Surface roughness of monolithic ceramic and ceramic-like CAD/CAM materials

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Abstract

The aim of this study was to compare surface roughness of three different types of chairside monolithic ceramic and ceramic-like CAD/CAM restorative materials finished and polished with two-stage diamond impregnated polishing disc systems. before- and after- clinician experience.

For each test material such as: glass ceramic (VITA Mark II, VITA-Zahnfabric, Bad Sackingen, Germany), polymer infiltrated ceramic (VITA Enamic, VITA-Zahnfabric, Bad Sackingen, Germany), nano hybrid ceramic (Lava Ultimate, 3M-ESPE, Seefeld, Germany), 20 disc shaped specimens (radius=10mm, thickness=2mm) were prepared. Then each test groups were subdivided into two groups depending on operator's experience. Finishing and polishing procedure was achieved before (n=10) and after (n=10) experience of operator, respectively.

Average surface roughness (Ra) measurement were obtained using a surface profilometer. For each test group ten specimens were prepared and roughness was measured in five different positions using a profilometer with a traversing distance of 4 mm and a cut-off value of 0.8mm. The radius of the tracing diamond tip was 5µm and measuring force and speed was 4mN and 0.5 mm/s, respectively. The surface roughness of each individual disk was taken as the arithmetic mean of the Ra values measured in five different positions.

It can be concluded that finishing and polishing of ceramic and ceramic-like CAD/CAM restorative materials are dependent both material structure and experience of operator.

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Introduction

Computer Aided Design/Computer Aided Manufacture (CAD/CAM) technology represents an important part of contemporary prosthetic dentistry. In the so-called chairside procedure, a single unit restoration can be fabricated in the dental office and delivered in a one-session appointment of reasonable time.[1]

Despite the different chemistry of ceramic and ceramic-like CAD/CAM materials, all of them are particularly indicated for monolithic restorations.[1,2] Once milled, the restorations are coarse in texture, so finishing and polishing are mandatory before delivery.[1,3] These procedeures render the surfaces smoother and more lustrous[1,4] as well as improve the restoration biocompatibility,[5] minimizing the incidence of biological complications such as plaque retention and antagonist tooth wearing.[1] Additionally, well-finished surfaces lead to less technical and esthetic problems because the material becomes tougher,[6] glossy,[7] and stable in translucency[8] and color.[9] Finishing can improve the aesthetics and longevity of tooth-coloured restorations. A rough, poorly finished surface contributes to staining, plaque accumulation and gingival irritation.[10]

A variety of instruments may commonly be used to finish tooth-coloured restorative materials. These include carbide and diamond burs, abrasive discs, abrasive finishing strips and polishing pastes.[10] Manual finishing and polishing can be affect differently ceramic and ceramic-like CAD/CAM materials. [3,7,11,12]

The aim of this study was to compare surface roughness of three different types of chairside monolithic ceramic and ceramic-like

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CAD/CAM materials finished and polished with two-stage diamond impregnated polishing disc systems using a surface profilometer by means of average surface roughness (Ra, µm) before- and after- clinician experience. The null hypothesis was no surface roughness difference between the different types of ceramic and ceramic-like CAD/CAM materials depending on before- and after- clinician experience.

Materials and methods

Materials and their specifications used in the study is given Table 1.

Material (Manufacturer)	Type	Composition
Vita Mark II (VITA-Zahnfabric)	Glass ceramic	
Vita ENAMIC (VITA-Zahnfabric)	Polymer infiltrated ceramic	Polymer-infiltrated-feldspatic ceramic-network material (UDMA, TEGDMA) with 86 wt% ceramic
Lava Ultimate ((3M-ESPE)	Nano hybrid ceramic	Composite resin material (Bis-GMA, UDMA, BisEMA, TEGDMA) with 80 wt% silica and zirconia nano particles and zirconia/silica nanoclusters
EVE Diacomp Plus Twist (EVE Ernst Vetter)	Two-stage diamond impregnated polishing discs	Flexible diamond impregnated spirals

Table 1. Materials and their specifications used in the study.

For each test material such as: glass ceramic (Vita Mark II, VITA-Zahnfabric, Bad Sackingen, Germany), polymer infiltrated ceramic (Vita ENAMIC, VITA-Zahnfabric, Bad Sackingen, Germany), nano hybrid ceramic (Lava Ultimate, 3M-ESPE, Seefeld, Germany), 20 disc shaped specimens (radius=10mm, thickness=2mm) were prepared. Then each test groups were subdivided into two groups depending on operator's experience. Finishing and polishing procedure was achieved before (n=10) and after (n=10) experience of operator, respectively. For each test specimen polishing and finishing were conducted upper surface of the specimen using two consecutive discs for 30 seconds time intervals. Pink and grey polishing wheels were sequentially applied low speed handpiece under 10,000 rpm speed and light pressure for 30 seconds. After polishing and finishing each specimen used disc was discarded. The set up was standardized bu means of a custom mold for both instrument and specimen. Mean Ra (µm) was recorded.[1] Before roughness measurements, test specimens were ultrasonically cleaned (Quantrex 90, L&R Ultrasonics, Kearny, NJ, USA) for 10 minute in a deionized water in sequence and allowed to air dry for 24 hours at room temperature before testing.

The average surface roughness (Ra) was measured utilising a surface profilometer (Surftest 211, Mitutoyo, Japan). For each test group (n=10) ten specimens were prepared and in each specimen surface roughness was measured before finishing and polishing experience and after finishing and polishing experience. In each specimen surface, Ra measurements were obtained in five different positions with a traversing distance of 4 mm and a cut-off value of 0.8 mm. The radius of the tracing diamond tip was 5µm and measuring force and speed was 4 mN and 0.5 mm/s, respectively. The surface roughness of each individual disc was taken as the arithmetic mean of the Ra values measured in five different positions. Therefore, in each test group and all tested groups 50 and 300 measurements were achieved, respectively.

The statistical analysis was performed using SPSS (version 20, IBM, Armonk, NY, USA) at an overall level of significance of at α=0.05. A two-way ANOVA with partial eta-squared statistics was performed to evaluate the effect of the factors "material" and "finishing protocol" on the following outcome variables: before finishing and polishing experience and after finishing and polishing experience.

Results

The results of roughness measurements are given in Table 2. The two way ANOVA demonstrated that the different types of ceramic and ceramic-like CAD/CAM materials and surface treatment depending on before- and after- clinician experience were significant factors for surface roughness ($p<0.001$).

Materials	Vita Mark II	Vita ENAMIC	Lava Ultimate
Before experience	0.28 (0.25 - 0.36)	0.25 (0.20 - 0.32)	0.55 (0.39 - 0.71)
After experience	0.23 (0.16 - 0.40)	0.20 (0.17 - 0.26)	0.16 (0.09 - 0.17)

Table 2. Average surface rougness Ra values for tested materials (for each test group n=10)

Average surface roughness Ra values of Vita Mark II, glass ceramic material before- and after-experience of the clinician were: 0.28 (0.25-0.36) and 0.23 (0.16-0.40)

Average surface roughness Ra values of Vita ENAMIC, polymer infiltre ceramic material

before- and after-experience of the clinician were: 0.25 (0.20-0.32) and 0.20 (0.17-0.26)

Average surface roughness Ra values of Lava Ultimate, nano hybrid ceramic material before- and after-experience of the clinician were: 0.20 (0.17-0.26) and 0.16 (0.09-0.17)

As seen Ra values were tested material dependent and Ra values decreased with increasing clinician's experience. Considering Lava Ultimate, nano hybrid ceramic material, this variation was remarkable. Vita Mark II, glass ceramic material and Vita ENAMIC, polymer infiltre ceramic material gave similar results that could be assumed as the more resistant materials than the Lava Ultimate, nano hybrid ceramic material

Discussion

In the current study, the effect of two stage diamond impregnated polishing disc on the surface roughness of different types of ceramic and ceramic-like CAD/CAM materials were evaluated. Vita Mark II, glass ceramic material and Vita ENAMIC, polymer infiltre ceramic material gave similar and different Ra values from Lava Ultimate, nano hybrid ceramic material, respectively. Therefore, the null hypothesis had to be rejected.

Except Lava Ultimate, clinician's experience didnot change initial measurements and latter measurements depending on clinician's experience. This might be explained by the differences in the microstructure of the three materials. Considering Vita ENAMIC, polymer infiltre ceramic material which exhibited least Ra values could be assumed as the more resistant material as Vita Mark II, glass ceramic material.
Surface roughness can be described by several linear (Ra, Rq, Rz) or three-dimensional (Sa, Sq, Sz) parameters[1,12,13] For the present study, Ra, which is defined as the mean arithmetical value of all the absolute distances of the profile inside of the measuring length,[3] was assessed because it is the most commonly used parameter for evaluating the effect of finishing protocols on dental ceramics.

For the present investigation, Ra, which is defined as the mean arithmetical value of all the absolute distances of the profile inside of the measuring length, was assessed because it is the most commonly used parameter for evaluating the effect of finishing protocols on dental ceramics. [1,3,10,14,15]

For the present study, the flat specimens were directly milled with CEREC MC-XL milling unit, with the twofold objective of high repeatibility of the specimens and test of the real after-milling surface, as achieved previous studies.[1,7] Polishing time played an important role in the final smoothness and luster, as perviously reported.[7] Moreover, longer polishing times might also cause greater substance loss, given that polishing is a subtractive procedure. This occurence should be given due consideration clinically.[1] Therefore, polishing time fixed as 2X30 seconds per specimen in the present study. Previous studies showed that zirconia reinforced lithium silicate (VITA Suprinity) and lithium disilicate (IPS e.max CAD) CAD/CAM materials, polishing and glazing yielded similar results with regard to surface rougness. Also, it was found that the time intervals as 30 seconds and 60 seconds were important factors for manual finishing and polishing procedures for dental ceramic materials. 60 seconds of manual finishing and polishing yielded significantly lower surface roughness than 30 seconds of manual finishing and polishing on lithium disilicate ceramic and zirconia-reinforced lithium disilicate ceramic CAD/CAM materials. Additionally, for lithium disilicate ceramic CAD/CAM material glazing sprey produced significantly higher surface roughness than the manual finishing and polishing treatment.[1]In the light of these studies, in the present study, neither glazing sprey nor glazing treatment were utilised on tested ceramic material. SEM (Scanning Electron Microscope) topographies could have been obtained in this study. However, previous studies have made SEM analysis with the similar materials, therefore it wouldnot be necessary to get SEM views.

To better understand the outcome of the present study, the obtained data have to be related to clinical requirements. Some in vivo studies[16] have suggested an ideal threshold surface roughness of 0.2µm, above which bacterial retention is facilitated and the incidence of biological complications increased. In addition, superficial roughness greater than 0.5µm can be detected by the sensorial fibers of the tongue, resulting in discomfort fort he patient.[17] Nevertheless, natural enamel roughness is reported to range between 0.64µm and 0.90µm with regard to the tooth type, location and patient age.[18,19] When referring to the clinical

acceptability of the finished surfaces, all the Ra values measured in the present study were far below the abrasive wearing threshold (1.5µm).[10,20]

From a clinical perspective it should also be noted that manual polishing systems have the main advantage of completing the in-office restoration in a single session, still ensuring comparable or better performance than glazing systems.[1,10,21] By manual polishing, the clinician finishes the in-office restoration without any thermal treatment, speeding up and simplifying the overall workflow; this is particularly relevant considering the increasing use of monolithic restorations.

Conclusions

It can be concluded that polishing of CAD/CAM restorative materials are dependent both material structure and experience of clinician. Resin nano ceramic material (Lava Ultimate, 3M-ESPE) gave lowest Ra values after clinician experience that support the importance of experience for finishing and polishing procedures.

Declaration of Intereset

The authors decleare no conflict of interest.

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