Influence of increment thickness on shear bond strength and light transmission of composite base materials

Tarek Omran[1,2], Sufyan Garoushi[1,2], Aous Abdulmajeed[1,2], Pekka Vallittu[1,2], Lippo Lassila[1,2]

[1] Department of Biomaterials Science, Institute of Dentistry, University of Turku, Turku, Finland

[2] Turku Clinical Biomaterials Centre (TCBC), University of Turku, Turku, Finland

Introduction

Biomimetic filling materials have given rise to the bilayering technique [1]; A Base material is used to mimic dentine with its high toughness and reinforcing qualities. While another material possessing similar enamel characteristics such as high hardness and wear resistance is used to overlay it. [2,3]

These new parameters of replacing dentine have been found to coherently go along with the superior properties of the novel fiber-reinforced composite (FRC); initially introduced as an enforcing base for large restorations and now, showing the potential of being placed in bulk. [4,5]

Currently, bulk-filling composite (BFC) materials are increasingly being used in restorative dentistry. BFCs are intended to be placed in 4mm bulk increments [6] and are deemed to be advantageous in:

- Saving valuable chair time for the dentist when filling larger cavities [7]
- Decreasing the possibility of incorporation of voids between increments [7]
- Possessing *improved* material properties such as enhanced marginal integrity, depth of cure and less polymerization shrinkage [8]

Nevertheless, an increase in increment height directly affects the amount of light passing through to the deepest layer. So, a compromise in its polymerization will drastically affect the restoration as a whole. [1]

Thus, this study investigated:

(i) The influence of increment thickness on the dentine bond strength of BFCs currently in the market alongside the novel FRC filling material

(ii) The variance in light cure irradiation and transmittance of the different groups being tested.

Materials & Methods

Table 1 - The materials used for this study.

Group	Manufacturer	Type	Matrix composition	Inorganic filler content	Application Procedure
G-aenial Anterior	GC Dental Products Corp., Japan	Nanohybrid	Methacrylate monomers	Prepolimerized filler with silicon	Scotchbond™ Universal Adhesive1 first applied to dentine according to manufacturers instructions2. Followed by composite build up and 40 sec light-curing* from the occlusal aspect.
EverX Posterior™	GC Dental Products Corp., Japan	Fiber Reinforced Base	Bis-GMA, PMMA, TEGDMA	Short E-glass fiber filler, barium glass 74.2 wt%, 53.6 vol%	
Tetric EvoCeram®	Ivoclar Vivadent AG, Liechtenstein	Bulk-fill	Dimethacrylate co-monomers	Barium glass filler 80 wt%, 60 vol%	
SDR™	Dentsply, USA	Bulk-fill	TEGDMA, EBADMA	Barium borosilicate glass 68 wt%, 44 vol%	

PMMA, polymethylmethacrylate; MMA, methylmethacrylate; bis-GMA, bisphenol-A-glycidyl dimethacrylate; TEGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate; EBADMA, ethoxylated bisphenol-A-dimethacrylate; bis-EMA, ethoxylated bisphenol-A- dimethacrylate; wt%, weight percentage; vol%, volume percentage.
1. Scotchbond™ Universal - Lot No. 522238 (3M Deutschland GmbH, Neuss, Germany)
2. Manufacturer's Instructions: Apply adhesive and rub in for 20 sec. Then, gently air dry for 5 sec. Finally, light cure for 10 sec
**Light-curing unit - Elipar S10, 3M Espe, Seefeld, Germany*

Shear bond testing

Four different groups of BFC (n=45, per group) were investigated (Table 1); by being bonded to dentine of wet-ground human teeth.

Application procedure was standardized for all groups (Table 1).

BFCs were applied in different height increments. Hence, further dividing each group into three subgroups (n=15) of different heights (i.e. 2mm, 4mm, and 6mm) (Figure 1).

The investigated groups where tested for shear bond strength using a universal testing machine (Model LRX, Lloyd Instruments Ltd., Fareham, England) at room temperature (23 ± 1°C). (Figure 2)

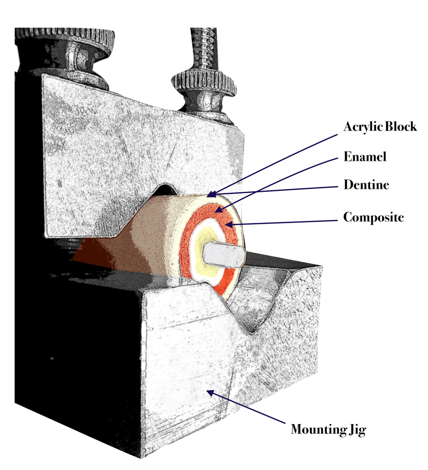
Light cure irradiation and transmittance

The investigated BFCs were evaluated to determine the amount of light irradiance (i.e. amount of light received by the bottom layer of the specimen), and total irradiant energy (defined as the mathematical product of the curing light irradiance (mW/cm2) multiplied by the exposure duration in seconds) through each thickness.

Light energy transmitted through each BFC, was quantified by MARC® Resin Calibrator (BlueLight analytics Inc., Halifax, Canada) (Figure 3)

Statistical analysis was performed using two-way ANOVA and post-hoc Tukey's tests ($p<0.05$).

Figure 1 Shows the three subgroups of prepared specimen after composite build up. (6.0mm, 4.0mm and 2.0mm; left to right).



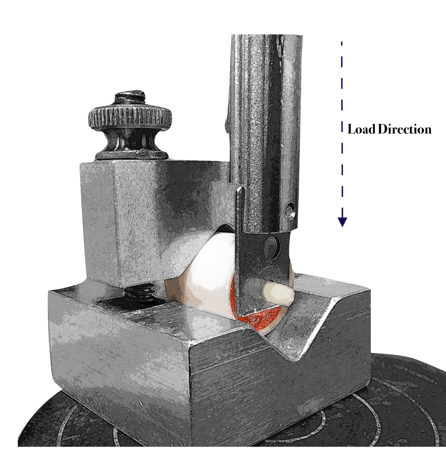
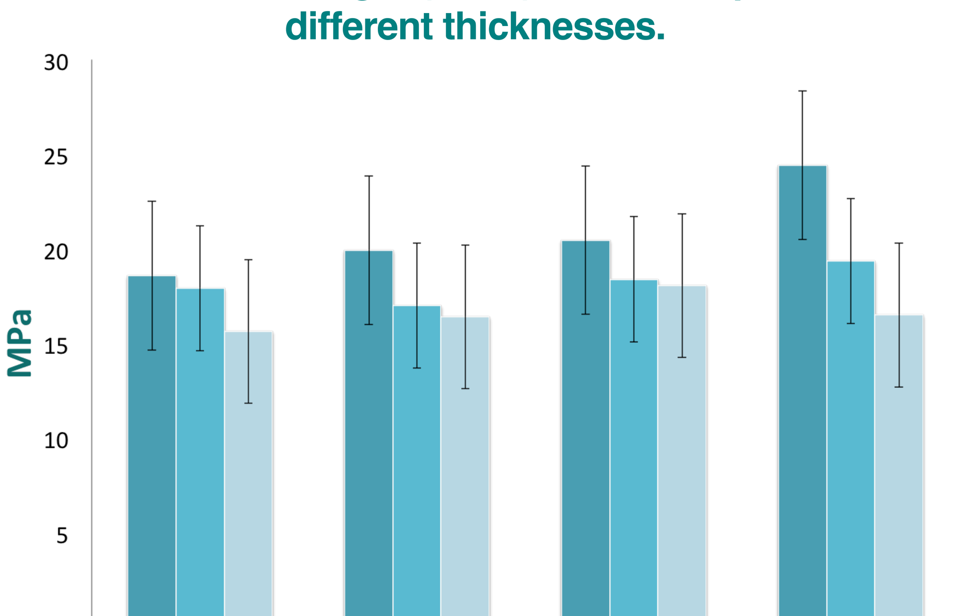


Figure 2a Specimen mounted and secured in a mounting jig.
Figure 2b Shear bond testing assembly.

Figure 3 MARC® Resin Calibrator

Results

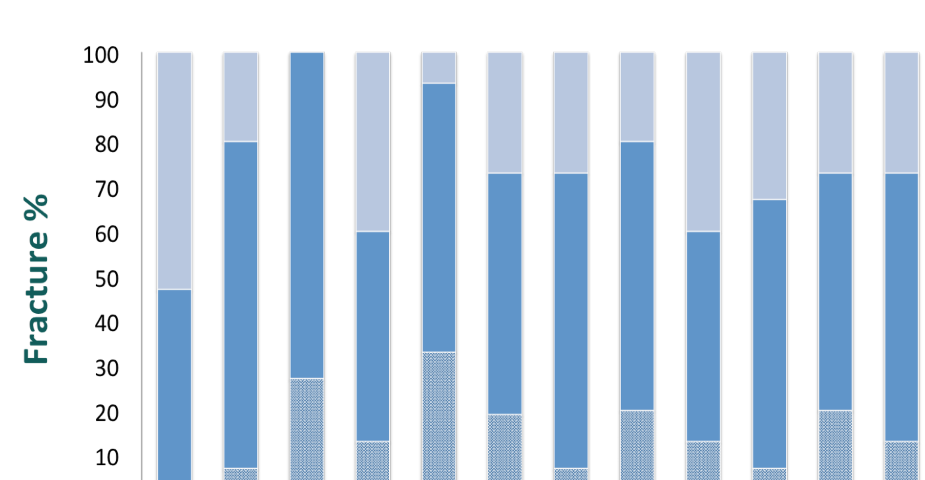
Shear bond strength (MPa*) of the composites at different thicknesses.



	G-aenial Anterior	Tetric Bulkfill	SDR	EverX Posterior
2	18.572	19.928	20.457	24.423
4	17.904	16.9925	18.3866	19.359
6	15.641	16.404	18.0607	16.495

**Data are presented as mean ± standard deviation (SD). Longer bar indicates stronger dentinal bond strength.*

Proportions of three failure types at fracture sites at different thicknesses.

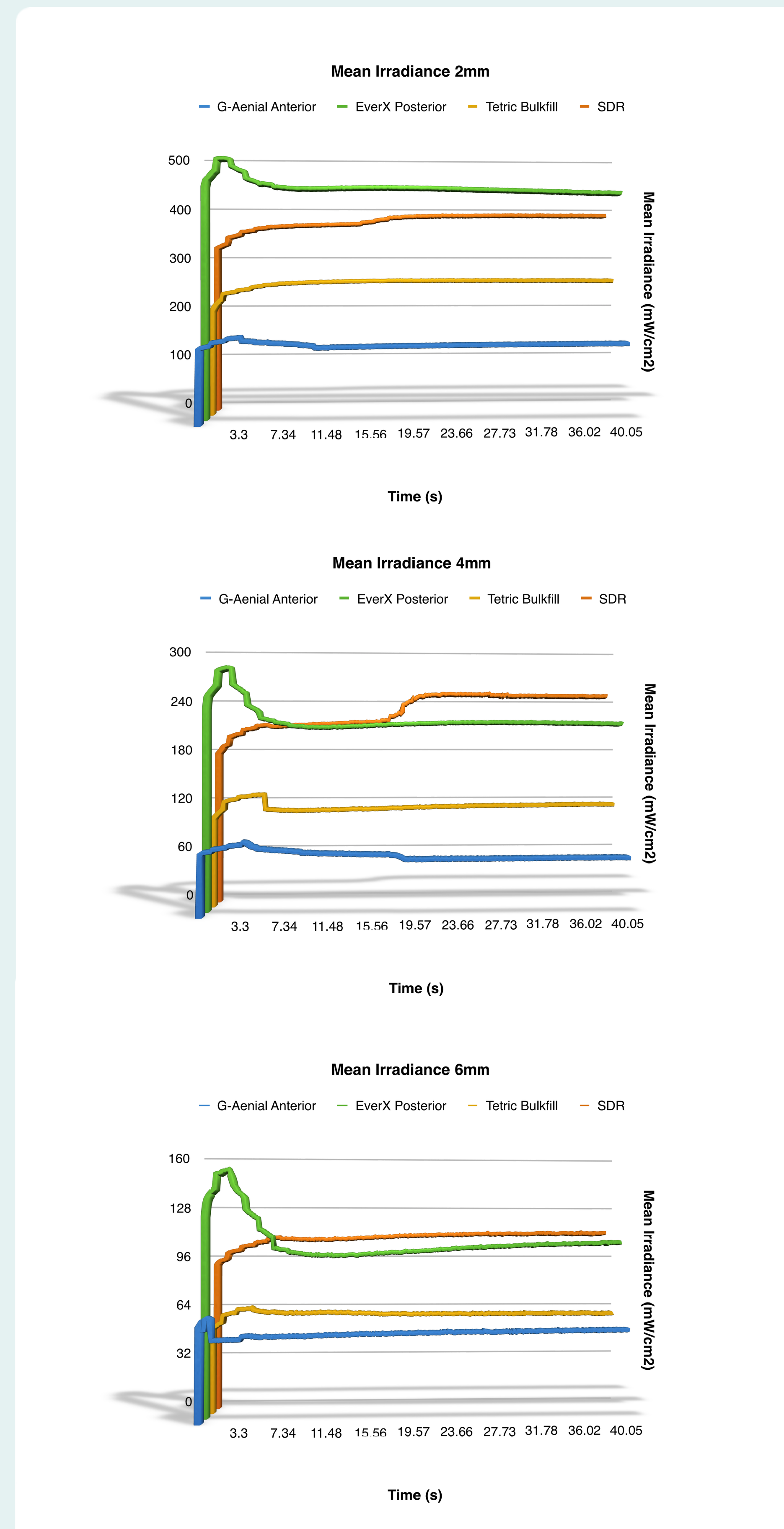


	G-aenial Anterior 2	G-aenial Anterior 4	G-aenial Anterior 6	Tetric Bulkfill 2	Tetric Bulkfill 4	Tetric Bulkfill 6	SDR 2	SDR 4	SDR 6	EverX Posterior 2	EverX Posterior 4	EverX Posterior 6
Mixed	53	20	0	40	7	27	27	20	40	33	27	27
Cohesive	47	73	73	47	60	54	66	60	47	60	53	60
Adhesive	0	7	27	13	33	19	7	20	13	7	20	13

Failures examined at fracture sites, categorized into three categories; Cohesive failure, Adhesive failure and Mixed failure.

Line graphs represent the amount of light passing through the filling material and reaching the sensor.

Higher graphs represent higher light transmission.



**Irradiance cascade measured in real-time for all groups.*

Conclusions

- The fiber-reinforced base, EverX Posterior, showed high means of shear bond strength even when placed in bulk.
- Therefore, saving valuable chair time and further promoting the biomimetic approach of restoring cavities.
- This can be achieved by restoring teeth in a bi-layered manner (enamel and dentine); Similar to our naturally existing dentitions.

References

[1] Garoushi, S.K., L.V. Lassila, and P.K. Vallittu, Direct composite resin restoration of an anterior tooth: effect of fiber-reinforced composite substructure. European Journal of Prosthodontics and Restorative Dentistry, 2007. 15(2): p. 61-6.

[2] Roggendorf, M.J., et al., Marginal quality of flowable 4-mm base vs. conventionally layered resin composite. Journal of Dentistry, 2011. 39(10): p. 643-7.

[3] Sfondrini, M.F., V. Cacciafesta, and A. Scribante, Shear bond strength of fibre-reinforced composite nets using two different adhesive systems. European Journal of Orthodontics, 2011. 33(1): p. 66-70.

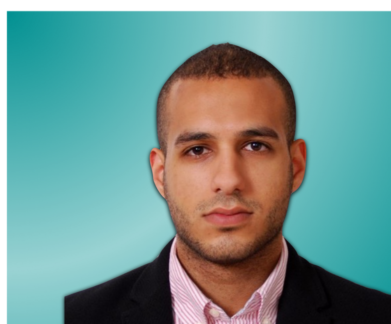
[4] Ilie, N., A. Kessler, and J. Durner, Influence of various irradiation processes on the mechanical properties and polymerisation kinetics of bulk-fill resin based composites. Journal of Dentistry, 2013. 41(8): p. 695-702.

[5] Garoushi, S., et al., Physical properties and depth of cure of a new short fiber reinforced composite. Dental Materials, 2013. 29(8): p. 835-41.

[6] El-Damanhoury, H.M. and J.A. Platt, Polymerization Shrinkage Stress Kinetics and Related Properties of Bulk-fill Resin Composites. Operative Dentistry, 2013. 39(4): p. 374-382.

[7] Abbas, G., et al., Cuspal movement and microleakage in premolar teeth restored with a packable composite cured in bulk or in increments. Journal of Dentistry, 2003. 31(6): p. 437-44.

[8] Truffier-Boutry, D., et al., A physico-chemical explanation of the post-polymerization shrinkage in dental resins. Dental Materials, 2006. 22(5): p. 405-12.



Tarek Omran
BDS, PhD Candidate

E-mail: tarek.omran@utu.fi

Turku Clinical Biomaterials Centre (TCBC)
Department of Biomaterials Science
Institute of Dentistry, University of Turku,
Lemminkäisenkatu 2, FI-20520,
Turku, Finland

Turun yliopisto
University of Turku