

# LINEAR POLYMERIZATION SHRINKAGE OF NEW RESTORATIVE COMPOSITE RESINS

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**INTRODUCTION:** Resin-based dental restorative materials shrink during their setting reaction. Consequently, contraction stresses build up on the cavity walls. As a result, the marginal integrity at the resin-tooth interface may be compromised and a gap formation with subsequent bacterial infiltration may occur [1, 2]. Hence, polymerization shrinkage is a major drawback of composite resins and its reduction is an actual challenge in the dental restorative field.

In the past years, strategies used to reduce the shrinkage were mainly 1) to increase the volume of the inorganic filler incorporated in the composite, 2) to use different co-monomers such as multi-methacrylate [3], highly branched methacrylates [4, 5] and ormocers [6], 3) to develop new monomers with low volumetric shrinkage [7], 4) to improve the photo-initiator system.

This last strategy has been recently used by Vivadent and Saremco resulting in the commercialization of two new composite resins (InTenS and ELS).

The aims of the present study were 1) to measure the polymerization shrinkage of two new composite resins and to compare it to the shrinkage of currently used dental composites. 2) to measure the mechanical properties of these materials. The hypothesis tested was that the new initiator systems effectively reduce the shrinkage of the composite resins, without compromising their mechanical properties.

**METHODS:** Four restorative composite resins: ELS and Trendy Restore (Saremco, Switzerland), InTenS (Vivadent, France) and Herculite (Kerr, Switzerland) were tested.

The device used to measure the free linear polymerization shrinkage was developed by Watts and Cash [8]. A disk-shaped unset composite specimen ( $\phi$ :8mm; h:2mm) was placed on a rigid glass microscope slide, in the middle of a brass ring holding 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 the bottom of the composite by illuminating the specimen through the rigid glass

slide. A QTH curing unit with an output irradiance of 800 mW/cm<sup>2</sup>, was employed (Elipar Trilight, 3M-ESPE). Specimens were exposed to the light for 60s. The shrinkage data were registered during 30 min with a data acquisition device (Hydra, Fluke). There were five replicates for each material.

The flexural strength and the flexural elastic modulus were determined using a three-point bending test. Rectangular samples of 25x2x2 mm were prepared in Plexiglas molds. The samples were illuminated for 60s on each side with the QHT curing unit. Half of the specimens were light-cured and post-cured for 75s in a laboratory polymerization device (MPa 2000, Columbus) outfitted with a halogen bulb of 400W. All samples were stored at 37°C in water for 24h and tested with an universal testing machine (Instron 1114) at a crosshead speed of 0.5 mm/min.

The filler content of the composites was measured by calcination at 600°C for 3 hours.

The data were compared with a one way analysis of variance followed by a Tukey HSD multiple range test ( $p < 0.05$ ). A t-test was also used to compare the mechanical properties of the composites cured with the two different devices.

**RESULTS:** Mean linear shrinkage values and filler content for each material are given in Table 1.

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

Material	Shrinkage	Filler
ELS	1.64 (0.02) a	72.6 (0.1) b
InTenS	1.61 (0.02) a	66.9 (0.4) a
Herculite	2.11 (0.08) b	72.2 (0.6) b
Trendy Restore	1.54 (0.04) a	77.7 (0.3) c

*Mean values marked with the same letter displayed no significant statistical differences*

There were no significant differences between the linear shrinkage of Trendy Restore, ELS and InTenS. However, these three composites showed significant differences in their filler content.

The flexural strength and the flexural elastic modulus of the composites polymerized with the

QHT unit and the laboratory device are given in Tables 2 and 3 respectively.

*Table 2. Flexural strength (MPa) of the resin composites cured with the Elipar Trilight and MPA 2000 curing devices.*

Material	Elipar Trilight	MPA 2000
ELS	93 (20) a,b	132 (42) b
InTenS	95 (9) a,b	83 (11) a
Herculite	78 (10) a	90 (10) a,b
Trendy Restore	106 (6) b	104 (18) a,b

*Mean values marked with the same letter displayed no significant statistical differences*

*Table 3. Flexural elastic modulus (GPa) of the resin composites cured with the Elipar Trilight and MPA 2000 curing devices.*

Material	Elipar Trilight	MPA 2000
ELS	5.5 (1.8) a	11.5 (4.4) b,c
InTenS	6.3 (0.6) a	6.8 (1.0) a
Herculite	7.1 (1.2) a	8.1 (1.0) a,b
Trendy Restore	14.3 (0.9) b	13.9 (1.1) b,c

*Mean values marked with the same letter displayed no significant statistical differences*

For the post-cured specimens, an increase in the flexural strength and the flexural elastic modulus were observed. This increase was statistically significant only for ELS.

### DISCUSSION & CONCLUSIONS:

Previous research has shown an inverse linear relationship between the composite filler content and the shrinkage [9]. Trendy Restore showed the lowest linear shrinkage, which was expected as this composite resin had also the highest filler content. Herculite and ELS had the same filler content, but ELS displayed a lower linear shrinkage than Herculite. InTenS did not show the highest shrinkage value as expected from its filler content. These observations probably indicate that modifications in the initiator system effectively reduced the polymerization shrinkage of ELS and InTenS.

Differences in the monomer to polymer conversion ratio can also account for the observed discrepancy. The degree of conversion was not determined in the present study, as it required a sophisticated equipment. Instead the mechanical properties were measured, because a strong dependence between the extent of curing and the flexural strength or the

elastic modulus has been previously established [10]. Moreover, a laboratory curing device with a powerful halogen bulb was used to enhance the cure of the composites. For InTenS, Herculite and Trendy Restore, no statistically significant differences in the mechanical properties were observed between specimens cured with the QHT unit and specimens post-cured. Hence, it can be assumed that the degree of curing of these resin composites was equivalent, whatever the polymerization device used. This is not probably the case for ELS, as better mechanical properties were obtained with the laboratory curing device. Consequently, it can be assumed that the reduction in the polymerization shrinkage for ELS is due to a lower monomer to polymer conversion ratio.

In conclusion, modifications of the initiator system can efficiently help to reduce the polymerization shrinkage. The mechanical properties obtained for the ELS and InTenS are superior to those required for posterior restorative materials. The slightly lower elastic modulus of ELS may represent an additional advantage, as some flow of the composite during the polymerization may result in lower contraction stresses at the restoration interface.

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