Toothpaste and Surface Roughness of Resin-Contained Dental Materials

Subjects: Dentistry, Oral Surgery & Medicine

Contributor: Adolfo Di Fiore

Ceramic is the most used material for esthetic restorations in fixed prosthodontics. Surface roughness, translucency, resistance to wear, and mechanical properties are the main investigated characteristics of the ceramic surface. The surface roughness is one of the factors that influenced the clinical survival of prosthetic rehabilitation, optical properties, wear of the antagonist teeth, and initiation of cracks. Different factors influenced the surface roughness of the prosthetic materials, but the effect of brushing or polishing with toothpaste or prophylactic polishing pastes could be considered as one of the factors.

Keywords: CAD/CAM materials ; toothbrushing wear ; surface ; roughness ; surface integrity

1. Introduction

With growing awareness of esthetic rehabilitation, many patients require metal-free solutions [1]. Ceramic is the most used material for esthetic restorations in fixed prosthodontics. Surface roughness, translucency, resistance to wear, and mechanical properties are the main investigated characteristics of the ceramic surface [2]. In the last few years, computer-aided design/computer-aided manufacturing (CAD/CAM) has been introduced in the dentistry world and has improved the accuracy of prostheses, comfort for patients, and operative time [3][4]. Consequently, new different materials have been realized with different surfaces and mechanical behaviors [5][6]. The surface roughness is one of the factors that influenced the clinical survival of prosthetic rehabilitation, optical properties, wear of the antagonist teeth, and initiation of cracks [7]. Above the threshold Ra value of 0.2 µm for roughness, an increase of plaque accumulations has been observed on prosthetic materials [7]. The presence of bacteria on prosthetic rehabilitation becomes the main cause of biological complication, therefore, daily dental hygiene is necessary to remove plaque and prevent gingival inflammations [8]. Different factors influenced the surface roughness of the prosthetic materials, but the effect of brushing or polishing with toothpaste or prophylactic polishing pastes could be considered as one of the factors [9][10][11]. Regarding the polishing procedure by using the prophylactic pastes, several authors demonstrated the possible surface roughness alteration on prosthetic materials [10][11]. Few investigations on brushing are published [9]. However, most studies presented in the literature reported the abrasive effect of toothpaste and/or prophylactic pastes on the surface of composite materials and poly(methyl)methacrylate resin materials [12][13][14][15][16]. Commercially, resin-based CAD/CAM materials are used to produce prosthetic rehabilitation, moreover, different kinds of toothpastes are available with different relative dentine abrasivity (RDA indexes) [17].

2. Current Insights

The systematic review reported the relationship between toothpaste, RDA index, and surface roughness (Ra) for five articles [18][19][20][21][22] and maximum relative depth (Rv) for one [23] on resin-contained CAD/CAM dental materials.

Flury et al. [20] investigated the effect of artificial toothbrushing on the CAD/CAM materials including different resin containing dental materials such as Lava Ultimate (3M ESPE), Vita Enamic (Vita Zahnfabrik), and Ambarino High-Class (Creamed). All the materials were stored in tap water in an incubator for 6 months at 37 °C. Each month all the samples were undergoing artificial toothbrushing for 500 cycles using a toothbrushing machine. The surfaces' roughness was measured by using a profilometer before and after the procedures of storage and toothbrushing. The findings demonstrated different behaviors of the resin-contained CAD/CAM materials. The surface roughness (Ra) significantly increased after artificial toothbrushing and storage for Ambarino High-Class (Ra and Rz, $p < 0.001$). Instead, Lava Ultimate and Vita Enamic showed no significant change in surface roughness after artificial toothbrushing and storage compared with after polishing ($p > 0.05$). The reason could be explained by the different filling materials used to compose the blocks. The Ambarino High-Class presents a 70 weight % ceramic-like inorganic silicate glass filler particles and 30

weight % highly cross-linked polymer blends, the Lava Ultimate has 80 weight % (65 vol%) nanoceramic particles (zirconia filler (4–11 nm), silica filler (20 nm), aggregated zirconia/silica cluster filler), 20 weight % (35 vol%) highly cross-linked (methacrylate-based) polymer matrix, and the Vita Enamic is composed of a 86 weight % feldspathic-based ceramic network and 14 weight % acrylate polymer network (infiltrated into feldspathic-based ceramic network). The first difference that emerged among the blocks is the low percentage of the matrix which is below 20% in the materials that did not change the surface roughness after toothbrushing.

Koizumi et al. [19] tested six different “resin-ceramic” CAD/CAM materials such as Vita Enamic (Vita Zahnfabrik), Gradia Block (GC), Shofu Block HC (Shofu), Lava Ultimate (3M ESPE), Katana Avencia block (Kuraray Noritake Dental), and Cerasmart (GC) after simulating a toothbrushing of five years. The profilometer was used to detect the surface roughness. The results showed a significant difference, regarding the Ra, in the Cerasmart and Shofu Block HC materials after toothbrush abrasion compared with the control group represented by the ceramic (Vita Marks II, Vita Zahnfabrik). Also, these findings are conducible to the “nanofillers” type, not only to the inorganic filler contents but also filler size, filler form, and polymeric matrix [24]. Kamonkhantiku et al. [21] tested the surface roughness of six resin-contained CAD/CAM materials such as Shofu Block Hc (Shofu), Cerasmart (GC), Gradia Block (GC), Hybrid Resin, Block (Yamamoto), Lava Ultimate (3M, ESPE), and Vita Enamic (Vita Zahnfabrik) after 40,000 cycles of toothbrushing. The statistical analyses indicated that significant differences were found in Ra between the measuring stages for each material tested except for the Gradia Block (GC) and Vita Enamic (Vita Zahnfabrik). The authors attributed the differences in wear to the chemical compositions. The Gradia Block (GC) consists of large irregularly shaped silicate glass and numerous pre-polymerized filler particles that could possibly protect its soft resin matrix from toothbrushing, instead the Vita Enamic (Vita Zahnfabrik) is constructed with ceramic filler. However, the conclusions reported that all materials present an acceptable toothbrush wear resistance.

No relationships between toothbrushing and surface roughness (Ra) emerged in the study conducted by Mormon et al. [18]. The investigated samples include Lava Ultimate (3M ESPE),Vita Enamic (Vita Zahnfabrik), and other ceramic blocks such as zirconia and lithium disilicate. All the specimens were stored for 7 days in 37 °C deionized water, and successively were mounted in a toothbrushing machine for 40,000 cycles. However, the authors concluded that the experimental toothbrushing wear in the present study significantly reduced the gloss of enamel and of all material specimens, except zirconium dioxide ceramic. Instead, de Andrade et al. [22] determined significant differences among the chairside CAD-CAM materials and simulated toothbrushing. The authors submitted the sample to 100,000 brushing strokes, which simulated 10 years of clinical wear. The sample analyzed was composed of IPS Empress CAD (Ivoclar Vivadent AG), Cerasmart (GC), Vita Enamic (Vita Zahnfabrik), Lava Ultimate (3M, ESPE), and Grandio Block (VOCO GmbH). After brushing, the IPS Empress CAD (Ivoclar Vivadent AG) showed the lowest Ra values, followed by the Lava Ultimate (3M, ESPE) and the Vita Enamic (Vita Zahnfabrik). Instead, the other materials have the highest Ra values after brushing. Indeed, the Cerasmart (GC) and Grandio Block (VOCO GmbH) reached mean roughness values higher than the threshold Ra value of 0.2 µm reported in the literature [25].

Nima et al. [23] submitted ten specimens of Vita Enamic (Vita Zahnfabrik) and Lava Ultimate (3M, ESPE) to 300,000 toothbrushing strokes. The results showed an increase in roughness (Rv = maximum relative depth) and gloss before and after toothbrushing. Although all the articles examined used different toothpastes with no homogeneous RDA, different toothbrushing machine, and cycles of brushing, the findings are about the same. Some authors tested the resin-contained CAD/CAM materials from 40,000 cycles to 1500 cycles [18][19][20][21][22][23]. Koizumi et al. [19] brushed the specimens for 120 min (20,000 cycles). Assuming that the ideal time for toothbrushing is 120 s two times a day [26][27], the 20,000 cycles may correspond to an amount of five years. However, in literature the articles reported that the actual mean brushing time is 65.2 to 83.5 s per day [27]. Therefore, the studies may correspond to a clinical simulation with a range of 1 to 20 years. Regarding the different granulometry present in the toothpastes, the authors used different RDA index values in the experiments, which influenced the surface roughness of the resin-contained CAD/CAM materials investigated in the articles in the same ways [18][19][20][21][28][29].The reason for this comportment is attributable to the compositions of the resin-contained CAD/CAM materials. Indeed, blocks such as Lava Ultimate present 69% SiO_2 and 31% ZrO_2 fillers that improve the surface resistance to wear and the slight change in surface roughness after toothbrushing were considered clinically acceptable [19][20]. The aspect of the surface roughness remains a difficulty that clinicians do not consider. The literature reported 0.2 µm as the threshold value above which the plaque accumulation on dental materials increase [25]. However, it is difficult to measure the value clinically and no authors assessed the bristles’ effects on the materials. Therefore, a correct knowledge of the composition of dental material and the possible effect of toothbrushing is fundamental to obtain success and survival of the prosthetic rehabilitations. In summary, the main limitation encountered in the majority of the included studies consists of the assessment of resin-contained CAD/CAM material only in vitro studies without including the different clinical aspects such as saliva, blood, different types of beverages, and the daily comportment of patients.

3. Conclusions

The surface roughness of most resin-contained CAD/CAM materials was affected by artificial toothbrushing. Therefore, a correct knowledge of the composition of the dental material and toothpastes is fundamental to avoid an increase of surface roughness on the prosthetic rehabilitations. Moreover, future clinical studies are needed to assess the behavior of resin-contained CAD/CAM materials in clinic situations.

References

1. Reich, S.; Wichmann, M.; Nkenke, E.; Proeschel, P. Clinical fit of all-ceramic three-unit fixed partial dentures, generated with three different CAD/CAM systems. Eur. J. Oral Sci. 2005, 113, 174–179.
2. Aykent, F.; Yondem, I.; Ozyesil, A.G.; Gunal, S.K.; Avunduk, M.C.; Ozkan, S. Effect of different finishing techniques for restorative materials on surface roughness and bacterial adhesion. J. Prosthet. Dent. 2010, 103, 221–227.
3. Di Fiore, A.; Vigolo, P.; Graiff, L.; Stellini, E. Digital vs. Conventional Workflow for Screw-Retained Single-Implant Crowns: A Comparison of Key Considerations. Int. J. Prosthodont. 2018, 31, 577–579.
4. Granata, S.; Giberti, L.; Vigolo, P.; Stellini, E.; Di Fiore, A. Incorporating a facial scanner into the digital workflow: A dental technique. J. Prosthet. Dent. 2020, 123, 781–785.
5. Strasser, T.; Preis, V.; Behr, M.; Rosentritt, M. Roughness, surface energy, and superficial damages of CAD/CAM materials after surface treatment. Clin. Oral Investig. 2018, 22, 2787–2797.
6. Arena, A.; Prete, F.; Rambaldi, E.; Bignozzi, M.C.; Monaco, C.; Di Fiore, A.; Chevalier, J. Nanostructured Zirconia-Based Ceramics and Composites in Dentistry: A State-of-the-Art Review. Nanomaterials 2019, 9, 1393.
7. Checketts, M.R.; Turkyilmaz, I.; Asar, N.V. An investigation of the effect of scaling-induced surface roughness on bacterial adhesion in common fixed dental restorative materials. J. Prosthet. Dent. 2014, 112, 1265–1270.
8. Bressan, E.; Tessarolo, F.; Sbricoli, L.; Caola, I.; Nollo, G.; Di Fiore, A. Effect of chlorhexidine in preventing plaque biofilm on healing abutment: A crossover controlled study. Implant Dent. 2014, 23, 64–68.
9. Garza, L.A.; Thompson, G.; Cho, S.H.; Berzins, D.W. Effect of toothbrushing on shade and surface roughness of extrinsically stained pressable ceramics. J. Prosthet. Dent. 2016, 115, 489–494.
10. Monaco, C.; Arena, A.; Özcan, M. Effect of prophylactic polishing pastes on roughness and translucency of lithium disilicate ceramic. Int. J. Periodontics Restor. Dent. 2014, 34, 26–29.
11. Monaco, C.; Arena, A.; Scheda, L.; Di Fiore, A.; Zucchelli, G. In vitro 2D and 3D roughness and spectrophotometric and gloss analyses of ceramic materials after polishing with different prophylactic pastes. J. Prosthet. Dent. 2020, 124, 787.e1–787.e8.
12. Neme, A.M.; Wagner, W.C.; Pink, F.E.; Frazier, K.B. The effect of prophylactic polishing pastes and toothbrushing on the surface roughness of resin composite materials in vitro. Oper. Dent. 2003, 28, 808–815.
13. Liljeborg, A.; Tellefsen, G.; Johannsen, G. The use of a profilometer for both quantitative and qualitative measurements of toothpaste abrasivity. Int. J. Dent. Hyg. 2010, 8, 237–243.
14. Gungor, H.; Gundogdu, M.; Duymus, Z.Y. Investigation of the effect of different polishing techniques on the surface roughness of denture base and repair materials. J. Prosthet. Dent. 2014, 112, 1271–1277.
15. Sahin, O.; Koroglu, A.; Dede, D.Ö.; Yilmaz, B. Effect of surface sealant agents on the surface roughness and color stability of denture base materials. J. Prosthet. Dent. 2016, 116, 610–616.
16. Yurdaguven, H.; Aykor, A.; Ozel, E.; Sabuncu, H.; Soyman, M. Influence of a prophylaxis paste on surface roughness of different composites, porcelain, enamel and dentin surfaces. Eur. J. Dent. 2012, 6, 1–8.
17. Hamza, B.; Attin, T.; Cucuzza, C.; Gubler, A.; Wegehaupt, F.J. RDA and REA Values of Commercially Available Toothpastes Utilising Diamond Powder and Traditional Abrasives. Oral Health Prev. Dent. 2020, 18, 807–814.
18. Mörmann, W.H.; Stawarczyk, B.; Ender, A.; Sener, B.; Attin, T.; Mehl, A. Wear characteristics of current aesthetic dental restorative CAD/CAM materials: Two-body wear, gloss retention, roughness and Martens hardness. J. Mech. Behav. Biomed. Mater. 2013, 20, 113–125.
19. Koizumi, H.; Saiki, O.; Nogawa, H.; Hiraba, H.; Okazaki, T.; Matsumura, H. Surface roughness and gloss of current CAD/CAM resin composites before and after toothbrush abrasion. Dent. Mater. J. 2015, 34, 881–887.
20. Flury, S.; Diebold, E.; Peutzfeldt, A.; Lussi, A. Effect of artificial toothbrushing and water storage on the surface roughness and micromechanical properties of tooth-colored CAD-CAM materials. J. Prosthet. Dent. 2017, 117, 767–

774.

21. Kamonkhantikul, K.; Arksornnukit, M.; Lauvahutanon, S.; Takahashi, H. Toothbrushing alters the surface roughness and gloss of composite resin CAD/CAM blocks. Dent. Mater. J. 2016, 35, 225–232.
22. de Andrade, G.S.; Augusto, M.G.; Simões, B.V.; Pagani, C.; Saavedra, G.S.F.A.; Bresciani, E. Impact of simulated toothbrushing on surface properties of chairside CAD-CAM materials: An in vitro study. J. Prosthet. Dent. 2021, 125, 469.e1–469.e6.
23. Nima, G.; Lugo-Varillas, J.G.; Soto, J.; Faraoni, J.J.; Palma-Dibb, R.G.; Correa-Medina, A.; Giannini, M. Effect of toothbrushing on the surface of enamel, direct and indirect CAD/CAM restorative materials. Int. J. Prosthodont. 2021, 34, 473–481.
24. Ferracane, J.L.; Mitchem, J.C.; Condon, J.R.; Todd, R. Wear and marginal breakdown of composites with various degrees of cure. J. Dent. Res. 1997, 76, 1508–1516.
25. Bollen, C.M.; Lambrechts, P.; Quirynen, M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: A review of the literature. Dent. Mater. 1997, 13, 258–269.
26. Dentino, A.R.; Derderian, G.; Wolf, M.; Cugini, M.; Johnson, R.; Van Swol, R.L.; King, D.; Marks, P.; Warren, P. Six-month comparison of powered versus manual toothbrushing for safety and efficacy in the absence of professional instruction in mechanical plaque control. J. Periodontol. 2002, 73, 770–778.
27. Creeth, J.E.; Gallagher, A.; Sowinski, J.; Bowman, J.; Barrett, K.; Lowe, S.; Patel, K.; Bosma, M.L. The effect of brushing time and dentifrice on dental plaque removal in vivo. J. Dent. Hyg. 2009, 83, 111–116.
28. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G.; PRISMA Group. Prefered reporting items for systematic reviews and meta-analyses: The PRISMA statement. J. Clin. Epidemiol. 2009, 62, 1006–1012.
29. Sterne, J.A.; Hernán, M.A.; Reeves, B.C.; Savović; J; Berkman, N. D.; Viswanathan, M.; Henry, D.; Altman, D.G.; Ansari, M.T.; Boutron, I.; et al. ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. BMJ 2016, 355, i4919.