Introduction

Dental sealing has been introduced in dentistry in the middle of 60’s in order to reduce caries incidence on irregular dental surfaces. The term “dental sealants” indicates all materials (low and medium viscosity resins, GICs and compomers) placed in occlusal pits and fissures to create a protective barrier against cariogenic bacteria and their metabolites.

At present, the most used sealants are photoactivated resins. They need adequate light intensity and a sufficient irradiation time to reach an optimal degree of conversion.

Polymerisation continues after the restoration procedure is completed and the percentage of reacted double bonds does not exceed the 73.8% using the conventional halogen curing units [Amaral et al., 1990; Tarle et al., 1998]. Incomplete curing may lead to releasing of residual monomers in the oral cavity and biological fluids, with a peak in the first 24 hours [Ferracane et al., 1990; Nalcaci et al., 2006]; after one week photocured composites reach their maximum hardness [Watt et al., 1987]. Johnston et al. [1985] and Pilo & Cardash [1992] observed that microhardness values increase rapidly during the first hour after photoactivation and then gradually in the following 24 hours. Several studies demonstrated a significant correlation between microhardness of the surface opposite to light exposure and light intensity [Shortall & Harrington, 1996; Baharav et al., 1998], while other studies [Rueggeberg & Jordan, 1993; Strang et al., 1986] showed that the depth of cure limit (usually considered 2 mm) is strongly correlated with light intensity and time of exposure. Moreover, Kim et al. [2002] demonstrated that long curing exposures significantly increase the microhardness of dental sealants.

Comparative evaluation of the microhardness of 4 dental sealants

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ABSTRACT. Aim Aim of this study was the evaluation of the microhardness of 4 dental sealants polymerised with two different curing units. Methods Twenty samples (5x5x2 mm) were prepared with 4 different sealants; 10 samples for each group were polymerised with a plasma curing unit (Apollo 95 E DMD) and 10 with a halogen curing light (Heliodur DLX Vivadent ETS, Schaan, Liechtenstein). For each section 6 Vickers microhardness measurements were performed (VMHT 30A, Leica Wien, Austria), 3 on the surface exposed to the light and 3 on the opposite surface. After the baseline assessment all samples were stored in artificial saliva at 37°C for 30, 60, 90, 180 and 360 days, and then analysed again with the microhardness indenter and observed under stereomicroscope 10X (Leica DM2500 Wien, Austria). Data were then statistically analysed. Results The hybrid composite Tetric flow (group IV) showed the higher microhardness values compared to the other tested materials (group I, II, III); surfaces exposed to curing light showed higher microhardness values than opposite surfaces. Moreover, a significant microhardness reduction was observed after 30 days; values remained unmodified after 60, 90, 180 and 360 days. Statistics Data were then statistically analysed with Anova test for repeated measures, with a global significance level of 0.05. Conclusion Because of the good mechanical properties of dental sealants they represent the first choice materials in pits and fissures sealing.

KEYWORDS: Dental sealants, Compomers, Vickers microhardness, Light-curing.
On the contrary, incomplete resin polymerisation seems responsible for an increase in water sorption and a softening of the organic matrix of unreacted monomers, thus reducing the mechanical properties of the material (microhardness and wear resistance).

In the last ten years plasma arc curing units have been introduced in dentistry. They develop an extremely high intensity, able to reduce exposure times and increase the depth of penetration of the curing light. These units have output of intensity up to 2400 mW/cm², compared to 600 mW/cm² of conventional curing units. Nevertheless, it has been hypothesised that after exposure to light with high intensity the reaction is too rapid and leads to the formation of short polymeric chains, with poor physical and mechanical properties [Sharkey et al., 2001; Labella et al., 1999]. Moreover it has been postulated that with this curing method the stress caused by polymerisation contraction and transmitted to the adhesive interface is very high. Furthermore, there is a risk of pulp heating due to high temperatures produced by the curing unit [Hannig & Bott, 1999; Loney & Price, 2001].

Microhardness has been shown to be a simple and reliable indicator of double bond conversion and it is used as an indirect measurement of the extent of polymerisation [Ferracane et al., 1985; Yap et al., 2002].

As microhardness values are comparable only within the same resin material [Tantbirojn et al., 2003; Toledano et al., 2005] because they are not linearly correlated to the degree of cure if compared across different materials, the results obtained in this study were useful in comparing the polymerisation achieved at different depths and with different curing units by each sealant.

Aim of this study was the evaluation of the microhardness of 4 dental sealants light cured with two different units. The null hypothesis tested was that there is no difference between the materials using different curing outputs.

**Materials and methods**

Four light curing dental sealants were selected:
- group I Concise, 3M Espe;
- group II Helioseal F, Vivadent;
- group III Dyract Seal, Dentsply;
- group IV Tetric Flow, Vivadent.

Using a 5x5x2 mm matrix, 20 samples for each material were prepared, 10 polymerised with a plasma arc curing unit (Apollo 95 E DMD, 1320 mW/cm² for 9 sec) and 10 with a halogen curing unit (Heliolux DLX Vivadent ETS, Schaan, Liechtenstein, 500-700 mW/cm² for 20 sec). For each section 6 Vickers microhardness measurements were performed (VMHT 30A, Leica Wien, Austria), 3 on the surface exposed to the light (surface A) and 3 on the opposite surface (surface B). After baseline assessment all samples were stored in artificial saliva at 37°C. After 30, 60, 90, 180 and 360 days they were retested with the microhardness indenter and observed under steromicroscope 10X (Leica DM2500 Wien, Austria). Data were then statistically analysed by Anova test for repeated measures, with a global significance level of 0.05.

**Results**

Vickers microhardness mean values (indirect measure of the degree of conversion) of sealants are reported in figures 1 and 2 for samples light cured with the halogen unit and in figures 3 and 4 for the plasma cured samples.

Statistical analysis demonstrated that all surfaces exposed to the light (surface A) had higher microhardness values in comparison with the opposite surfaces (p<0.001) (surface B).

Tetric Flow samples (group IV) light cured with the plasma light showed higher microhardness values on the surfaces exposed to the curing unit than those cured with the halogen lamp (p<0.001). On the other hand the halogen light determined increased microhardness values on opposite surfaces using Dyract Seal (group III, p<0.001). Helioseal F and Dyract Seal (groups II and III) light cured with the halogen unit showed a higher microhardness degree in the follow-up measurements than those prepared with the plasma light (p<0.001). The hybrid composite Tetric Flow (group IV) showed higher microhardness values than the other materials (groups I, II, III, p<0.001). Thirty days of storage in artificial saliva lead to a significant reduction in microhardness for all materials (p<0.001) which remained unmodified at the following measurements (60, 90, 180 and 360 days).

**Discussion**

The results of this study, as expected, confirmed that surfaces directly exposed to both curing lights have significantly higher microhardness values in comparison with opposite surfaces. Different microhardness values of the same material polymerised with different curing units may be ascribed to the characteristics of the photoactivator, in particular its susceptibility to the wave length of the curing units tested.
The hybrid composite Tetric Flow (group IV) showed higher microhardness values than the other materials (groups I, II, III). This result is correlated to the filler amount of this material (64.6% in weight, and 39.7% in volume). Filler particles (usually glass and silica dioxide) are added to the organic matrix to improve the mechanical properties of the material. It has been demonstrated that filled sealants have increased microhardness values and wear resistance compared to conventional unfilled sealants. Nevertheless, the filler presence increases the material viscosity, reducing the mobility of monomers in the organic matrix, slowing down the development of polymeric chains [Labella et al., 1999] and leading to a more difficult penetration of the sealant into pits and fissures. Moreover, these particles represent an obstacle to the speed and depth of penetration of the curing light [Baharav et al., 1998]. Some authors (Strang et al., 1986) demonstrated that the 50% of the light intensity that reaches the composite is lost at 0.5 mm of depth, while at 2 mm only the 9% of the original light intensity is available. According to previous studies [Nalcaci et al., 2006] the microhardness reduction observed over time might be explained with the water sorption in the sealant; this may lead to a softening of the organic matrix and the release of unreacted monomers, which reduces the mechanical properties of the material. During the water storage period the elution of unreacted monomers and the water sorption happen...
simultaneously [Ferracane et al., 1990]. Several studies demonstrated that long-term (30-120 days) storage in distilled water, artificial saliva or 0.9% sodium chloride followed by thermocycling significantly reduces microhardness, wear resistance [Ferracane et al., 1995, Kim et al., 2002] and bond strength to enamel surface of resins.

The mechanical properties of the dental materials are often influenced by the adverse environment of the oral cavity that can invalidate the aims for which these materials are used. Choosing a high flow dental sealant with an optimal adhesion to the enamel and with good mechanical properties means reducing the onset of decay in occlusal pits and fissures.

Conclusions
Further studies are necessary to evaluate the long-term effects (24-48 months) of water storage on mechanical properties of sealants. Moreover, a standardised protocol to simulate oral conditions would be useful to correlate the results of in vitro studies with the clinical behaviour of materials tested.

References
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