POLYMERIZATION SHRINKAGE OF ORMOCER BASED DENTAL RESTORATIVE COMPOSITES

M. Cattani-Lorente, S. Bouillaguet, Ch. Godin, and J.M. Meyer

Dental School, University of Geneva

INTRODUCTION: Resin based dental restorative materials shrink during their setting reaction, which is a radical polymerization. Stresses exercised on the cavity walls during polymerization result in either postoperative sensibility or gap formation at the resin-tooth interface with subsequent bacterial infiltration and secondary caries [1, 2]. Hence, the reduction of the polymerization shrinkage is an actual challenge in the dental restorative field.

New monomers with low volumetric shrinkage have been prepared recently. Multi-methacrylates and highly branched methacrylates were respectively prepared by Culbertson *et al*. [3] and Klee *et al*. [4]. Wolter and Storch [5] proposed the use of ormocers (organic modified ceramics). Ormocers can be depicted as macromonomers with an inorganic silica core grafted with multifunctional methacrylate groups [(poly)alkoxysiloxanes].

The aim of the present study is to measure the polymerization shrinkage of two ormocers and to compare it to the shrinkage of a hybrid and four condensable dental composites. The hypothesis tested is that the use of ormocers effectively reduce the shrinkage of dental restorative materials.

METHODS: Two commercially available ormocers (Admira from Voco and Definite from Degussa), a hybrid (Z250 from 3M) and four condensable composites (Solitaire from Heraeus, SureFil from DeTrey, Synergy from Coltene and P60 from 3M) have been used.

The device used to measure the free linear polymerization shrinkage has been validated by Watts and Cash [6]. A disk-shaped unset composite specimen (ϕ:7mm; h:2mm) was placed at the center of a brass ring of 16mm diameter and 2mm height between a rigid glass microscope slide and a glass microscope cover-slip of 0.16mm thickness. A LVDT linear transducer (TESA) was placed on the top of the cover-slip and centrally aligned with the specimen. The polymerization was initiated from below by illuminating the specimen through the rigid glass slide. The polymerization device employed was an ELIPAR Trilight (ESPE). One condition of polymerization only was chosen. The specimen was illuminated for 40 sec with a constant power of 800 mW/cm2.

The shrinkage was measured for 300 sec. Five specimens were measured for each material.

Vickers Hardness was measured with a Hauser indentometer. Five indentations were made by the application of a load of 500 gr. The hardness was measured on the surfaces exposed and unexposed to the light during the polymerization of the same specimens used for the shrinkage determination. The hardness profiles were established by measuring the hardness at different depths. For that purpose, the specimens were first embedded in a resin (Technovit) then cut in half and polished.

RESULTS: The mean linear shrinkage values and the filler content with their respective standard deviations are given in Table 1. Mean values marked with the same letter displayed no significant statistical difference using a one way ANOVA followed by a LSD multiple test ($p<0.05$).

Table 1. Linear shrinkage (%) and filler content (%) of the dental composites.

Material	Shrinkage	Filler
Admira	1.6 (0.2) c	0.72 (0.01) b
Definite	1.1 (0.1) b	0.69 (0.01) b
Solitaire	2.6 (0.2) d	0.59 (0.02) a
Surefil	0.8 (0.1) a	0.76 (0.01) c
Synergy	1.8 (0.1) c	0.70 (0.01) b
P60	1.0 (0.04) b	0.79 (0.01) c
Z250	1.1 (0.1) b	0.76 (0.02) c

The Vickers Hardness of the surfaces exposed and unexposed to light are given in the Figure 1.

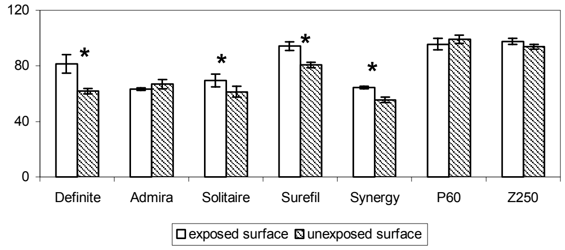

Fig. 1: Vickers hardness [VHN] of exposed and unexposed surfaces.

For each composite, values marked with an asterisk are significantly different.

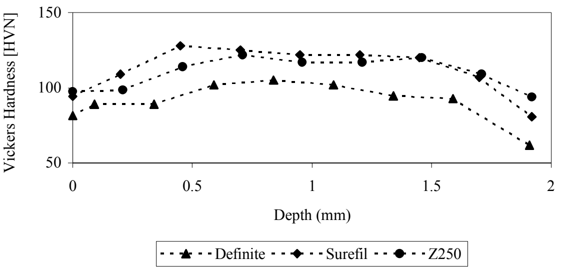

Fig. 2: Vickers hardness [VHN] profiles. On the x ordinate axis, the zero point corresponds to the light exposed surface.

DISCUSSION & CONCLUSIONS:. The shrinkage of dental composites can be related to their resin content, the chemical nature of the resin, the degree of conversion (DC) from monomers to polymers and the conditions used for the polymerization initiation. In the present study, the later was minimized by using the same source of light, illumination time conditions and temperature.

There is a good linear correlation (r=0.99) between the shrinkage of five composites and their filler content (Figure 3). This probably means that for those materials the quantity of resin is the determinant factor influencing the shrinkage. Based on their respective filler content, a higher shrinkage should be expected for Definite and Surefil. The lower values observed may be due to differences in the chemical composition of their resins.

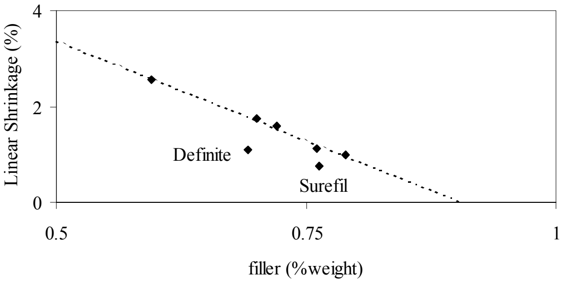

Fig. 3: Correlation between the linear shrinkage and the filler content of the composites.

Surefil is a urethane modified BisGMA resin blended with an irregular shape inorganic filler. These interlocking particles were designed to produce a compact composite with handling characteristics comparable to that of amalgams. It is possible that the interlock of filler particles reduced the shrinkage during polymerization. Provided that the lower shrinkage of Definite is due to the presence of the ormocer, this effect is not observed for Admira, the other ormocer-based composite. There are some differences in the chemical composition of the grafted organic molecules. For instance, functional pending groups of the polysiloxane are methacrylates for Definite. Whereas for Admira there are also carboxylic functions, which do not participate to the radical polymerization. Besides, classical dimethacrylates (Bis-GMA; UDMA; TEGDMA) are present in the two composites to control their viscosity and handling properties. The presence of those monomers can also affect the polymerization shrinkage.

It is often considered that if the hardness of the surfaces exposed and unexposed to light is similar, the polymerization is efficient. In this study four composites presented differences in hardness between exposed and unexposed surfaces. However, at the surface of composites the inhibition layer due to the presence of oxygen lower the hardness, as can be seen in the Figure 2.

Rueggeberg *et al.* [7] showed that the degree of conversion and the volumetric shrinkage of composites are related. The determination of the DC was not done in the present experience. However, based on the fact that there is a good correlation between increasing hardness and increasing degree of conversion [8], we expected a relationship between hardness and shrinkage. However, a multiple regression analysis of the maximum Vickers hardness in function of the filler content and the linear shrinkage showed that the later parameter is not statistically significant at the 90% or higher confidence level. Nevertheless, Surefil presented a high hardness. Hence a high degree of conversion along with a high crosslinking of the polymeric network should be expected for this composite. In the case of Definite the residual double bonds should be quantified to be certain that the lower shrinkage is not due a low degree of conversion.

REFERENCES: [1] AJ De Gee, CL Davidson (1987) *J Dent Res* **66**:1636-1639. [2] A Mehl, R Hickel, KH Kunzelmann (1997) *J Dent* **25**:321-330. [3] BM Culbertson, Q Wan, Y Tong (1997) *J Mater Sci: Pure Appl Chem* **A34**:2405-21. [4] JE Klee, F Neidhart, HJ Flammersheim, R Mülhaupt (1999) *Macromol Chem Phys* **200**:517-523. [5] H Wolter, W Storch (1994) *J Sol-Gel Sci Tech* **2**:93-96. [6] DC Watts, AJ Cash (1991) *Dent Mater* **7**:281-287. [7] F Rueggeberg, K Tamareslvy (1995) *Dent Mater* **11**:265-268. [8] JL Ferracane (1985) *Dent Mater* **1**:11-14