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Effect of Surface Conditioning with Airborne-Particle Abrasion on Certain Properties of Nano-Ceramic Material

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A paper extracted from Doctor Thesis entitled “Effect of Surface Conditioning with Airborne-Particle Abrasion on Certain Properties of Nano-Ceramic Material Luted with Different Types of Resin Cements”

ABSTRACT

Purpose: This study was conducted to evaluate the influence of air born-particle abrasion using three sizes of AL_2O_3; (50 μm, 110 μm, 150μm) on translucency and flexure strength of resin nano-ceramic (Lava Ultimate) material. **Materials and Methods** Forty samples were divided into 4 groups (n=10) according to the type of surface treatment conducted: **Group (1):** Lava Ultimate samples with no surface treatment (control group), **Group (2):** Lava Ultimate samples air- abraded with AL_2O_3 particle size 50μm, **Group (3):** Lava Ultimate samples air- abraded with AL_2O_3 particle size 110μm and **Group (4):** Lava Ultimate samples air-abraded with AL_2O_3 particle size 150μm, Translucency was determined using a portable reflective spectrophotometer and biaxial flexure strength test with a ball on ring was conducted. Data were statistically analyzed. **Results:** Samples treated with 110 um particle size (group 3), recorded the highest mean translucency value, meanwhile the lowest mean value was recorded for 150 um particle size treated samples (group 4). Regarding biaxial flexural strength 150 um particle size treated samples (group 4), recorded the highest mean value, meanwhile the lowest mean value was recorded the control group. **Conclusions**: Air- abrasion can be done with different particle size without affecting translucency and biaxial flexural strength of Lava Ultimate.

KEYWORDS

Lava Ultimate, Airborne-Particle Abrasion, Translucency, Biaxial Flexure Strength.

INTRODUCTION

Owing to the increased demand for safe and esthetically pleasing dental materials, new high strength ceramic materials have been recently introduced as restorative materials for dental use [1,2]. Since these materials have proved to be inimical to conventional dental

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processing technology, new sophisticated processing technologies and systems have been anticipated for introduction into dentistry. In relation to the rapid progress being made in computer-assisted processing technology in various industries since the 1970s, research and development of dental CAD/CAM systems has been actively pursued worldwide [3-5].

A recently introduced unique CAD/CAM block is based on the integration of nanotechnology and ceramics. This nanoceramic material (Lava Ultimate) is purported to offer the ease of handling of a composite material with the surface gloss and finish retention similar to porcelain. Lava Ultimate contains three ceramic filler particles. Silica particles of 20 nm, zirconia particles of 4nm to 11nm, and agglomerated nanoparticles of silica and zirconia with approximately 80% ceramic load, all embedded in a highly cross-linked polymer matrix[6].

Restorative materials are often tested by subjecting standardized beams to a 3 or 4-point flexural cyclic load. Only 2 modes of fatigue can be simulated by this process: contact and flexure. However, loading a restored tooth in a 3-point/facet contact can generate a large variety of stresses (compressive, tensile, shear), as well as water sorption and aging in wet conditions creating a totally different environment [7].

Apast study determined the flexural strength (σf), flexural modulus (Ef) and fracture toughness (KIC) of two nano-ceramic resin composite CAD/CAM blocks (Lava Ultimate and Enamic) and compared them to those of CAD/CAM IPS e.max glass ceramic. Properties of Lava Ultimate and Enamic were considerably lower than those of IPS e.max. Aging of Lava Ultimate and Enamic lowered their flexural strength (σf) by 27 % and 12 % respectively but increased their fracture toughness (KIC) by 10 % and 40 %, respectively. Aging also significantly lowered flexural modulus (Ef) of both materials. The (σf) of Enamic was statistically significantly lower than that of Lava Ultimate, while the (Ef) of Enamic was statistically significantly higher [8].

Translucency is an important factor for achieving clinically acceptable results in esthetically demanding areas.

Beside the translucency of restorative materials, it is of particular interest whether the materials exhibit fluorescent properties, as this parameter impacts the optical behavior of dental restorations in the oral cavity. The light transmission of a resin material is related to multiple refractions and reflections at the matrix/filler interfaces, which are influenced by the difference in refractive indices between the filler particles and the matrix. Differences also occur regarding the fluorescence properties of the individual materials. To achieve increased esthetic integration of the restorations, the ideal restorative material should have similar translucency and fluorescence properties as a natural tooth. Therefore, it can be assumed that the occurring differences in the fluorescence properties originate from the application of different rare earth elements and different amounts of them in the materials [9].

A previous study compared the light translucency and fluorescence of five manual and eleven CAD/CAM polymer materials with different compositions to a glass-ceramic material (Vita Mark II) using a spectrophotometer. Disk-shaped test-specimens from each material with comparable shades (A3) were prepared. The intensity of the monochromatic light, Io, and the light, I, transmitted through the specimen was continuously measured at 2 nm intervals at visible light wavelengths (λ) from 400 nm to 700 nm. The transmission coefficients (tc) [%] were calculated by the software of spectrophotometer for each wavelength. Tested polymers recorded light transmission values ranged between (33.6%-54.5%) with Lava Ultimate nano-ceramic recording (47.1%) while glass-ceramic Vita Mark II recorded (50.8%). The study stated that polymers show varying translucent and fluorescent properties when compared with glass-ceramics of the same color [10].

Another study evaluated the translucency of restorative CAD/CAM materials and direct composite resins with respect to thickness and surface roughness. 240 disk-shaped specimens (12×14×1 mm and 12×14×2 mm) of 3 different CAD/CAM glass ceramics (CELTRA Duo, IPS e.max CAD, IPS Empress CAD), (VITA Mark II), (VITA Enamic), (LAVA Ultimate), an experimental (CAD/CAM nanohybrid composite resin), 2 interim materials (Telio CAD; VITA CAD-Temp), and 3 direct composite resins (Tetric EvoCeram; Filtek Supreme XTE; Tetric EvoCeram Bulk Fill) were fabricated. After three different surface pretreatments (polishing, roughening using SiC P1200, or SiC P500), absolute translucency and surface roughness were measured using spectrophotometry and tactile profilometry. The greatest influence on the measured translucency was thickness, closely followed by type of material, and the pretreatment method. The surface roughness was strongly influenced by the pretreatment method and type of material. It was concluded that thickness and surface roughness are major factors affecting the absolute translucency of adhesively luted restorations [11].

MATERIALS AND METHODS

Lava-Ultimate blocks were milled by diamond micro-saw with cutting speed 2500 rpm, using diamond disk 0.7 mm thickness under cooling system: water coolant: anticorrosive agent (30:1). (Guilin Measuring & Cutting Tool Co., Ltd China (Mainland).

Forty circular disc samples, of 10 mm diameter and 1.5 mm thickness were confirmed using digital caliper. Milled Lava-Ultimate samples were milled and air abraded according to the following procedure: One surface of each sample was marked with indelible pencil. Each sample was fixed on the attachment unit of sandblasting machine (Sandstorm, vaniman manufacturing co, Fallbrook, California, USA) and the marked surface was sandblasted according to the following parameters: Pressure: 2 bars, Time: 10 seconds, Distance: 10 mm [12] Al_2O_3 particles' sizes: 50μm or 110μm or 150μm.

Samples were divided into 4 groups (n=10) according to the type of surface treatment conducted: **Group (1),** Lava Ultimate samples with no surface treatment (control group). **Group (2),** Lava Ultimate samples air- abraded with AL_2O_3 particle size 50μm. **Group (3),** Lava Ultimate samples air-abraded with AL_2O_3 particle size 110μm. **Group (4),** Lava Ultimate samples air-abraded with AL_2O_3 particle size 150μm. The conditioned surface of each sample was cleaned using 70 % alcohol concentration (PURE Misr) using brush. The samples were then immersed in an ultrasonic bath of distilled water (Exceed Pharma Egypt) for 5 minutes then gently dried with compressed air. Samples were stored in an air tight clean container to avoid contamination. Samples in each group were used to conduct the following examinations:

a. Translucency determination (10 samples).

b. Biaxial flexure strength determination (10 samples).

Testing Procedures:

a. Translucency (TP)*:*

Translucency Parameter (TP) represents the color difference between a material of uniform thickness over a black and a white background, and corresponds directly to a common visual assessment of translucency. Ten TP samples for each group were measured using a portable Reflective spectrophotometer, The aperture size was set to 4 mm and each sample was exactly aligned with the device.

The TP values were calculated by using the following equation: TP= [(Lb* - Lw*)2 + (ab* - aw*)2 + (bb* - bw*)2]1/ 2

Where letters "b" and "w" refer to color coordinates over the black and white backgrounds, respectively.

b. Biaxial Flexure Strength:

A Biaxial flexure test (uniform pressure on disc) with a ball on ring was conducted. Testing was done at a cross-head speed of 1 mm/min with a computer controlled materials testing machine (Model LRX-plus; Lloyd Instruments Ltd., Fareham, UK) with a load cell of 5kN and data were recorded using computer software (Nexygen-4.1; Lloyd Instruments). The test was conducted at room conditions (30±1°C, and 70% ±5% relative humidity). The disc sample was supported along its periphery on ring with a diameter of 8 mm. Discs were loaded centrally with a round indenter of 2.7-mm diameter. The polished surface of the disc was the tension side while the unpolished surface was the loaded one. A thin sheet of tin foil was placed between each sample and load applicator tip to facilitate a uniform distribution of the load. The bi-axial flexure strength was calculated according to the following equation:

$$\sigma = P/h2 \{(1+v) [0.485x \ In(a/h) + 0.52] + 0.48\}$$

Statistical analysis

Data analysis was performed using Aasistat 7.6 (Campina Grande, Paraiba state, Brazil) statistics software for Windows. P values ≤0.05 are considered to be statistically significant in all tests.

RESULTS

I) Results of Translucency parameter: (Table 1)

The results showed that samples treated with 110 um particle size (group 3), recorded the highest mean translucency value (14.179±2.2) followed by control non-treated samples, (group 1), (13.558±1.4), then 50 um particle size treated samples, (group 2), (13.228±0.3). Meanwhile the lowest mean value was recorded for 150 um particle size treated samples, (group 4), (12.934±0.25). ANOVA showed that, there was no significant difference between control group and different surface treated groups.

Table (1) *Mean values, standard deviation (SD) and statistical analysis of translucency parameter for all surface treatment groups*

Groups	***Translucency parameter***		***Statistics***
	Mean values± SD	***Rank***	***ANOVA***
Group(1)Control no-treatment	13.558±1.4	A	*P* value 0.3432 Ns
Group(2) 50 um	13.228±0.3	A	
Group(3) 110 um	14.179±2.2	A	
Group(4) 150 um	12.934±0.25	A	

Different letters in the same column indicate statistically significant difference (p < 0.05);

**significant (p < 0.05) ns; non-significant (p>0.05)*

II) Biaxial flexure strength (MPa): (Table 2)

The results showed that 150 um particle size treated samples, (group 4), recorded the highest mean value (239.1369±15.06 MPa) followed by 110 um particle size treated samples, (group 3), (235.0398±21.42 MPa) then 50 um particle size treated samples, (group 2), (231.3911±37.22 MPa). Meanwhile the lowest mean value was recorded with control non-treated (group 1), (212.5761±30.13 MPa). The difference between **control** group and **different surface treated** groups was statistically **non-significant** as indicated by one-way ANOVA (F=2.01, P=0.1492 > 0.05).

Table (2) *Mean values, standard deviation (SD) and statistical analysis of biaxial flexure strength results for all groups.*

Variables	*Biaxial flexure strength*		*Statistics*
	Mean values± SDs	*Rank*	*ANOVA*
Group(1)Control no-treatment	212.5761±30.13	A	*P* value 0.1492 Ns
Group(2) 50 um	231.3911±37.22	A	
Group(3) 110 um	235.0398±21.42	A	
Group(4) 150 um	239.1369±15.06	A	

Different letter in the same column indicating statistically significant difference (p < 0.05)

**; significant (p < 0.05) ns; non-significant (p>0.05)*

DISCUSSION

As a newly introduced material; verification and reliability of Lava Ultimate should be validated through in-vitro as well as in-vivo studies. Mechanical, biological and esthetic characterization of this material should be tested thoroughly. Moreover; bonding capacity of restorative material is considered a major key to success in adhesive dentistry. Promoting bonding to resin cement is a widely investigated field where materials' surface treatment gains a major interest. Air abrasion was identified as a key –factor in establishing a durable bond between the luting agent and the restoration [13].

In the present study; surface treatment of Lava Ultimate RNC using air abrasion was investigated. Three particles' sizes were examined (50um, 110um, and 150um particle sizes) and compared to non-treated control samples. The effect of these surface treatments on shear bond strength of resin cements which utilize different adhesive strategies was tested in addition to its effect on translucency, flexural strength, and surface topography of Lava Ultimate.

Translucency is an important factor for achieving clinically acceptable results in esthetically demanding areas. In the present study the translucency of resin-nanoceramic Lava Ultimate samples was measured after air abrasion (AL_2O_3) using size 50 um, 110 um and 150 um particles in comparison to control, where no surface treatment was conducted.

There are three methods of quantifying the translucency of materials: direct transmission, total transmission, and spectral reflectance [14].In the present study a portable Reflective spectrophotometer; a commonly used method to quantitatively measure color and translucency in dentistry [15-16] was used. Different parameters can be used to describe translucency, such as the contrast ratio or the translucency parameter (TP), which makes it difficult to compare studies [17-19].

Translucency of dental ceramics is influenced by factors such as crystalline structure, grain size, pigments, as well as number, size, and distribution of defects, and porosity. [20-21] If the crystals are smaller than the wavelength of visible light (400 to 700 nm) the glass will appear transparent; however, in case of light scattering and a diffuse reflection, the material will appear opaque [22].

Within the limitation of thickness used in this study (1.5mm) equal to the thickness of shoulder finish line of all ceramic restorations there was no significant difference in translucency of Lava Ultimate after different surface treatment used, (table 1) The null hypothesis was thus accepted. Air abrasion using (AL_2O_3) particles of different sizes (50 um, 110 um and 150 um) can be done safely without affecting the selected shade and translucency of lava ultimate restorations.

The nanofiller particle sizes could explain the high translucency of lava ultimate, because particles with a diameter smaller than the wavelength of visible light cause less light scattering and absorbance [11]. While no one property can be used to predict a material's clinical success or failure;

parameters such as flexural strength, flexural modulus, and modulus of resilience provide insight into the dynamic behavior of these materials under simulated occlusal stresses [23].

Flexural strength can be measured using a three-point flexure test, a four-point flexure test or a biaxial flexure test. Fabrication of samples for three-point and four-point flexural tests can introduce edge-defects that may not present the standard clinical conditions. The quality of samples for this type of test is thus highly dependent on the superficial finish at the edges; where fracture begins, values thus show great variations [24, 25].

On the contrary, biaxial flexural strength test does not involve edge chippings or fractures because this area is not subjected directly to the load, producing less variation in the resulting values. Accordingly, biaxial flexure testing is becoming widely recognized as a reliable technique for studying brittle materials, since the maximum tensile stress occurs within the central loading area and edge failures are eliminated. The biaxial stress state is possibly more severe than the uniaxial type and thus better suited to conservative strength design, with practical similarities to stresses occurring within the thin tooth section [26]. In the present study biaxial flexure strength was measured for Lava Ultimate using circular discs 10mm diameter and 1.5mm thickness for all groups.

Results of biaxial flexural strength determination of the present study revealed that *150 um* particle size treated samples, group (4), yielded higher values than 110 *um*, 50 *um* and control groups respectively; However, differences were not statistically significant (table 2). The null hypothesis was thus accepted for the flexural strength as the particle size used for air abrasion did not affect the flexural strength of lava ultimate samples.

CONCLUSIONS

Within the limitations of this study, the following can be concluded:

1. Air-abrasion can be done with different particle size without affecting translucency of Lava Ultimate.
2. Biaxial flexural strength of Lava Ultimate is not affected by air born-particle abrasion.

REFERENCES

1. Raigrodski AJ and Chiche GL. The safety and efficiency of anterior ceramic fixed partial dentures. A review of the literature. J Prosthet Dent 2001; 86: 520- 25.
2. Raigrodski AJ. Contemporary materials and technologies for all-ceramic fixed partial dentures. A review of the literature. J Prosthet Den 2004; 92: 557- 62.
3. Mormann WH, Brandestini M, Lutz F, Barbakow F. Chair side computer-aided direct ceramic inlays. Quintessence Int 1989; 20: 329- 39.
4. Duret F and Preston JD. CAD/CAM imaging in dentistry. Curr Opin Dent 1991; 1: 150- 54.
5. Rekow ED. Dental CAD/CAM systems: what is the state of the art? J Am Dent Assoc 1991; 122: 43- 8.
6. Dennis J. Fasbinder: Chairside CAD/CAM. Inside Dentistry Published by AEGIS Communications 2012; 8:5.
7. Park SH, Yoo YJ, Shin YJ, Cho BH, Baek SH. Marginal and internal fit of nano-composite CAD/CAM restorations. Restor Dent Endo 2016; 41:37-43.
8. Chaimongkon P and Sanohkan S. Effect of thermocycling on flexural strength and weibull statistics of machinable glass–ceramic and composite resin. J Indian Prosthodont Soc 2013; 13:191-213.
9. Albero A, Pascual A, Camps I, Grau-Benitez M. Comparative characterization of a novel CAD/CAM polymer-infiltrated-ceramic-network. J Clin Exp Dent 2015; 7:495-500.
10. 10.Nakajima M, Arimoto A, Prasansuttiporn T, Thanatvarakorn O, Foxton RM, Tagami J. Light transmission characteristics of dentine and resin composites with different thickness. J Dent 2012; 40: 77-82.
11. Guth J, Zuch T, Zwinge S, Engels J, Stimmelmayr M, Edelhoff D. Optical properties of manually and CAD/CAM-fabricated polymers J Dent Mater 2013; 32:865–71.
12. Stawarczyk B, Basler T, Ender A, Roos M, Mutluzcan, Christoph H. Effect of surface conditioning with airborne-particle abrasion on the tensile strength of polymeric CAD/

CAM crowns luted with self-adhesive and conventional resin cements. J Prosthet Dent 2012; 107: 94-101.

13. Battaglia D, Cerutti F, Augusti G, Tranchida F, Augusti D. Effects of sandblasting on early bond strength. J Dent Mater 2014; 30: 1–180.
14. Kara HB, Dilber E, Koc O, Ozturk AN, Bulbul M. Effect of different surface treatments on roughness of IPS empress 2 ceramic. Lasers Med Sci 2012; 27:267-72.
15. Chen YM, Smales RJ, Yip KH, Sung WJ. Translucency and biaxial flexural strength of four ceramic core materials. J Dent Mater 2008; 24:506-11.
16. Ahn JS and Lee YK. Difference in the translucency of all-ceramics by the illuminant. J Dent Mater 2008; 24:1539-44.
17. Wang F, Takahashi H, Iwasaki N. Translucency of dental ceramics with different thicknesses. J Prosthet Dent 2013;110:14-20.
18. Barizon KT, Bergeron C, Vargas MA, Qian F, Cobb DS, Gratton DG, et al. Ceramic materials for porcelain veneers. Part I: Correlation between translucency parameters and contrast ratio. J Prosthet Dent 2013; 110:397-401.
19. Bagis B and Turgut S. Optical properties of current ceramics systems for laminate veneers. J Dent 2013; 41:24-30.
20. El-Meliegy M. Preparation and characterization of low fusion leucite dental porcelain. Br Ceram Trans 2003; 102:261-4.
21. Ilie N and Hickel R. Correlation between ceramics translucency and polymerization efficiency through ceramics. J Dent Mater 2008; 24:908-14.
22. Van Noort R. Introduction to dental materials - 4th Edition: Elsevier Inc. Mosby Ltd; 2013; 231-46.
23. Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P, et al. Buonocore memorial lecture. Adhesion to enamel and dentin: Current status and future challenges. Oper Dent 2003; 28: 215-35.
24. Yilmaz H, Aydin C, Gul BE. Flexural strength and fracture toughness of dental core ceramics. J Prosth Dent 2007; 98: 120–28.
25. Bhamra G, Palin WM, Fleming GJ. The effect of surface roughness on the flexure strength of an alumina reinforced all ceramic crown material. J Dent 2002; 30: 153–60.
26. Zeng K, Odén A, Rowcliffe D. Flexure tests on dental ceramics. Int J Prosth 1996; 9: 434–39.