

How Do Dental Materials React On Tooth brushing?

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Abstract

Background: Novel dental materials have created the need for new knowledge, in terms of abrasion both in a quantitative, i.e. how much of the surface that has been abraded as well as in a qualitative way, i.e. the roughness of the surface after brushing. Furthermore, the development of new measuring techniques has created a new interest in this type of research.

Objective: To investigate if and how, different filling-materials and an acrylic are affected by brushing with and without tooth pastes.

Methods: The following dental materials were used: a cold cured acrylic, a flow composite and three different hybrid composites. The specimens were attached to acrylic plates and were exposed to brushing in a brushing machine using water alone and two different toothpastes: a low abrasive toothpaste and a whitening toothpaste. After one and six hours of brushing the results were evaluated using a profilometer. A surface roughness value (Ra-value) was calculated from the profilometer measurements for each material.

Results: Brushing with water alone caused negligible abrasion. There was a clear difference in abrasivity between the two toothpastes. Brushing with Pepsodent Whitening[®] resulted in a rougher surface than after brushing with Colgate Smiles[®].

Conclusions: The present study has shown that toothpaste is needed to create a significant abrasion on dental materials. Most materials exhibited a rougher surface after six hours of brushing than after one hour, however some of the materials obtained a smoother surface indicating a polishing effect between one and six hours of brushing. The surface roughness was dependent on the type of toothpaste used.

Keywords: Toothpaste; Dental materials; Abrasivity; Profilometer

Introduction

Besides the wear from occlusion, the influence of tooth brushing with and without toothpastes on teeth and dental materials has been in focus of interest for many years [1,2]. Due to the wide range of test methods, comparisons of the results from different studies are difficult.

Different methods have been used in order to evaluate abrasion. Both the quantitative aspect, i.e. how much of the surface that has been abraded, and the qualitative aspect, i.e. the roughness of the surface after brushing have been considered. Weight and Volume loss techniques [3,4] and radiotracer techniques [3,5], are examples of quantitative techniques, while profilometer techniques [6,7], and light reflection techniques [8-10] are examples of qualitative techniques.

The development of novel composite fillings started when methylmethacrylate was introduced into dentistry during the 1930s, which in the beginning was a denture-based material hardened by heat curing. During the 1940s researchers were able to cure methacrylates by a cold curing process, thus making it possible to use in the oral cavity. To reduce the problem of shrinkage, dimethylmethacrylate, i.e. bis-GMA (Bowen's resin) was created. Bowen's resin is an important ingredient in the composite fillings of today.

In recent years dental filling materials containing amalgam have been replaced by composite materials, which are now being used in all areas of the mouth. The composites used in the anterior region often contain bis-GMA with filler particles 30-60% by weight, while in the molar region the amount of filler particles can reach 83% by using hybrid composites. By using three different particle sizes the filler load can be as high as 90%. The composites have during the years been improved to withstand chewing forces in the molar region. They have also been modified either to be used in the anterior or the posterior (molar) region of the mouth. It is of utmost importance

that these materials are not influenced negatively by tooth brushing with toothpaste or water, since increased surface roughness will lead to discoloration and plaque accumulation, which would consequently lead to increased risk for caries and gingivitis [11,12].

The aim of the present study was therefore to investigate the influence of tooth brushing with and without toothpastes on the wear resistance of four different composite materials and methylmethacrylate, and also to compare a low abrasive toothpaste (Colgate Smiles[®]) with a whitening toothpaste (Pepsodent Whitening[®]).

Materials and Methods

Materials tested

Tetric Ceram HB[®]: (Heavy Body, Ivoclar), Capsules-Bis-GMA 19 w%, Fillers 81 w%. Particles sizes 0.04-3.0 µm. Multi fractions (to be used both for anterior and posterior teeth).

Charisma[®]: (Heraeus), Capsules-Bis-GMA and TEGDMA (reducing viscosity), Fillers 78 w% Two filler fractions 0.01-0.07 resp 0.7-2.0 µm (to be used both for anterior and posterior teeth).

Dyract[®] flow: (Dentsply), Syringe- A compomer- alkyle, aryle or

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alkylearyle esters from monomethacrylateacid 25-50% (to be used as an underfilling and for class V fillings).

Grandio®: (Voco), Capsules-Bis-GMA, Modified methacrylate 2.5-5%, Fillers 87 w%, (to be used both for anterior and posterior teeth).

TAB 2000®: (Swedon), Cold-cured acrylic-methacrylate. Methylmetacrylate more than 90% (to be used primarily in temporary crowns and bridges).

Brushing machine

The brushing machine had reciprocating movements of 85mm, 2000 double strokes per hour. Load 2.35 N. The apparatus had six brush sites and each brush site had a trough for the toothpaste water slurry in which the test plates were placed. Between each test, new brushes were mounted in the machine.

Toothbrushes

The Toothbrushes used were TePe Straight Classic®. The toothbrushes were manufactured according to the ISO standard 20126:2005 where the properties are defined and the general requirements and test methods regarding physical inspection, tuft removal force, fatigue resistance and chemical challenge are described.

Toothpastes

Pepsodent Whitening® and Colgate Smiles®

Profilometer

Surface profilometer, P15, KLA Tencor, San Jose, USA [13].

Test procedure

12 specimens of each of the composites/and methyl methacrylate were prepared (10 × 25 mm) and each was placed in the middle of an acrylic plate, dimensions (115×25×3 mm), at a depth of 2.5 mm. The composite materials were cured in three different locations, along the plate, close to the borders and in the center for 2 × 20 seconds. This was then repeated on the opposite side of the plate. This is considered satisfactory according to Caughman et al. [14]. Curing light unit used was Demi LED, 921640 from Kerr®. The TAB 2000 is a self and cold cured material. The curing was confined between two acrylic plates; the prepared plate, mentioned above and one untouched on top, resulting in a comparable surface structure. The untreated plate on top has a surface structure similar to that of a plastic strip used in the mouth. The two plates were fixed together with two clamps for at least 10 minutes. The force from the clamps was approximately 40 N each.

The plates were then subjected to brushing in the brushing machine with toothpaste-water slurry (25 mg toothpaste+50 ml water). The slurry was replaced with new slurry every hour. Two different toothpastes were used and also water alone. The total brushing time was 6 hours corresponding to 12000 double strokes but the plates were also analyzed after one hour of brushing (2000 double strokes).

Altogether, 60 plates were manufactured, 12 of each material. Two plates of each material were brushed with Colgate Smiles®, two with Pepsodent Whitening® and two plates were brushed with water alone. Brushing was performed both for 1 hour and 6 hours.

The plates were then analyzed in the profilometer (P15, KLA Tencor), which has a diamond stylus with a tip radius of 2 μm that scans the surface profile of the sample in a direction perpendicular to the brushing direction. The force of the tip can be controlled, as well as the scanning speed and the sampling interval of the depth values.

The profilometer is using a flat glass surface as vertical reference. The vertical repeatability is 0.03 μm for a range of 30 μm. The maximum vertical range of the profilometer is 130 μm, which was enough for all the samples. The scan rate was 0.2 mm/s giving a collection time for each profile of 100 seconds.

3 profiles were collected for each sample, one at midpoint of the plate and two profiles 3 mm above and 3 mm below the midpoint. Roughness average (R_a) values were computed for each profile. R_a is defined as the arithmetic average deviation of the absolute values of the roughness profile from the mean line or the center line. Porosities were formed on some of the samples, due to the properties of the material. The calculation of R_a was made so these porosities were excluded. For some of the samples it was also possible to compute the volume of the removed material. To find an initial value for R_a , prior to brushing, R_a was also computed from parts of each profile that were outside the abraded area. All profiles started and ended outside of the abraded area.

Results

The results are presented in 3 tables. Since all samples had different roughness (R_a) initially, we decided to compute the ratio between the initial roughness and the roughness of the abraded area for each sample. These values are presented in Table 1. The highest ratio was obtained for brushing with Pepsodent for 6 hours, while negligible difference was shown for water after 6 hours. No differences were found after brushing with water for 1 hour, therefore that table was excluded.

Tables 2 and 3 show the specific R_a values for unbrushed and brushed materials after 1 and 6 hours of brushing. Table 2 shows data for Pepsodent Whitening® and Table 3 for Colgate Smiles®. The p-values are showing the significance of difference of abrasion.

TAB 2000® exhibited the highest R_a values both after brushing with Colgate for one and six hours (0.554 and 0.541 respectively) and after brushing with Pepsodent Whitening® (1.213 and 7.024 respectively). For Grandio®, the R_a values increased between 1 and 6 hours both after brushing with Colgate (0.044 to 0.068) and after brushing with Pepsodent Whitening® (0.089 to 0.169). This was also the case for

Material	Colgate		Pepsodent		Water
	1 hr	6 hr	1 hr	6 hr	6 hr
Charisma	2.0	6.2	7.4	11.1	1.0
Dyract flow	2.8	1.7	7.3	5.7	1.5
Tetric Ceram	4.2	5.6	16.7	9.8	1.4
TAB 2000	1.2	1.0	0.7	12.1	1.2
Grandio	3.7	4.2	5.3	10.4	0.9

Table 1: The ratio of R_a for brushed parts to R_a for un-brushed parts of the profiles.

Material	Colgate							
	1 hr				6 hr			
	Initial		Abraded		Initial		Abraded	
	R_a	Standard Deviation						
Charisma	0.013	0.005	0.026	0.011	0.012	0.004	0.076	0.051
Dyract flow	0.021	0.014	0.060	0.039	0.018	0.003	0.029	0.008
Tetric Ceram	0.039	0.039	0.165	0.087	0.015	0.008	0.086	0.042
TAB 2000	0.444	0.091	0.554	0.134	0.563	0.244	0.541	0.168
Grandio	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039

Table 2: Roughness average values (R_a) for all materials brushed with Colgate for 1 and 6 hours. All values in μm.

Material	Pepsodent							
	1 hr				6 hr			
	Initial		Abraded		Initial		Abraded	
	R _a	Standard Deviation						
Charisma	0.012	0.004	0.092	0.018	0.033	0.019	0.362	0.231
Dyract flow	0.015	0.005	0.111	0.077	0.020	0.007	0.114	0.036
Tetric Ceram	0.011	0.007	0.180	0.081	0.187	0.256	1.833	0.621
TAB 2000	1.772	1.208	1.213	0.767	0.581	0.127	7.024	1.707
Grandio	0.017	0.005	0.089	0.062	0.016	0.009	0.169	0.098

Table 3: Roughness average values (R_a) for all materials brushed with Pepsodent for 1 and 6 hours. All values in µm.

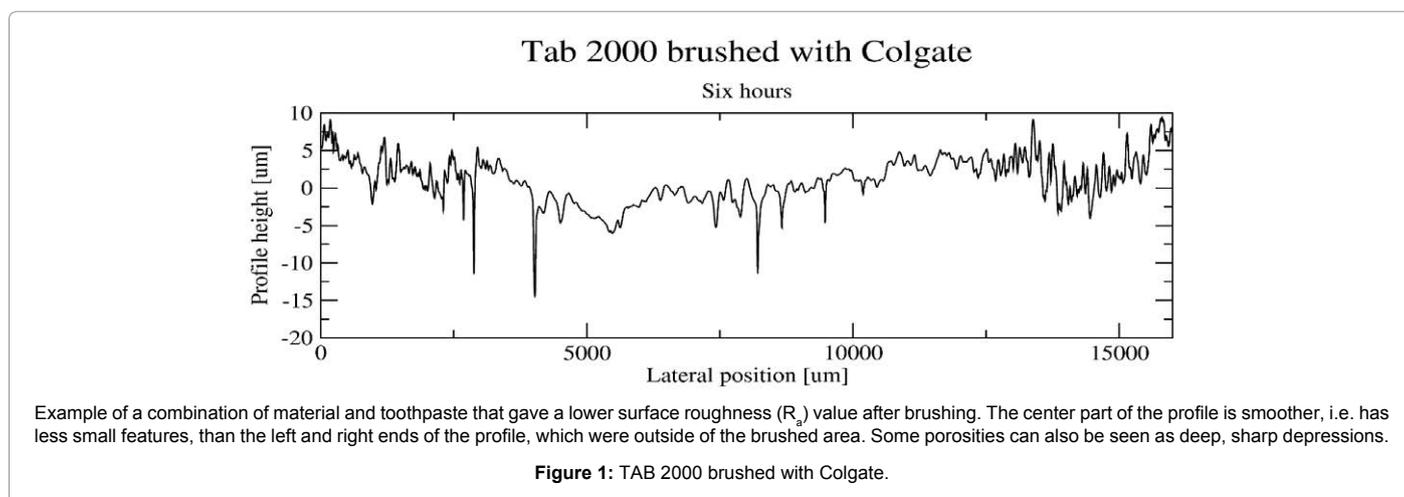


Figure 1: TAB 2000 brushed with Colgate.

Charisma[®], from 0.026 to 0.076 after brushing with Colgate and from 0.092 to 0.362 after brushing with Pepsodent Whitening[®].

A polishing effect could be seen in some cases, i.e. the roughness was lower in the abraded area than in the unabraded. This can be concluded from the R_a values as well as when inspecting the profiles. The abraded areas had in these cases a smoother appearance (Figure 1). This polishing effect could also be seen in the cases when the ratio was smaller for six hours of brushing than for one hour. This is the case for Dyract[®] and TAB 2000[®] brushed with Colgate. This effect can also be seen for Dyract and Tetric Ceram brushed with Pepsodent.

Discussion

The present study indicates that most composite materials are influenced by brushing with a toothpaste. Since brushing with water influenced neither of the materials, the influence of the toothbrush on the abrasion of dental materials is negligible, which is in line with other studies [15,16]. Those composites showed various results regarding wear and surface roughness have earlier been found by Tanoue et al. who measured surface roughness on seven different composites that had been subjected to brushing for 20000 strokes [17]. He found that the type of prosthetic composite used significantly influenced the surface condition after tooth brushing.

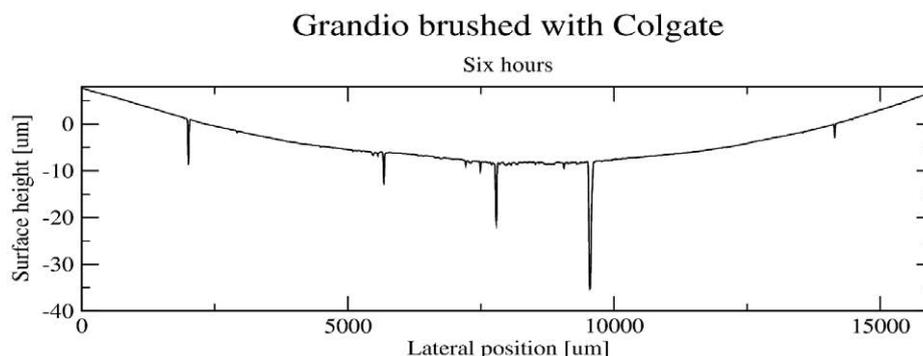
In a study by Frazier et al. the wear resistance of different resin-based composites and compomers were compared, and they found that all but one hybrid resin-ionomer type material exhibited a resistance to tooth brushing with toothpaste that was as good as or better than that of the traditional resin-based materials [18]. However, they only measured mass-loss after 120000 strokes. In the present study mass or volume loss was not investigated since we, due to initial porosities,

were not able to detect volume loss except for TAB 2000[®]. The R_a values represent a qualitative measurement of the surface roughness and do not measure the quantitative loss of material. The relevance of measuring the surface roughness is obvious since a rougher surface will attract plaque and discoloration more easily, thus resulting in a greater risk for caries and gingivitis.

The R_a values for most of the composite materials increased between 1 and 6 hours of brushing, indicating that the surface became rougher. This might be explained by the fact that when brushing on the composite materials the resin material wears away leaving the large filler particles sticking up from the surface, which also is in line with results from van Dijken et al. [16]. For Dyract, however, a lower R_a value after 6 hours of brushing than after one hour brushing was found, indicating that the surface had become smoother. This was the case for brushing with both Pepsodent and Colgate. An explanation for this can be that the micro filler particle content is such that no or very few filler particles have emerged. The same smoothening effect could be seen for Tab 2000[®] brushed with Colgate.

The importance of the toothpaste used is obvious. Together with the toothbrush we used in this study the toothpaste played a significant role. In the present study brushing with Pepsodent Whitening[®] resulted in higher R_a values, i.e. created a rougher surface, compared to Colgates Smiles[®]. This has an impact especially in the anterior region where a rougher surface more easily is subjected to discoloration and risk for plaque accumulation, and in the long perspective increased risk for caries and gingivitis/periodontitis [12]. On the other hand Pickles et al. [19] and Johannsen et al. [20] have shown that whitening toothpastes do not necessarily exhibit higher abrasivity.

The hybrid- resin modified glass ionomers have been shown



Typical profile with some abrasion in the middle part of the profile and several porosities most likely formed by air bubbles during preparation of the sample. These deep pores make it necessary to use a manual method to evaluate the surface roughness caused exclusively by abrasion.

Figure 2: Grandio brushed with Colgate.

to be as good as the traditional resin based composite materials in terms of resistance to toothbrush wear and no correlation between wear resistance and filler content have been found [18]. Other studies have shown that microfilled and hybrid resin composites expressed significantly rougher surfaces than packable composites, compomers and resin modified glass-ionomers following tooth brushing [21].

Furthermore, the wear rate of most novel composites has been shown to be near that of enamel [22]. This might explain the minor influence brushing with a toothpaste had on the composites in the present study. Hardness of a material is not always directly proportional to the wear rate. Some composites can show the same hardness number as gold alloys, but significantly less resistance to wear [23].

The presence of porosities is something we have to take into account in the clinical setting, when fillings are made. Even in an in-vitro study with ideal conditions it was not possible to avoid porosities [24].

The influence of the polymerization light used has also been discussed by Tanoue et al. [17]. They found that the use of a high intensity metal halide photo-curing unit effectively enhanced the abrasion resistance. In the present study a polymerization light usually found in a dental clinic was used in the same way for all materials, thereby not influencing the relative results. An interesting aspect is how temperature changes might influence the abrasion of the materials. This was however not investigated in the present study.

The denture base acrylic showed, as expected, greater wear in our study. This is in accordance with other studies [22]. Even though there are differences in terms of wear when comparing different brands [25], it is important that cleaning of dentures or gold crowns with acrylic veneers should not involve toothpaste, at least not with any abrasives. To transform these results into a clinical reality is difficult, but a rough estimate of 12000 double strokes would be equal to two years with twice daily brushing [26].

All samples had varying amount of porosities. These porosities were generally much deeper than the roughness caused by the abrasion. They were excluded from the computation of the roughness using manual evaluation of the profiles. This was done since this study was aimed towards measuring the roughness caused by the brushing only. Of course the porosities would have an impact on the amount of plaque, discoloration, etc. in a real situation; however, since the porosities cause a roughness of a completely different character than the roughness caused by abrasion, they were excluded in this study.

An example of a profile with both porosities and abrasion is shown in Figure 2.

Volume loss could only be calculated for a few of the samples brushed for six hours. Therefore no further evaluation was performed on these specimens in terms of volume loss, even though the abrasion in these cases was sufficiently large to make reliable measurements of the volume loss using the method described by Liljeborg et al [13].

Conclusion

The present study showed that the surface of composites was not influenced by tooth brushing with water alone, however when a toothpaste was added, most of the materials exhibited a rougher surface after 6 hours of brushing than after 1 hour. On some of the materials a smoother surface was obtained, thus indicating a polishing effect between 1 and 6 hours of brushing. It is important to take this into consideration, since a rougher surface attracts plaque more easily and favors discoloration and increases the risk for caries and gingivitis/periodontitis.

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