Pediatric Interproximal Slot Preparation Depth of Cure Analysis via Microhardness and Photopolymerization Assays

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Purpose: To evaluate the efficacy of a novel rapid curing light on composite photopolymerization within pediatric interproximal dental slot preparations.

Methods: Flat, hard, opaque, tan plastic discs of 7 mm outer diameter, 2.5 mm height, 2.5 mm inner diameter were milled by Unlimited Dental Labs NYC. Tetric PowerFill (Ivoclar Vivadent) and Mosaic Universal (UltraDent) composites were acquired and stored per manufacturer's recommendations. The discs were placed on a flat, orange, glass slide. Composite (Tetric or Mosaic) was expressed and condensed completely into intaglio of disc with standard dental condenser. A translucent, cleaned, glass slide was placed on top of the composite containing disc. BluePhase PowerCure (Ivoclar Vivadent) curing light was placed into custom polyvinyl siloxane housing. Housing held curing light at a predetermined distance of either 0 mm, 3 mm, or 3 mm at 45º from light tip to composite surface. Composite was cured at curing times * irradiance as follows: 3 s * 3,000 mW/cm^2, 10 s * 1,200 mW/cm^2, or 5 s * 2,000 mW/cm^2 at aforementioned distances and angles. After curing, all samples were stored in a dark environment. After 24 h, all samples were tested using using Vickers Hardness Test at 50 gf with dwell time of 15 s. Three microhardness measurements (VHN) on top and bottom surfaces were completed and recorded per each composite sample. All samples were made and tested in batches of 10 discs.

Results: All groups showed lower top-to-bottom hardness ratio when cured with increased composite-to-curing tip distance. Across all tip-to-composite distances, UltraDent Mosaic showed higher top surface hardness when compared to Tetric PowerFill. Across all tip-to-composite distances (68-76 VHN vs 40-51 VHN), UltraDent Mosaic showed the lowest bottom surface hardness when compared to Tetric PowerFill (15-23 VHN vs 21-34 VHN). Across all composite and light combinations, overall Irradiance and Energy delivered (time × irradiance) to the composite sample trended with increased composite cure.

Conclusions:
1. Due to low top-to-bottom composite hardness ratio across all tested samples (0.20-0.66), all composites are recommended to be cured in increments of less than 2.5 mm in a slot preparation in order to maximize completeness of cure.
2. Due to Tetric PowerFill's increased top and bottom hardness when cured on the BluePhase 3 s (3,050 mW/cm^2) mode when compared to the 10 s (1,200 mW/cm^2) mode, it is recommended that it be cured with the 3 s (3,000 mW/cm^2) mode.
3. Due to the decreased curing of all composites with increased tip-to-composite distance, it is recommended that all composites be cured with minimal tip-to-composite distance.
4. It was noted that the 3 mm tip-to-composite distance did not vary much compared to the 3 mm tip-to-composite distance with 45º angulation. However, it is still recommended that users attempt to maximize orthogonal light tip direction when curing composites in the slot preparation design.

Introduction

•"Box-only" composite preparation extending 2.5 mm I-G is common in pediatric practice.

•Access for curing light and sufficient curing time are challenges with limited mouth opening.

Objectives: To evaluate the efficacy of a rapid curing light and tip distance on top/bottom hardness ratio of box-only composite design.

METHODS & MATERIALS

•Tetric PowerFill nanohybrid composite (Ivoclar Vivadent, Lot# Z006HT, Schaan, Liechtenstein)

•Mosaic universal composite (UltraDent, Lot# BLZNM, South Jordan, UT)

Composite Specimen Fabrication (N=10)

•Opaque plastic discs with cylindrical cavity 2.5 mm diameter * 2.5 mm height (Unlimited Dental Labs NYC)

•Placed on an orange glass plate (Bullseye Glass Company, Portland, OR), filled with the composite, covered with a glass cover slip.

•Light curing with 'Regular' or 'High Power' regimen at 3 light tip distances

Light Curing Regimen

BluePhase PowerCure curing light (Ivoclar Vivadent)

•'Regular' – 10 s * 1,200 mW/cm^2

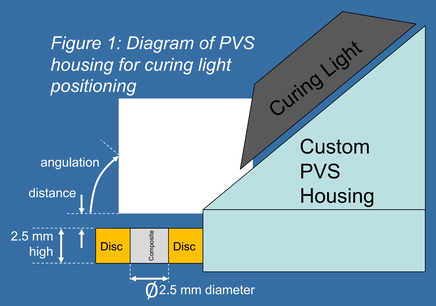
•'High Power' – 5 s * 2,000 mW/cm^2 for Mosaic OR 3 s * 3,000 mW/cm^2 for Tetric PowerFill

Light Tip Distance

Curing light tip was placed into custom polyvinyl siloxane (PVS) housing to have tip-to-composite distance as follow: 0 mm
3 mm
3 mm at 45°

Irradiance at each distance/angle was measured using MARC (Bluelight Analytics, Halifax, NS, Canada)

Figure 1: Diagram of PVS housing for curing light positioning



Microhardness Test

•Composite specimens were stored for 24 h in a dark environment

•Vickers Hardness Test (QV-1000 Micro Hardness Tester, Qualitest, Fort Lauderdale, FL) at 50 gf with dwell time of 15 s.

•3 measurements on top and bottom surfaces

•3-way ANOVA statistical analysis

Figure 2: Microhardness Testing Apparatus

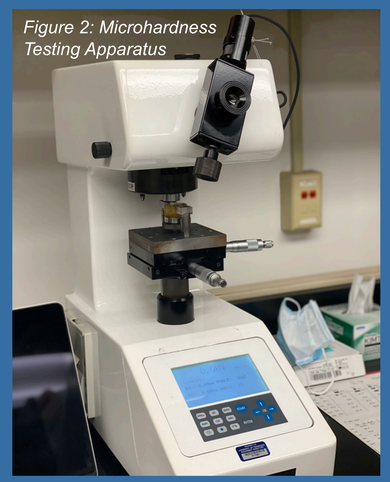
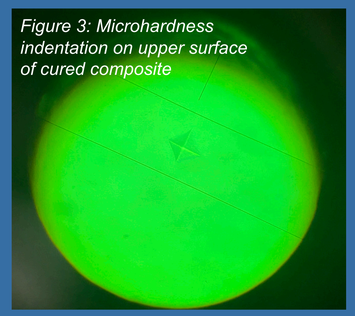


Figure 3: Microhardness indentation on upper surface of cured composite



RESULTS & DISCUSSION

Mean (standard deviation) of top, bottom hardness values and T_{max}/B ratio of the composites at 'Regular' or 'High Power' light-curing regimen and various tip-to-composite distances. Letters denote significant differences among the T_{max}/B ratio within the same composite (2-way ANOVA, significance level 0.05).

Microhardness was used to test the cure of the composites because it has a linear correlation with conversion.

Tetric PowerFill and UltraDent Mosaic exhibited different hardness and depth of cure. The average T_{max}/B hardness ratios across all Tetric and Mosaic specimens were 0.629 and 0.250, respectively. This indicated that Tetric had better curing at 2.5 mm depth compared to Mosaic.

For both composites, with regard to the light tip distances when cured at 10 s 'Regular' mode, the light tip distance of 0 mm was significantly more effective for curing the bottom than the 3 mm distance, which was more effective than the 3 mm/45° angle.

Tip Distance (mm)	Curing Time (s)	Total Energy (J/cm^2)
0	3	10.8
	5	12.2
	10	12.6
3	3	9.9
	5	12.2
	10	12.6
3 at 45º	3	8.6
	5	10.1
	10	11.9

Tetric PowerFill had better top-to-bottom hardness ratio when cured at 'High Power' mode and short curing time across the light tip distances (T_{max}/B ratio ~ 0.6) than Mosaic (T_{max}/B ratio ~ 0.2).

As seen in the table, total energy delivered trends with increased curing time for all distances.

CONCLUSIONS

Our study serves as supportive evidence for the importance of proper light tip angulation, minimal tip-to-composite distance, and increased curing time when using materials that rely on photoinitiated polymerization. Material choice and curing regimen affected the effectiveness of curing at the bottom surface, representing the depth of a slot preparation. This study is clinically relevant within the scope of pediatric dentistry due to the potential difficulty facing practitioners with regard to accurate handling a curing light on a potentially uncooperative and highly mobile pediatric patient.

ACKNOWLEDGEMENTS

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