SURFACE ROUGHNESS OF LITHIUM DISILICATE PRESS CERAMICS AFTER DIFFERENT TYPES OF POLISHING

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Abstract:

INTRODUCTION: The smoothness of a ceramic's surface is very important of its esthetic and prophylactic qualities.

AIM: The purpose of this investigation is to study the possibilities of polishing lithium disilicate ceramics after making a correction on the glazed ceramic surface.

MATERIALS AND METHODS: The subject of the study were 20 test samples made of lithium disilicate press ceramics. They were divided into 4 groups according to the method of processing and polishing. Group 1 was treated with a red diamond bur and polishing set; Group 2 was treated with a green diamond bur and polishing set; Group 3 was treated with a red diamond bur, polishing set and diamond paste; Group 4 was treated with a diamond bur with green coding, polishing set and diamond paste. The samples were examined with an atomic force microscope to observe the change in surface relief. The reference point for comparison was the surface of the glazed ceramic.

RESULTS: After polishing with diamond paste, the surface became smoother compared to the treatment of the surface with a polishing kit alone.

CONCLUSION: Regardless of the polishing protocol used, there was a difference in the topography of the ceramic surface before and after treatment.

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Keywords: brushes, bur, paste, polishing

Introduction

The glass-ceramic materials processed by pressing have extremely high aesthetic qualities, good mechanical properties and wear resistance.

Crystals with a size of 2000 - 4000 nm are observed in the structure of the pressed lithium disilicate ceramics, which is important for the polishing possibilities of this particular ceramic material according to Kisov (2019). The glazing process helps to achieve a smooth surface and retains high luster for a long period of time. After adjustment, the restoration is returned to the laboratory for final glazing. Sometimes it may be necessary to adjust the construction after cementation according to Alhabdan & El-Hadjazi (2015). Unpolished ceramics can subsequently lead to a number of undesirable complications: wear of antagonists, staining, plaque retention, inflammation of the gingiva and reduction of fracture resistance as stated by Bollen et al. (1997) and da Silva et al. (2016). As Heintze et al. (2005) and Jones et al. (2004) wrote a smooth surface adds to the patient's comfort, as already a change of surface roughness in order of 0.3µm can be detected by the tip of the patient's tongue.

Observations and research by Silva et al. (2015) show that to avoid these unpleasant consequences polishing the ceramic structure to achieve a smoother surface is required. Different techniques for polishing different ceramic materials are described in the literature. Their effect on the treated ceramic surface is of great interest to the dentist and has been the subject of the studies by Wang et al. (2009), Amaya-Pajares et al. (2016), Camacho et al. (2006) and Martinez Gomiz et al. (2003). According to Kisov (2019) each dental ceramic manufacturer has created thier own polishing set. They contain combinations of diamond burs, abrasive rubbers, felts and diamond polishing paste as da Silva et al. (2004) stated. The occlusal adjustments in all-ceramic restorations shall be made in advance, in the

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laboratory, or if necessary, after their cementation. If a larger correction on the ceramic is required, the restoration can be sent back to the dental lab for re-glazing as da Silva et al. (2016) mentioned.

Aim

The aim is to present a study of the possibilities for polishing press ceramics with a crystalline phase of lithium disilicate – IPS e.max Press, Ivoclar Vivadent after treatment.

Materials and methods

The objects of the study were the surfaces of twenty test samples with a rectangular shape: 20 mm in length, 8 mm in width and 2 mm in thickness made of lithium disilicate press ceramics IPS E.max Press (Ivoclar Vivadent, Lichtenstein). The test samples were invested using investment powder and liquid Press Vest (Ivoclar Vivadent, Lichtenstein). The process of pressing was performed in Programat EP 3000 (Ivoclar Vivadent, Lichtenstein) according to the manufacturer's instructions. All samples were cleaned from the investment material, polished and glazed in the dental laboratory.

Half of the test samples were ground chairside with a red diamond bur and the other half with a green diamond bur. From all the twenty surfaces one surface was not treated with diamond burs and subsequently polished, this surface was used as a control (E0).

The polished samples were divided into four groups according to the polishing protocol and burs were used. The specimens from the Group 1 and Group 2 were polished with a two-step polishing system for press ceramics (Vita Enamic Polishing set clinical, Vita Zahnfabrik). The set contains six rubbers divided into two groups, each one with three members according to their roughness (with pink and gray coding). All test samples from Group 1 and 2 (E1 - ground with a red bur; E2 - ground with a green bur) were polished for six minutes - with every type of rubber per minute. Polishing was performed without the use of diamond polishing paste.

The test samples from Group 3 and Group 4 (E3 ground with red bur; E4 ground with green bur) were polished with the same set of rubbers in the exact same manner (with each rubber for a minute, 6 minutes in total). In this case diamond polishing paste for lithium disilicate ceramics was used at the end.

The measurements and the recordings were made using an atomic force microscope (Easyscan 2 Nanosurf - Switzerland). This type of microscopy is not based on the reflection or transmission of light waves or electron beams, but on the mechanical contact of a working tip with the tested surface, as a result of which a computer image of the surface profile is generated.

The images were made under the following conditions:

- working area of the image – square field with linear size of 49.5 μm
- resolution – the surface was divided into 256 dots for a single line with 256 lines in total. The recording speed was from 5 to 10 second per line.
- The analysis and the evaluation of the test sample's surface includes the following roughness parameters:

$$S_y = S_p - S_v$$

Results

After taking measurements of the test samples through atomic force microscopy (glazed, polished with a polishing kit with the use of diamond polishing paste and without paste) it was found that in all types of processing, the glazing without additional treatment provided the smoothest surfaces. The values of the surface roughness of the samples that were glazed without treatment were significantly lower than the values of the other samples. Using the atomic force microscopy method, data on the displacement of the needle in the vertical direction for each measured point on the surface was recorded. This displacement had vector properties in a direction perpendicular to the surface. The reference point of all vectors begins from the base (middle) line in a horizontal direction.

From the comparison of the values of the surface roughness parameters it was evident that when using green diamond burs and subsequent polishing with a set of rubbers and diamond paste, the obtained values were significantly lower compared to the values of polishing after using red diamond burs. The surface was also smoother after polishing only with a set of rubbers than when the surface was polished with rubbers and diamond paste. When we used green diamond burs and polishing only with a set of rubbers, the obtained values were lower (Table 1).

Table 1: Measurements of the roughness parameters.

Test samples	E0	E1	E2	E3	E4
Area	2.462 nm ²	2.462 nm ²	2.462 nm ²	2.462 nm ²	2.462 nm ²
Sa	30.048 nm	300.26 nm	458.51 nm	91.213 nm	306.72 nm
Sm	212 pm	212.89 pm	211.69 pm	164.56 pm	173.01 pm
Sv	-112.99 nm	-1867 nm	-1677.6nm	-409.68nm	-1241.6nm
Sp	116.82 nm	978.36 nm	1780.5 nm	330.66 nm	676.56 nm
Sy	229.81 nm	2845.3 nm	3458,1 nm	740.35 nm	1918.2 nm

Source: Authors

The colour coding of the diamond bur affects the values of the roughness parameters. When using a red diamond bur and subsequent polishing (test samples E1 and E3) it resulted in a smother surface compared to the use of a green diamond bur (test samples E2 and E4). The using of diamond paste (test samples E3 and E4) also makes the surface smoother. The biggest difference was measured among the test samples of lithium disilicate ceramic treated with green diamond burs and polished with set of rubbers (Fig. 1).

Figure 1: Test samples A. E0: glazed lithium disilicate press ceramics; B. E1: lithium disilicate press ceramics treated with red diamond burs and polished with rubbers; C. E2: lithium disilicate press ceramics treated with green diamond burs and polished with rubbers; D. E3: lithium disilicate press ceramics treated with red diamond burs and polished with rubbers and diamond paste; E. E4: lithium disilicate press ceramics treated with green diamond burs and polished with rubbers and diamond paste.

Source: Authors (2021)

Discussion

This study evaluated the effect of four different polishing protocols on the surface roughness of lithium disilicate press ceramic IPS e.max Press. The efficiency of ceramic polishing systems is a controversial issue in the literature. Different materials require different polishing systems. Lithium disilicate press ceramics is a well-known product on the market. Alhabdan & Hejazi (2015), when studying restorations made of lithium disilicate glass ceramics, claimed that polishing this type of ceramic with certain types of discs result in a surface as smooth as a glazed surface. The studies of Bollen et al. (1997) and Martinez-Gomiz et al. (2003) reported that the final result after polishing cannot be compared with the result after re-glazing. Another study by da Silva et al. (2015) reported that polishing could produce a surface comparable with that of a glazed ceramic surface. This study confirmed the results from the studies claiming that polishing after corrections on the ceramic surface cannot achieve the smoothness of glazed ceramics. There are various alternative techniques for polishing of ceramics, each of which

involves particular types of polishing rotational instruments used in a particular sequence. There are several sets on the market specially designed for polishing of ceramic restorations, and each company producing ceramic materials also offers its own polishing system. Martinez-Gomis et al. (2003) reported that the use only of the rubber cup showed poor efficiency for mechanical polishing of the ceramic surface. Our research confirmed this statement. Heintze et al. (2005) writes that surface roughness is material-dependent and influenced by the polishing time and applied force. For better results, polishing with diamond paste is recommended by da Silva et al. (2015), Camacho et al. (2006) and Martinez-Gomis et al. (2003). The protocol used in this study includes a six-step system of polishing rubbers with three different shapes and two different grain sizes with or without the use of diamond polishing paste and each rubber is used for the duration of one minute. The polishing properties of press ceramics are due to the size of the crystals of the ceramic material after pressing - the crystal phase is composed of lithium disilicate crystals with a size of 2000 – 4000 nm according to Kisov (2019). Despite the time spent polishing, in this study the smoothness of glazed ceramics was not achieved. The glazed ceramic surface is the gold standard for comparison when corrections are made on the surface of ceramic restorations as da Silva et al. (2014) highlighted.

Conclusion

The superficial quality is a very important factor for the clinical success of a restoration. It is important for the dentist to know what is happening to the surface on which the corrections are made and whether these corrections could lead to further complications if no measures are taken. There is a difference in the smoothness of ceramic samples before and after clinical treatment. The use of diamond polishing paste in combination with a polishing kit contributes to making the ceramic surface smoother after the correction. Despite the existence of various polishing protocols, maximum smoothness can only be achieved by re-glazing. However, this is not an option after the cementation of the restorations.

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