Comparative evaluation of surface roughness in composite resins incorporated with silver and Titanium dioxide nanoparticles

Surface roughness of modified nanocomposites

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Abstract:

Introduction: The addition of nanoparticles into the restorative materials is the recent trend and innovative procedure for the development of modified restorative materials.
Aim: The study aims to evaluate the efficiency of surface roughness after finishing and polishing the tooth surface filled with a modified restorative material.
Materials and methods: addition of silver and titanium dioxide nanoparticles into commercially available restorative materials like composite, which is the esthetic material of choice for the patients.
Statistical analysis: ANOVA test followed by Tukey's posthoc test for all the samples, and p-value $p<0.05$ was taken as statistically significant.
Results: The results obtained showed Group I to be having the highest number of grade A enamel surface (70%), while group IV showed the least number of grade A(10%). Group II showed higher grade B(60%), while Group III and IV showed higher grade C and grade D (40%).
Discussion: The results of the study showed that the highest surface roughness for titanium dioxide nanocomposite with polishing pate group followed by Silver nanocomposite with polishing paste.
Conclusion: TiO2 composite with polishing paste shows the highest surface roughness than silver Group due to differences in their particle size. Silver nanoparticles significantly affect the aesthetic appearance of the restorative materials in clinical dentistry due to its gray color in nature.

Keywords: Finishing, Polishing, Dental Composite, Nanoparticles, Surface Roughness.

Abbreviations:

NPs - Nanoparticles
Ag - Silver
TiO2 - Titanium Dioxide

Introduction:

Aesthetics is the primary concern for the patients seeking dental treatment. The branch of the dental science that deals with the appearance with the appearance of patient's teeth and oral cavity as the major dental reconstruction. With the emergence of new concepts and techniques in the field of dentistry direct composite resins undoubtedly remain the first choice of material for restoration and bonding of the attachments.[1]

The selection of restorative material depends on several factors, including marginal integrity, color and surface characteristics. Several studies have reported material-dependent surface roughness alterations of restorative materials after bleaching.[2-4] The property of surface smoothness of restorative procedure is of clinical importance for success of clinical restorations. The presence of surface irregularities or improper finishing leads to plaque accumulation.[5]

Plaque is a major cause of caries, periodontitis and other dental diseases is a complex community of bacteria or fungi that causes infection by protecting pathogenic microorganisms from external drug agents and escaping the host defense mechanisms.[6] Although signifificant numbers of study that focus on developing antimicrobial agents to overcome this problem exist, most of these attempts failed to achieve desired outcomes due to the rapid degradation and fast release of antibacterial agents causing low effificiency and safety concerns. [7,8]

The use of specific nanoparticles (NPs) as antimicrobial agents has attracted much attention in the field of medicine and dentistry. Some of the commonly used nanoparticles with antimicrobial activity are Titania (TiO2) Silver (Ag), Gold (Au), Silica (SiO2), Copper (Cu/CuO), Zinc oxide ZnO.[9]

The incorporation of silver nanoparticles(AgNPs) into bonding adhesives was successful on both physical and antimicrobial levels.[10] Titanium dioxide (TiO2) has been widely applied in organic degradation processes due to its bio-compatibility and chemical stability.[11] These nanoparticles are incorporated at low level into the restorative adhesives to avoid unwanted side effects.

The addition of nanoparticles into the restorative materials is the recent trend and innovative procedure for development of experimental composite resins. Various studies conducted on mechanical properties of composite resins and restorative materials.[12] Despite the antibacterial and mechnaical properties of these nanoparticles into restorative materials their effect on change in color to the adhesives and their efficacy in final finishing and polishing is the point of interest for conducting this study.

Aim:

The aim of the study is to evaluate the efficiency of surface roughness after finshing and polishing the tooth surface filled with modified restorative material.

Materials and methods:

The materials and equipment used in the study are
1) Tetric N-Cream (ivoclar, vivadent)
2) primer (ivoclar, vivadent)
3) 37% phosphoric acid (Eazetech, Anabond)
4) **Titanium oxide nanoparticles**(TiO2 NPs), Dry Powder form, Anatase,
Average particle size: 20-30nm, Purity: 99.9%, Surface area: 200-220 m2/g.[Fig 1]
5) **Silver nanoparticles**, (Ag NPs) Dry Powder form, Average particle size:
50-70nm, Purity: 99.9%, Surface area: 15-20 m2/g, Color: Gray. [Fig 1]
6) Extracted premolar teeth
7) Curing light (woodpecker)
8) Polishing paste (proxyt, ivoclar, vivadent)
9) Rubber cups
10) Extra fine diamond tip
11) Stereomicroscope (Zeiss ProgRes C3)
12) Composite mixer (HIGH ENERGY BALL MILL)

Fig 1: Silver nanoparticles and TiO2 nanoparticles.

Modified composite preparation:

To achieve composite resin containing 1% TiO2 (w/w), 40mg of TiO2 NPs were added to the 4000 mg of Tetric N-Cream (ivoclar vivadent) and blended by using composite mixer (HIGH ENERGY BALL MILL) at a speed of 3500 revolutions per minute in dark environment for 5min. The obtained new orthodontic adhesive is modified composite containing 1% (w/w) TiO2 nanoparticles and similarly for the silver nanocomposite preparation(1% w/w Ag-NPs). [Fig 2]

Fig 2: Modified nanocomposites (nanoparticles incorporated within adhesive)

Sample preparation

120 freshly extracted teeth were cleaned to remove blood or any tissue debris and stored in distilled water until the start of study to prevent dehydration. The teeth were then mounted in dental plaster such that the roots were completely embedded into the plaster up to cemento-enamel junction to stabilize the teeth during experiment. We have intentionally created the class V cavities on buccal surface of the tooth and the cavities were filled with modified restorative materials and the samples were distributed based on materials used for restoration and agents used for finishing and polishing.

Restorative procedure:

The intentionally created class V cavities were acid etched with 37% phosphoric acid(Eazetech,Anabond) for 30 secs then wash away the etchent with water and air spray till the white frosty appearance is seen. Then apply a thin coat of primer(ivoclar, vivadent) on the cavity preparation and light cured for 10 secs now fill the cavity with modified restorative materials and light cured for 30 secs each on mesial and distal sides.

Fig 3: Intentionally created class V cavity preparation and restoration with modified restorative materials.

Finishing and polishing:

The finishing and polishing procedure was performed by same operator. For finishing extra fine diamond tip was used at high speed with airotor handpiece and water coolant to remove excess material. Later use of rubber cups with or without polishing paste(proxyt, ivoclar, vivadent) in circular motion at low speed. [Fig 4] The surface roughness of the teeth were evaluated using stereomicroscope (Zeiss ProgRes C3) under 200X magnification. The stereomicrophotographs were graded according to the Howell and Weekes (1990). [13] (Table 2)

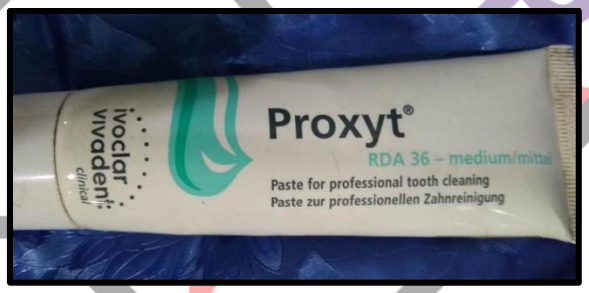

Fig 4: polishing paste

Table 1: sample distribution

Groups	**Modified restorative material with/without polishing materials**
Group- I (n=30)	TiO2 restorative material + with polishing paste
Group- II (n=30)	Ag restorative material + with polishing paste
Group- III (n=30)	TiO2restorative material + without polishing paste
Group- IV (n=30)	Ag restorative material + without polishing paste

Table :2 The stereomicroscopic photographs of respective samples were graded using Howell and Weekes (1990).[13] [Fig 5]

Grade A	Acceptable surface,fine scattered scratches.
Grade B	Mildly rough surface denser fine scratches,some coarser scratches.
Grade C	Rough surface,numerous coarse scratches over the entire surface.
Grade D	Very rough surface,deep,very coarse scratches over the entire surface.

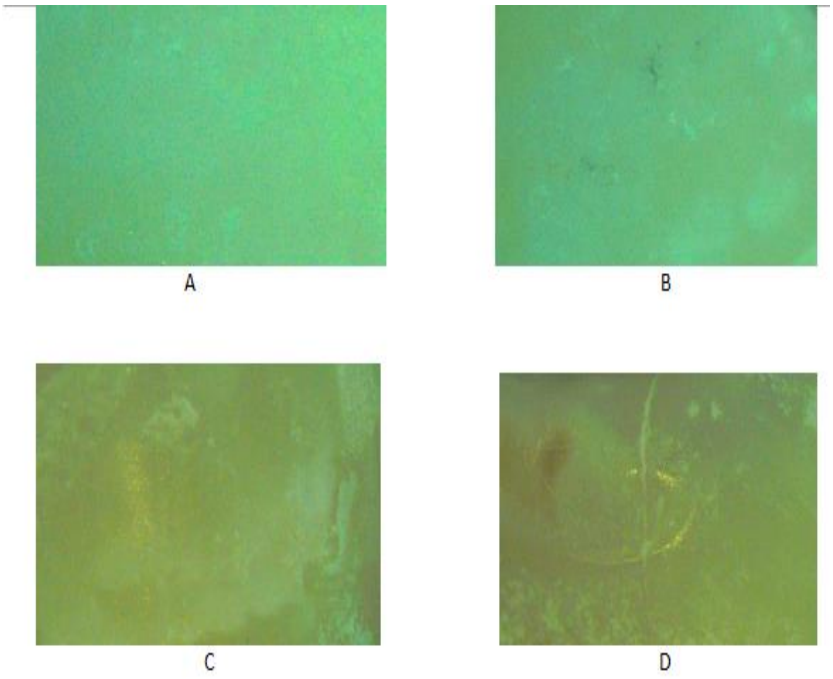

Fig 5: stereomicrophotographs of samples were graded according to Howell and Weekes (1990).

STATASTICAL ANALYSIS

The data obtained were presented as grades per sample per group. Intragroup comparison of the data obtained was done by ANOVA test and for the inter group comparison by Tukey's posthoc test for all the samples and p value $p<0.05$ was taken as a statistically significant.

RESULTS

The results obtained showed Group I to be having the highest number of grade A enamel surface (70%) while group IV showed least number of grade A(10%). Group II showed higher grade B(60%) while group III and IV showed higher grade C and grade D (40%).(Table:3)

Table 3:Frequency distribution of samples among group I-IV

GROUPS	GRADE-A		GRADE-B		GRADE-C		GRADE-D	
	N	%	N	%	N	%	N	%
GROUP-I	21	70	6	20	3	10	0	0
GROUP-II	6	20	18	60	6	20	0	0
GROUP-III	0	0	6	20	12	40	12	40
GROUP-IV	0	0	6	20	12	40	12	40

Illustrates the frequency distribution of samples shows group I has grade A I.e.,70%, grade B=20%, grade C=10% while group II shows grade A=20%, grade B =60%, grade C=20%, group III & IV shows grade A=10%, grade B=20%, grade C i.e.,40% and grade D=40%.

Table 4: ANOVA test for intragroup comparison from group I to group IV

	N	MEAN	SD	F	P
GROUP I	30	1.4000	0.67466	34.118	0.0001*
GROUP II	30	2.0000	0.64327		
GROUP III	30	3.2000	0.76112		
GROUP IV	30	3.2000	0.76112		

Table 5: Inter-group comparison of ANOVA followed by TUKEY'S POST HOC.

PAIR	MEAN DIFF.	P
GROUP I VS GROUP II	-.60000*	0.002
GROUP I VS GROUP III	-1.20000*	0.000*
GROUP I VS GROUP IV	-1.80000*	0.000*
GROUP II VS GROUP III	-1.80000*	0.000*
GROUP II VS GROUP IV	-1.20000*	0.000*
GROUP III VS GROUP IV	-.60000*	0.002

Illustrates ANOVA followed by Tukey's posthoc multigroup comparison of the enamel clean-up procedure. There was a statistically significant difference found when group I was compared with group II, III and group IV. Similarly, statistically significant difference found when comparing group II with group III, IV and there is no significant difference between group I with group II and group III with group IV.

ANOVA followed by post hoc showed a statistically significant difference between Group I when compared with Group II, III, IV (p=0.002, p=0.000, p=0.000 respectively) and statistically significant difference between group II when compared with Group III, IV (p=0.000, p=0.000 respectively). Tukey's posthoc shows a statistically significant difference between each group.

Discussion:

Despite the great scientific advances in adhesive materials used in field of dentistry, further improvements are needed in order to prevent the undesirable effects. In order to overcome these inconsistencies, different processing and manipulations in conventional (commercial) composite adhesives are made, leading to the development of what has been called 'experimental composite adhesives' (ECA).[14]

Incorporation of different antimicrobial agents in the adhesives, With the emergence of nanotechnology and the different behavior expressed by nanoparticles, attempts have been made to take advantage of this concept in restorative procedures. Nano sized materials are attracting a great deal in biological and pharmaceutical applications. Especially, metal oxide nanoparticles are known to possess antibacterial properties.

Despite the antibacterial and mechnaical properties of these nanoparticles into restorative materials their effect on change in color to the adhesives and their efficacy in final finishing and polishing is the point of interest in conducting this study. Though both 1% w/w Ag-NPs and 1% w/w TiO2-NPs were added at the same concentration in this study silver groups showed a decrease in surface roughness than Titanium dioxide groups. The difference might be due to the difference in the particle size. TiO2-NPs size use in this study was 20-30nm which was smaller than the particle size of ZnO-NPs which was 50-70 nm which might have been influenced the surface roughness.

Titanium dioxide is more structurally stable and forms less agglomeration of particles than zinc. Agglomeration property of the nanoparticle depends on the PH and structure of the nanoparticles. Titanium dioxide nanoparticle has low PH which decreases the agglomeration property.[15] Ag-NPs which is star shaped agglomerates faster than TiO2-NPs which is rod shaped.[16] Silver nano-particles create a dark grey color change in composite and are not suitable for esthetic applications.[17]

The results of the study showed that the highest surface roughness for titanium dioxide nanocomposite with polishing pate group followed by Silver nanocomposite with polishing paste, titanium withouth polishing paste group and the silver without

polishing paste group respectively. Amongst the group's finer smooth surface obtained when using polishing paste along with diamond burs and rubber cups for titanium nanocomposite groupthan silver group.

Conclusion:

TiO2 composite with polishing paste shows highest surface roughness than silver group due to difference in their particle size.

Silver nanoparticles significantly affects the aesthetic appearance of the restorative materials in clinical dentistry due to its gray color in nature. Unlike silver, TiO2 groups showed creamy white in color that gives aesthetic appearnce to the restorative procedure and clinically acceptable surface roughness.

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