Surface quality of Cerec CAD/CAM ceramic veneers treated with four different polishing systems

D. GLAVINA*, I. SKRINJARIC*, S. MAHOVIC*, M. MAJSTOROVIC**

ABSTRACT. Aim To achieve satisfactory aesthetic appearance of ceramic veneers food debris retention and plaque formation, resulting in possible irritation of surrounding tissues, should be avoided. It is, therefore, necessary to decrease the roughness of ceramic surfaces as much as possible. The aim of this study was to evaluate surface roughness of ceramic veneers after polishing with four different techniques. Methods Twenty veneers were fabricated using Cerec 2 CAD/CAM method (Sirona AG, Bensheim, Germany) from Cerec VITA MARK II ceramic blocks (Vita Zahnfabrik, Bad Säckingen, Germany) and cemented onto prepared extracted teeth. Veneers were divided into 4 groups of 5 specimens and polished with 4 different techniques: 1. Sof-lex discs grit 150, 360, 600, 1200 (3M, St. Paul, MN, USA); 2. Hawe brushes (Hawe Neos Dental, Bioggio, Switzerland); 3. Hawe brushes and diamond paste Diabrill (Oralia Dental GmbH, Kostanz, Germany); 4. Politip-P rubber cups (Vivadent, Schaan, Liechtenstein). Surface profile was measured using Perthometer Perthen S8P 4.5 (Feinprüf Perthen GmbH, Goettingen, Germany) profilometer. Statistics Data were analysed using ANOVA with Tukey HSD test. Results Sof-lex discs revealed significant statistical differences for Rz, Ra, Rk, Rpk values (p=0.0002) (Rz=2.92 mm; Ra=0.462 mm; Rk=1.098 mm; Rpk=0.472 mm). Values for Rvk were statistically significant only for rubber cups with diamond paste (p=0.002) (Rvk 4=3.04 mm). Rvk values for all other techniques were not statistically significant (Rvk 1=1.148 mm; Rvk 2=1.936 mm; Rvk 3=1.18 mm). Conclusion The best surface smoothness was achieved with Sof-lex discs polishing system. All other methods are clinically acceptable. Selection of polishing technique should be made according to geometric construction of the polishing instrument and possibility of reaching various restoration areas with the polishing instrument.

KEYWORDS: Surface roughness, Ceramic polishing systems, CAD/CAM restorations, Ceramic veneers.

Introduction
An important clinical problem in the construction of ceramic veneer restorations, using Cerec technology, is the possibility of satisfactory polishing of veneers cemented on the tooth structure. Rough veneer surfaces can enhance plaque retention, secondary caries lesions, periodontal irritation, trigger temporomandibular joint dysfunction and abrasion of opposite teeth, and aesthetic impairment [Quirynen et al., 1990; Krejci, 1992; Hahn et al., 1992; Karapetian et al., 1996; Bouvier et al., 1997]. Ceramic materials used in the CAD/CAM method require more adjustment and contouring than sintered veneers, and consequently their polishing is also more demanding [Schmid et al., 1991; Stoll et al., 1996]. Moreover, the shape and geometric construction of polishing devices can affect polishing in narrow spaces or can damage the bond between cement material and ceramic veneer [Schmid et al., 1991]. Many authors have studied surface roughness after the application of various polishing devices (laboratory instruments, diamond burs, discs, pastes etc.) [Sulik and Plekavich, 1981; Klausner et al., 1982; Bessing and Wiktorsson, 1983; Goldstein et al., 1991; Jefferies et al., 1992; Scurria and Powers, 1994; Chung, 1994; Karapetian et al., 1996; Stoll et al., 1996; Bouvier et al., 1997]. Such numerous investigations lead to a conclusion that there is no universally accepted polishing technique that can guarantee satisfactory surface roughness. For polishing of feldspatic CAD/CAM ceramic blocs, utilisation of Sof-lex polishing system, silicon carbide rotating brushes with or without diamond paste was proposed [Mörmann and Bindl, 2002].
The aim of this study was to evaluate different techniques for polishing Cerec Vita Mark II ceramic veneers.

**Materials and methods**

Twenty ceramic veneers were fabricated from Cerec Vita Mark II (Vita Zahnfabrik, Bad Säckingen, Germany) ceramic blocks using Cerec 2 (Sirona AG, software C.O.S. 4.21, Bensheim, Germany) CAD/CAM system. The veneers were cemented onto prepared surfaces of premolars, extracted for orthodontic reasons. The teeth were fixed in stone blocks for better manipulation during veneer production and profilometric measurement.

The veneers were divided into 4 groups of 5 specimens, according to the following polishing procedure:
- Sof-lex discs system, grit 150, 360, 600, 1200 (3M, St. Paul, MN, USA);
- Hawe brushes (Hawe Neos Dental, Bioggio, Switzerland);
- Hawe brushes and diamond paste Diabrill (Oralia Dental GmbH, Kostanz, Germany);
- Politip-P rubber cups (Vivadent, Schaan, Liechtenstein) and diamond paste.

The polishing systems studied and their respective manufacturers are listed in Table 1. Each polishing procedure was applied for a period of two minutes. Collected data were analyzed by ANOVA with Tukey HSD test. For measurement of surface profile Perthenometer Perthen S8P 4.5 (Feinprüf Perthen GmbH, Goettingen, Germany) was used. The following variables were measured:
- mean roughness depth – Rz;
- arithmetical mean deviation – Ra;
- core roughness depth – Rk;
- reduced peak height – Rpk;
- reduced valley depth – Rvk.

The parameters analysed were defined as follows. Mean roughness depth Rz was the mean value of the single roughness depth Z of consecutive sampling lengths. Single roughness depth Z was the vertical distance of the highest to the deepest profile point that can be expressed by equation:

\[ R_z = R_{\text{zav}} = \frac{1}{n}(Z_1 + Z_2 + \ldots + Z_n) \]

Arithmetical mean deviation Ra was defined as average value of the areas of all profile values of the roughness profile. Rk value, core roughness depth, represents depth of the roughness core profile. Reduced peak height Rpk was the mean height of the peaks protruding from the core area. Rvk value or reduced valley depth represented the value of the mean depth of the valleys extending from the core area.

**Results**

Results showed significant statistical difference in the roughness of surfaces treated with Sof-lex discs system in categories Rz (p=0.0002), Ra (p=0.0002), Rk (p=0.0002), and Rpk (p=0.005) (Tables 2 and 3). Namely, the Sof-lex discs system showed lower values and consequently a better polished surface.

Reduced valley depth (Rvk values) showed a statistically significant difference only for rubber cups with diamond paste (Rvk 4=3.04 µm, p=0.002) and

<table>
<thead>
<tr>
<th>Group</th>
<th>Type of polishing system</th>
<th>Composition</th>
<th>Batch number</th>
<th>Producer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sof-lex discs 150, 360, 600, 1200 grit</td>
<td>Al₂O₃ coated discs</td>
<td>5970769, REF 1982</td>
<td>3M, St. Paul, MN, USA</td>
</tr>
<tr>
<td>2</td>
<td>Hawe brush</td>
<td>Brush with incorporated silicium carbide particles</td>
<td>2510</td>
<td>Hawe Neos Dental, Bioggio, Switzerland</td>
</tr>
<tr>
<td>3</td>
<td>Diabrill polishing paste</td>
<td>Diamond polishing paste</td>
<td>45012</td>
<td>Oralia Dental, Kostanz, Germany</td>
</tr>
<tr>
<td>4</td>
<td>Politip-P rubber polishing cups</td>
<td>Silicon rubber cups</td>
<td>47263, 47264, 47265, 47266</td>
<td>Vivadent, Schaan, Liechtenstein</td>
</tr>
</tbody>
</table>

**Table 1 - List of polishing systems investigated for CAD/CAM ceramic veneers.**
showed slightly more porosity than other techniques. Rvk values for all other techniques were not statistically significant (Rvk 1=1.148 µm; Rvk 2=1.936 µm; Rvk 3=2.18 µm). However, in the Rvk category Sof-lex discs showed the best results (Table 3). Differences in surface roughness can be observed in the profiles of surfaces treated with Sof-lex discs and rubber cups with diamond paste (Figs. 1A and 1B).

The values obtained in all measured categories (Ra, Rz, Rk, Rpk, Rvk) correspond with values for untreated enamel surfaces, indicating that they are all lower or close to natural enamel values (Fig. 2).

**Discussion**

Surface roughness after treatment with different devices and techniques has been studied in numerous investigations. In some of them laboratory instruments for polishing were used [Sulik and Plekavich, 1981; Klausner et al., 1982; Bessing and Wiktorsson, 1983]. Goldstein stated in his study on feldspar ceramic materials that most of the available polishing systems are clinically acceptable for polishing rough ceramic material [Goldstein et al., 1991; Scurria and Powers, 1994]. Stoll et al. [1996] obtained values for arithmetical mean (Ra), mean roughness depth (Rz) and core roughness depth (Rk) for 4 industrially sintered feldspath ceramics after polishing with a Sof-lex disc system between 0.1-0.98 mm for Cerec Vita Mark 2 ceramic blocs. Values for rubber cup polishing were 0.1-0.9 mm. In a study by Karapetian et al. [1996] values of arithmetical mean (Ra) for Sof-lex discs were 0.036 mm. Feher and Mörmann [1995] obtained 0.03 mm for Sof-lex discs to 1.30 mm for diamond burs of 15 mm grit. It is interesting to note that diamond paste does not improve the quality of the veneer surface. In

<table>
<thead>
<tr>
<th>Group</th>
<th>Polishing technique</th>
<th>Ra Means</th>
<th>Ra SD</th>
<th>Rz Means</th>
<th>Rz SD</th>
<th>Rk Means</th>
<th>Rk SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (A)*</td>
<td>Sof-lex discs</td>
<td>0.46 B,C,D</td>
<td>0.13</td>
<td>2.92 B,C,D</td>
<td>0.59</td>
<td>1.1 B,C,D</td>
<td>0.29</td>
</tr>
<tr>
<td>2 (B)</td>
<td>Hawe brush</td>
<td>1.40</td>
<td>0.19</td>
<td>6.08</td>
<td>1.10</td>
<td>4.29</td>
<td>0.77</td>
</tr>
<tr>
<td>3 (C)</td>
<td>Hawe brush + diamond paste</td>
<td>1.23</td>
<td>0.60</td>
<td>6.24</td>
<td>0.76</td>
<td>3.91</td>
<td>0.40</td>
</tr>
<tr>
<td>4 (D)</td>
<td>Rubber cups + diamond paste</td>
<td>1.40</td>
<td>0.11</td>
<td>7.37</td>
<td>0.61</td>
<td>4.37</td>
<td>0.81</td>
</tr>
</tbody>
</table>

*Letters indicate statistical significance between groups at the level of significance p=<0.05

**Table 2** - Measured Ra, Rz and Rk values with statistical significance (Tukey HSD test) in investigating various polishing systems on CAD/CAM ceramic veneers (values in mm).

<table>
<thead>
<tr>
<th>Group</th>
<th>Polishing technique</th>
<th>Rpk Means</th>
<th>Rpk SD</th>
<th>Rvk Means</th>
<th>Rvk SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (A)*</td>
<td>Sof-lex discs</td>
<td>0.47 B,D</td>
<td>0.10</td>
<td>1.15 D</td>
<td>0.51</td>
</tr>
<tr>
<td>2 (B)</td>
<td>Hawe brush</td>
<td>1.20</td>
<td>0.46</td>
<td>1.94</td>
<td>0.67</td>
</tr>
<tr>
<td>3 (C)</td>
<td>Hawe brush + diamond paste</td>
<td>0.81 D</td>
<td>0.26</td>
<td>2.8</td>
<td>0.80</td>
</tr>
<tr>
<td>4 (D)</td>
<td>Rubber cups + diamond paste</td>
<td>1.39</td>
<td>0.31</td>
<td>3.04</td>
<td>1.04</td>
</tr>
</tbody>
</table>

*Letters indicate statistical significance between groups at the level of significance p=<0.05

**Table 3** - Measured Rpk and Rvk values with statistical significance (Tukey HSD test) (values in mm).
the present study there were no significant statistical difference between group 3 and group 4, that used diamond paste in combination with either the Hawe silicon brush or rubber tip. Kunzelmann and Hickel [1990], Shearer et al. [1994] and Stoll et al. [1996] also obtained similar results. The effect of diamond paste depends on size, shape and selection of particles, type of matrix and type of diamonds [Kunzelmann and Hickel, 1990; Shearer et al., 1994; Stoll et al., 1996]. It is important to emphasise that different polishing systems were used in particular studies. This also indicates that existing polishing systems are not completely satisfactory. Some studies showed very low values of surface roughness after polishing with diamond burs [Haywood et al., 1988; Scurria and Powers, 1994]. Jung [2002] obtained in his study of IPS-Empress ceramic best results in polishing with MPS diamond gel (Ra=0.21 µm). Sof-lex polishing systems obtained Ra value of 0.6 µm. In this study the best results were obtained with Sof-lex discs, although the values are generally higher. This could be explained by the design of the study. Namely, in this study the veneers cemented on the extracted teeth were real. The study was performed on natural surfaces and components of waviness and microwaviness were included. Because of the convexity of the veneer surface, access of the polishing instrument was not the same as in other studies that used materials in blocs or specially designed polishing machines. It is reasonable to expect that the arithmetical mean (Ra) values for veneers polished intraorally will be higher than experimental values.

In their study on the surface roughness of implants Quirynen and Bollen [1995] reported that the minimal arithmetical mean (Ra) value required for bacterial colonisation on the restoration surface and dental tissue is 0.2 mm. According to these studies bacterial adhesion occurs in 4 phases: bacterial transport toward the dental or restoration surface, initial bacterial adhesion, adherence with specific interactions and finally surface colonisation. An important goal to achieve is a low degree of roughness, for example higher smoothness, because a rough surface can shelter bacteria from brushing forces and enable sufficient time for bacterial colonisation [Quirynen et al., 1990; Quirynen et al., 1993; Quirynen et al., 1994; Quirynen and Bollen, 1995; Quirynen et al., 1996; Bollen et al., 1997].

In the majority of studies dealing with surface roughness arithmetical mean values (Ra) only have been measured. However, they do not obtain complete insight into the surface quality of veneers. Complete evaluation of the polishing quality can be obtained when values for mean roughness depth (Rz), core roughness depth (Rk), reduced peak height (Rpk) and reduced valley depth (Rvk) are taken into consideration [Bessing and Wiktorsson, 1983; Campbell, 1989; Quirynen et al., 1996; Stoll et al., 1996; Bollen et al., 1997].

In clinical conditions the protruding peaks of the veneer roughness profile are first exposed to wear and the core roughness profile takes maximum loading. When the values of reduced peak height (Rpk) and core roughness depth (Rk) are as low as possible, the area subjected to wear and the maximum loading area...
are smaller. Clinically, values of reduced valley depth or valleys extending from core roughness profile are very important, as the porosity of the veneer surface can harbour bacteria [Bollen et al., 1997]. The creation of deep porosity on the veneer surface can be linked to extensive wear of the polishing devices. This is also an important factor with regard to the surface quality of veneers that should be considered in clinical practice. Ideal values of Rk, Rp and Rvk would be those approaching 0.

**Conclusion**

From the results obtained it was concluded that all tested polishing techniques are clinically acceptable. However, the best results were achieved with Soflex discs polishing system. Selection of polishing technique should be made according to the geometric construction of the polishing instrument and the possibility of the instrument reaching various restoration areas.

**References**


