ORIGINAL RESEARCH

Light Transmission for a Novel Chairside CAD/CAM Lithium Disilicate Ceramic

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Abstract

Aim: To evaluate light transmission in a novel chairside CAD/CAM lithium disilicate ceramic with different thicknesses and with and without polishing.

Materials and methods: Sixty flat samples (10 specimens/group) were fabricated from novel chairside CAD/CAM lithium disilicate ceramic blocks (Amber Mill, Hass Bio) with different thicknesses and with and without polishing as follows: (1) 1.0 mm thickness without polishing (1.0NoP); (2) 1.0 mm thickness with polishing (1.0Po); (3) 1.5 mm thickness without polishing (1.5NoP); (4) 1.5 mm thickness with polishing (1.5Po); (5) 2.0 mm thickness without polishing (2.0NoP); and (6) 2.0 mm thickness with polishing (2.0Po). Specimens were polished with a polishing system for lithium disilicate restorations following the manufacturer's recommendations. Light transmission was evaluated with a curing radiometer. Obtained data were subjected to two-way ANOVA followed by Tukey's *post hoc* tests ($\alpha = 0.05$). SEM observations were conducted to evaluate surface microstructure.

Results: The light intensity through the lithium disilicate blocks with and without polishing was 200.9 mW/cm^2 (16.1%) and 194.4 mW/cm^2 (15.6%) for 1.0 mm specimens, 119.3 mW/cm^2 (9.5%) and 111.9 mW/cm^2 (9.0%) for 1.5 mm specimens, and 102.3 mW/cm^2 (8.2%) and 96.0 mW/cm^2 (7.7%) for 2.0 mm specimens. SEM images showed a smoother surface with polishing compared to nonpolished specimens.

Conclusion: The thickness and polishing of the restorations were both significant influential factors in light transmission.

Clinical significance: The range of light transmission percentage through the novel chairside CAD/CAM lithium disilicate blocks was 7.7–16.1%, suggesting that light attenuation through the material may influence the polymerization reaction of resin luting cement in the bonding process.

Keywords: CAD/CAM, Ceramics, Light transmission, Lithium disilicate, Polishing, Thickness.

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Introduction

Computer-aided design and computer-aided manufacturing (CAD/CAM) technology for dentistry was introduced in the 1980s and has become a very common technology in both clinic and laboratory.[1] Early applications of the novel technology focused on fabricating inlay restorations to be delivered the same day in the dental chair.[2] Currently, chairside CAD/CAM systems allow clinicians to fabricate a large variety of restorations including single and multiple crowns, inlays, onlays, veneers, fixed resin dental bonded prosthesis, implant prosthesis, night guards, diagnostic models, and surgical guides.[3–5] Furthermore, CAD/CAM technology allows clinician to even do full mouth reconstructions in less appointments and with more comfort to the patient.[6,7]

Dental ceramics fabricated for use in chairside CAD/CAM systems have evolved tremendously in recent years and have demonstrated their longevity and improved optical and mechanical properties.[8] Chairside CAD/CAM ceramics are fabricated in dense blocks for single or multiple restorations, and blocks should be able to be milled rapidly, resisting the subtractive process, and be finished easily before cementation.[9] Lithium disilicate has become one of the most common chairside CAD/CAM ceramic blocks because of its advantages such as esthetics and high fracture resistance. Chairside CAD/CAM material is available in high translucency, medium translucency, and low translucency blocks in pre-sintered stage and clinician needs to fully sinter in-office prior cementation.[10]

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Given the success of the first commercial chairside CAD/CAM lithium disilicate block, e.max CAD (Ivoclar Vivadent), many other companies are also developing lithium disilicate blocks.[11] Amber Mill (Hass Bio, Gangneung, Gangwon-do, South Korea) is a novel chairside CAD/CAM material, and its manufacture claims to have improved optical properties such as translucency, opalescence, and fluorescence that are key factors for esthetic results. Optical properties of ceramic restorations are vital since they can influence the polymerization reaction of the resin luting cement as a result of light attenuation during the bonding process.[12] Recent studies evaluating mechanical properties on this novel ceramic have demonstrated positive results.[13,14] However, there are no studies evaluating the degree of light transmission in the novel chairside CAD/CAM lithium disilicates. The degree of light transmission through a dental ceramic is important to know so clinician can select in between light- and self-cured resin cement.

The purpose of this study was to evaluate the LED light transmission of a novel chairside CAD/CAM lithium disilicate ceramic (Amber Mill, Hass Bio) with different thicknesses and with and without polishing. The first null hypothesis tested was that there would be no difference in light transmission among different thicknesses. The second null hypothesis was that there would be no light transmission difference between polished and nonpolished specimens.

Materials and Methods

Sixty flat specimens were obtained with a low-speed precision cutting machine (Isomet; Buehler, Lake Bluff, Illinois, USA) from novel chairside CAD/CAM lithium disilicate blocks (Amber Mill, Hass Bio, Gangwon-do, Korea) and divided into six groups ($n = 10$/group). The sectioned specimens had different thicknesses and were treated with and without polishing as follows: (1) 1.0 mm thickness without polishing (1.0NoP); (2) 1.0 mm thickness with polishing (1.0Po); (3) 1.5 mm thickness without polishing (1.5NoP); (4) 1.5 mm thickness with polishing (1.5Po); (5) 2.0 mm thickness without polishing (2.0NoP); and (6) 2.0 mm thickness with polishing (2.0Po). The thickness of the sectioned specimens was evaluated with a digital caliper (Absolute Digimatic Caliper, Mitutoyo, Kawasaki, Japan).

All prepared specimens were sintered at the temperature and time recommended by the manufacture in order to obtain high translucency. Half of the specimens of each different thickness were polished with a polishing system for lithium disilicate restorations (K0293 IPS e.max Chairside Adjustment and Polishing System, Brasseler USA, Savannah, Georgia, USA) following the manufacturer's recommendations. Each specimen was evaluated for light transmission with a LED light curing unit (Allegro, Den-Mat, Lompoc, California, USA) using a curing radiometer (LM-1 LED Light Meter, Guilin Woodpecker Medical Instrument, Guilin, China) and recording the average light intensity through the specimen in mW/cm^2.

The microstructure of the ceramic specimen was observed with a tabletop scanning electron microscopy (SEM, TM3000, Hitachi-High Technology, Tokyo, Japan). A thin coating of gold was applied to the specimens in a sputter coater (Quick Coater Type SC-701, Sanyu Electro, Tokyo, Japan) to give electron conductivity. The samples were observed in order to evaluate the microstructure of the surface of the ceramic with different thicknesses with and without polishing provided.

The data were analyzed using statistics software (SPSS ver.20, IBM, Armonk, New York) using two-way analysis of variance (ANOVA) at a significance level of 0.05 ($p < 0.05$) followed by a Tukey HSD *post hoc* test to determine the differences between the groups.

Results

Table 1 shows the mean values, standard deviations, and percentage of light transmission representing the translucency of ceramic specimens. Influences of ceramic thickness and surface condition are presented. Two-way ANOVA proved that thickness and polishing significantly affect the transmittance of the ceramic specimens ($p < 0.05$).

The transmittance was significantly affected by the ceramic thickness ($p = 0.01$). For ceramic, 1.0-mm-thick specimens showed the highest transmittance values and percentage compared with other groups ($p < 0.05$). As ceramic thickness increased, transmittance ceramic 1.5 and 2.0 mm thick both decreased significantly ($p < 0.05$), indicating a reduction in translucency.

As to the groups of 1.0, 1.5, and 2.0 mm thick, the transmittance of polished specimens was statistically significantly higher than unpolished specimens ($p < 0.05$), indicating that the translucency increased after surface polishing. On the other hand, there was a negative correlation between ceramic thickness and polishing ($p = 0.98$).

The results of SEM analysis of polished surfaces showed different morphological patterns compared to original unpolished surfaces (Figs 1 to 6). The untreated (unpolished) ceramic surface specimens showed some porosity and rougher appearance across their surfaces than the polished group, irrespective of the ceramic thickness. Polished surfaces showed a regular morphology with some striations. The surface irregularities and voids were reduced by polishing, even though some voids still persisted (Fig. 6). In addition, polished surfaces appeared to be the smoother, with some remnants of the polishing paste.

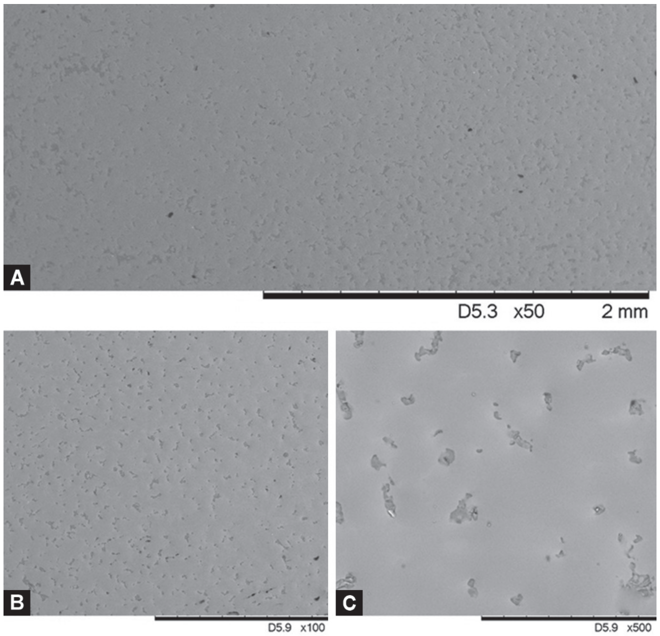
Discussion

This study evaluated LED light transmission for a novel chairside CAD/CAM lithium disilicate ceramic (Amber Mill, Hass Bio). The results indicated that the amount of light transmission changes significantly depending on the thickness and on whether the specimens are polished. Thus, both null hypotheses, (1) there would be no difference in light transmission between different thicknesses and (2) there would be no light transmission difference between polished and nonpolished specimens, were rejected.

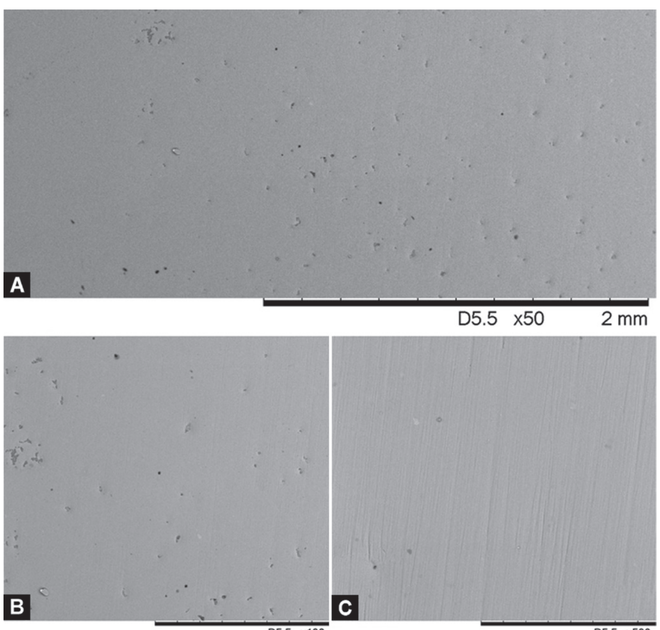
Table 1: Light transmittance values (mW/cm^2) and percentage as function of ceramic thickness and surface condition obtained using a LED light curing and radiometer

Surface condition	*Ceramic thickness*		
	1.0 mm	*1.5 mm*	*2 mm*
Without polishing (NoP)	194.40 ± 12.38^a 15.6 %	111.90 ± 9.05^b 9.0 %	96.00 ± 6.04^c 7.7 %
With polishing (Po)	200.90 ± 13.30^d 16.1 %	119.30 ± 8.46^e 9.5 %	102.30 ± 7.21^f 8.2 %

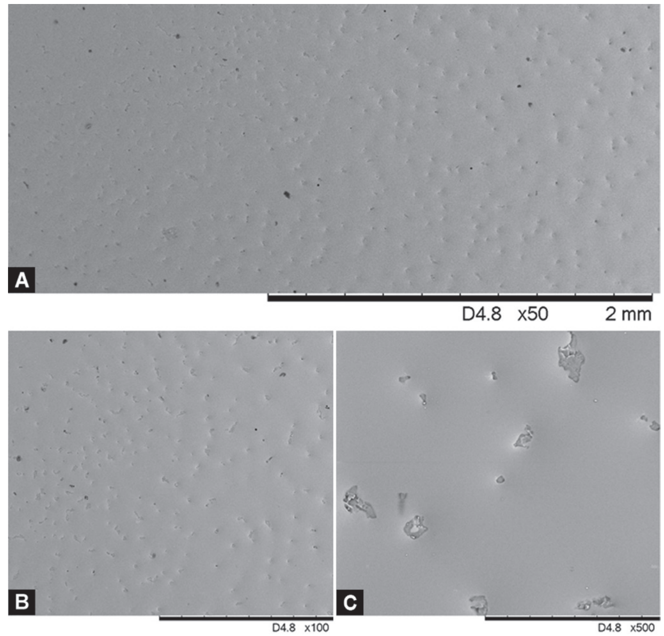
Data are presented as mean ± standard deviation values and light transmission percentage ($n = 10$); Different superscript lowercase letters indicate that there were statistically significant differences within each column ($p < 0.05$)



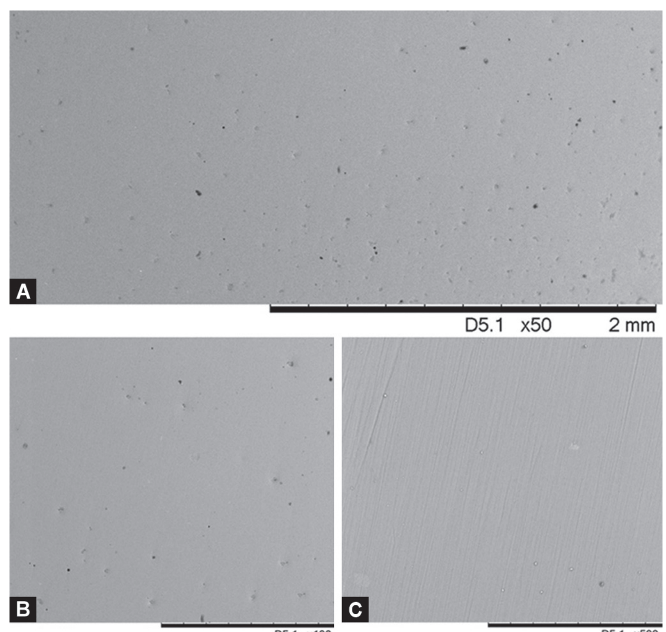
Figs 1A to C: SEM images of Group I—Amber Mill of 1.0 mm thickness without polishing treatment at magnifications of (A) ×50; (B) ×100; (C) ×500



Figs 2A to C: SEM images of Group II—Amber Mill of 1.0 mm thickness with polishing treatment at magnifications of (A) ×50; (B) ×100; (C) ×500. In higher magnifications, some striations are seen

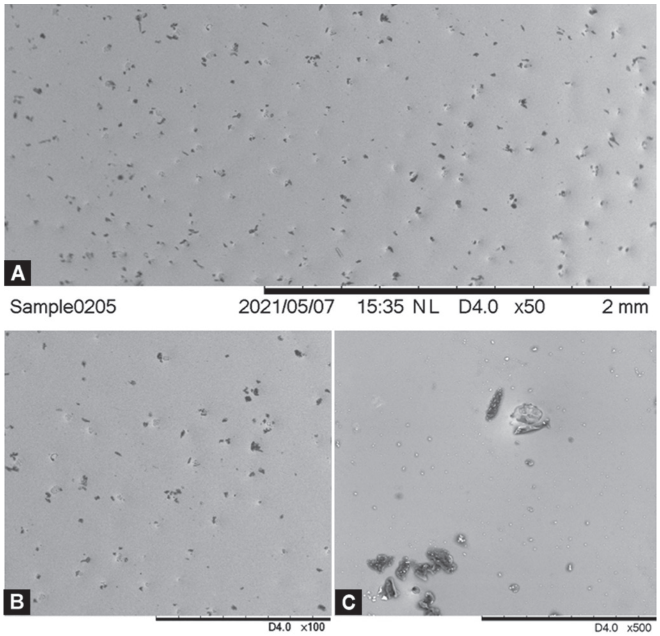


Figs 3A to C: SEM images of Group III—Amber Mill of 1.5 mm thickness without polishing treatment at magnifications of (A) ×50; (B) ×100; (C) ×500

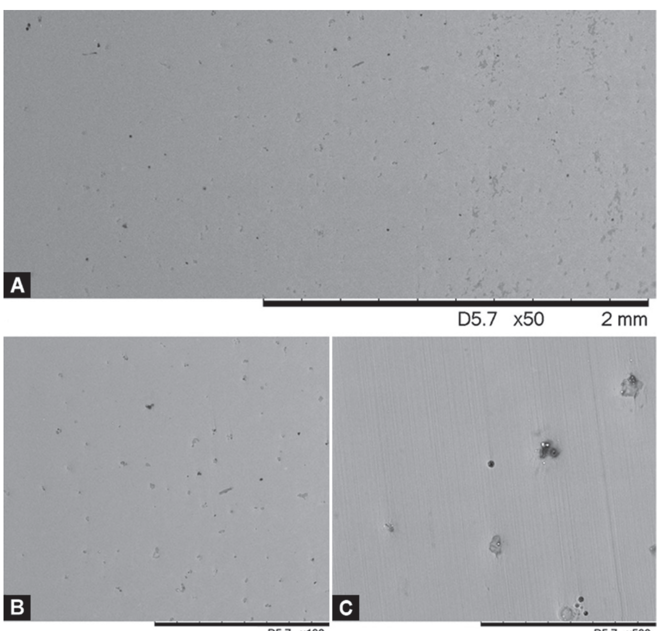


Figs 4A to C: SEM images of Group IV—Amber Mill of 1.5 mm thickness with polishing treatment at magnifications of (A) ×50; (B) ×100; (C) ×500. In higher magnifications, some striations are seen

The specimens in the present study were prepared in thicknesses that resembled clinical conditions. For instance, in an anterior restoration, the thickness of the ceramic may be around 1 mm at the margins, potentially increasing to 1.5–2 mm on the incisal edge or cuspal areas. The curing radiometer used in this study is capable of measuring the light intensity of the LED light curing unit through the prepared block, taking into account the radiating surface area as well as the light emitted. The measured light transmission percentage through polished blocks was 16.1% for 1.0, 9.5% for 1.5, and 8.2% for 2 mm thickness (Table 1). A previous study reported that the light transmission percentage through conventional lithium disilicate blocks was lower than 15% for 1 mm and 10% for 2 mm thickness.[15] Therefore, the results with novel chairside CAD/CAM lithium disilicate blocks were consistent with the previous study with the conventional equivalent, and the light transmission ability of the newer lithium disilicate was similar to the conventional one.



Figs 5A to C: SEM images of Group V—Amber Mill of 2.0 mm thickness without polishing treatment at magnifications of (A) ×50; (B) ×100; (C) ×500



Figs 6A to C: SEM images of Group VI—Amber Mill of 2.0 mm thickness with polishing treatment at magnifications of (A) ×50; (B) ×100; (C) ×500. In higher magnifications, some striations and fine flaws are seen

This would suggest that the thickness of restorations made of lithium disilicate blocks would have a strong effect on the polymerization reactions of resin luting cements in the bonding process. However, a previous study has shown that there was no difference in the microhardness of dual-cure resin luting cement cured through 1.0 or 2.0 mm thickness of conventional lithium disilicate, the value when cured through more than 3 mm thickness was below the critical threshold.[16] Manufacture recommends to fabricate restorations with 1.0 mm thickness with polishing treatment therefore, so Group II (1.0Po) can be considered as the control group. Furthermore, the thickness of most of chairside CAD/CAM ceramic restorations is less than 2 mm,[17] and thus, light attenuation through the restoration may not pose a problem for the polymerization reaction for dual-cure resin luting cement, even though a reduction of light transmission of more than 90% was seen with the restorations of 1.5 and 2.0 mm thickness. However, in addition to the thickness of the restorations, the shade of the lithium disilicate blocks, the light source, the distance to the restoration, the chemical composition of the resin luting cements, and the light intensity of the curing unit are also considered to influence the polymerization reactions of dual-cure resin luting cements. It is therefore important to bear in mind that the thickness of the restoration may interact with these other factors to give a significant effect on polymerization. Further, these results indicate that clinicians should also be careful of the influence of the surface condition of chairside CAD/CAM lithium disilicate on light transmittance.

The SEM observations of specimens showed that, unsurprisingly, nonpolished specimens exhibited more surface irregularities compared to polished specimens (Figs 1 to 6). The observed differences influence the light intensity transmitted, as the polishing reduces roughness and enhances light transmittance through the block. These results reinforced the importance of appropriate polishing of restorations after occlusal adjustment not only for appearance but also for light transmittance through the restorations.

Further, many companies are currently developing their own chairside CAD/CAM lithium disilicate blocks, and they claim that these have modified and improved optical properties in comparison to conventional equivalents. In the case of one novel lithium disilicate block, Amber Mill, the material showed similar light transmittance to conventional equivalent, but other materials may differ. This indicates it is important for clinicians to make decisions and plan clinical handling based on the properties of each material. However, there is still little data on the properties of these materials, and further studies are desirable to evaluate more novel pre- and fully sintered chairside CAD/CAM lithium disilicate ceramics available on the market.

Conclusion

The results of this study indicate that light transmission decreases as the thickness of the novel chairside CAD/CAM lithium disilicate ceramic (Amber Mill) increases. Moreover, polishing for material significantly influences the amount of light transmitted through it.

Clinical Significance

This study provides evidence that the thickness and polishing of the restorations were both significant influential factors in light transmission. It is important to ensure adequate light transmission through the CAD/CAM restorations to polymerize the light-cured resin cements. Incomplete cement polymerization can adversely affect its physical and biological properties, including surface hardness, color stability, toxicity from residual monomers, and bond strength between the tooth and the ceramic restoration.[18–20]

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