

# Evaluation of Surface Roughness of Nanofilled Composite Restorations after Simulated Tooth Brushing using Various Dentifrices

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## ABSTRACT

### Background

Teeth restored with direct composite resin are constantly exposed to specific challenges of the oral cavity. These challenges can modify the material properties and, when associated with daily brushing, eventually change its surface roughness, allowing bacterial growth and retention of extrinsic pigments. Dentifrices plays an important role in dental wear (abrasion) and over time, can also cause an increase in the surface roughness of restorative materials.

### Objective

To assess the effect of dentifrices on the longevity of direct nanofilled composite resins restorations as far as wear and roughness is concerned.

### Method

Class V cavity were prepared on 90 extracted human teeth and restored with Filtek Z350 composite. Teeth were randomly divided into 6 experimental groups of 15 each labelled as Group-1 (Colgate Dental cream) Group-2 (Colgate Active Salt toothpaste), Group-3 (Pepsodent Regular toothpaste), Group-4 (Dabur red toothpaste), Group-5 (Dabur Lal tooth powder) and Group-6 Control (water). The samples were fixed on tooth brushing machine and subjected to mechanical tooth brushing using various dentifrices according to respective groups in 3 phases and reading of surface roughness (Ra) was recorded.

### Result

Surface roughness (Ra) had increased in following order: Group 6 < Group 3 < Group 2 < Group 1 < Group 4 < Group 5. All the tooth pastes were compared, their behaviour was found to be similar as there was no statistically significant difference amongst them. Though all of them were inferior to control group and the difference was statistically significant. Whereas the only tooth powder Dabur lal tooth powder gave the maximum roughness when compared with the other tooth pastes and the difference was statistically significant.

### Conclusion

With increase in time of brushing there was increase in surface roughness in all the 5 dentifrices among them Ra was maximum for Dabur lal tooth powder.

## KEY WORDS

*Dentifrices, Filtek Z350 composite, Surface roughness (Ra)*

## INTRODUCTION

One of the primary concerns of both practitioner and patient after restoration is placed in Class V cavities is to maintain pleasing aesthetics, desirable contour and smooth surface. With increase in life expectancy, the numbers of geriatrics patients who have increased root caries and cervical erosion or abrasion defects are getting enhanced.<sup>1</sup>

Various types of recent direct tooth colour restorative materials are available in market among these nanofilled composites are most commonly advocated for class V restoration. There are some drawbacks of these materials like wear, surface roughness etc. Clinically the wear of a restoration may result from the centric and functional contacts, as well as tooth brushing (abrasion wear) by the action of toothbrush and dentifrice.<sup>2</sup> Wear is a complex process that involves abrasion, fatigue, erosion and friction which interact among themselves.<sup>3,4</sup> Wear of restorative materials can result in loss of contour, increase in surface roughness, staining and plaque retention. Evaluation of mechanical properties of restorative materials is necessary to ascertain their indications and limitations.<sup>5</sup>

Wear by tooth brushing can happen on any dental surface but the effect is more on the buccal surfaces of the teeth since these tend to receive a more intense action of brushing further more wear rates vary with various dentifrices used for different period of time.

This study was conducted to assess the effect of dentifrices on the longevity of direct nanofilled composite resins by giving class V restoration on the buccal surfaces and subjecting them to mechanical tooth brushing simulating different period of time using six different commonly used dentifrices such as Colgate dental cream, Colgate Active Salt, Pepsodent (regular), Dabur Red toothpaste and Dabur Lal tooth powder.

## METHODS

Freshly extracted non carious and non-fractured ninety human permanent maxillary and mandibular teeth (n= 15 for each group) with facial surface intact and the facial surface should be of the size to accommodate the standardized cavity preparation within the angles of tooth were collected.

### Preparation of samples

Class V tooth preparation was made on the maximum contour of tooth i.e. on the center of buccal surface of the tooth following the tooth contour occlusally, cervically, mesially and distally. Then the cavities were restored with Filtek Z 350 Composite material. Composite margins were finished and polished with composite finishing and polishing discs (Sof-Lex finishing and polishing discs). All the samples were mounted on wax blocks.

## Grouping

After finishing and polishing, the 90 samples were randomly divided into six equal groups for which various dentifrices were used. As follows:-

Groups	Dentifrices
Group-1	Colgate Dental cream
Group-2	Colgate Active Salt toothpaste
Group-3	Pepsodent Regular toothpaste
Group-4	Dabur red toothpaste
Group-5	Dabur Lal tooth powder
Group-6	Control (water)

## Description of Toot Brushing Machine

A simulated tooth brushing machine was designed to perform 266 strokes per minute. The value of sixteen thousand (16000) strokes is equivalent to brushing a tooth 22 strokes twice per day for one year.<sup>7</sup> The mechanical tooth brushing was accomplished with horizontal movement of the toothbrush under a weight of 200 gram force and a travelled course of 2 to 3 cm. The toothbrush used was with soft bristles (Colgate Palmolive India Ltd.)

### a) Fixation of samples on the machine.

Two specimens were sequentially attached to tooth brushing wear testing machine. Before the wear test began, the equipment was adjusted to level the toothbrush bristles parallel to the sample surface, thereby, providing uniform tooth brushing.

### b) Simulated tooth brushing

All the 90 samples were then subjected to tooth brushing with different dentifrices or were kept dipped in the water (control group) according to their respective groups. Tooth brush was changed after brushing every ten specimens or when bristle fraying was observed whichever was earlier. This tooth brushing was conducted in 3 phases in each respective group. In 1<sup>st</sup> phase the samples were subjected to 16000 strokes with the help of mechanical tooth brushing which would be equivalent to 1 year of brushing a tooth with 22 strokes twice per day and surface characteristics were studied under the profilometer and reading thus obtained was recorded. In 2<sup>nd</sup> phase these samples were again subjected to another 16000 strokes (total of 32000 strokes) and reading of surface characteristic was recorded. In 3<sup>rd</sup> phase these samples were again subjected to another 16000 strokes (total of 48000 strokes) and reading of surface characteristic was recorded.

## RESULTS

Table 1 showed surface roughness (Ra) of all six groups before and after simulated tooth brushing at different intervals. Table 2 showed mean change in surface roughness (Ra) of all six groups before and after simulated

**Table 1.** Showing surface roughness (Ra) of all six groups before and after simulated tooth brushing at different intervals.

Group	N	Initial roughness(μm)		Roughness (μm) after 1 hour		Roughness (μm) after 2 hour		Roughness (μm) after 3 hour	
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
1	15	0.096	0.0281	0.328	0.0863	0.359	0.0850	0.394	0.0853
2	15	0.096	0.025	0.324	0.0935	0.365	0.0874	0.413	0.0924
3	15	0.094	0.028	0.315	0.069	0.350	0.069	0.392	0.0831
4	15	0.094	0.025	0.336	0.083	0.375	0.077	0.412	0.0703
5	15	0.098	0.0277	0.4326	0.063	0.485	0.060	0.546	0.072
6	15	0.106	0.0296	0.189	0.053	0.211	0.051	0.246	0.054

**Table 2.** Showing Mean difference surface roughness (Ra) among six groups before and after simulated tooth brushing at different intervals.

Groups	Pair I			Pair II			Pair III		
	Mean difference	S.D.	Sig.	Mean difference	S.D.	Sig.	Mean difference	S.D.	Sig.
Colgate toothpaste	-0.23133	.09516	.000	-0.3133	.01187	.000	-0.3467	.01356	.000
Colgate Active Salt toothpaste	-0.22867	.10106	.000	-0.04067	.01792	.000	-0.04800	.01265	.000
Pepsodent Regular toothpaste	-0.22067	.08328	.000	-0.03533	.01246	.000	-0.04200	.02210	.000
Dabur red toothpaste	-0.24200	.08402	.000	-0.03867	.01727	.000	-0.03667	.01496	.000
Dabur red toothpaste	-0.33400	.05040	.000	-0.05267	.02120	.000	-0.06133	.02748	.000
Control (water)	-0.08267	.04906	.000	-0.02200	.00676	.000	-0.03467	.01598	.000

**Table 3.** Multiple comparison of surface roughness after 1 hour tooth brushing by post hoc test tukey hsd between all groups

Group (I)	Group(J)	Mean Difference(I-J)	Std. Error	Sig.
Colgate toothpaste	Colgate Active Salt toothpaste	.00333	.02783	1.000
	Pepsodent (Regular) toothpaste	.01267	.02783	.997
	Dabur red toothpaste	-.00867	.02783	1.000
	Dabur Lal tooth powder	-.10467(*)	.02783	.004
	Control (water)	.13867(*)	.02783	.000
	Colgate Active Salt toothpaste	Colgate toothpaste	-.00333	.02783
Pepsodent (Regular) toothpaste		.00933	.02783	.999
Dabur red toothpaste		-.01200	.02783	.998
Dabur Lal tooth powder		-.10800(*)	.02783	.003
Control (water)		.13533(*)	.02783	.000
Pepsodent (Regular) toothpaste	Colgate toothpaste	-.01267	.02783	.997
	Colgate Active Salt toothpaste	-.00933	.02783	.999
	Dabur red toothpaste	-.02133	.02783	.972
	Dabur Lal tooth powder	-.11733(*)	.02783	.001
	Control (water)	.12600(*)	.02783	.000
Dabur red toothpaste	Colgate toothpaste	.00867	.02783	1.000
	Colgate Active Salt toothpaste	.01200	.02783	.998
	Pepsodent (Regular) toothpaste	.02133	.02783	.972
	Dabur Lal tooth powder	-.09600(*)	.02783	.011
	Control (water)	.14733(*)	.02783	.000
Dabur Lal tooth powder	Colgate toothpaste	.10467(*)	.02783	.004
	Colgate Active Salt toothpaste	.10800(*)	.02783	.003
	Pepsodent (Regular) toothpaste	.11733(*)	.02783	.001
	Dabur red toothpaste	.09600(*)	.02783	.011
Control (water)	Colgate toothpaste	-.13867(*)	.02783	.000
	Colgate Active Salt toothpaste	-.13533(*)	.02783	.000
	Pepsodent (Regular) toothpaste	-.12600(*)	.02783	.000
	Dabur red toothpaste	-.14733(*)	.02783	.000
Dabur Lal tooth powder	Colgate toothpaste	-.24333(*)	.02783	.000
	Colgate Active Salt toothpaste	-.24333(*)	.02783	.000
	Pepsodent (Regular) toothpaste	-.24333(*)	.02783	.000
	Dabur red toothpaste	-.24333(*)	.02783	.000

\* The mean difference is significant at the .05 level.

**Table 4. Multiple comparison of surface roughness after 2 hour tooth brushing by post hoc test tukey hsd between all groups**

Group (I)	Group(J)	Mean Difference(I-J)	Std. Error	Sig.
Colgate toothpaste	Colgate Active Salt toothpaste	-.0060	.0267	1.000
	Pepsodent (Regular) toothpaste	.0087	.0267	1.000
	Dabur red toothpaste	-.0160	.0267	.991
	Dabur Lal tooth powder	-.1260(*)	.0267	.000
	Control (water)	.1480(*)	.0267	.000
Colgate Active Salt toothpaste	Colgate toothpaste	.0060	.0267	1.000
	Pepsodent (Regular) toothpaste	.0147	.0267	.994
	Dabur red toothpaste	-.0100	.0267	.999
	Dabur Lal tooth powder	-.1200(*)	.0267	.000
	Control (water)	.1540(*)	.0267	.000
Pepsodent (Regular) toothpaste	Colgate toothpaste	-.0087	.0267	1.000
	Colgate Active Salt toothpaste	-.0147	.0267	.994
	Dabur red toothpaste	-.0247	.0267	.939
	Dabur Lal tooth powder	-.1347(*)	.0267	.000
	Control (water)	.1393(*)	.0267	.000
Dabur red toothpaste	Colgate toothpaste	.0160	.0267	.991
	Colgate Active Salt toothpaste	.0100	.0267	.999
	Pepsodent (Regular) toothpaste	.0247	.0267	.939
	Dabur Lal tooth powder	-.1100(*)	.0267	.001
	Control (water)	.1640(*)	.0267	.000
Dabur Lal tooth powder	Colgate toothpaste	.1260(*)	.0267	.000
	Colgate Active Salt toothpaste	.1200(*)	.0267	.000
	Pepsodent (Regular) toothpaste	.1347(*)	.0267	.000
	Dabur red toothpaste	.1100(*)	.0267	.001
	Control (water)	.2740(*)	.0267	.000
Control (water)	Colgate toothpaste	-.1480(*)	.0267	.000
	Colgate Active Salt toothpaste	-.1540(*)	.0267	.000
	Pepsodent (Regular) toothpaste	-.1393(*)	.0267	.000
	Dabur red toothpaste	-.1640(*)	.0267	.000
	Dabur Lal tooth powder	-.2740(*)	.0267	.000

\* The mean difference is significant at the .05 level.

**Table 5. Multiple comparison of surface roughness after 3 hour tooth brushing by post hoc test tukey hsd between all groups**

Group (I)	Group(J)	Mean Difference(I-J)	Std. Error	Sig.
Colgate toothpaste	Colgate Active Salt toothpaste	-.01933	.02829	.983
	Pepsodent (Regular) toothpaste	.00133	.02829	1.000
	Dabur red toothpaste	-.01800	.02829	.988
	Dabur Lal tooth powder	-.15267(*)	.02829	.000
	Control (water)	.14800(*)	.02829	.000
Colgate Active Salt toothpaste	Colgate toothpaste	.01933	.02829	.983
	Pepsodent (Regular) toothpaste	.02067	.02829	.978
	Dabur red toothpaste	.00133	.02829	1.000
	Dabur Lal tooth powder	-.13333(*)	.02829	.000
	Control (water)	.16733(*)	.02829	.000
Pepsodent (Regular) toothpaste	Colgate toothpaste	-.00133	.02829	1.000
	Colgate Active Salt toothpaste	-.02067	.02829	.978
	Dabur red toothpaste	-.01933	.02829	.983
	Dabur Lal tooth powder	-.15400(*)	.02829	.000
	Control (water)	.14667(*)	.02829	.000
Dabur red toothpaste	Colgate toothpaste	.01800	.02829	.988
	Colgate Active Salt toothpaste	-.00133	.02829	1.000
	Pepsodent (Regular) toothpaste	.01933	.02829	.983
	Dabur Lal tooth powder	-.13467(*)	.02829	.000
	Control (water)	.16600(*)	.02829	.000
Dabur Lal tooth powder	Colgate toothpaste	.15267(*)	.02829	.000
	Colgate Active Salt toothpaste	.13333(*)	.02829	.000
	Pepsodent (Regular) toothpaste	.15400(*)	.02829	.000
	Dabur red toothpaste	.13467(*)	.02829	.000
	Control (water)	.30067(*)	.02829	.000
Control (water)	Colgate toothpaste	-.14800(*)	.02829	.000
	Colgate Active Salt toothpaste	-.16733(*)	.02829	.000
	Pepsodent (Regular) toothpaste	-.14667(*)	.02829	.000
	Dabur red toothpaste	-.16600(*)	.02829	.000
	Dabur Lal tooth powder	-.30067(*)	.02829	.000

\* The mean difference is significant at the .05 level.

tooth brushing at different intervals. Post hoc multiple comparison test Tukey HSD and Paired t-test (Table 3, Table 4 and Table 5) comparison of surface roughness (Ra) within the same groups at different time interval showed with increase in time of brushing, there was increase in surface roughness and when one hour brushing was compared with 2 hour brushing and 2 hour brushing with 3 hour brushing the difference among them was very highly significant in all the six groups. Surface roughness had increased in following order:- Control < Pepsodent Regular toothpaste < Colgate Active Salt toothpaste < Colgate toothpaste < Dabur red toothpaste < Dabur Lal tooth powder.

## DISCUSSION

Abundance of dentifrices containing different formulation has been introduced in the market, with some trying to improve efficiency of cleaning. The first thorough study of the relation between dentifrices and certain types of wasting of tooth tissue was reported in 1907 by W.D. Miller. He concluded that certain types of the tooth pastes and tooth powders then in use were capable of producing wedge-shaped notches in the cervical region of anterior teeth. The abrasives in dentifrices have been related to dental wear (abrasion) and over time, can also cause an increase in the surface roughness of restorative materials, leading to greater plaque retention and pigmentation.<sup>6</sup> Therefore, dentists who select materials for clinical use still look at the wear resistance of prospective materials.

Oliveira et al. observed that although restorative materials suffer alterations under mechanical challenges, such as toothbrushing, the use of nanofilled materials seem to be more resistant to roughness and wear than microhybrid composite resins.<sup>22</sup> That's why in this study Filtek™ Z350 Universal restorative nanocomposite was used.

For this study, a simulated tooth brushing machine was designed to perform 16000 brushing strokes per hour which is equivalent to brushing a tooth 22 strokes twice per day for one year.<sup>7</sup> The value of 16,000 strokes equal to one year tooth brushing was established previously by Aker et al. and Heath et al.<sup>8,9</sup> Madikos et al. used the same number of brushing strokes for evaluation of wear resistance and hardness of indirect composite resin.<sup>10</sup>

The applied load during tooth brushing was 200 gm as it is in line with the technical specification of ISO on wear testing by tooth brushing, which defines a force between 0.5 and 2.5 N (ISO 1999). Similar force of 200 gm were detected in other studies.<sup>11-16</sup>

A surface profilometer was selected to be used in this present study, as it is an instrument that is capable of measuring surface roughness (Ra) directly. The surface area roughness (Sa) parameter or generally known as average roughness (Ra) parameter was used in this study because it is the commonly employed parameter for roughness measurement.<sup>17</sup>

Simulated tooth brushing was performed in three phases that is for 1 year, 2 years and 3 years. This would help us to know exactly after which interval the patient or restoration should be re-evaluated as to adjust its replacement or repolishing. This study however not only evaluates the long term effects but also assesses the material at different simulated time periods of tooth brushing for life of the restoration in the oral cavity. The result of present study showed that there was increase in surface roughness over the time in every group irrespective of dentifrices used even the control group. Surface roughness had increased in following ascending order:- Control < Pepsodent Regular toothpaste < Colgate Active Salt toothpaste < Colgate toothpaste < Dabur red toothpaste < Dabur Lal tooth powder. When all the tooth pastes were compared, their behaviour was found to be similar as there was no statistically significant difference amongst them. Though all of them were inferior to control group and the difference was statistically significant, however the only tooth powder Dabur lal tooth powder gave the maximum roughness when compared with the other tooth pastes and the difference was statistically significant. This finding is in line with Grizon et al. who found that all toothpowders which contained insoluble abrasive grains were associated with a significantly higher effect than the control brushes with either distilled water or toothpastes.<sup>18</sup> The larger and harder abrasive particles will abrade the surface of the specimens in a shorter period of time as compared to smaller particles. Costa et al. found that the medium to moderate RDA dentifrices were more abrasive than the low RDA dentifrice on all composites.<sup>23</sup> Therefore dentifrices of lower abrasivity promote less reduction in gloss and surface roughness for composites of after brushing.

Present study demonstrated that the higher surface roughness with increased brushing time or brushing strokes when one hour brushing was compared with 2 hour brushing and 2 hour brushing with 3 hour brushing and the difference among them was very highly significant in all the six groups. This finding is in line with a study by Teixeira et al. and Dos Santos et al.<sup>19,20</sup>

The results of study are in concordance with our observations in clinics that most of the patients suffering from deep facial abrasion defects gave history of use of Dabur lal tooth powder. Thus we can assume that the use of Dabur lal tooth powder is harmful not only to the composite restoration but also the tooth surface and adjoining gingival tissue due to high RDA value. It would not be wrong to say that the use of the tooth powder should not be advocated for long periods. Whereas an increase in mean roughness with 4 toothpaste used in the study ranging from 0.32  $\mu\text{m}$ -0.43  $\mu\text{m}$  which is way higher than the higher limit of surface roughness as advocated by Bollen et al.<sup>21</sup> He stated that surface roughness (Ra) greater than 0.2  $\mu\text{m}$  may lead to bacterial colonization onto the restoration and increase the risk of secondary caries. Hence

it can be concluded that every composite restoration needs to be re-evaluated yearly so as to whether it needs to be repolished or replaced.

In this study, as the readings observed in profilometer were clear enough, it could be inferred that the results would probably be confirmed by a qualitative analysis obtained stereomicroscopy or AFM generated images.

## CONCLUSION

Within the limits of the present study, it can be concluded that with increase in time of brushing, there is increase in surface roughness in all the six groups. Amongst the five tested dentifrices Dabur Lal tooth powder showed the maximum surface roughness of nanofilled composite after toothbrushing. The reason could be the more percentage of abrasive particles (RDA) in tooth powder compared to toothpaste. Therefore every composite restoration needs to be re-evaluated yearly.

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