

Effect of Saliva pH and Polishing Techniques on the Surface Roughness of Different Esthetic Restorative Materials in Primary Teeth

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Received: March 06, 2019; **Published:** April 24, 2019

Abstract

Aim: The purpose of this study was to evaluate the effect of saliva pH and polishing on the surface roughness of esthetic restorations. Class V cavities were prepared on the buccal surface of 120 primary molars then divided into two main groups according to restoration used: group I Composite resin (Filtek Z350 xt) and group II Compomer (Compoglass F). The restorative materials were placed and cured into the prepared cavities using the clear cervical matrix and then divided to: subgroup A Sof-Lex polishing discs and subgroup B polishing stones. Each subgroup was divided into three divisions according to saliva pH: division (a) "acidic saliva; pH 5.5", division (b) "neutral saliva; pH 7.5" (control) and division (c) "alkaline saliva; pH 8". Restored teeth were immersed in artificial saliva for 7 days. Surface roughness was measured by stylus profilometer after immersion process. Data were collected, and statistically analyzed by SPSS version 21.

Results: Surface roughness was significant in saliva pH 5.5 ($p < 0.05$). Compomers displayed significantly more surface roughness than Composite resin ($p < 0.05$). Polishing by high speed polishing stones displayed a significant more increase in surface roughness than polishing by Sof-Lex discs ($p < 0.05$).

Conclusion: Saliva pH has a key role in surface roughness change of esthetic restorations. Polishing is effective in reducing surface roughness of restorative materials.

Keywords: Saliva pH; Roughness; Restorative Materials; Teeth

Introduction

The presence of saliva is vital to maintain healthy hard and soft oral tissues. Saliva has many functions as lubrication, protection, antibacterial, cleansing, agglutination, preservation the tooth integrity and buffering effects [1]. Buffering mechanism occurs by saliva as it contains bicarbonate, phosphorus and some protein systems that not only have a buffer effect but also eliminate certain bacterial components which require a very low pH to survive. When pH is greater than 6, the saliva is supersaturated with phosphate with regard to hydroxyapatite (HA), but when it falls below the

critical level (5.5) the HA begins to dissolve, freeing phosphates which attempt to restore the pH balance. This process depends on the phosphate and calcium ion content of the medium [2].

Many factors affect saliva flow rate and pH. Saliva pH could be more alkaline in gingivitis and periodontitis cases as they show elevated pH [3]. Also may be due to diseases as liver and pancreas dysfunction or food as vegetables. Saliva pH could be more acidic due to diseases as diabetes mellitus and bulimia nervosa or medications as antidepressant and antiasthma drugs or diet as lemon and orange consumption [4,5].

Pediatric dentistry has evolved away from the old amalgam to the nowadays esthetic restorations [6]. Color, surface texture and natural teeth appearance are essential requirements for esthetic restorative materials [7]. Composite resin and compomers are very effective in restoring the primary teeth due to their good physical and mechanical properties [8].

Composite resin was introduced in the early 1970s. It is composed of three major components: a highly cross-linked polymeric matrix reinforced by dispersion of glass, mineral, or resin filler particles bound to the matrix by coupling agents [9]. It bonds micromechanically to the tooth structure [10]. Compomer was introduced in early 1990s. It is a combination of glass ionomer cement and resin composite. It contains poly-acid modified monomers and fluoride –releasing silicate glass [9].

Surface roughness is an essential factor of the restorative material surface. The material should have smooth surface without porosity as rough surface causes plaque accumulation leading to gingival irritation. Rough surface also diminishes the restoration gloss resulting in more discoloration [11].

To overcome the surface roughness changes of esthetic restoration, precise finishing and polishing should be done which lead to enhance esthetic appearance of the tooth colored restorative materials [12]. Proper finishing and polishing procedures should be employed to remove the coarse restoration excess, contour the restoration to the desired anatomy and to obtain smooth surface with light reflection similar to the dental enamel [13]. Nowadays, a wide variety of finishing and polishing devices are found as: Sof-Lex polishing system, carbide finishing burs, surface coated ceramic diamond rotary instruments, rubber or silicon wheels, aluminum-oxide coated abrasive discs, and clear cervical matrices [14].

Surface roughness changes of esthetic dental restorations by acidic colored beverages and food had been examined in many studies. However, few studies focus on the effect of salivary pH on the surface roughness of esthetic restorations. So, further studies are needed to evaluate the effect of salivary pH and different polishing procedures on the surface roughness of different esthetic restorative materials.

Methodology

Specimen preparation

One hundred and twenty caries free extracted deciduous second molars were selected, disinfected and stored in distilled water. Teeth then were scaled with an ultrasonic scaler to remove tissue tags, plaque, and calculus. They were polished with pumice and stored in 4% thymol at room temperature until further use. Crowns were separated from the roots 1-2 mm apical from the cement-enamel junction (CEJ) using a fine diamond disc with straight low-speed hand-piece under copious water sprays. The crowns were embedded horizontally into self-curing acrylic resin blocks with buccal surface exposed.

Figure 1: Crown in acrylic resin.

Class V cavity preparation

Class V cavities were prepared on the buccal surfaces of the teeth using rose head bur mounted in high-speed contra angle hand-piece under copious water spray. The cervical margins were located 1.5 mm above the cemento-enamel junction. Cavity dimensions were standardized 4.0 mm wide and 3.0 mm high. The depth of the cavity was approximately 1.5 mm, which was measured using a periodontal probe.

Figure 2: Class V dimensions.

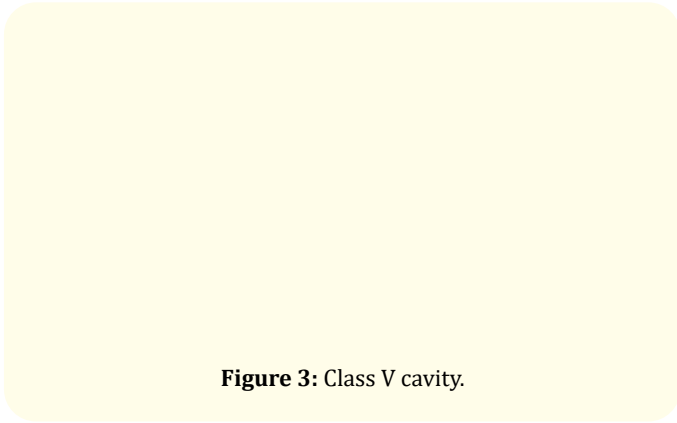


Figure 3: Class V cavity.

Cavity restoration

Specimens were randomly divided in two equal main restoration groups (n=60) as following: Group I: Cavity restored by Composite resin (Filtek Z350xt), Group II: Cavity restored by Compomer (Compoglass F). At each group, the cavities were dried by cotton pellets, then light curing self-etch bonding agent (Optident All-in-one self-etch adhesive) was applied by disposable micro applicator brushes and cured for 10 seconds and then composite resin and compomer were applied as one increment in the cavity. The restorative materials were placed and cured into the prepared cavities using the clear cervical matrix; Premier. The cervical matrix should be chosen larger than the cavity preparation. After investing the restorative material, the matrix was pressed over the uncured restoration until the proper curvature was attained. Any excess material was removed by the explorer. Then polymerization of the restoration was done for 40 seconds according to the manufacturer instructions.

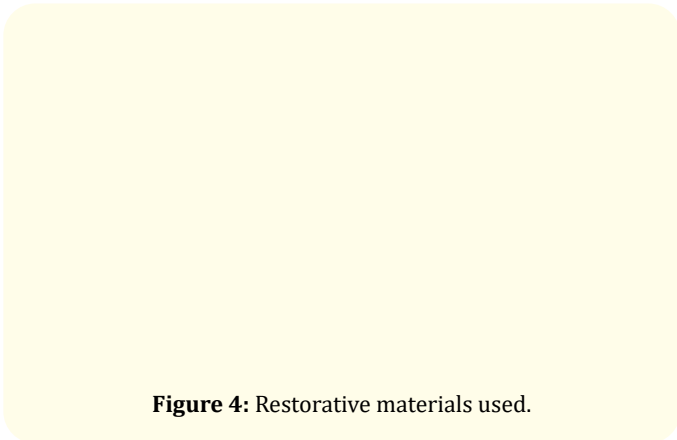


Figure 4: Restorative materials used.

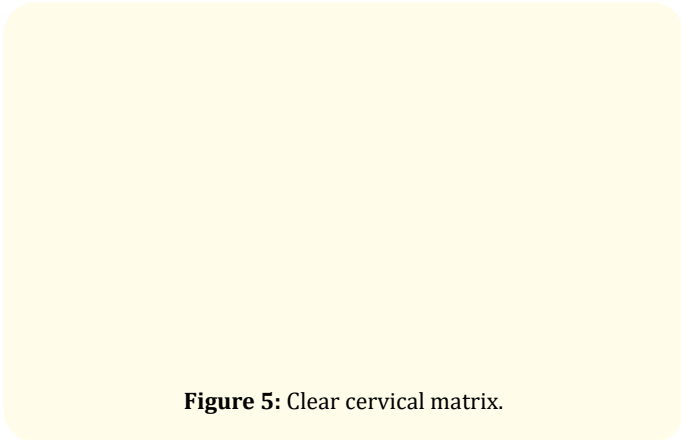


Figure 5: Clear cervical matrix.

Restorative material polishing

The restored teeth were then divided into 2 subgroups according to polishing applied as the following: Subgroup A: Specimens polished by Sof-Lex discs; 3M, Subgroup B: Specimens finished by high speed polishing stones; China Dental Supply. At subgroup A: any irregularity on the tooth surface was removed by Sof-Lex medium discs. Finally, polishing was done by fine and super fine Sof-Lex discs. At subgroup B: the restorative material was polished by the high speed polishing stones.




Figure 6: Sof-Lex polishing discs.

Artificial saliva preparation and use

Artificial saliva was prepared at the Faculty of Pharmacy, Mansoura University. It was composed of Albumin, methyl cellulose, sodium carboxymethyl cellulose hydroxypropylmethyl cellulose, potassium chloride, di-potassium hydrogen phosphate, sodium fluoride, Magnesium chloride, Glucose, Methyl paraben [15]. The saliva was prepared at three different pH (5.5, 7.5, 8). The pH was

measured by pH meter device. To obtain the alkaline artificial saliva, di-potassium hydrogen phosphate was added. To obtain the acidic artificial saliva, di-hydrogen potassium phosphate was added. Each subgroup was divided into three equal divisions according to saliva pH: Division a: (n=10) specimens immersed in acidic saliva with pH 5.5. Division b: (n=10) specimens immersed in neutral saliva with pH 7.5 (control). Division c: (n=10) specimens immersed in alkaline saliva with pH 8. The specimens were immersed in the artificial saliva and mouthwash for 7 days and kept at room temperature 37°C.

Surface roughness evaluation

USB digital surface profile gauge (Elcometer 224/2, Elcometer instrument, Great Britain) was used to evaluate the surface roughness, while computer software of roughness tester supplier (Elcomaster 2, Elcometer instruments) was used to record data. Stylus profilometer consists of at least two parts – a needle and a sample stage. The needle determines where the points on the sample are and the sample stage holds the sample. After the needle scanned a stretch of 2mm length and a cut-off 0.25mm, the mean roughness value (Ra,um) was presented by the arithmetic mean between the peaks and valleys registered. Each surface was read three times and the needle always scanned the geometric center of the tested specimen starting from three different points. The mean value of the roughness of each specimen was obtained from the mean value of the three readings [16].

Figure 7: Stylus profilometer.

Result

Table 1 illustrated comparison of surface roughness between the two restorations regarding the saliva pH. Composite resin and compomers polished by Sof-Lex discs displayed a significant increase in surface roughness when immersed in saliva pH 5.5 than saliva pH 7.5 and 8 where $p < 0.05$. Composite resin and compomers polished by high speed polishing stones displayed a highly significant increase in surface roughness when immersed in saliva pH 5.5 than saliva pH 7.5 and 8 where $p < 0.001$.

Figure 8: Effect of saliva pH on surface roughness of the two restorations.

Subgroups	Division a	Division b	Division c	ANOVA test	p-value
IA	0.38 ± 0.08 qr	0.29 ± 0.09 q	0.25 ± 0.09 r	5.14	0.013*
IB	0.44 ± 0.07 qr	0.31 ± 0.06 q	0.28 ± 0.04 r	18.28	<0.001**
IIA	0.44 ± 0.02 qr	0.34 ± 0.04 q	0.31 ± 0.04 r	32.1	0.021*
IIB	0.58 ± 0.06 qr	0.39 ± 0.03 q	0.34 ± 0.02 r	79.9	<0.001**

Table 1: Comparison of surface roughness between the two restorations regarding saliva pH
qr: similar letters indicate significant p value between groups by post hoc LSD test

Table 2 illustrated comparison of surface roughness between resin composite and compomer. Compomers displayed a significantly higher surface roughness than resin composite when polished by Sof-Lex discs and immersed in saliva pH 5.5 where $p < 0.05$. However, there was no significant increase in surface roughness when resin composite and compomers polished by Sof-Lex discs and immersed in saliva pH 7.5 and 8 where $p > 0.05$. Compomers displayed a highly significant increase in surface roughness than composite resin when polished by high speed polishing stones and immersed in saliva pH 5.5 where $p < 0.001$. However, there was no significant increase in surface roughness when composite resin and compomers polished by high speed polishing stones and immersed in saliva pH 7.5 and 8 where $p > 0.05$.

Subgroups	Group I	Group II	t-test	p-value
Aa	0.38 ± 0.08	0.44 ± 0.02	4.036	0.011*
Ab	0.29 ± 0.09	0.34 ± 0.04	3.699	0.052
Ac	0.25 ± 0.09	0.31 ± 0.04	1.73	0.099
Ba	0.44 ± 0.07	0.58 ± 0.06	4.269	<0.001**
Bb	0.31 ± 0.06	0.39 ± 0.03	3.392	0.068
Bc	0.28 ± 0.04	0.34 ± 0.02	1.65	0.082

Table 2: Comparison of surface roughness between the two restorations.

Discussion

Esthetic appearance becomes the main demand for adult as well as children. A variety of tooth colored restorative materials is now used in pediatric dentistry as composite resin and compomers for their esthetic appearance [17]. Since oral cavity is a dynamic environment due to presence of saliva, microflora and food, the esthetic restorative materials are always susceptible to changes in surface roughness [18].

Many factors affect saliva pH as diseases, medications, food and drinks. The change in saliva pH can adversely affect the tooth structure and the esthetic restorative materials [19]. Saliva pH was selected in this study as the teeth are always in contact with saliva. Artificial saliva was prepared with three different pH: acidic pH 5.5, neutral pH 7.5 and alkaline pH 8.

Class V was selected in this study because erosion is a common lesion in the cervical area. Primary upper 2nd molars were selected because they are broad and wide. Class V cavity dimensions were standardized 4.0 mm wide and 3.0 mm high. The depth of the cavity was approximately 1.5 mm. Restorative materials were then applied as one increment because the cavities were shallow. After polishing, specimens were immersed in the artificial saliva for seven days, similar to Bata, *et al.* study [15]. Although the tested specimens should be exposed to thermo-cycling to simulate the dynamic oral environment, this procedure was avoided because it may cause deterioration of artificial saliva ingredients.

Surface roughness can be a result of disintegration of restorative materials when exposed by chemicals or acids retained in the oral cavity. Erosive potential of acidic solution is associated with its pH, titratable acidity and buffering capacity. Rough surface leads to many problems as discoloration, plaque retention and gingival irritation [20]. Surface roughness was measured in this study by stylus profilometer.

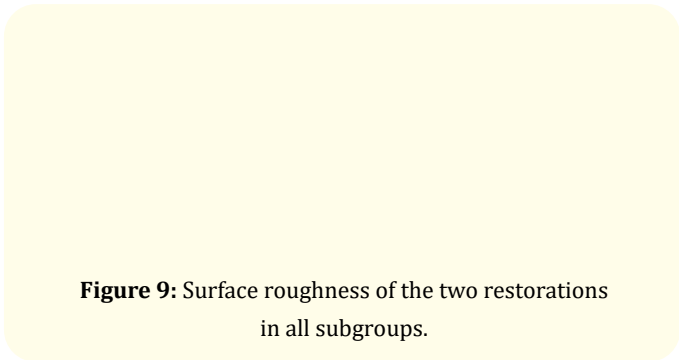


Figure 9: Surface roughness of the two restorations in all subgroups.

Life span and success of esthetic restorative materials depend on their proper finishing and polishing procedures [21]. Finishing refers to removal of the excess material to obtain the desired anatomy while polishing refers to removal of the scratches created by finishing tools to obtain smooth surface [22]. Inaccurate finishing and polishing lead to formation of irregularities and rough surface that lead to restoration discoloration, gingival irritation, plaque accumulation and secondary caries. So, accurate finishing and polishing is mandatory not only to maintain color stability but also to preserve good oral health [23].

Higher surface roughness was recorded when specimens were immersed in acidic medium. This result came in agreement with Pribadi, *et al.* [24], Karda, *et al.* [25], and Tanthanuch, *et al.* [26]. They attributed their results to the bond between the -OH functional groups and the polar side of the methacrylate monomer present in matrix of Bis-GMA or TEGDMA leading to water sorption and matrix dissolution. However, Cilli, *et al.* [27] reported that alkaline medium caused significant increase in surface roughness of esthetic restorative materials than acidic medium. They discussed that the alkaline medium provided million times hydroxyl groups more than acidic medium resulting in more microstructural damage of the material.

Composite resin displayed less surface roughness than compomers. This result was supported by Hamouda [28], Khan, *et al.* [20], and Santos, *et al.* [29]. Compomers when immersed in acidic medium, hydrolysis of silane coupling agent and plasticizing of resin matrix took place resulting in de-bonding of filler particles. However, nano-composites contain smaller filler particles that are not prominent on the surface resulting in smoother surface.

Specimens polished by Sof-Lex discs displayed less roughness than specimens polished by polishing stones in different saliva pH. This result was supported by Uctasli, *et al.* [30], Koh, *et al.* [31], Erdemir, *et al.* [32], and Abzal, *et al.* [33]. They attributed the decrease in roughness of restorative materials to the proper polishing techniques.

In this study, specimens polished by Sof-Lex discs resisted increase in surface roughness significantly than those polished by polishing stones in the acidic medium. Polishing was done by the clear cervical matrix to avoid the formation of oxygen inhibited layer then followed by polishing by Sof-Lex discs. Sof-Lex discs

produce smooth surface due to their ability to remove inorganic filler and organic matrix equally. However, polishing by the matrix only is not enough because the superficial layer of the material is rich in resin which should be removed by polishing. If this layer is left unpolished, rough inorganic filler will be protruded at the surface and the material will be easily abraded in the oral cavity. So, acids couldn't attack the surface aggressively. Alkaline and neutral media had little effect on the surface roughness.

Conclusion

- Compomer displayed significant surface roughness more than composite resin.
- Most significant surface roughness was noticed in the acidic saliva pH.
- Polishing procedure had an important role in maintaining a smooth surface.

Limitations of this Study

- This study compared the surface roughness change of restorative material in only one medium with different pH. However we should evaluate surface changes at different media.
- The dynamic oral environment wasn't simulated in this study as the specimens remained static in the artificial saliva for 7 days.

Recommendation

- Composite resin is the recommended esthetic restoration in cases of acidic saliva pH.
- Acidic beverages consumption should be reduced to increase the life of esthetic restorations.
- Polishing procedure is important to maintain smooth surface of the restorative materials.

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Volume 3 Issue 5 May 2019

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