

# LIGHT DIFFUSION THROUGH COMPOSITE RESTORATIONS ADDED WITH SPHERICAL GLASS MEGA FILLERS

M. ANDREASI BASSI<sup>1</sup>, S. ANDREASI BASSI<sup>1</sup>, C. ANDRISANI<sup>2</sup>, S. LICO<sup>3</sup>, L. BAGGI<sup>4</sup>, D. LAURITANO<sup>5</sup>

<sup>1</sup> Private practice in Rome, Italy

<sup>2</sup> Private practice in Matera, Italy

<sup>3</sup> Private practice in Olevano Romano (RM), Italy

<sup>4</sup> Department of Clinical Sciences and Translational Medicine, University of Tor Vergata, Rome, Italy

<sup>5</sup> Department of Medicine and Surgery, University of Milan-Bicocca, Milan, Italy

## SUMMARY

**Purpose.** Evaluate how the spherical glass mega fillers (SGMFs) can positively interfere with light diffusion when incorporated in a composite restoration.

**Materials and methods.** 30 samples (Ss) were performed, applying 2 composite layers of 3 mm each: 6 were made with composite only; 6 with a layer of SGMFs of Ø1.5mm within the first layer of composite; 6 with 2 overlapping layers of SGMFs of Ø1.5mm; 6 with a layer of SGMFs of Ø2mm; 6 with 2 overlapping layers of SGMFs of Ø2mm. The curing time was set at 40s for the first layer, and 120s for the second layer, transilluminated through the first layer. Digital pictures were taken, in standardized settings, during the transillumination, and the light intensity was measured with a digital image analysis software.

**Results.** From a lateral view the Ss with a single layer of SGMFs of Ø1.5mm and Ø2mm, the relative increments of light intensity, were of 24.37% and 33.33% respectively. Concerning the Ss made with 2 layers of SGMFs, the relative increments were of 67.99% and 66.4% respectively. In front view has emerged a relative increase rate of light intensity of 53.66% and 79.58%, in the Ss with a single layer of SGMFs of Ø1.5mm and of Ø2mm respectively. Furthermore, in the Ss with two layers of SGMFs of Ø1.5mm and Ø2mm the relative increments were of 267.53 and 319.63% respectively.

**Conclusion.** The SGMFs are reliable in facilitating light diffusion within the light-curing composite resins.

**Key words:** composite fillers, spherical glass mega fillers, polymerization shrinkage, composite shrinkage, photo-polymerization, curing light, depth of cure.

## Introduction

The increasing use of composite restorative materials in direct and indirect dental restoration, when affected by caries or traumatic pathologies, is drawing attention to some problematic related to the use of such materials, including the resistance to wear, the polymerization shrinkage, and the curing light penetration through the composite (1-3).

The research in this field is directed towards the pro-

duction of composite materials that, while ensuring high aesthetics, have both a clinical reliability and good mechanical properties, making these restorations suitable also in areas subjected to masticatory stress. To achieve this purpose, different inorganic fillers have been added to the composite materials, mostly based on glass or ceramic particles. Incorporation of these inorganic particles imparts several advantages: improved strength and wear properties; decreased linear coefficient of thermal expansion; reduced polymerization shrinkage. In addition, due to their transparency, these fillers facilitate the diffusion of the cur-

ing light through the composite material (3, 4).

Curing depth is considered a primary factor for clinical success of composite resin restorations, since it directly affects the physical properties of materials and longevity of restorations (5). Several variables may affect the light-curing effectiveness of composite resin materials, some of these are material-related (i.e.: resin shade; amount of photoinitiators; organic and inorganic matrix), others are operator-related (i.e.: the distance and orientation of light beams; restorative techniques) and others are even light-curing units-related (i.e.: the emission spectrum; light intensity; period of exposure; general status of the equipment) (5-10).

Energy of the light emitted from a light-curing unit decreases drastically when transmitted through resin composite, leading to a gradual decrease in degree of conversion of the resin composite material at increasing distance from the irradiated surface (5-7).

Decreases in degree of conversion compromise physical properties and increase elution of monomer and thus may lead to premature failure of a restoration or may negatively affect the pulp tissue (5, 10). When restoring cavities, with light-curing resin composites, the gold standard procedure recommend to apply and cure the resin composite in increments of limited thickness. The maximal thickness, for the single increment, has been generally defined as 2 mm (5-7). However, restoring cavities, especially deep ones, with resin composite increments of 2 mm thickness is time-consuming and implies a risk of incorporating air bubbles or contaminations between the increments. Thus, various manufacturers have recently introduced new types of resin composites, so-called "bulk fill" materials that are claimed to be curable to a maximal increment thickness of 4 mm (4, 5, 11). The use of Bulk-fill, besides the practical advantages, is also aimed to enable the bulk polymerization, since the latter seems to develop less shrinkage stress, in comparison to the incremental technique (12, 13). However, despite the use these latter materials, the problem to reach an adequate polymerization, in direct composite restorations, is still present and able to influence their ultimate success and longevity (5, 14). This issue depends not only on the irradiance of the curing light and irradiation time but also on the distance of the light tip from the tooth-restorative material (5, 15,

16). Because the light intensity diminishes as the tip of the source light moves away from the resin composite's surface, the light-curing tip unit should be in direct contact with the restoration's surface. However, sometimes cavity design does not allow the polymerization within this distance (5, 17).

In previous studies the use of spherical glass mega fillers (SGMFs) was proposed in order to reduce the shrinkage of composite resin in direct restorations (18-23). By means of both clinical evidences and *in vitro* experiments it has been possible to observe that SGMFs enabled the bulk polymerization, of the composite, in particular in the deep proximal boxes of Black class II cavities.

The aim of this article is to investigate the capacity of SGMFs, in increasing the depth of polymerization of photocurable composite resins.

## Materials and methods

### SGMFs preparation

Soda lime glass balls (SLGBs) (Rgpballs, Cinisello Balsamo - MI, Italy) of different diameter (i.e. 1.5, and 2mm) were selected for this study. The SDGBs were previously acid etched with a 40% Hydrofluoric acid (Suprapur®, Merk Millipore, Darmstadt, Germany) for 20 sec and then washed with deionized water for 3 min, followed by acetone (Emplura®, Merk Millipore, Darmstadt, Germany) for further 3 min prior to be dried in a preheated thermostatic oven (SCN 58 DG; Enrico Bruno, Torino, Italy) (100°C) for 10min. The SLGBs were then silanized with a mixture of silane methacrylate, phosphoric acid methacrylate and sulphide methacrylate in etanol solution (Monobond Plus, Vivadent, Schaan/Liechtenstein) for 60 sec. The silanated SDGBs were dried, in the above-mentioned preheated thermostatic oven, at 80°C for 10 minutes, then left at room temperature for 1h prior to be covered with a photocurable mixture of Bis-GMA (60%wt.) and triethylene glycol dimethacrylate (40%wt.) (Heliobond, Vivadent, Schaan/ Liechtenstein). Two groups, of approximately 300 units each, of SGMFs, were thus prepared.

## Calibration method

An halogen curing unit (Blue light Pro, Mectron, Carasco - GE, Italy) was used for the test. Its light intensity was measured by means of a digital radiometer (Cure Rite Efes, model 8000, Efes Inc., Mississauga, Ontario, Canada). After 10 min of use, 6 consecutive measurements were made. The mean value of the light intensity was  $307 \pm 30,81 \text{ mW/cm}^2$ . The measurement was performed by placing the free end of tip on the sensor of the radiometer (Figure 1b).

Digital color pictures of the tip of the functioning curing lamp were taken, in complete darkness conditions, with a 1:1 ratio, by means of a full-frame digital camera (Alpha 7S, Sony, Tokyo, Japan) equipped with a macro objective (SP AF 90mm – f/2.8 Macro 1:1, Tamron, Saitama, Japan). During the procedure the camera sensor was orthogonal to the main axis of the PVC cylinder.

The digital color pictures were then converted to grayscale (8-bit) to calibrate the digital image analysis software (Image Pro Plus 4.1, Media Cybernetics, US), using Windows OS. Knowing the intensity value of the light, it was possible to assign, to each one of the 256 gray tones, an accurate value of light intensity expressed in  $\text{mW/cm}^2$ . To black (tone 0) it was given the intensity value of  $0 \text{ mW/cm}^2$ , while to the white color (tone 255) it was assigned the value of  $307 \text{ mW/cm}^2$ .

The images were studied using as reference a line having the thickness of a pixel. In correspondence with this line the software attributed to the gray tone of each pixel, on the basis of the calibration, a light intensity value in  $\text{mW/cm}^2$  (Figure 1c).

The scale of 256 shades of gray was also converted to a scale of pseudo-color, corresponding to the 256 luminous intensity values detected. Furthermore, 3D images were developed, and at each point of the analyzed section, the light intensity was converted in a height value on a third axis (Figure 1d).

The light emission at the lamp tip level was measured to be seen homogeneous during all tests. Thus the radiometer has been taking measurement characterized by a particularly low standard deviation value.

## Samples preparation

A black PVC cylinder was used, one end had an inner diameter of 0.8 cm, equivalent to the diameter of the tip of the lamp, and the other end an inner diameter of 0.74 cm. This latter portion had a height of 0.67 cm.

The PVC black cylinder was inserted, with its large end, on the tip of the curing unit, and used as mold (Figure 1a). With a microhybrid composite resin material (Esthetic shade A2 Vita®, Surgi, Lainate – Mi, Italy) 30 cylindrical composite samples were performed, applying 2 composite layers of 3 mm each. Regarding the production method they were divided in 5 groups, of 6 each, as follow:

- Group 1: samples made with composite only;
- Group 2: samples with a layer of SGMFs of  $\varnothing 2 \text{ mm}$ , within the first layer of composite;
- Group 3: samples with 2 overlapping layers of SGMFs of  $\varnothing 2 \text{ mm}$ , each within a layer of composite;
- Group 4: samples with a layer of SGMFs of  $\varnothing 1.5 \text{ mm}$ , within the first layer of composite;
- Group 5: samples with 2 overlapping layers of SGMFs of  $\varnothing 1.5 \text{ mm}$ , each within a layer of composite.

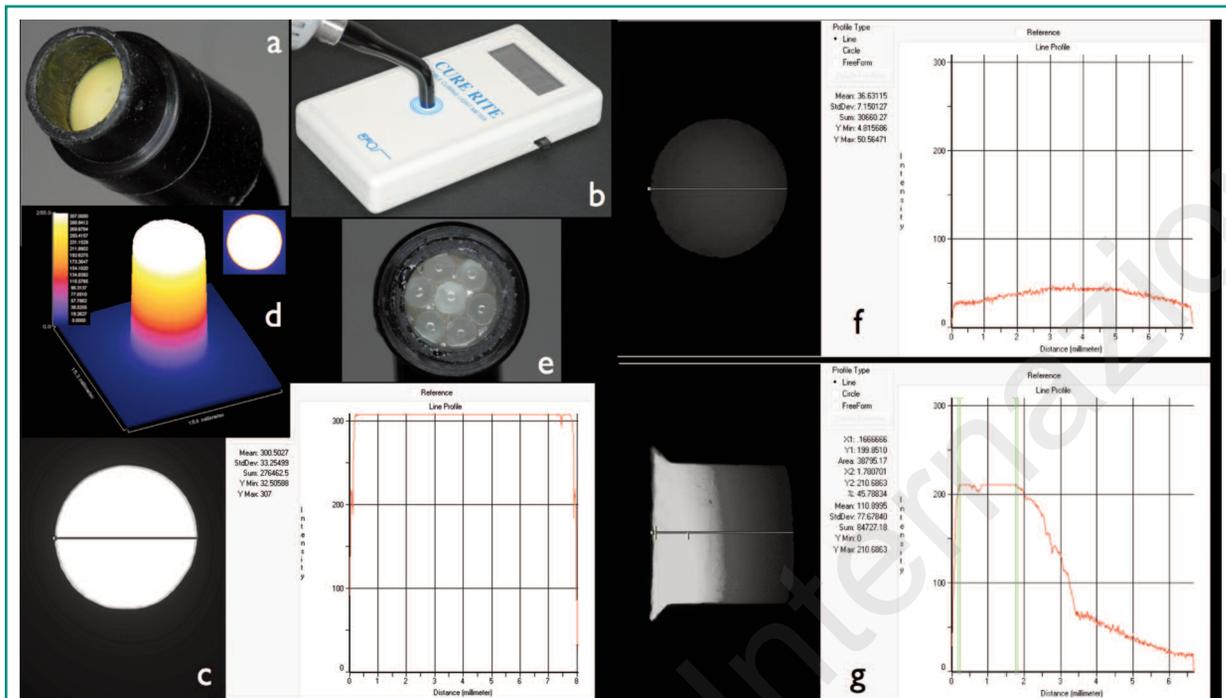
The curing time, for the first layer, was set at 40s, while the second composite layer was light cured for 120s, by means of transillumination through the first layer.

Each composite layer, added with SGMFs, contained the same number of spheres: 7 when spheres of  $\varnothing 2 \text{ mm}$  were used (Figure 1e), and 16 when spheres of  $\varnothing 1.5 \text{ mm}$  were used; thus the total volume occupied by the SGMFs for each layer was comparable and respectively  $29,4 \text{ mm}^3$  e  $28,8 \text{ mm}^3$ . Both the layers of composite only and composite layers added with SGMFs, prior to the photopolymerization, were condensed by means a stainless steel cylinder, with a diameter of 6,5 mm, specifically made for the purpose.

Authors have chosen not to use SGMFs of  $\varnothing 1 \text{ mm}$ , because it would have been hardly repeatable and reproducible to make samples with 56 spheres each.

The samples were made and held in position, for all the procedure, on top of the free surface of the lamp tip, by means of the PVC black cylinder.

At the end of the process, for each sample during transillumination, a picture from a frontal view, was taken, then, removing the PVC black cylinder, another



**Figure 1**  
**a)** The PVC black cylinder, used as a mold for the samples, connected with the tip of the curing unit; **b)** the radiometer used in our experiences; **c)** once recorded the light intensity of the curing unit the calibration of the software was performed; **d)** 3D images were developed converting the light intensity in a height value on a third axis; **e)** the spherical glass mega fillers (SGMFs) of Ø2 mm were placed on the composite layer prior to be condensed; **f, g)** the analysis of a sample made of composite only, in frontal view (f) and lateral view (g).

picture was taken from a lateral view. Then the pictures were analyzed by means of the image analysis software. The both the instruments and the settings were the same of those above described for the calibration method.

Each sample, still connected with the tip of the curing unit, prior to remove the PVC black cylinder, was applied, with its free surface, on the sensor of the radiometer and then transilluminated in order to measure the light intensity.

## Results

### Group 1

The analysis of the transilluminated samples from a frontal view shows that the maximum values of light intensity are recorded in the central portions of the sam-

ple (mean value [MV]  $50.56 \pm 4.32$  mW/cm<sup>2</sup>) (Figure 1f). Given the high thickness of the samples (6.7 mm) it is understandable that in these conditions the diffusion by the light is strongly hampered. Observing the samples on their lateral surface, always under transillumination, it's evident that the light intensity remains constant for  $1.7 \pm 0.2$  mm, reaching in these conditions its maximum value (MV  $210.6 \pm 17.8$  mW/cm<sup>2</sup>). Subsequently the intensity rapidly decreases (MV  $60.3 \pm 4.8$  mW/cm<sup>2</sup>) in a space of  $1.5 \pm 0.1$  mm, then a further minor decrease is observed (MV  $22.5 \pm 1.9$  mW/cm<sup>2</sup>) at the distal limit of the sample (Figure 1g). The average values were, for the frontal view  $38.2 \pm 3.1$  mW/cm<sup>2</sup>, while for the lateral view  $112.8 \pm 10.1$  mW/cm<sup>2</sup>.

With regard to the measurements made by the radiometer, these have shown a particularly low value (MV  $1.33 \pm 0.52$  mW/cm<sup>2</sup>) probably due to both a filter effect exerted by the samples and the modification of the length wave of light when passing through the same samples.

## Group 2

The frontal view analysis of the transilluminated samples, made with a layer of spheres of  $\varnothing 2$  mm, highlights that the maximum luminous intensity (MV  $84.27 \pm 6.9 \text{ mW/cm}^2$ ) is reached always in the central area of the sample (Figure 2a).

The analysis of the samples, from a side view, shows that the maximum luminous intensity in this group of specimens is superior to that obtained in those made of only composite (MV  $211.89 \pm 17.8 \text{ mW/cm}^2$ ). The intensity is maintained constant for a mean thickness of  $3 \pm 0.2 \text{ mm}$ , after which, in the following  $1.9 \pm 0.2 \text{ mm}$ , rapidly decreases (MV  $53.5 \pm 5.1 \text{ mW/cm}^2$ ), then a further minor decrease is observed, until the distal limit of the sample (MV  $42.32 \pm 3.7 \text{ mW/cm}^2$ ) (Figure 2b). The average values were, for the frontal view  $68.6 \pm 5.8 \text{ mW/cm}^2$ , while for the lateral view  $150.4 \pm 12.6 \text{ mW/cm}^2$ .

Even in this case the intensity values, detected by the radiometer, are very low (MV  $1.66 \pm 0.75 \text{ mW/cm}^2$ ).

## Group 3

The analysis from the frontal view, of the transilluminated samples, made with 2 layer of spheres of  $\varnothing 2 \text{ mm}$ , shows that the maximum values of light intensity are recorded close to the central portions of the sample (MV  $205.87 \pm 12.6 \text{ mW/cm}^2$ ), even if with a slightly less homogeneous distribution in comparison to the samples of the other previous groups (Figure 2c).

From a lateral view the samples shows that the light intensity reaches the maximum value (MV  $276.9 \pm 24.8 \text{ mW/cm}^2$ ) at a mean distance of  $1.9 \pm 0.2 \text{ mm}$  from the light source. At the mean distance of  $3.4 \pm 0.3 \text{ mm}$ , from the tip of the lamp, the light intensity is still relatively high (MV  $208.13 \pm 15.5 \text{ mW/cm}^2$ ), then progressively decreases, until reaching a MV of  $53.5 \pm 3.9 \text{ mW/cm}^2$  close to the distal end of the sample (Figure 2d). The average values were, for the frontal view  $160.3 \pm 13.3 \text{ mW/cm}^2$ , while for the lateral view  $187.7 \pm 13.7 \text{ mW/cm}^2$ .

The radiometer recorded very low values of light intensity, not in agreement with those highlighted by the analysis of the images (MV  $1.83 \pm 0.37 \text{ mW/cm}^2$ ).

## Group 4

From a frontal view the analysis of this group of samples, made with a layer of spheres of  $\varnothing 1.5$  mm, shows that the maximum intensity of the light is always found in the central portion of the sample (MV  $69.82 \pm 4.6 \text{ mW/cm}^2$ ) (Figure 3a). This value is higher than the ones detected in the samples with only composite, but, as expected, is lower than the value resulting from the analysis on the samples made with a layer of spheres of  $\varnothing 2$  mm.

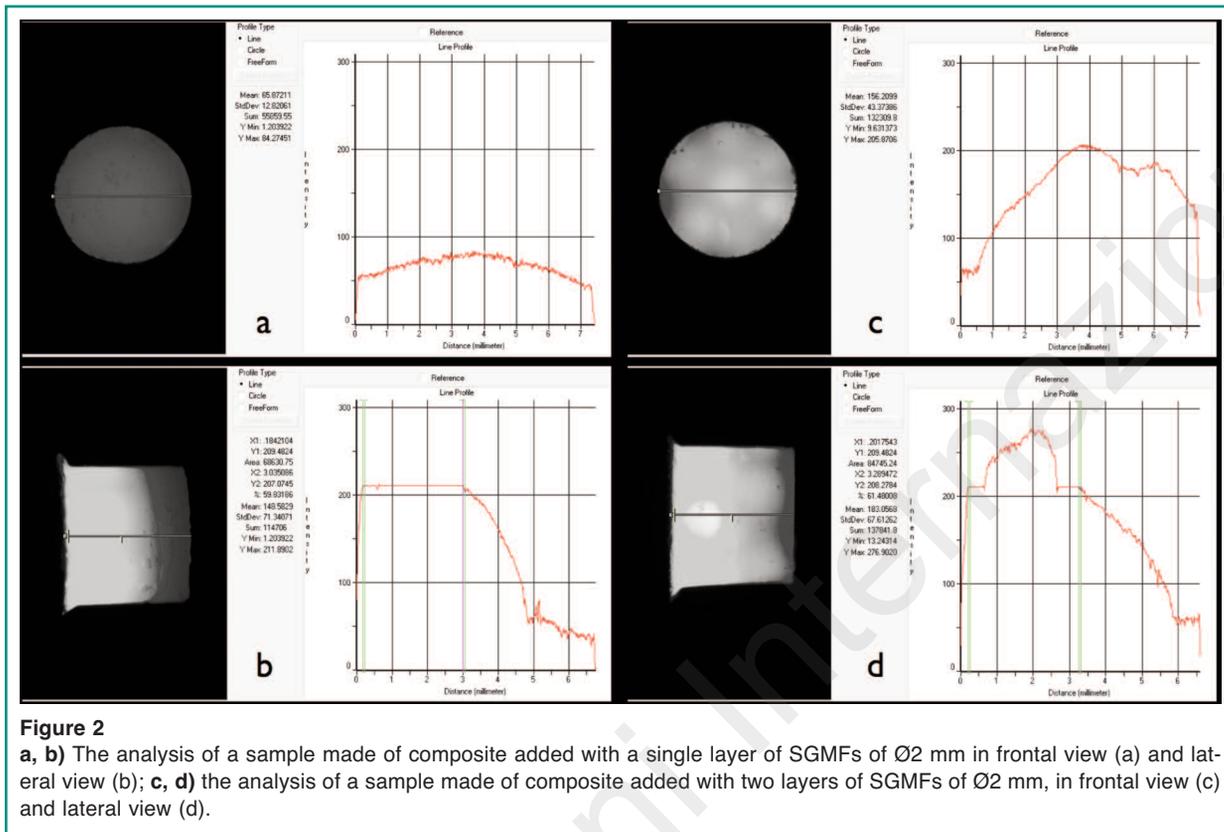
The examination of the side images highlights that for the first  $2.7 \pm 0.2$  mm of the sample the light intensity is maintained constant (MV  $211.9 \pm 19.7 \text{ mW/cm}^2$ ), then a sharp decrease, in light intensity, is observed at a mean distance of  $4.5 \pm 0.3$  mm (MV  $58.14 \pm 5.5 \text{ mW/cm}^2$ ), while, at the distal end of the sample, the intensity of residual light reached a MV of  $34.65 \pm 2.8 \text{ mW/cm}^2$  (Figure 3b). The average values were, for the frontal view  $58.7 \pm 4.5 \text{ mW/cm}^2$ , while for the lateral view  $140.3 \pm 9.8 \text{ mW/cm}^2$ .

The intensity detected by the radiometer are, also in this case, very low (MV  $1.5 \pm 0.5 \text{ mW/cm}^2$ ).

## Group 5

From a frontal view, the analysis of this group of samples, made with 2 layers of spheres of  $\varnothing 1.5 \text{ mm}$ , shows that the maximum intensity is close to the central portion of the sample (MV  $210.68 \pm 28.9 \text{ mW/cm}^2$ ) (Figure 3c). The samples express a pattern of the light intensity curve quite irregular, thus not constantly decreasing from the center towards the periphery of the sample circumference.

The analysis of the images shows, in a lateral representation of some samples, a luminous intensity peak (MV  $261.25 \pm 25.8 \text{ mW/cm}^2$ ), likely due to the very peripheral position of some spheres. This phenomenon was also observed in some samples pertaining to Group 3 (Figure 3d). Yet, along the first  $3.3 \pm 0.3 \text{ mm}$  of the sample the light intensity is maintained constant (MV  $210.46 \pm 25.8 \text{ mW/cm}^2$ ) then begins to decrease up to the distal portion of the sample (MV  $65.11 \pm 5.8 \text{ mW/cm}^2$ ). The average values were, for the frontal view  $140.4 \pm 28.3 \text{ mW/cm}^2$ , while for the lateral



view  $189.5 \pm 37.3 \text{ mW/cm}^2$ .

The intensity measured by means of the radiometer assumes, also in this case, very low values ( $\text{MV } 2.17 \pm 0.4 \text{ mW/cm}^2$ ).

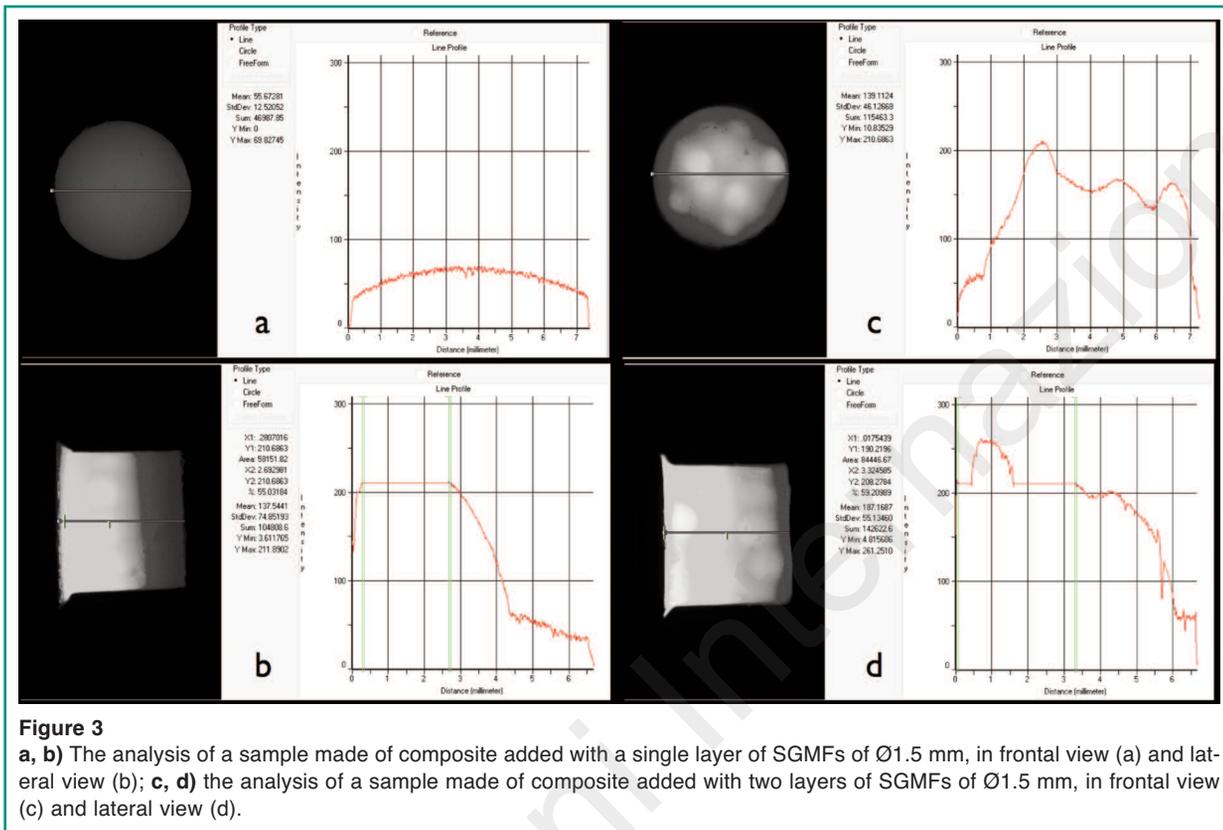
## Discussions

Previous studies analyzed, both *in vivo* and *in vitro*, the effectiveness of spherical glass mega fillers (SGMFs) in composite direct fillings (8, 13). SGMFs are introduced into the mass of the composite prior to its polymerization in order to reduce the amount of resinous matrix, thus reducing the polymerization shrinkage. Furthermore SGMFs significantly contribute to the reduction of the adhesive interface solicitation; help to improve the marginal seal in interproximal cavities with cervical margins on the root cementum; facilitate the light diffusion in the context of the filling material; allow to carry out a bulk polymerization; shift to a more coronal level, the shrink-

age stress facilitating its dissipation by the cuspal compliance (18-23). This is relevant since sometime lost teeth can be cause of legal quarrel (24, 25) since they can substitute with dental implant (26-76) or orthodontic treatment (77-83).

The fact that the SGMFs could positively interfere with the photopolymerization reaction had been shown in a previous study which proved that, in accordance with the ISO 4049 regulations, an increase of polymerization depth was shown in samples containing these mega-fillers. This increase was supposed to be dependent to the transparency of the SGMFs, in which the light is diffused in a homogeneous way, thanks to the refractive indices of the constituents of the composite restoration (resin matrix and filler) closer to those of the spheres of mega-filler (22).

This study confirms the validity of SGMFs in increasing the diffusion of light through composite restorations. Results showed that the spheres of Ø2 mm determine, on an equal composite thickness, a lower light intensity attenuation than spheres of Ø1.5 mm. Previously had already been supposed that there was a



direct correlation between the diameter of the sphere and the depth of polymerization gain, along the axis of the light beam, passing through the center of the sphere; in this analysis this hypothesis is supported, especially since it is clear that the greater is the size of the element, with a lower coefficient of light attenuation compared to composite, the lower will be the same light attenuation (22).

The spheres of Ø2 mm are also positioned in the context of the samples in a repeatable and reproducible pattern, ensuring a more uniform distribution of light within the composite, while the spheres of Ø1.5mm, especially in the samples made by 2 layers, are distributed in a not-uniform pattern, thus making the diffusion of the light non-homogeneous.

This phenomenon is probably due to the fact that to obtain comparable samples between the groups, it was necessary to employ a greater number of spheres of Ø1.5 mm that, when compacted in the cylinder, couldn't arrange in a single-layer of spheres, as in the case of Ø2 mm.

The spheres of Ø1.5 mm resulted to be arranged on

two layers, where the spheres often presented a regular distribution on the deep layer, and a random distribution on the surface layer.

From a lateral view, analyzing samples with a single layer of spheres of Ø1.5 mm and Ø2 mm and samples with a two layers of spheres of Ø1.5 mm and Ø2 mm, the relative increments of light intensity compared with whole composite samples were of 24.37, 33.33, 67,99 and 66,4% respectively.

From a front view, analyzing samples with a single layer of spheres of Ø1.5 mm and Ø2 mm and samples with a two layers of spheres of Ø1.5 mm and Ø2 mm, the relative increments of light intensity compared with whole composite samples were of 53.66, 79.58, 267,53 and 319,63% respectively.

Therefore the transparency of the SGMFs facilitates the diffusion of light through the composite restoration, with obvious advantages, especially during critical situations such as in the case of deep proximal boxes in Black class II cavities.

## References

1. Bocalon AC, Mita D, Narumyia I, Shouha P, Xavier TA, Braga RR. Replacement of glass particles by multidirectional short glass fibers in experimental composites: Effects on degree of conversion, mechanical properties and polymerization shrinkage. *Dent Mater.* 2016;32:e204-10.
2. Kleverlaan CJ, Feilzer AJ. Polymerization shrinkage and contraction stress of dental resin composites. *Dent Mater.* 2005;21:1150-7.
3. Al Sunbul H, Silikas N, Watts DC. Polymerization shrinkage kinetics and shrinkage-stress in dental resin-composites. *Dent Mater.* 2016;32:998-1006.
4. Al-Ahdal K, Ilie N, Silikas N, Watts DC. Polymerization kinetics and impact of post polymerization on the Degree of Conversion of bulk-fill resin-composite at clinically relevant depth. *Dent Mater.* 2015;31:1207-13.
5. Malik AH, Baban LM. The effect of light curing tip distance on the curing depth of bulk fill resin based composites. 2014;26:46-53.
6. Salgado VE, Borba MM, Cavalcante LM, Moraes RR, Schneider LF. Effect of photoinitiator combinations on hardness, depth of cure, and color of model resin composites. *J Esthet Restor Dent.* 2015;27 Suppl 1:S41-8.
7. Albuquerque PP, Bertolo ML, Cavalcante LM, Pfeifer C, Schneider LF. Degree of conversion, depth of cure, and color stability of experimental dental composite formulated with camphorquinone and phenanthrenequinone photoinitiators. *J Esthet Restor Dent.* 2015;27 Suppl 1:S49-57.
8. Baharav H, Brosh T, Pilo R, Cardash H. Effect of irradiation time on tensile properties of stiffness and strength of composites. *J Prosthet Dent.* 1997;77:471-4.
9. Price RB, Murphy DG, Derand T. Light energy transmission through cured resin composite and human dentin. *Quintessence Int.* 2000;31:659-67.
10. Sideridou ID, Achilias DS. Elution study of unreacted Bis-GMA, TEGDMA, UDMA, and Bis-EMA from light-cured dental resins and resin composites using HPLC. *J Biomed Mater Res B Appl Biomater.* 2005;74:617-26.
11. Rosatto CM, Bicalho AA, Verissimo C, et al. Mechanical properties, shrinkage stress, cuspal strain and fracture resistance of molars restored with bulk-fill composites and incremental filling technique. *J Dent.* 2015;43:1519-28.
12. Versluis A, Tantbirojn D, Douglas WH. Do dental composites always shrink toward the light? *J Dent Res.* 1998;77:1435-45.
13. Pilo R, Oelgiesser D, Cardash HS. A survey of output intensity and potential for depth of cure among light-curing units in clinical use. *J Dent.* 1999;27:235-41.
14. Ceballos L, Fuentes MV, Tafalla H, Martinez A, Flores J, Rodriguez J. Curing effectiveness of resin composites at different exposure times using LED and halogen units. *Med Oral Patol Oral Cir Bucal.* 2009;14:E51-6.
15. Curtis MA, Slaney JM, Aduse-Opoku J. Critical pathways in microbial virulence. *J Clin Periodontol.* 2005; 32 Suppl 6:28-38.
16. Yazici AR, Muftu A, Kugel G. Temperature rise produced by different light-curing units through dentin. *J Contemp Dent Pract.* 2007;8:21-8.
17. Thome T, Steagall W Jr., Tachibana A, Braga SR, Turbino ML. Influence of the distance of the curing light source and composite shade on hardness of two composites. *J Appl Oral Sci.* 2007;15:486-91.
18. Cito C, Andreasi Bassi M, Maccaroni M, Goracci G. Chemical analysis of a new kind of megafiller: preliminary results. *J Dent Res.* 1999;78 (Spec. Issue).
19. Andreasi Bassi M, Esposito C, Cito C, Goracci GA. SEM analysis of a new kind of megafiller. *J Dent Res.* 2001;80:1241, Abstr. 326.
20. Andreasi Bassi M, Esposito A, Rossani F. Otturazioni dirette in composito e mega riempitivi sferici: studio sulle microinfiltrazioni in vitro. *Doctor OS.* 2003;14:1-9.
21. Andreasi Bassi M, Gambarini G, Gallottini L. L'uso dei mega riempitivi sferici nei restauri diretti in composito: studio clinico longitudinale. *Il Dentista Moderno.* 2003;2:115-26.
22. Rossani F, Andreasi Bassi M. Mega riempitivi e profondità di polimerizzazione dei compositi. *Dental Cadmos.* 2003;8:89-95.
23. Andreasi Bassi M. La riduzione dello stress da contrazione delle resine composite mediante mega riempitivi: analisi fotoelastica. *Il Dentista Moderno.* 2005;7:83-95.
24. Feltracco P, Gaudio RM, Barbieri S, et al. The perils of dental vacation: possible anaesthetic and medicolegal consequences. *Med Sci Law.* 2013;53:19-23.
25. Gaudio RM, Barbieri S, Feltracco P, et al. Traumatic dental injuries during anaesthesia. Part II: medico-legal evaluation and liability. *Dent Traumatol.* 2011;27:40-5.
26. El Haddad E, Lauritano D, Carinci F. Interradicular septum as guide for pilot drill in postextractive implantology: a technical note. *J Contemp Dent Pract.* 2015;16:81-4.
27. Andreasi Bassi M, Lopez MA, Confalone L, Carinci F. Hydraulic sinus lift technique in future site development: clinical and histomorphometric analysis of human biopsies. *Implant Dent.* 2015;24:117-24.
28. Lopez MA, Andreasi Bassi M, Confalone L, Carinci F. Maxillary sinus floor elevation via crestal approach: the evolution of the hydraulic pressure technique. *J Craniofac Surg.* 2014;25:e127-32.
29. Lucchese A, Carinci F, Saggese V, Lauritano D. Immediate loading versus traditional approach in functional implantology. *European Journal of Inflammation.* 2012;10:55-58.

30. Danza M, Paracchini L, Carinci F. Tridimensional finite element analysis to detect stress distribution in implants. *Dental Cadmos*. 2012;80:598-602.
31. Fanali S, Carinci F, Zollino I, Brugnati C, Lauritano D. One-piece implants installed in restored mandible: a retrospective study. *European Journal of Inflammation*. 2012;10:19-23.
32. Scarano A, Murmura G, Carinci F, Lauritano D. Immediately loaded small-diameter dental implants: evaluation of retention, stability and comfort for the edentulous patient. *European Journal of Inflammation*. 2012;10:19-23.
33. Fanali S, Carinci F, Zollino I, Brugnati C, Lauritano D. A retrospective study on 83 one-piece implants installed in resorbed maxillae. *European Journal of Inflammation*. 2012;10:55-58.
34. Scarano A, Perrotti V, Carinci F, Shibli JA. Removal of a migrated dental implant from the maxillary sinus after 7 years: A case report. *Oral and Maxillofacial Surgery*. 2011;15:239-43.
35. Scarano A, Piattelli A, Assenza B, Carinci F, Donato LD, Romani GL, Merla A. Infrared thermographic evaluation of temperature modifications induced during implant site preparation with cylindrical versus conical drills. *Clinical Implant Dentistry and Related Research*. 2011;13:319-23.
36. Gargari M, Ottria L, Morelli V, Benli M, Ceruso FM. Conservative zirconia-ceramic bridge in front teeth. Case report. *Oral Implantol (Rome)*. 2015;7:93-98.
37. Andreasi Bassi M, Andrisani C, Lopez MA, Gaudio RM, Lombardo L, Carinci F. Guided bone regeneration by means of a preformed titanium foil: A case of severe atrophy of edentulous posterior mandible. *J Biol Regul Homeost Agents*. 2016;30 (S2):35-41.
38. Milillo L, Fiandaca C, Giannoulis F, Ottria L, Lucchese A, Silvestre F, Petruzzi M. Immediate vs non-immediate loading post-extractive implants: A comparative study of Implant Stability Quotient (ISQ). *Oral Implantol (Rome)*. 2016;9:123-31.
39. Bartuli FN, Luciani F, Caddeo F, et al. Piezosurgery vs High Speed Rotary Handpiece: a comparison between the two techniques in the impacted third molar surgery. *Oral Implantol (Rome)*. 2013;6:5-10.
40. Clementini M, Ottria L, Pandolfi C, Agrestini C, Barlattani A. Four impacted fourth molars in a young patient: a case report. *Oral Implantol (Rome)*. 2012;5:100-3.
41. Gargari M, Comuzzi L, Bazzato MF, Sivoletta S, Di Fiore A, Ceruso F. Treatment of peri-implantitis: Description of a technique of surgical 2 detoxification of the implant. A prospective clinical case series with 3-year follow-up. *Oral Implantol (Rome)*. 2015;8:1-11.
42. Inchingolo F, Marrelli M, Annibali S, et al. Influence of endodontic treatment on systemic oxidative stress. *Int J Med Sci*. 2014;11:1-6.
43. Scarano A, Piattelli A, Assenza B, Sollazzo V, Lucchese A, Carinci F. Assessment of pain associated with insertion torque of dental implants. A prospective, randomized-controlled study. *International Journal of Immunopathology and Pharmacology*. 2011;24:65-69.
44. Traini T, Danza M, Altavilla R, et al. Histomorphometric evaluation of an implant retrieved from human maxilla after 13 years. *International Journal of Immunopathology and Pharmacology*. 2011;24:25-30.
45. Danza M, Grecchi F, Zollino I, Casadio C, Carinci F. Spiral implants bearing full-arch rehabilitation: Analysis of clinical outcome. *Journal of Oral Implantology*. 2011;37:447-55.
46. Danza M, Zollino I, Avantiaggiato A, Lucchese A, Carinci F. Distance between implants has a potential impact of crestal bone resorption. *Saudi Dental Journal*. 2011;23:129-33.
47. Scarano A, Murmura G, Sinjiari B, Sollazzo V, Spinelli G, Carinci F. Analysis and structural examination of screw loosening in oral implants. *International Journal of Immunopathology and Pharmacology*. 2011;24:77-81.
48. Scarano A, Murmura G, Sinjiari B, Assenza B, Sollazzo V, Spinelli G, Carinci F. Expansion of the alveolar bone crest with ultrasonic surgery device: Clinical study in mandible. *International Journal of Immunopathology and Pharmacology*. 2011;24:71-75.
49. Traini T, Danza M, Zollino I, et al. Histomorphometric evaluation of an immediately loaded implant retrieved from human mandible after 2 years. *International Journal of Immunopathology and Pharmacology*. 2011;24:31-36.
50. Carinci F, Danza M. Clinical outcome of implants inserted in piezo split alveolar ridges: A pilot study. In: *Perspectives on Clinical Dentistry*. 2011:29-30.
51. Danza M, Zollino I, Guidi R, Carinci F. Computer planned implantology: Analysis of a case series. In: *Perspectives on Clinical Dentistry*. 2011:287-300.
52. Grecchi F, Pagliani L, Mancini GE, Zollino I, Carinci F. Implant treatment in grafted and native bone in patients affected by ectodermal dysplasia. *Journal of Craniofacial Surgery*. 2010;21:1776-80.
53. Danza M, Carinci F. Flapless surgery and immediately loaded implants: a retrospective comparison between implantation with and without computer-assisted planned surgical stent. *Stomatologija*. 2010;12:35-41.
54. Grecchi F, Zingari F, Bianco R, Zollino I, Casadio C, Carinci F. Implant rehabilitation in grafted and native bone in patients affected by ectodermal dysplasia: evaluation of 78 implants inserted in 8 patients. *Implant Dent*. 2010;19:400-8.
55. Grecchi F, Mancini G, Parafioriti A, Mineo G, Zollino I, Pricolo A, Carinci F. Ectodermal dysplasia treated with one-step surgical rehabilitation: a case report. *Singapore Dent J*. 2010;31:9-14.
56. Danza M, Quaranta A, Carinci F, Paracchini L, Pompa G, Voza I. Biomechanical evaluation of dental implants in D1 and D4 bone by Finite Element Analysis. *Minerva stomatologica*. 2010;59:305-13.

57. Carinci F, Brunelli G, Franco M, Viscioni A, Rigo L, Guidi R, Strohmer L. A retrospective study on 287 implants installed in resorbed maxillae grafted with fresh frozen allogeneous bone. *Clin Implant Dent Relat Res.* 2010;12:91-8.
58. Viscioni A, Rigo L, Franco M, Brunelli G, Avantaggiato A, Sollazzo V, Carinci F. Reconstruction of severely atrophic jaws using homografts and simultaneous implant placement: a retrospective study. *J Oral Implantol.* 2010;36:131-9.
59. Danza M, Riccardo G, Carinci F. Bone platform switching: a retrospective study on the slope of reverse conical neck. *Quintessence Int.* 2010;41:35-40.
60. Degidi M, Piatelli A, Iezzi G, Carinci F. Wide-diameter implants: Analysis of clinical outcome of 304 fixtures. *Journal of Periodontology.* 2007;78:52-58.
61. Degidi M, Piatelli A, Gehrke P, Felice P, Carinci F. Five-year outcome of 111 immediate nonfunctional single restorations. *J Oral Implantol.* 2006;32:277-85.
62. Degidi M, Piatelli A, Gehrke P, Carinci F. Clinical outcome of 802 immediately loaded 2-stage submerged implants with a new grit-blasted and acid-etched surface: 12-month follow-up. *Int J Oral Maxillofac Implants.* 2006;21:763-8.
63. Danza M, Fromovich O, Guidi R, Carinci F. The clinical outcomes of 234 spiral family implants. *J Contemp Dent Pract.* 2009;10:E049-56.
64. Scarano A, Piatelli M, Carinci F, Perrotti V. Removal, after 7 years, of an implant displaced into the maxillary sinus. A clinical and histologic case report. *Journal of Osseointegration.* 2009;1:35-40.
65. Carinci F, Brunelli G, Danza M. Platform switching and bone platform switching. *J Oral Implantol.* 2009;35:245-50.
66. Grecchi F, Danza M, Bianco R, Parafioriti A, Carinci F. Computer planned implant-orthognathic rehabilitation: a case of one step surgical procedure with implants insertion, Le Fort I advancement, grafting and immediate loading. *J Osseointegration.* 2009;3.
67. Franco M, Rigo L, Viscione A, et al. CaPO4 blasted implants inserted into iliac crest homologue frozen grafts. *The Journal of oral implantology.* 2009;35:176-80.
68. Danza M, Guidi R, Carinci F. Comparison Between Implants Inserted Into Piezo Split and Unsplit Alveolar Crests. *Journal of Oral and Maxillofacial Surgery.* 2009;67:2460-65.
69. Grecchi F, Zollino I, Parafioriti A, Mineo G, Pricolo A, Carinci F. One-step oral rehabilitation by means of implants' insertion, Le Fort I, grafts, and immediate loading. *J Craniofac Surg.* 2009;20:2205-10.
70. Viscioni A, Franco M, Rigo L, Guidi R, Brunelli G, Carinci F. Implants inserted into homografts bearing fixed restorations. *Int J Prosthodont.* 2009;22:148-54.
71. Danza M, Scarano A, Zollino I, Carinci F. Evaluation of biological width around implants inserted in native alveolar crest bone. *Journal of Osseointegration.* 2009;1:73-76.
72. Concolino P, Cecchetti F, D'Autilia C, et al. Association of periodontitis with GSTM1/GSTT1-null variants-A pilot study. *Clinical Biochemistry.* 2007;40:939-45.
73. Giannitelli SM, Basoli F, Mozetic P, et al. Graded porous polyurethane foam: A potential scaffold for oro-maxillary bone regeneration. *Materials Science and Engineering C.* 2015;51:329-35.
74. Giacchetti A, Romanini G, Di Girolamo R, Arcuri C. A less-invasive approach with orthodontic treatment in beckwith-wiedeman patients. *Orthodontics and Craniofacial Research.* 2002;5:59-63.
75. Germano F, Bramanti E, Arcuri C, Cecchetti F, Cicciù M. Atomic force microscopy of bacteria from periodontal subgingival biofilm: Preliminary study results. *European Journal of Dentistry.* 2013;7:152-58.
76. Bramanti E, Maticena G, Cecchetti F, Arcuri C, Cicciù M. Oral health-related quality of life in partially edentulous patients before and after implant therapy: A 2-year longitudinal study. *ORAL and Implantology.* 2013;6:37-42.
77. Lucchese A, Carinci F, Saggese V, Lauritano D. Orthodontic tooth movement and distraction osteogenesis. *European Journal of Inflammation.* 2012;10:49-54.
78. Lucchese A, Carinci F, Brunelli G. Skeletal effects induced by twin block in therapy of class II malocclusion. *European Journal of Inflammation.* 2012;10:83-87.
79. Mancini GE, Carinci F, Zollino I, Avantaggiato A, Lucchese A, Puglisi P, Brunelli G. Lingual orthodontic technique: A case series analysis. *European Journal of Inflammation.* 2011;9:47-51.
80. Mancini GE, Carinci F, Zollino I, Avantaggiato A, Puglisi P, Caccianiga G, Brunelli G. Effectiveness of self-ligating orthodontic treatment. *European Journal of Inflammation.* 2011;9:53-58.
81. Mancini GE, Carinci F, Avantaggiato IZ, Puglisi P, Caccianiga G, Brunelli G. Simplicity and reliability of invisalign® system. *European Journal of Inflammation.* 2011;9:43-52.
82. Avantaggiato A, Zollino I, Carinci F. Impact of orthodontic treatment on crestal bone resorption in periodontally compromised patients: A case series. *Acta Stomatologica Croatica.* 2010;44:188-94.
83. Busato A, Vismara V, Bertele L, Zollino I, Carinci F. Relation between disk/condyle incoordination and joint morphological changes: A retrospective study on 268 TMJs. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology.* 2010;110.

---

*Correspondence to:*

Dorina Lauritano  
 Department of Medicine and Surgery  
 Center of Neurosciences of Milan  
 University of Milan-Bicocca  
 Via Cadore 48  
 20052 Monza, Italy  
 Phone: +39.0392332301 - Fax: +39. 03923329892  
 E-mail: dorina.lauritano@unimib.it