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COMPARATIVE EVALUATION OF SURFACE ROUGHNESS OF FIVE DIFFERENT COMPOSITE RESIN MATERIALS USING CONFOCAL LASER SCANNING MICROSCOPE (CLSM).

Dentistry

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ABSTRACT

Aim: Comparative evaluation of surface roughness of five different composite resin materials using confocal laser scanning microscope (CLSM). **Methods And Materials:** Composite resin from five different manufacturers were selected namely Omnichroma (Tokuyama, Japan), Charisma Topaz ONE (Kulzser, Japan), Ceram.x® SphereTECTM one (Dentsply sirona) Tetric N-ceram Composite IVA (Ivoclar vivadent) and Beautifil II composite (Shofu, Japan) and a total of 125 microscopic slides were prepared which were divided into 5 groups containing 25 slides each and a layer of composite resin of each type was placed on the slide and light cured for 40 seconds. Each sample was polished for 20 seconds and surface roughness was calculated using a confocal laser scanning microscope. Results were statistically analysed using analysis of variance (ANOVA) and the post-hoc Tukey's HSD analysis at a $p<0.05$ significance level. **Results:** Statistically significant difference were observed among the groups ($p<0.05$), with minimum average roughness (Ra) seen in Group A (0.050 µm), followed by Group E (0.058 µm), Group B (0.194 µm), Group D (0.234 µm) and maximum roughness in Group C (0.318 µm). **Conclusion:** Omnichroma gave the smoothest finished surface while Beautifil II gave the roughest surface. The findings of the present study have clinical relevance in the choice of composite resin to be used.

KEYWORDS

Surface roughness, Omnichroma, Charisma Topaz ONE,), Ceram.x, Beautifil II

INTRODUCTION

Dental caries is the disease that is most widely distributed, affecting more than 95% of world's population. Caries causes teeth to lose their capacity to absorb the force of mechanical impact. Therefore, the restorative substance must possess qualities that can enable it to appropriately recover when this naturally complex structure is altered.[1] G V Black proposed a balanced amalgam formula (silver 72.5% and tin 27.5%) in 1895 which was further modified by Dr. William Youdelis who created high copper amalgam in 1963.[2] Dr. Michael Buonocore's seminal discovery in 1955 made new advances in dentistry by using phosphoric acid to increase mechanical bonding of resin to enamel.[3,1] The usage of silicate and acrylic resin from cosmetic dentistry was replaced by development of composites by R. L. Bowen.[4] The development of ultraviolet light-curing systems and improvement in color-stability of tooth-colored restorations after use of dentin bonding agent made cosmetic dentistry more effective and convenient.[1] Different tooth-coloured restorative materials like composites are preferred over amalgam in the current dentistry world, because of esthetically pleasing characteristic, simple bonding technique, good physical and mechanical properties of composites.
Some newly marketed composite resin materials are described below:

Omnichroma is the world's first universal composite made of uniformly sized supra-nano spherical fillers (260nm spherical SiO_2-ZrO_2) that esthetically matches every patient, from A1 to D4, with a single shade. OMNICHROMA is made up of an equal amount of zirconium dioxide (ZrO_2), a round composite filler with the same properties, and supra-nanospherical silicon dioxide (SiO_2) filler with small particle size.[5]

Charisma Topaz ONE (Kulzser, Japan) is a novel development in direct adhesive restorations. These materials were created for simple, straightforward, and quick restorations, primarily in the posterior area. Charisma Topaz is a light-curing, Radiopaque Nano-Hybrid Composite Based On The Unique TCD-Matrix.[6]

Ceram.x®SphereTEC™ is based on the advanced granulated filler technology spheretec. The spheretec fillers' morphology, particle size distribution and surface microstructure are key for the enhanced handling comfort and esthetic outcome. [7]

Tetric n ceram is a light cure nano optimized anterior/posterior composite. Tetric n-ceram demonstrates an exceptionally high level of radiopacity and thus significantly facilitates the diagnosis of secondary caries.[8]

Beautifil ii composite, with the proprietary bioactive giomer technology, is used in the cervical area, specifically for the aesthetic correction of gingival recession, wedge-shaped defects and exposed cervical areas.[9]

The proper finishing and polishing of dental restoratives are significant to promote a plaque-free environment and to enhance the esthetics and longevity of restoration. Weitman and Eames stated that plaque accumulation occurs on composite samples with a surface roughness of 0.7-1.44 um. Unfortunately, in the clinical environment such a finish cannot be obtained, further some degree of finishing and polishing of restorations is usually necessary.[10] Confocal laser scanning microscopy (CLSM) is a relatively new imaging

technique in dentistry. This technique can be regarded as 'reflection' microscopy rather than the now more conventional fluorescence microscopy. Essentially, the surface topography is optically sectioned and a topographical image is reconstructed from the resulting slice series. A variety of roughness parameters may then be obtained using the appropriate algorithms.[3]

MATERIALS AND METHODS

The present in-vitro study was conducted to comparatively evaluate surface roughness of different composite resin materials using confocal laser scanning microscope (CLSM) in the Department of Conservative Dentistry and Endodontics, Babu Banarasi Das College of Dental Sciences (BBDCODS) in collaboration with Central Drug Research Institute (CDRI) Lucknow. This study was carried out in a period of 6 months from the time of obtaining ethical clearance.

Composite resin from five different manufacturers are selected namely Omnichroma (Tokuyama, Japan), Charisma Topaz ONE (Kulzser, Japan), Ceram.x® SphereTEC™ one (Dentsply sirona)Tetric N-ceram Composite IVA (Ivoclarvivadent) and Beautifil II Gingiva shade composite (Shofu, Japan).

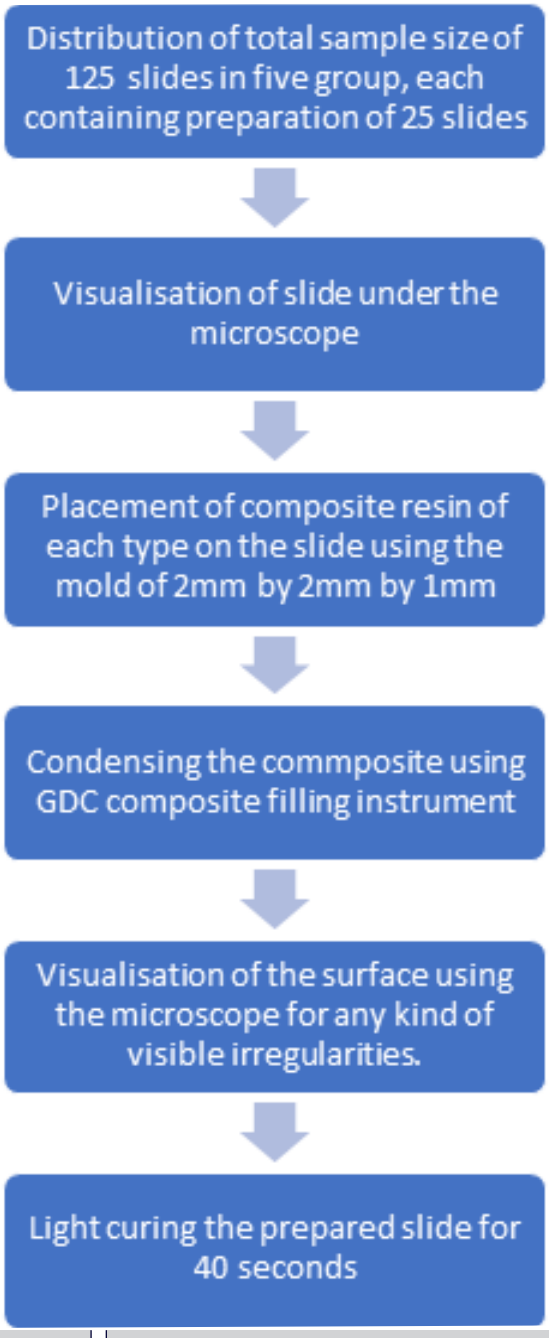
To make a standardized specimen, a mold of size 2mm by 2mm by 1mm was created using polytetrafluoroethylene. 125 sterilised

microscopic slides (G lab, India) were taken and further 25 slides were assigned to each group.25 samples were prepared for each composite restorative material. The selected composite of individual group was scooped out of the layered over the slide surface using GDC composite filling instruments and composite was adapted over the slide surface. Specimens will be prepared at room temperature (23.5± 2°C) and 50% relative humidity. All the materials will be manipulated exactly according to the manufacturer's instruction.

Group I (n=25)- Omnichroma (Tokuyama, Japan)
Group II(n=25)- Charisma Topaz ONE (Kulzser, Japan)
Group III (n=25)- Ceram.x®SphereTEC™ one (Dentsply sirona)
Group IV (n=25)- Tetric N-ceram Composite IVA (Ivoclarvivadent)
Group V (n=25)- Beautifil II Gingiva shade composite (Shofu, Japan)

Using Sof-Lex finishing and polishing discs, all 125 samples were polished. 13-mm Sof-Lex discs were used for this investigation. For polishing, three different sof-lex discs of size—medium, fine, and superfine—with corresponding grain sizes of 29, 14, and 5 mm were utilised.

Flow Chart Depicting The Method Of The Study



Methodology

Following the computation of the statistically suitable sample size (n=25 per group), the investigation was planned with the goal of examining distinct composite resins using standardized polishing regimens.

Five types of marketed and existing composite resins were evaluated in the present study which were divided into five groups, each group individually consisting of 25 samples. The distribution of sample has been described in detail through the table and graph given below.

Distribution Of Samples

Table 1 : Distribution Of Samples

GROUPS	NUMBER OF SAMPLES	TYPE OF RESTORATION
GROUP A	25	Omnichroma
GROUP B	25	Charisma Topaz ONE
GROUP C	25	Beautil II
GROUP D	25	Ceram.x SphereTEC
GROUP E	25	Tetric N-Ceram

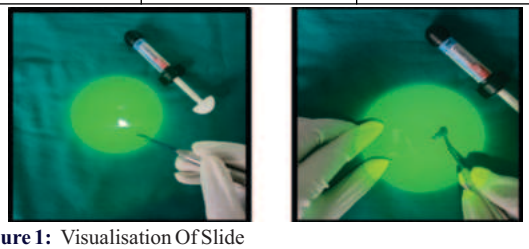


Figure 1: Visualisation Of Slide
Figure 2: Placement Of Sample On The Slide

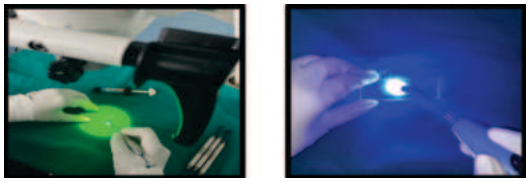


Figure 3: Condensation Of Sample In The Mold
Figure 4: Light Curing For 40 Seconds

Figure 5: Finishing With Sof-lex Discs
Figure 6: Omnichroma (n=25)

Figure 7: Confocal Laser Scanning Microscope (clsm)

RESULTS

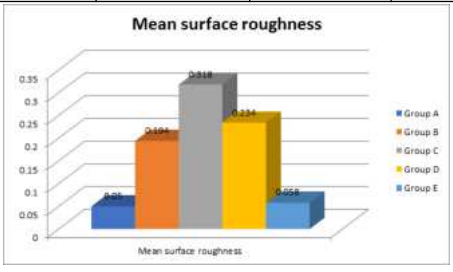
Statistical Analysis

The data were submitted and statistical analysis was done with the help of one-way analysis of variance for multiple comparisons followed by post hoc Tukey test for inter and intragroup comparisons. Data was analysed using SPSS Software, Version 20.0 for Windows.

Result shows the mean surface roughness among the 5 groups. The results shows that on comparison using ANOVA, there is statistically significant difference among the groups ($p<0.05$), with minimum roughness seen in Group A, followed by Group E, Group B, Group D and maximum roughness in Group C.

Table 2 : Results Of All Groups

Groups	Mean	Sd	p-value
Group A	0.050	0.021	**<0.001**
Group B	0.194	0.071	
Group C	0.318	0.065	
Group D	0.234	0.068	
Group E	0.058	0.029	



Graph 1 : Comparison Of Mean Surface Roughness Of Different Groups

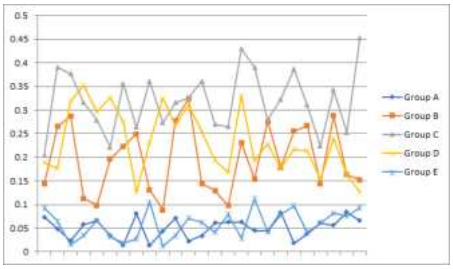
The intergroup comparison was done using the post hoc test. The results shows that there is statistically significant difference among the Group A-Group B, Group A- Group C, Group A- Group D, Group B-Group C, Group B- Group E, Group C- Group D, Group C- Group E and Group D- Group E ($p<0.05$), while there is statistically non-significant difference among the Group A- Group E and Group B-Group D ($p>0.05$).

Intergroup Comparison Results

Table 3: Intergroup Comparison Table

Group I	Group II	Mean Difference (I- II)	p-value
Group A	Group B	-.144	**<0.001**
	Group C	-.268	**<0.001**
	Group D	-.183	**<0.001**
	Group E	-.008	.986
Group B	Group A	.144	**<0.001**
	Group C	-.124	**<0.001**
	Group D	-.039	.101
	Group E	.136	**<0.001**
Group C	Group A	.268	**<0.001**
	Group B	.124	**<0.001**
	Group D	.084	**<0.001**
	Group E	.260	**<0.001**
Group D	Group A	.183	**<0.001**
	Group B	.039	.101
	Group C	-.084	**<0.001**
	Group E	.175	**<0.001**
Group E	Group A	.008	.986
	Group B	-.136	**<0.001**
	Group C	-.260	**<0.001**
	Group D	-.175	**<0.001**

Intergroup Comparison



Graph 2: Multiple Line Graph Comparing All The Groups

DISCUSSION

The appearance of the restoration is affected by the degree of surface gloss after polishing and is based on reflected light from the restoration. With increased surface roughness, the degree of light reflection increases, resulting in decreased gloss.[11]

With regard to the impact of surface roughness on gingival health, clinical studies have shown that rough surfaces increase plaque formation and reduce the cleaning efficiency of oral hygiene procedures.[12] The surface micromorphology of resin composites after finishing and polishing has been shown to be influenced by the size, hardness and amount of filler particles.

The present study was conducted to evaluate and compare the surface roughness of different composite resins using confocal laser scanning microscope. Five marketed and existing composite resins were evaluated in the present study which were divided into five groups, each group individually consisting of 25 samples-Group A (Omnichroma), Group B (Charisma Topaz One), Group C (Beautifil II), Group D (Ceram.xSphere TEC) and Group E (Tetric N-Ceram).

The results of the present study showed that the surface roughness of Omnichroma (Group A) was lowest followed by Tetric N Ceram. The average surface roughness value of Omnichroma was 0.050 µm and of Tetric N Ceram was 0.058 µm. There was no significant difference between the surface roughness of Omnichroma and Tetric N Ceram. The findings are in agreement with the study conducted by Mohammed Jabbar Atyiah et al[13] who compared the surface roughness of three composite materials –Omnichroma, Tetric N Ceram and Z350XT from 3M . When the collected Ra values were analysed using One-way ANOVA, there were no significant differences between the groups.

In the present study the surface roughness of Omnichroma (Group A) was significantly higher than the surface roughness of Charisma Topaz One (Group B) although both of them are monochromatic universal shade composites. The study conducted by **Cemile Kedici Alp[14] on the surface roughness of th**ree monochromatic (Omnichroma, Vittra Unique, and Charisma Diamond One) resin composite which concluded that the surface roughness of Charisma Diamond One was highest and significantly different from Omnichroma at different time intervals. The findings are also in consensus with the study conducted by Adham A. Khairy[15] et al, which showed the lowest surface roughness values with the nanofill resin composite (Omnichroma) as compared to nanohybrid Composites (Charisma Topaz One).

The reason for its polishability and polish retention of Omnichroma might be due to the clustered arrangement of its filler particles. The wear mechanism suggested that the clusters of the particles wear off instead of taking out the whole particles.[16] Another important factor that might explain these results is the filler particle shape. The spherical shaped particles of the Nano-fill resin composite showed lower surface roughness than the hybrid shaped particles. This might be due to that the irregular shaped filler particles can be subjected to more friction

during the polishing process as they have sharp edges and corners that can be easily removed as suggested by Tamura et al[17]. In the present study the surface roughness of Omnichroma was significantly higher than the Beautifil II (Group C) composite resins. The study conducted by Kana Hyeshi et al[18] found that the cavities restored with Beautifil II had higher surface roughness and lower color stability as compared to the cavities restored with Omnichroma composite restorative material. In the present study the surface roughness of Charisma Topaz one was lower than the Omnichroma and Tetric N Ceram . The difference between the surface roughness of Tetric N Ceram and Charisma One was statistically significant. The findings are in line with findings of the study by Indhira Melo[19] et al who reported higher surface roughness of Charisma One as compared to Tetric N-Ceram when polished with So-Flex polishing system. In the present study the surface roughness of Charisma Topaz One (Group B) was lower than the Beautifil II (Group C). The findings are in contrast to the findings of Magrur Kazak et al[20] who reported the highest surface roughness of Charisma Topaz One as compared to the Beautifil II. The high surface roughness of Charisma Topaz One has also been reported by other studies[21]. The reason for the high surface roughness of Charisma Topaz One has been attributed to its nano hybrid structure. The Nano-hybrid resin composite which has small fillers particles, and the resin matrix surrounds the filler particles which is the first thing that is worn out after abrasion of the composite, leading to the protrusion of the fillers, and formation of filler bumps on the outer surface of the resin based composite.

A Sof-Lex disc was used in the present study to polish the surface of resin composites as it has been reported that this allows obtaining a lower surface roughness compared with any other polishing system[22] It should be noted that the surface roughness of all resin composites decreased significantly after polishing, with and without oil control, with final values ranging from 0.0025 µm to 0.8 µm, which is acceptable according to the ISO 1302:2002 quality standard (ISO; Geneva, Switzerland: 2002).[23]

The measurement of the surface roughness was done by confocal laser scanning microscope which is the best method to evaluate the surface roughness as compared to the linear method - Optimal profilometer. With linear roughness measurement (profile method type), the degree of roughness in the surface is measured along an arbitrary straight line. Long, continuous dimensions are measured, and a contact stylus is commonly used to perform the roughness measurement.[24] With areal roughness measurements (CLSM), the degree of roughness in the surface is measured over an arbitrary rectangular range. Areal roughness measurement uses a larger sampling area of the surface, providing a more accurate depiction of the state of the surface.[25]

Limitations Of The Study

The present study has certain limitations –The surface of the sample in the present study was flat which does not exist clinically. Also, the study was performed in vitro, so the effect of oral environment was neglected. These limitations can be improved by preparing the sample in the tooth itself to follow the tooth morphology. Also, in vivo studies are required to investigate the possible effect of oral environment on the surface roughness of such restorations.

CONCLUSION

The results of this study concludes the surface roughness (Ra) of different composite resins in the following order:

- Group A < Group E < Group B < Group D < Group C.
- Omnichroma < Tetric N-Ceram < Charisma Topaz One < Ceram.x® SphereTEC™ one < Beautifil II.

Omnichroma is a better choice for aesthetic restoration as it had the lowest surface roughness, which in turn have a smoother finish and high gloss, compared to other composite evaluated in the study. The surface roughness of Omnichroma was comparable to Tetric N Ceram and significantly lower as compared to Beautifil II, Ceram.x SphereTEC and Charisma Topaz One. Also, the chances of bacterial and plaque accumulation will decrease significantly, along with increasing the color stability and longevity of the restoration.

The surface roughness of Beautifil II was highest and significantly different from other materials making it less suitable for the anterior aesthetic restoration as these materials are difficult to polish and have greater chances of plaque accumulation and bacterial invasion due to their surface irregularities. Thus, making it an unsuitable choice for anterior aesthetic cases.

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