学位論文内容の要約

学位論文題目

Durability for mechanical property and bonding performance of resin materials bonded to CAD/CAM resin block
(CAD/CAM レジンブロックに対するレジン系材料の機械的性質および接着力における耐久性について)

博士の専攻分野名称　　博士（歯学）

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Laminate veneers become the preferred choice for the restoration of anterior teeth because of their better esthetic effect and minimal invasion. According to the different material, laminate veneers are mainly divided into porcelain veneers and resin laminate veneers. Although porcelain veneers are highly accepted by patients for their rather good chemical stability and biocompatibility, their high brittleness, high difficulty of processing, and considerable repair challenges limit their widespread clinical application. To overcome these problems, indirect resin laminate veneers, made of CAD/CAM resin blocks, are becoming more and more popular in clinics. However, they are detrimental to adhesion because they are highly polymerized and free of residual monomers.

Light-cured and dual-cured resin cements are usually used to bond the laminate veneers to dental tissues. Dual-cured resin cements combine the light-activated polymerization with the chemical curing mode, which can compensate for the curing light. It has been reported that the bond strength of dual-cured resin cement was higher than that of light-cured resin cement. However, other researchers considered that acidic monomers in self-etch adhesives inhibited the polymerization of dual-cured composite resins. Light-cured resin cements can only be polymerized when light-cured, they can provide sufficient working time, facilitate excess cement removal, and acquire immediate final polymerization and strength. In addition, resin composite is suggested to be used as cement, as its large filler size and big volume, can offer better bond strength and mechanic performance. Therefore, in this study, four resin materials (two types of light-cured resin cement, one dual-cured resin cement, and one resin composite) were evaluated by the microtensile bond strength (μTBS) of bonded between dentin and

CAD/CAM resin block, as long as their Knoop hardness number (KHN) and cohesive strength. The null hypothesis of the study was that (i) there were no differences in the μTBS, KHN, and cohesive strength of four resin materials, and (ii) time did not affect the μTBS, KHN, and cohesive strength of four resin materials.

The resin materials were used in this study as follows: (1) Panavia Veneer LC (PL; light-cured), (2) Variolink Esthetic LC (VE; light-cured), (3) Panavia V5 (PV; dual-cured), and (4) Clearfil AP-X (AP; resin composite).

Based on the types of resin materials, twenty-four caries-free human third molars were randomly divided into four groups: PL, VE, PV, and AP. The flat, occlusal middle dentin surfaces were exposed using a slow-speed diamond saw and polished with #600 SiC paper to produce a standardized smear layer. Then the adhesive was applied to the exposed dentin surface following the manufacturer's recommendations (Panavia V5 tooth primer for the PL and PV group, Adhese Universal for the VE group, and Clearfil SE Bond 2 for the AP group), light cured for 10 s. Subsequently, resin materials were applied to the tooth surface, and the prepared CAD/CAM resin slices (sectioned from CAD/CAM resin blocks and treated following the manufacturer's recommendations) were firmly pressed over the resin materials, light-cured for 20 s. To obtain the 4 mm standard height for the μTBS test, the upper side of the CAD/CAM resin slice was piled with a 2.5 mm height of light-cured resin composite layer. All specimens were stored in the distilled water at 37℃ for 24 hours. After 24 hours, each specimen was sectioned to 1x1mm beams. The μTBS of 24 hours and 6 months was tested. After testing, the fracture modes were confirmed by scanning electron microscopy (SEM).

The specimens of Knoop Hardness test and cohesive strength test were fabricated

and tested after 24 hours and 6 months of storage.

Statistical analysis showed that resin materials significantly influenced on μTBS, KHN, and cohesive strength ($p<0.001$), while time had no significant effects on μTBS and cohesive strength ($p>0.05$). Additionally, the μTBS of the VE group was significantly lower than that of the other three materials ($p<0.001$). There was no significant difference between PL and AP either after 24 hours or 6 months ($p>0.05$). Moreover, the μTBS of the PV group significantly increased after 6 months ($p<0.001$). In the PL, VE, and PV groups, the primary fracture mode was cement failure both after 24 hours and 6 months. Conversely, in the AP group, the predominant failure mode was dentin failure.

Based on the current results, the first null hypothesis was rejected, which means that the μTBS, microhardness, and cohesive strength were significantly affected by types of resin materials. The second null hypothesis was partially rejected, symbolizing that the dual-cured resin cement achieved an increasing μTBS after 6 months of water storage. All materials showed better durability, which means the degradation of all materials didn’t excessively occur.

AP showed very high and durable bong strength, KHN, and cohesive strength, which might contribute to its amount of inorganic filler and particle size. AP is a highly filled hybrid-filled composite containing barium glass and colloidal silica fillers with a mean particle size of 3μm and a particle distribution between 0.1 mm and 15 mm, with a filler percentage of 70 vol% (86 wt%). The higher bond strength also might be related to its bond agent SE2, a two-step, self-etch, light-cure bonding agent. Due to the presence of 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), SE2 might improve the

resin degree of conversion (DC), produce high quality of the hybrid layer and acid-base resistant zone at the resin-dentin interface.

PL, when bonded with Panavia V5 tooth primer, also showed comparable high μTBS to AP ($p < 0.05$) both after 24 hours and 6 months of water storage. Panavia V5 tooth primer can seal the tooth-adhesive interface securely as soon as paste is applied. Its unique touch and cure technology can initiate the polymerization at the adhesive interface without light curing and establish a strong bond to enamel and dentin. The considerably higher μTBS may also be attributed to its component. According to the manufacturer, the total amount of inorganic filler is approximately, 47 vol% (66 wt%) and the particle size of inorganic fillers ranges from 0.05 μm to 8 μm. At the same time, newly developed spherical silica fillers used in PL may further enhance the translucent structure of light-cured resin cement, leading to improved polymerization kinetics and better bond strength, KHN, and cohesive strength.

In this study, the μTBS of the PV group is significantly lower than AP and PL after 24 hours. However, after 6 months of water storage, it significantly increased, which was comparable to PL and AP. As a dual-cured resin cement, PV contains chemical initiators that continue the polymerization reaction to compensate for incomplete light curing. Consequently, PV will provide a better bond effect when the restorations are of poor translucency, greater thickness, or darker shade which will impede light curing. The KHN of PV is relatively lower than other materials. Although KHN can reflect the degree of conversion (DC) of resin materials, the cross-linking density in the polymer matrix, the chemical composition, amount of fillers, and matrix composition can also affect it.

Whether after 24 hours or 6 months of water storage, the μTBS of VE is significantly tthe lowest. According to the manufacturer, the total volume of inorganic fillers is approximatly 38 vol % and the mean particle size is 0.1 μm. The other possible reason may be the universal adhesive. It was argued that universal adhesives mix together components that previously belonged to multiple bottles and do not significantly improve adhesive performance.

Within the limitations of this in vitro study of resin cement, it can be concluded that: (i) When bonded between dentin and CAD/CAM resin block, PL, PV and AP showed better bond strength and good durability. (ii) The KHN and cohesive strength of all resin materials showed significant differences. However, all of them have good durability. (iii) PL exhibited good bonding performance and durability, which might be attributed to its specific translucency structure. Further studies would focus on color stability, water sorption, and degree of conversion to verify this research results.