin-modified glass ionomer cement (RMGIC) applied onto dentine air-abraded using Bioglass 45S5 (BAG) with/without polyacrylic acid (PAA) conditioning.

Methods: RMGIC (Ionolux, VOCO) was applied onto human dentine specimens prepared with silicon-carbide abrasive paper or air-abraded with BAG with or without the use of PAA conditioning. Half of bonded-teeth were submitted to load cycling (150,000 cycles) and half immersed in deionised water for 24 h. They were cut into matchsticks and submitted immediately to microtensile bond strength (μTBS) testing or 6 months in AS immersion and subsequently μTBS tested. Results were analysed statistically by two-way ANOVA and Student-Newman–Keuls test (α = 0.05). Fractographic analysis was performed using FE-SEM, while further RMGIC-bonded specimens were surveyed for interfacial ultramorphology characterisation (dye-assisted nanoleakage) using confocal microscopy.

Results: RMGIC applied onto dentine air-abraded with BAG regardless PAA showed no significant μTBS reduction after 6 months of AS storage and/or load cycling (p > 0.05). RMGIC-dentine interface showed no sign of degradation/nanoleakage after both aging regimens. Conversely, interfaces created in PAA-conditioned SiC-abraded specimens showed significant reduction in μTBS (p < 0.05) after 6 months of storage and/or load cycling with evident porosities within bonding interface.

Conclusions: Dentine pre-treatment using BAG air-abrasion might be a suitable strategy to enhance the bonding performance and durability of RMGIC applied to dentine. The use of PAA conditioner in smear layer-covered dentine may increase the risk of degradation at the bonding interface.

Clinical significance: A combined dentine pre-treatment using bioglass followed by PAA may increase the bond strength and maintain it stable over time. Conversely, the use of PAA conditioning alone may offer no significant contribution to the immediate and prolonged bonding performance.

\end{abstract}

1. Introduction

Conventional rotary instruments equipped with tungsten-carbide, carbon-steel or diamond burs are used routinely in clinical practice for dental cavity preparation. In minimally invasive dentistry (MID), the underlying tenet is to preserve sound dental hard tissues and minimise the unnecessary alteration of healthy tooth structure [1–5]. Air-abrasion has been advocated to be a suitable approach to reduce the risk for unnecessary removal of sound dental tissues [2,4], although the choice of powders used may affect the quality and durability of the tooth-restoration interface [6,7]. Bioglass 45S5 (BAG), a calcium/sodium phosphate-phyllosilicate glass, is used in air-abrasion with several advantages including the absence of pain during the operative procedure and the opportunity to leave cavities with rounded internal line angles, thus minimising the contraction stress of resin composites [8–10]. Moreover, BAG will embed into the dentine surface so creating a bioactive smear layer [5,6,11] that can react with body fluids, encouraging mineral deposition through formation of hydroxyapatite...
The stabilisation of the interface between tooth and restorative material, as well as the creation of in loco conditions that might protect and/or repair the retained demineralised dental hard tissues are of particular importance in MID [16–18]. The use of fluoride-releasing restorative materials such as glass ionomer cements (GIC) or resin-modified glass ionomer cements (RMGIC) may contribute to interfacial protection because of their buffering ability and their fluoride release/re-charge [19–21]. Moreover, since GIC-based materials have the aptitude to induce crystal growth [22] within the interface of the restoration after long-term storage in water, with a chemical composition similar to that of dental hard tissues [23,24], it is hypothesised that the combination of dentine pre-treatment with BAG air-abrasion and subsequent restoration using GIC-based materials could be a suitable strategy to achieve longer-lasting bonding interfaces that can resist degradation over time.

RMGICs combine the therapeutic properties of GICs with the mechanical properties of resin polymers [25]. The setting process of RMGIC is based on free-radical polymerisation as well as the acid–base reaction between polyalkenoic acids and fluoride-releasing siliceous glass [26–28]. The self-adhesive mechanism of GIC-based materials to dentine is the micromechanical interlocking achieved by shallow hybridisation of the micro-porous collagen network. There is a chemical reaction that occurs through the formation of ionic bonds between the carboxyl groups of the polyalkenoic acids and calcium of hydroxyapatite in bone matrix. This interfacial bond is formed in the presence of water, and it is necessary for the ionic bond to be strong, which is achieved by the presence of water.

Table 1

<table>
<thead>
<tr>
<th>Subgroups: [number of specimens for MTBS/Confocal/FE-SEM]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main groups (8 teeth each)</td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>SiC paper NO</td>
</tr>
<tr>
<td>SiC paper YES</td>
</tr>
<tr>
<td>Air-abrasion NO</td>
</tr>
<tr>
<td>Air-abrasion YES</td>
</tr>
</tbody>
</table>

The roots were removed 1 mm beneath the cemento–enamel junction (CEJ) using a diamond-embedded blade (high concentration XL 12205; Benetec, London, UK) mounted on a hard-tissue microtome (Remet evolution, REMET, Casalcio di Reno, Italy). A subsequent parallel cut was performed to remove the occlusal enamel and expose mid-coronal dentine. This flat dentine surface was polished with silicon-carbide paper (SiC #320-grit) for 1 min under continuous water irrigation to simulate the creation of a smear layer that would be created clinically after rotary dentine preparation. The specimens were divided into experimental groups and subgroups as shown in Table 1.

2.2. Experimental design: dentine pre-treatments and aging protocols

The experimental design required that half of the dentine specimens were air-abraded with BAG (Sylic, VELOPEX International, London, UK) under water irrigation. An Aquacare air-abrasion unit (VELOPEX International) was used with an air pressure of 4 bar (400 MPa) for 1 min at a distance of 1 cm from the dentine surface and with continuous mesio-distal and bucco-lingual movements. Subsequently, the air-abraded dentine surface were conditioned with 10% PAA gel (GC Fuji conditioner, Newport Pagnell, UK) for 20 s and rinsed with water for 20 s, or left unconditioned.

Overall, four primary groups (n = 32 specimens/group) were created for this experimental design based on the preparation of the dentine substrate:

Group 1. Specimens abraded using 320-grit SiC abrasive paper (1 min) under continuous irrigation, followed by a water rinse (20 s), air-drying (2 s) and restored with a light-cured RMGIC (no PAA conditioning).

Group 2. Specimens abraded with 320-grit SiC abrasive paper (1 min), conditioned with 10% PAA gel for 20 s rinsed with water (20 s), dried, and restored with a light-cured RMGIC (PAA conditioning).

Group 3. Specimens abraded using 320-grit SiC abrasive paper (1 min) under continuous irrigation and then air-abraded with BAG particles under a continuous water shroud (1 min), rinsed with water (20 s), dried, and restored with a light-cured RMGIC (BAG-PAA conditioning).

Group 4. Specimens abraded using 320-grit SiC abrasive paper (1 min) under continuous irrigation, air-abraded with BAG particles under a continuous water shroud (1 min), rinsed with water (20 s), conditioned with 10% PAA (20 s), rinsed with water (20 s), dried, and restored with a light-cured RMGIC (BAG-PAA conditioning).

The restorative procedure was performed by applying the content of two mono-dose capsules of a commercial RMGIC (Ionolux; Voco GmbH, Cuxhaven, Germany), mixed for 10 s in a triturating unit and applied in bulk on to the dentine surface and light-cured for 30 s with a light-
Table 2
The results show the mean ± SD of the MTBS (MPa) to dentine when resin-modified glass ionomer cement was applied after different dentine pre-treatments.

<table>
<thead>
<tr>
<th>Main groups [8 teeth each]</th>
<th>Dentine etching (10% PAA gel)</th>
<th>24 h AS (CTR)</th>
<th>Load cycling in AS (LC)</th>
<th>6-month in AS (AS)</th>
<th>Load cycling + 6-month (AS + LC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. SiC paper (100/0)</td>
<td>YES</td>
<td>19.5 ± 7.4 (A1) [0/13/87]</td>
<td>21.8 ± 5.5 (B1) [0/8/92]</td>
<td>7.2 ± 2.8 (A2) [5/75/20]</td>
<td>6.9 ± 4.6 (A2) [12/80/81]</td>
</tr>
<tr>
<td>3. Air-abrasion NO</td>
<td></td>
<td>18.1 ± 6.6 (A1) [0/27/73]</td>
<td>23.1 ± 5.6 (B1) [0/18/82]</td>
<td>14.1 ± 4.9 (A1) [3/62/35]</td>
<td>16.9 ± 4.3 (B1) [8/60/52]</td>
</tr>
<tr>
<td>4. Air-abrasion BAG (100/0)</td>
<td>YES</td>
<td>20.8 ± 7.1 (A1) [0/5/95]</td>
<td>24.3 ± 7.0 (B1) [0/12/88]</td>
<td>15.3 ± 6.5 (A1) [0/38/62]</td>
<td>18.4 ± 6.6 (B1) [0/35/65]</td>
</tr>
</tbody>
</table>

* Also given are the percentage (%) of total number of beams (intact sticks/pre-failed sticks) in the dentine treatment groups and percentage of failure modes (adhesive/mix/cohesive). The same letter indicates no differences in columns with different dentine treatments maintained in the same aging condition (P > 0.05). The same number indicates no significance in rows for the same dentine treatment but different aging condition (P > 0.05).

The specimens were sectioned using a hard-tissue microtome (Remet evolution, REMET) in both X and Y planes across the dentine-RMGIC interface, obtaining approx. 20 matchstick-shaped specimens from each tooth with cross-sectional areas of 0.9 mm². These were stored in AS for 24 h or 6 months and then tested for their MTBS. The latter was performed using a microtensile bond strength device with a stroke length of 50 mm, peak force of 500 N and a displacement resolution of 0.5 mm. Modes of failure were classified as a percentage of adhesive (A), mixed (M) or cohesive (C) failures when the failed interfaces were examined at 30× magnification by stereoscopic microscopy. Five representative fractured specimens from each sub-group were critical-point dried and mounted on aluminium stubs with carbon attached to a cyclic loading machine (model S-MMT-250NB; Shimadzu, Tokyo, Japan) while immersed in AS [33].

3. Results

3.1. Micro-tensile bond strength (MTBS) and failure mode analysis

Microtensile bond strength means and standard deviations are expressed in MPa in Table 2. Dentine surface treatments and aging in AS influenced the MTBS results (P < 0.01). Interactions between factors were also significant (F = 58.15; P < 0.05). In brief, at 24 h (no load cycling) the use of air-abrasion and/or PAA as dentine pre-conditioners caused an increase in the microtensile bond strength of RMGIC compared to those created without the use of PAA and/or air-abrasion pre-conditioning. However, there was no significant difference among all groups (P > 0.05). After load cycling only, the lowest results (P < 0.05) were observed with the specimens created by applying the RMGIC onto the dentine that received no PAA conditioning and BAG air-abrasion. After 6 months of AS storage, the specimens created in dentine air-abraded with BAG and subsequently conditioned with or without PAA presented higher values compared to the specimens that received no air-abrasion. Again, no significant difference was found between the main groups (P > 0.05). The specimens with the lowest (P < 0.05) bonding after load cycling and subsequent immersion in AS for 6 months were those created by applying the RMGIC onto the dentine pre-conditioned with PAA.

The RMGIC applied onto dentine surfaces without PAA conditioning showed no significant drop (P > 0.05) in bond strength after any aging challenge (e.g. load cycling, AS 6 months or load cycling + AS 6 months). However, after aging in AS for 6 months or load cycling + AS 6 months there was no significant difference (P > 0.05) between the specimens created with the RMGIC applied onto dentine with or without PAA.

The RMGIC applied onto PAA-conditioned dentine surfaces showed...
a significant drop (p < 0.05) in bond strength after 6 months of AS storage as well as after load cycling followed by prolonged AS storage (6 months). However, the aging protocol induced no significant difference (p > 0.05) between groups 3 and 4 after aging (Table 2). Indeed, the specimens tested after 24 h, load cycling, AS for 6 months and after load cycling followed by prolonged AS storage (6 months) showed comparable results (p > 0.05).

Regarding the mode of failure, most of the specimens failed predominantly in cohesive mode within RMGIC (range: 73–95%) after 24 h and load cycling aging (Table 2). Most of the specimens tested after 6 months of storage in AS and those firstly load-cycled and then immersed in AS for 6 months failed prevalently in mixed mode (range: 38–80%), a part the group of specimens treated with BAG air-and PAA that still maintained a mode of failure prevalently in cohesive mode. The number of adhesive failures in the specimens after AS storage was higher (range: 3–12%) compared to those tested after 24 h or load cycling. However, the load-cycled specimens presented no adhesive failures, apart from those created with the RMGIC applied onto dentine without PAA conditioning.

3.2. Fractographic FE-SEM analysis

The fractographic analysis showed the specimens created without PAA conditioning and air-abraded with or without BAG presented a fractured surface constantly devoid of any exposed collagen fibrils and/or dentine tubules, even when samples failed in mixed mode (Fig. 1A and B). The specimens created with RMGIC applied onto dentine air-abraded with or without BAG and subsequently conditioned with PAA presented some exposed collagen fibrils still protected by apatite (Fig. 1C) and patent dentine tubules (1C-1).

The PAA-conditioned specimens that received no air-abrasion (BAG), which failed in mixed (Fig. 1D) or in adhesive mode (Fig. 1E) after prolonged AS storage with or without load cycling, were characterised by the presence of exposed partially demineralised collagen fibrils and patent dentine tubules (Fig. 1F). However, such fibrils were less abundant compared to the specimens that were stored in AS for 24 h (Fig. 1F-1). The PAA-conditioned specimens air-abraded with BAG, which failed in mixed or adhesive mode (Fig. 1G) after prolonged AS storage (6 months) with or without load cycling, showed a fractured dentine surface protected by mineral with no sign of patent tubules and/or degraded exposed collagen fibrils (Fig. 1H), but with some residual degraded resin present (Fig. 1I).

3.3. Ultramorphology of the bonded-dentine interfaces – confocal microscopy evaluation

The results of the ultramorphology and nanoleakage analysis of the RMGIC-dentine interfaces performed through dye-assisted confocal microscopy are shown in Fig. 2. In brief, it was possible to see at 24 h of AS storage a gap-free interface characterised by the presence of a thin fusion layer (IDF) in all the specimens created by applying RMGIC onto dentine air-abraded with (Fig. 2A) or without BAG (Fig. 2B), but without PAA conditioning. An IDF was not clearly distinguishable in the load-cycled specimens; the overall morphology of the interface remained unaltered both in the specimens created in dentine air-abraded (Fig. 2C) or not, with BAG (Fig. 2D).

After prolonged storage in AS (6 months), with or without load-cycling, the IDF was absent and the area subjacent to the RMGIC appeared subjectively less permeable to the fluorescent dye (low nanoleakage) in both groups of specimens created in dentine air-abraded (Fig. 2E) or not, with BAG (Fig. 2F).

As opposed to an IDF layer, a porous layer-like structure was observed at the interface of those specimens created by applying the RMGIC onto the dentine air-abraded with (Fig. 3A) and without BAG (Fig. 3B) and subsequently conditioned with 10% PAA gel. Such a hybrid zone remained affected by nanoleakage in those specimens created with RMGIC applied on dentine not air-abraded with BAG, but PAA-conditioned only and subsequently submitted to aging protocols (load cycling, 6 months in AS and load cycling + 6 months in AS) (Fig. 3C). The specimens created by applying RMGIC onto air-abraded dentine and subsequently PAA-conditioned showed after all aging protocols, no nanoleakage at the bonding interface as well as subjacent to the RMGIC and dentine tubules (Fig. 3D).

4. Discussion

The two null hypotheses tested in this study were partially rejected as only the specimens created using RMGIC applied onto PAA-conditioned dentine, without air-abrasion with BAG showed a significant reduction in bond strength after AS aging for 6 months and after load cycling and subsequent AS aging for 6 months. Conversely, this group of specimens showed no significant reduction in MTBS after load-cycle aging alone.

SEM ultramorphology analysis performed on the specimens after microtensile testing highlighted the ability of PAA to remove the smear layer without widening the dentine tubules and demineralising the collagen fibrils completely (Fig. 1C). The results from the specimens tested at 24 h showed that the use of PAA conditioner induced no significant increase of the bond strength compared to the specimens created without PAA conditioning (Table 1). These results are contrary to those observed by De Munck et al., [19] who showed that PAA-conditioned dentine yielded higher μTBS values compared to the specimens that received no PAA pre-treatment. On the other hand, current results confirm those of Inoue et al., [30] showing that bonding of the GIC-based materials to dentine can be achieved without the separate use of a polyalkenoic acid conditioner, even with the interposition of a smear layer within the GIC-dentine interface. Moreover, no significant difference was observed in those specimens created without PAA pre-treatment before and after 6 months of storage in AS. It is believed that the difference between the current results and those reported by De Munck et al.,[19] may be due to the use of different type of GIC (contemporary restorative RMGIC vs. RMGIC Bond) as well as to the storage time variations (i.e. 6 months vs. 4 years) and type of media for the aging protocols (i.e. artificial saliva vs. deionised water).

Current results are in agreement with previous published results [19,30] regarding the ultramorphology of the specimens that received no PAA pre-treatment; failures in adhesive mode occurred just above the dentine surface (Fig. 1A and 1B). The PAA-conditioned specimens that did not receive BAG air-abrasion were characterised by the presence of exposed collagen fibrils, before and after prolonged AS storage with or without load cycling. However, such fibrils were less abundant after prolonged AS storage compared to those observed in the specimens aged in AS for 24 h (Fig. 1F-1). These specimens also showed an increase in the number of adhesive failures. Such an outcome was possibly due to hydrolytic degradation processes that occur over time within the collagen. Indeed, within this specific bonding interface it is hypothesised that an enzyme-mediated degradation process may occur due to exposure and activation of endogenous matrix collagenolytic (MMP-1, MMP-8, MMP-13) and gelatinolytic (MMP-2 and MMP-9) metalloproteinases [34] as a result of PAA accumulation within the conditioned dentine surface and inside the dentine tubules. Es-Souni et al., [35] showed using X-ray photoelectron spectroscopy and staining experiments, a higher concentration of carbon products at the PAA-treated dental surfaces along with deconvolution patterns suggesting that carboxylic groups in PAA acid conditioner were involved in a reaction with residual calcium and formation of a PAA-based polymeric gel layer. The ionised hydrogen of the carboxylic acid and the non-ionised groups in PAA may interact with the negative charge of the polymer chain in RMGIC forming intermolecular bonds, thus limiting the availability of the carboxylic groups. This prevents them reacting with the metals in the RMGIC and causes more water sorption at the interface. The RMGIC itself may also have degraded and become more
porous over time in AS, thus facilitating diffusion of water towards the glass-ionomer–dentine interface and causing acceleration of the degradation processes [36].

Based on the results of this study, it is possible to confirm that modern RMGICs developed for restorative purposes can be applied onto a representative smear layer-covered dentine (no air-abrasion) without the use of PAA conditioning as there was no significant difference in bond strength before and after 6 months of AS storage and with or without load cycling (Table 2) [31]. However, the clinical decision of using PAA conditioner should depend upon the histological quality of the dentine retained after cavity preparation (e.g. sound/caries-affected dentine) rather than the immediate bonding performance such materials can achieve in vitro when bonded to standardised smear layer-covered sound dentine specimens. Further tests are ongoing to ascertain if the use of PAA dentine conditioner may affect the longevity of GIC-based materials when applied on caries-affected dentine or sound dentine prepared with conventional burs or chemo-mechanical hand excavation.

A possible explanation as to why the specimens prepared with or without PAA on BAG-abraded dentine showed no significant drop in microtensile bond strength along with no clear signs of nanoleakage after load cycling and/or prolonged AS storage, may be the synergic therapeutic properties of RMGIC to induce growth of mineral crystals [37] and the bioactivity of BAG [11–13] retained on the dentine surface during the air-abrasion procedure [11,38]. This has the potential to induce therapeutic remineralisation within the bonded-dentine interface, which protects it against the action of endogenous dentine proteases [39]. It is documented that the presence of bioglass particles (i.e. 45S5) within resin-dentine interfaces may induce the release of a hydrated silica Si(OH)₄, which polymerises into a porous SiO₂-rich layer, acting as a template for precipitation of amorphous calcium phosphate [11,13,38]. This subsequently converts into biomimetic nonstoichiometric apatite in an alkaline environment [40]. Such an alkaline environment is attained through a rapid exchange of sodium (Na⁺) and
hydrogen ions (H\(^+\)) or hydronium ion (H\(_3\)O\(^+\)), and along with Si(OH)\(_4\) condensation and precipitation of Ca\(^{2+}\) and PO\(_4\)\(^{3-}\) ions, contributes to fossilisation of proteolytic enzymes, thereby reducing their degradation activity [13,41,42]. It has been advocated that mineral precipitation and apatite crystallisation might immobilise proteases through the formation of [Ca/PO-MMP] complexes [43]. However, it is currently hypothesised that the alkalinity of the BAG may buffer the acidity of residual PAA gel within the dentine tubules as well as that of the polyalkenoic acid present within the composition of GIC-based materials. It is believed that such an alkalinisation effect may reduce the potential “retard” demineralisation effect of such acids on the collagen fibrils with consequential late activation of dentine proteases during prolonged aging in AS. Holman et al., [44] reported that an optimum pH 7 is required for several MMPs to function at near-maximum rates, while to degrade telopeptides at same rate of MMPs, cathepsin K works efficiently at pH 5.5 [45]. Tezvergil-Mutluay et al., [41] showed that BAG 45S5 and fluoride-doped bioactive glasses are able to alkalise the incubation media and reduce the enzymatic degradation of dentine induced by MMPs and Cathepsin K.

Teeth are subjected to stresses during mastication, swallowing and parafunctional habits. Maximum biting force in molars is approx. 0.4–0.9 kn, which can challenge the long-term durability of resin–dentine restorative interfaces in teeth [46]. Indeed, it is documented that load cycling produces increased collagen degradation in dentine etched with phosphoric acid (35–40%) and subsequently bonded to using dental adhesives [47]. Nevertheless, the current study showed a slight, but non-significant increase of bond strength values along with reduction of interfacial nanoleakage, in those specimens created with application of the RMGIC on BAG air-abraded dentine. It is believed that load cycling may have contributed to enhance the bioactive synergic effect of BAG and the RMGIC, which protected and remineralised the bonded-dentine interface due to mineral crystallites.
remaining within the collagen after partial demineralisation, acting as seed sites for apatite growth [48,49]. Indeed, Toledano at al., [33] showed that mechanical loading may promote dentine mineralisation at 24 h and 21 days of storage in distilled water, with increase of the mineral–matrix ratio, lack of nanoleakage and permeability at the resin–dentine interface of specimens created through self-etching and EDTA-conditioned bonding approaches.

5. Conclusions

Modern RMGICs can be applied onto dentine covered with smear layer with or without the use of PAA conditioning, although the latter may increase the risk of interface degradation after prolonged aging. However, the durability of modern resin-modified glass ionomer cements applied with or without the use of polyacrylic acid conditioner onto dentine surface air-abraded with bioactive glass is not affected by load cycling and/or prolonged aging in AS. Considering the limitation of this in-vitro study, it is possible to affirm that the synergic combination of the therapeutic properties of RMGIC to induce fluoride release and the bioactivity of BAG to induce mineral growth may represent an alternative restoration approach to achieve a long-lasting restoration.

Declaration of conflict of interest

We declare that we have no proprietary, financial, professional or other personal interest of any nature or kind in any product, service, and/or company that could be construed as influencing the position presented in, or the review of this manuscript.

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Fig. 3. Confocal images of interfaces created with or without BAG air-abrasion followed by PAA conditioning.

[A]: CLSM projection image exemplifies the interface of the specimens created by applying the RMGIC onto the dentine air-abraded with bioglass Sylc (BAG) and subsequently conditioned with PAA gel. It is possible to note that a hybrid layer-like structure and dentinal tubules (dt) appear totally infiltrated by the fluorescent dye solution (pointer). Similar features can be observed within the interface of a specimen created in dentine air-abraded that received no air-abrasion, but conditioned with PAA gel; the hybrid layer-like structure and dentinal tubules (dt) appear totally infiltrated by the fluorescent dye solution (pointer) [B].

[C]: A representative CLSM projection of the specimens created by applying the RMGIC onto a dentine that received no air-abrasion, but conditioned with 10% PAA gel. It is possible to observe that the aging protocols (load cycling, 6 months in AS and load cycling + 6 months in AS) had no effect on the overall morphology of the interface, and the hybrid zone is still evidently infiltrated by rhodamine, although its thickness resulted slightly reduced compared to the same specimens that received no aging (pointer). Please also note the presence of several fluoroluminosilicate fillers within the RMGIC layer (*).

[D]: A representative CLSM projection of the specimens created by applying the RMGIC onto a dentine air-abraded with BAG and subsequently conditioned with 10% PAA gel. In this case it is possible to see that the aging protocols (load cycling, 6 months in AS and load cycling + 6 months in AS) reduced presence of rhodamine at the hybrid zone and inside the dentinal tubules underneath the RMGIC layer (pointer).

References


