BBD UNIVERSITY

# COMPARATIVE EVALUATION OF SURFACE ROUGHNESS OF DIFFERENT COMPOSITE RESINS USING CONFOCAL LASER SCANNING MICROSCOPE : AN IN VITRO STUDY.

DISSERTATION

Submitted to

BABU BANARASI DAS UNIVERSITY, LUCKNOW, UTTAR PRADESH

In the partial fulfillment of the requirement for the degree

of

MASTER OF DENTAL SURGERY

In the subject of

CONSERVATIVE DENTISTRY & ENDODONTICS

Submitted by

DR. AAYUSH ANAND PODDAR

Under the guidance of

DR. AKANKSHA BHATT

DEPARTMENT OF CONSERVATIVE DENTISTRY & ENDODONTICS

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES, LUCKNOW

Batch: 2021-24 Enrolment No.: 12103222926

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**LUCKNOW.**

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I hereby declare that this dissertation entitled **"Comparative evaluation of surface roughness of different composite resins using confocal laser scanning microscope: an in vitro study"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. Akanksha Bhatt,** Reader, Department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

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**DR. AAYUSH ANAND PODDAR**

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# ABSTRACT

# 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® SphereTEC™ 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 of dimensions 2mm by 2mm by 1mm and light cured for 40 seconds.

**Group A (**n=25): Omnichroma (Tokuyama, Japan)

**Group B** (n=25): Charisma Topaz ONE (Kulzser, Japan)

**Group C** (n=25): Beautifil II composite (Shofu, Japan)

**Group D** (n=25): Ceram.x® SphereTEC™ one (Dentsply sirona)

**Group E** (n=25): Tetric N-ceram Composite IVA (Ivoclar vivadent)

Each sample was polished with 3M ESPE Sof-lex Polishing discs (Medium, Fine, Super fine) for 20 seconds each 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.

# INTRODUCTION

# INTRODUCTION

Direct restorative materials are the materials that can be directly inserted into a prepared tooth cavity in a single appointment. In the past, bone and ivory were used to make restorative materials. Later, these materials also included waxes, gums, alum, honey, pulverized mastic, powdered pearl, white Corelle, amalgam, tin, gold, gutta-percha, silicate cement, resins, and glass ionomer cement (GIC).[1]

In 1826, August Taveau of Paris mixed silver with mercury to create silver paste, which marked the birth of dental amalgam, a ground-breaking advancement in the field of operative dentistry.[2] The Crawcour brothers removed silver from coins and added extra mercury to create amalgam, which they later sold commercially in the United States in 1833.[3] Unfortunately, the material was utilized brutally, ruining its reputation and leading to what became known as the "Amalgam war."[3,4] Before G V Black proposed a balanced amalgam formula (silver 72.5% and tin 27.5%) in 1895, the dental profession was still apprehensive about using amalgam.[4] Dr. William Youdelis created high copper amalgam in 1963 to improve the long-term marginal integrity and address the shortcomings of low copper amalgam alloy.[4]

New avenues in the field of bonding resins and cosmetic dentistry were made possible by Dr. Michael Buonocore's seminal discovery in 1955 that phosphoric acid increased the mechanical bonding of resin to enamel.[5,6] The usage of silicate and acrylic resin from cosmetic dentistry was all but rendered obsolete in 1962 when composites were developed by the efforts and research of R. L. Bowen.[7] The development of ultraviolet light-curing systems made cosmetic dentistry more effective and convenient. Another important discovery in dentin bonding agent technology helped stabilize and retain a tooth-coloured restoration without removing too much of the healthy tooth structure.[5]

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 be appropriately recovered when this natural complex is altered.[6]

The composite resin, a hybrid material mostly made of fillers and organic matrix, is advised in order to attain an acceptable clinical performance. Due to their superior physical and mechanical qualities, ease of bonding, and patient demands for aesthetics, resin composites are frequently employed for the direct restoration of both anterior and posterior teeth.[7] Modern microhybrid composites contain fine inorganic fillers with a mean value of less than 1 μm and come in a range of different sizes. Such materials are appropriate for stress-bearing circumstances like Class IV restorations due to their substantial inorganic filler content.[8] However, the method sensitivity of the material is more likely to put packable composite at risk for the proximal area of posterior teeth where isolation is challenging. In order to decrease marginal leakage and provide additional stress relaxation, flowable composite is used.[9]

Bonding resin is an unfilled or semi filled resin which matches to the resin in the composite but has a lower viscosity to permit easy flow and penetration.[10] Bonding agents are divided into "generations" based on how they have developed. The bonding agents of the first and second generations were designed to be applied in a single step, while the bonding agents of the third generation required three steps: priming, conditioning, and bonding agent application.[11] Nakabayashi et al.'s concept of "hybridization," which involved resin diffusion and impregnation into partially decalcified dentin followed by polymerization, produced a resin-reinforced layer known as the "hybrid layer," was the basis for the fourth generation of dentistry.[12] The wet bonding method and hybridization were the foundations of the fifth generation of dentin bonding agents, which had the benefit of a strong bond. Sixth and seventh-generation adhesive agents have been attempted and are still widely used in adhesive restorative dentistry to increase the bond strength and facilitate handling.[14]

Composite materials were further improved by modifying the resin matrix and filler, which resulted in the introduction of microfilled, hybrid, microhybrid, flowable, packable, and modified hybrid composites.[15]

To encourage a plaque-free environment, improve the aesthetics and durability of restorations; dental restoratives must be finished and polished properly.[16] Plaque accumulation, according to Weitman and Eames, happens on composite samples with a surface roughness of 0.7-1.44 um. Early research has demonstrated that the smoothest surface is achieved when curing composite against a matrix strip. Unfortunately, such a finish cannot be achieved in a clinical setting; additional finishing and polishing of restorations are typically required.[16,17]

The main components of aesthetic restorative materials are an organic phase which is the resin matrix and mineral particles, which serve to increase their mechanical resistance among other things. Depending on the structure and makeup of each phase, these materials can be divided into a number of categories. More fluid or more compact materials created for various functions can be added to the most popular textures.[18]

One of the most recent global resin-based composites, Omnichroma from Tokuyama Dental Corp. in Japan, promises doctors' comfort in the area of a frequent battle, namely shade selection. Omnichroma is a universal shade composite repair, as its manufacturer claims. [19]

Featuring intelligent chromatic technology, which regulates their optical characteristics. This technique offers a flawless reflection of a certain wavelength in the shade of the teeth. It can thus complement all VITA traditional A1-D1 shades with a single universal 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. [20]

Manufacturer claims that after polymerization, omnichroma becomes more translucent, with an increase in the refractive index following polymerization. According to earlier study, which found a substantial correlation between the translucency parameter and the blending effect, which is connected to color shifting, this is the case. After being inserted into the cavity preparation, this shadeless composite will instantly take on the color of the surrounding and underlying dentin and enamel, saving both the clinician and the patient time and removing the need for additional steps of selecting a shade.[21]

Incorporating S-PRG (surface pre-reacted glass ionomer) technology, Beautifil II is a universal nano-hybrid composite that contains a stable phase of glass ionomer for aesthetically pleasing and durable restorations that release and recharge fluoride. While keeping the strength and stability of a composite resin, Beautifil II reacts to the level of fluoride in the mouth.[22] A significant clinical trial that was published in JADA reported that 95% of the luster and no secondary caries were present after 8 years. It is a fantastic option for pediatric treatment and patients with high caries risk since, in a follow-up clinical evaluation with a retention rate of 66%2, secondary caries was only discovered in 2 of the 61 restorations after 13 years.[23] Discrete nano fillers (10–20 nm) have also been added to the filler structure in addition to the S-PRG fillers to achieve a filler load of 83.3 wt% for quick and simple polishing with an exceptional surface shine that holds up over time.[24]

Tetric N-Ceram, the effective posterior composite of the nano-optimized Tetric N-Collection, is four millimetres long. It significantly increases efficiency by allowing posterior teeth to be rebuilt using just one layer up to four millimetres thick. The entire healing of the filling is made possible by the unique light activator Ivocerin. Ivocerin is a far more reactive light initiator than traditional light initiators. As a result, even in very deep cavities, polymerization begins, and the material is completely cured.[25]

Shrinkage and shrinkage stress are minimized during polymerization because of a specifically conditioned shrinkage stress reliever which is a component of Tetric N Ceram. IVA, IVB, and IVW (universal A shade, universal B shade, and for deciduous teeth or light-coloured permanent dentition) are the three universal shades of Tetric N-Ceram that are offered. [26]

Dimethacrylates make around 19–21% of the monomer matrix's weight. Inorganic fillers make up 75-77% of the total weight or 53-55% of the volume. Barium glass, prepolymer, ytterbium trifluoride, and mixed oxide make up the fillers. Additional ingredients (less than 1.0% weight) include additives, catalysts, stabilizers, and colours. The inorganic fillers have particles that range in size from 0.04 to 3 m. 0.6 m is the average particle size.[27]

Ceram.x SphereTEC is based on the sophisticated, patent-pending SphereTEC granulated filler technology. SphereTEC refers to a method of creating spherical superstructures that are microscaled, clearly defined, and made of submicron glass. For improved handling comfort and aesthetic results, the morphology, particle size distribution, and surface microstructure of the SphereTEC fillers are crucial.[28]

An improved resin matrix system and new filler technology with granulated spherical fillers produce superior handling characteristics so that it readily adapts to hollow surfaces, does not adhere to hand tools, it becomes simple to sculpt and resistant to sagging.[29]

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.
To withstand strong masticatory stresses, composites designed for the posterior region must have high flexural strength values. The maximal biting force is two times as strong in the posterior region as it is in the incisor region.[30]

The aging process of resin-based restoration materials occurs in the oral cavity, as is well known. Therefore, over time, a composite's flexural strength and resistance to the masticatory force likewise decline. Therefore, it is essential that a composite's flexural strength endures long as it ages. [31]

Studies on the impact of polishing on aesthetic attributes date back to 1979, when Lietha-Elmer and Kratky came to the conclusion that a material's shine was mostly determined by the microgeometry of its surface. The material seems matt when microrelief has highs and lows of corrugations that are higher than the wavelength of visible light. This is because the light scatters in the grooves and pits. The repair must be polished such that the microgrooves are smaller than the wavelength of light (about 0.5 m), which is then reflected on the surface, in order to give the material a shine and improve its aesthetic quality.[16]

In the modern era of dentistry esthetics plays a pivotal role in the success of restorations. Good polishability is one of the most essential characteristics for a composite or composite material since it affects not only the aesthetics but also the endurance of the obturation by preventing bacterial plaque from adhering to it. To assist with the final step of material insertion, get rid of flaws, and provide a high-quality surface state, many polishing technologies have been presented.[17] According to earlier research, it also improves compatibility when the material and polishing system are produced by the same company. Condensable composites are simpler to polish when polishing paste is employed, according to Ritter. However, the final surface quality after polishing also depends on the type and amount of filler used in the material, as well as how much of it there is in total. According to Ryba, Dunn, and Murchison's (2002) research, the surface after polishing becomes rougher the larger the size of the filler particles. They also demonstrated how having too little matrix in comparison to filler might lead to the biggest particles being rubbed off during polishing. Smaller particle composites, however, are simpler to polish.[18]

In the modern era of dentistry esthetics plays a pivotal role in the success of restorations. Too much plaque buildup, gingival irritation, increased surface staining, and poor aesthetics of restored teeth can all be caused by surface roughness resulting from improper finishing and polishing of dental restorations.[19] These issues may also raise the risk of demineralization of enamel, recurrent caries, and periodontal issues.[20] It's also concerning because the patient may not be aware that the restorations could irritate their tongue, lips, or cheeks. For this reason, the smoothness of restorations is crucial to their success.[21] Bard Parker blades and tungsten carbide carvers are examples of hand devices. Excess restorative material can be removed interproximally with a regular No. 12 or No. 15 Bard Parker blade.[22]

Another important factor which plays a major role in finishing and polishing of a composite is Acquired: inherent polish ratio. A polish can be either intrinsic or acquired. The surface that the operator placed is the gained polish.[23] The surface that the material inevitably returns to through erosion and mastication is known as the intrinsic polish. The size and solubility of the material's dispersed phases fillers, fibers etc. determine this surface to a great extent.[24]

The surface texture won't alter if the acquired-to-inherent polish ratio (A:I ratio) is 1:1. Since nearly all restorative materials are heterogeneous, they gradually get coarser.[25] Because the filler and matrix are comparable, microfills have a low A:I ratio. Big-particle macrofills have a high A:I ratio because they gradually become rougher on the surface.[26]

The majority of restoratives are severely harmed by dry finishing.[27] Particularly dentin composite margins, the heat and friction produced might cause dentin margins to open.[28] Microfilled composite resins should only be dry finished since they only include resin fillers, which melt and create an artificial resin smear layer that improves the shine on the surface.[29] Because wet finishing lowers heat and friction, it lessens surface damage to the body and the restoration's margins.[30]

Microscopic slides from G lab, India has been used in this study for placement of the desired composite and coverslips from G lab, India have been used.
All the samples are prepared under magnification of 1.6x with the help of Dental Microscope from Labomed, USA.

In this study, we have used Confocal laser scanning microscope (CLSM) for the evaluation of the sample. It was patented by Marvin Minsky in 1957.[31] Confocal laser scanning microscopy (CLSM) is a relatively new imaging technique in dentistry . In particular, the use of CLSM as a tool for measuring surface topography has been explored only to a very limited degree.[32] The functioning of confocal laser scanning microscope is such that as the illumination point is moved across the sample, the confocal image is built. Various methods have been devised to do this. The optics are kept fixed in a stage scanning system, such as the Minsky setup, and the object is scanned by moving the microscope stage. This approach offers a few benefits, such as the fact that every point in the image has the same optical characteristics, that edge artifacts are eliminated by focusing solely on the objective lens's central axis, and that the sample size is only constrained by the stage's translation range. However, due to the force required for translation, this is slow compared to scanning the beam and necessitates great mechanical precision for optimal resolution. It may also cause motion artifacts or tissue rearrangement.[33]

# AIM & OBJECTIVES

# AIM & OBJECTIVES OF THE STUDY

## AIM

The aim of this study is to comparatively evaluate surface roughness of different composite resin materials using confocal laser scanning microscope (CLSM).

## OBJECTIVES

1. To evaluate and compare the surface roughness of five composite resin materials.
2. To evaluate surface roughness of Omnichroma (Tokuyama, Japan)
3. To evaluate surface roughness of Charisma Topaz ONE (Kulzser, Japan)
4. To evaluate surface roughness of Ceram.x® SphereTEC™ one (Dentsply sirona)
5. To evaluate surface roughness of Tetric N-ceram Composite IVA (Ivoclar vivadent)
6. To evaluate surface roughness of Beautifil II Gingiva shade composite (Shofu, Japan)

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

1. **R. Terrell Weitman, Wilmer B. Eames (1975)** conducted a clinical study and determined the rate at which plaque accumulates on the surfaces of composite restorations on which four finishing techniques were used. It was observed that plaque did not collect on adjacent control teeth to this degree until the third day, although the difference remained statistically significant. Surface discrepancies on the polished composites were shown in scanning electron micrographs and with laboratory measurements.[17]

2. **H L Lee, J A Orlowski, P D Kidd (1975)** studied seven commercial composite filling materials to check their ability to take smooth polish measured by an electronic roughness gauge. The test formulations indicated that polishability and ability to retain a good polish are interrelated and are functions of filler particle size and filler hardness. Also, optimization in the filler particles from the point of view of polishability also results in improved wear resistance to toothbrushing.[34]

3. **C B Horton, H M Paulus, G B Pelleu, J J Rudolph (1977)** conducted a study to determine the effectiveness of several commercial pastes in polishing the surfaces of composite resin material indicated that the smoothest surface was found immediately after removal of the Mylar matrix and that pastes leave a rougher surface than is left with a disc.[35]

4. **W Mörmann, E Lietha-Elmer, C Meier, F Lutz (1977)** did analysis of surface quality of 2 composite filling materials using profilometry, scanning electron microscopy and light reflectometry after finishing with experimental diamond discs, 3M discs, corundum discs, polishing paste and also after sealing. Results suggested that reflectometry showed that the finishing methods unfavourably affected composite surface smoothness and among all finishing methods, polishing paste produced the highest reflection value on the Cosmic surface.[36]

5. **T A Garman, C W Fairhurst, G A Heuer, H A Williams, D L Beglau (1977)** designed a study to compare the durability of two resin coating materials used on two brands of composite restorative materials. Through this study, it was concluded that composites on which the resin coating is intact maintain their colour match, lustre, and smoothness significantly better than uncoated composite restorations.[37]

6. **L G Tolley, W J O'Brien, J B Dennison (1978)** conducted a study in which Five composite filling materials were finished using six finishing procedures and it was found out that the roughest surfaces were produced by the use of a diamond instrument which is contraindicated. Acceptable finishing procedures for the composite materials tested include silicon carbide disks for accessible areas or 12 fluted finishing burs for more inaccessible areas.[38]

7. **H A Williams, T A Garman, C W Fairhurst, J D Zwemer, R D Ringle (1978)** conducted a study to evaluate surface characteristics of resin coated composites as compared to uncoated ones through SEM and found out that coated restorations had smooth surfaces after 23 months, in comparison with rough surfaces of uncoated restorations.[39]

8. **R J Smales, P J Creaven (1979)** conducted a study to assess the surface roughness of Concise and Spheraloy samples finished with four different treatments and it was found out that no clinical assessment method differentiated clearly between all treatments. They also suggested that the use of suitable visual ranking assessment methods rather than clinical ratings or scores to assess surface roughness is preferred for dentists untrained as evaluators.[40]

9. **R J Smales, P J Creaven (1979)** did evaluation of four different clinical methods to assess the surface roughness of Concise and Spheraloy samples finished with four different treatments and found out that differentiation between the surface treatments was shown best for Spheraloy by the clinical

criteria, abraded glass blocks, and ranked photographic negatives. They suggested the use of suitable visual ranking assessment methods rather than clinical ratings or scores to assess surface roughness.[41]

10. **J W van Dijken, J H Meurman, J Järvinen (1980)** conducted a study to assess the effect of different finishing procedures on the surface textures of a conventional composite material, two newly introduced microfiller composite resins, a visible light polymerized resin, and a glass ionomer cement. Study results proved that two micro-filler composite materials appeared to be superior in finishability compared with those materials loaded with larger filler particles. Also, use of a polishing paste improved the surface finish of the micro-filler materials in contrast to the materials with larger filler particles.[42]

11. **J B Dennison, P L Fan, J M Powers (1981)** evaluated the surface microstructures of three microfill composites and a conventional composite and it was found out that the finished surfaces of the microfill composites were smoother than the corresponding surfaces of Concise for each finishing instrumentation evaluated.[43]

12. **W F Bailey, S L Rice, R L Albert, S C Temin (1981)** examined the influence of several experimental parameters on the sliding-wear behaviour of a composite restorative and found out that changes in surface finish and sliding velocity have little effect on the moderate wear-rate observed at nominal levels of stress, and increased contact stress can profoundly alter wear mechanisms and produce marked surface failure at levels well within the range associated with human mastication.[44]

13. **J B Dennison, P L Fan, J M Powers (1981)** studied surface roughness values, profile tracings, and surface microstructures of three microfilled composites and a conventional composite. Results of this study showed that the surfaces cured against Mylar matrix strips were the smoothest where as White stones produced the roughest surfaces.[45]

14. **K Itoh, M Iwaku, T Fusayama (1981)** checked the effectiveness of glazing composite resin restoration. Through this study, they concluded that microleakage gets prevented when the margins of composite resin restorations were covered with a glaze. They also mentioned that the roughness of the composite resin was exposed when the glaze was lost in the oral environment.[46]

15. **J F Roulet, T K Roulet-Mehrens (1982)** investigated the effect of prophylaxis and polishing pastes on bovine tooth hard tissues and dental materials. The results showed that the surface roughness of conventional composites increases tremendously during each polishing with pastes. Also, conventional composites should be polished afterwards with aluminium silicate coated discs.[47]

16. **J Kanter, R E Koski, D Martin (1982)** designed a study to measure percentage of weight loss and surface roughness during simulated toothbrushing of five different composite resins and concluded that all composite resins tested tended to have a decreasing wear rate with the increasing time of toothbrushing. Also, loss of the filler as an alkaline reaction in water due to soluble barium compounds may cause the binder to release filler particles prematurely.[48]

17. **J W van Dijken, J Stadigh, J H Meurman (1983)** conducted an SEM study to evaluate the appearance of finished and unfinished surface of composite after toothbrushing. Study concluded that when the unfinished and finished specimens of the large filler-containing materials were brushed with toothpaste or pumice, rough surface characteristics were obtained and microfiller materials may be finished with successively finer devices to smooth surfaces that will stay smooth after toothbrushing.[49]

18. **W J O'Brien, W M Johnston, F Fanian, S Lambert (1984)** measured The contrast gloss and the average roughness or four commercial composite

filling materials. They concluded that surface gloss plays a major role in the esthetic appearance of composite restorations as a significant difference was found in the contrast gloss among finishing methods.[50]

19. **J F Roulet, T Hirtand, F Lutz (1984)** compared three experimental inhomogeneous microfilled composites (IMC) containing spherical prepolymerized particles with an interpenetrating network (IPN) and the reference materials Estic MF, Adaptic and the amalgam Dispersalloy. The experimental materials showed a superior adaptation to the walls of proximal boxes of Class II cavities than the reference materials. This superiority was increased by the use of a filled bonding agent. It was concluded that especially designed diamonds with very fine abrasive particle size (40 μ*m* and 15 μm) are the best for finishing and contouring composite fillings.[51]

20. **J W van Dijken, P Hörstedt, J H Meurman (1985)** studied surface characteristics and marginal adaptation of 278 anterior resin fillings 3-4 yr old and noticed degradation of surfaces and margins with eroded areas and exposed macro- and microfiller particles. The microfiller resin fillings activated by visible light, in particular, showed relatively smooth surface characteristics with less surface degradation and less porosity.[52]

21. **P M Campbell, W M Johnston, W J O'Brien (1986)** evaluated light scattering and gloss of experimental quartz-filled composite. This study suggested that optical scattering by composite fillers is shown to be linearly related to the concentration of the filler material and the efficiency of optical scattering for the granular quartz filler increased as the size of the filler decreased.[53]

22. **R L Cooley, R M Lubow, G A Patrissi (1986)** checked the effect of air abrasive instrument on composite resin by applications of sodium bicarbonate with an air-powder abrasive instrument. It was concluded that the light-cured

composite resin should be the material used for patients undergoing a recall maintenance program in which the instrument is used.[54]

23. **J W van Dijken (1986)** did a six year follow up and clinical evaluation of anterior conventional, microfiller and hybrid composite resin to check the surface roughness and various other properties and found that unacceptable marginal adaptation was seen for 13.7% and recurrent caries occurred at the margins of 18.9% of the composite fillings dur to increased surface roughness.[55]

24. **R D Davis, R B Mayhew (1986)** did a clinical comparison of three anterior restorative resins namely a conventional composite resin, a chemically cured microfilled resin, and a small-particle, glass-filled, visible light-cured composite resin at 3 years and concluded that all materials were satisfactory, but the conventional composite resins had significantly more surface roughness than did the other resins.[56]

25. **J W van Dijken [1], I E Ruyter (1987)** studied surface characteristics of eight posterior and two anterior composite resins after polishing and toothbrushing. Results demonstrated that polishing with diamond pastes gave various results, with a 20-fold difference in surface roughness values from the smoothest to the roughest material. Toothbrushing after polishing with the Sof-lex system increased the surface roughness for all materials, but to various degrees.[57]

26. **R Eide , A B Tveit (1988)** studied four different methods for finishing and polishing the surfaces of two different composite materials. Results showd that after the initial finishing, all four methods gave significant effect when used on the Silux, but on the P30 only. However, the degree of effectiveness of the methods varied greatly.[58]

27. **F G Serio , H E Strassler, L J Litkowski, W C Moffitt, C M Krupa (1988)** conducted a study to compare surface textures of a small particle composite resin (average particle size 5 microns) after polishing with prophylaxis and polishing pastes and the results of the evaluator ratings

determined that the composite resin surface gets rougher with the use of any polishing paste.[59]

28. **A Matsumoto, M Yamauchi, K Yamamoto, M Sakai, S Noda, S Yamaguchi *etal* (1989)** used digital image analyser to evaluate surface texture of fine finishing diamond points for composite resins. Results showed that the surface roughness of a submicron filler type composite resin finished at a low speed was less than that at a high speed. They concluded that the grain size of diamond point and revolution speed may play an important role in surface texture of composite resin.

29. **G Johannsen [1], G Redmalm, H Rydén (1989)** investigated surface changes and wear resistance using a laser reflexion technique and a profilometer. Two different toothpastes were used separately; Clinomyn and Colgate. The results showed that all the materials were to some extent affected by the brushing. Titanium was the most and SR Isosit N the least wear resistant material. Clinomyn and Colgate influenced the materials in different ways depending on their abrasive properties.[60]

30. **H Hosoda, T Yamada, T Kimoto, C Harnirattisai (1989)** examined surface roughness to establish the most efficient polishing technique using four kinds of silicone cup had on two semi-hybrid composites. Individual silicone cup consisted of a hard rubber and silicone carbide abrasive particles being sized into #180 (P0), #360 (P2), #600 (P3), and #2500 (P4). They found out that combination polishing with both P3 and P4, as well as from P0 through P4 in this order, efficiently created the smoothest surfaces for the semihybrid composite resins.[61]

31. **A Fujishima, T Miyazaki, M Takatama, E Suzuki, T Miyaji (1989)** evaluated chemical durability of posterior composite resins were stored in NaOH (0.1 mol, 1 mol), HCl (0.1 mol, 1 mol), acetone (99%), and distilled water at 37 degrees C for a week. Results of the study showed that NaOH caused the degradation of composite resins, decrease of tensile strength and increase of surface roughness.[62]

32. **S Howell , W T Weekes (1990)** conducted a study in which enamel surface roughness was investigated following the use of various combinations of bonding agents, burrs and polishing procedures and they found out that The use of a Sof-lex disc followed by pumice slurry resulted in the roughest enamel surface and the use of pumice alone produced the smoothest enamel surface.[63]

33. **James W. Stoddard, Glen H. Johnson (1991)** evaluated polishing agents for composite resins. The surfaces of four anterior and posterior composite resins were compared using a Mylar strip, an unfilled resin as a glaze, polishing with three rubber polishers, and three different manufacturers' series of disks. The results verified that different surface roughness can be created using identical instruments on different composite resins. The Vivadent polisher produced the smoothest surface of the rubber points, while Moore's disks created a surface similar to that of both Mylar and a resin glaze of Prisma-Bond material.[64]

34. **E Berastegui , C Canalda, E Brau, C Miquel (1992)** evaluated the results of polishing composite resin by using Arkansas stone burs; eight-blade tungsten-carbide burs; diamond burs; aluminium-oxide disks; no polishing; and 12- and 30-blade tungsten-carbide burs on 120 class V restorations on extracted human teeth with a profilometer. The conclusions from the results of the study were that microfilled composite resins provided a better finish when treated with aluminium-oxide disks.[65]

35. **S K Sidhu , L J Henderson (1993)** compared the surface finish of composite resin restorative material when finished with white stones, superfine diamond burs and aluminium trioxide discs in which the results demonstrated that the aluminium trioxide discs gave the best and most consistent results. However, none of the methods used achieved the smoothness of composite resin cured against a transparent matrix.[66]

36. **K H Chung (1994)** Investigated the effects of finishing and polishing procedures on the roughness and color of four composites surfaces using three different polishing systems using a colorimeter. It was observed that polishing procedures produced a decrease in the roughness, ranging from 26 to 74%. It was concluded that Mylar strip can create a smoother surface than the other types of tested polishing procedures. Because of the greater values in color differences and surface roughness, the shades of tested resin composites were lighter after the polishing procedures. A custom-made shade guide is suggested based on the results of this study.[67]

37. **S A Whitehead , A C Shearer, D C Watts, N H Wilson (1996)** evaluated the significance of selected surface texture parameters used to describe and quantify the effect of tooth brushing with various "tooth whitening" dentifrices and found out that all the toothpastes chosen for this investigation left a surface on the resin composite which may be prone to crack propagation during "vertical barrelling" movements generated during mastication.[68]

38. **E Sepet , Z Aytepe, H Oray (1997)** investigated the surface texture and enamel-restoration interface of Class II glass ionomer restorations and they concluded that there was no marginal gap formation for Chemfil II, Chelon-Silver and Dyract samples. Also, in Dyract samples wear of restorations was considerable.[69]

39. **A U Yap , C W Sau, K W Lye (1998)** compared the effects of immediate and delayed finishing/polishing procedures on the surface characteristics (surface roughness and hardness) of tooth-coloured restoratives including a microfilled, a heavily filled and a polyacid-modified composite resin and a resin-modified glass-ionomer cement on Eighty-four specimen discs. It was found out that there are effects of delayed finishing/polishing procedures on surface roughness and hardness. Thus it was concluded that delayed finishing/polishing of polyacid-modified composite resins and resin-modified glass-ionomer cements generally results in a smoother surface and delayed finishing/polishing with the various techniques generally resulted in a surface

of similar hardness to or harder than that obtained with immediate finishing/polishing and the control group.[70]

40. **H K Yip , W T Lam, R J Smales (1999)** assessed the surface roughness of eight esthetic restorative materials and the relationship with weight changes during fluoride release and uptake. SEM showed that roughness increased from the resin composite to the conventional glass ionomer cements. The marked erosive effect of APF gel on glass ionomer restorations could increase surface colonization by plaque micro-organisms, and reduce the longevity of the restorations.[71]

41. **L B Roeder , W H Tate, J M Powers (2000)** examined the average surface roughness (Ra, micron) of three packable composites and one hybrid composite cured against mylar, before and after treatment with a fine finishing diamond bur, a resin finisher followed by fine and extrafine polishing paste, two silicone-based finishing and polishing systems, fine and super-fine aluminum-oxide polishing disks, a silicon carbide-impregnated polishing brush and a surface-penetrating composite sealant. This study concluded that Sof-Lex Contouring and Polishing Discs were able to produce the smoothest surfaces, followed by the Jiffy Composite Polishing Cups, the Enhance Composite Finishing & Polishing System/Prisma-Gloss Composite Polishing Paste, the Diacomp Intra-Oral Composite Polishers and the Jiffy Composite Polishing Brushes, respectively. The smoothest surfaces were produced using Z-100, followed by SureFil + C (carbide finishing bur), Solitaire, SureFil and ALERT, respectively.[72]

42. **L Marigo , M Rizzi, G La Torre, G Rumi (2001)** conducted a study to do profile analysis of finished and polished surface using four methods: Enhance system, Sof-Lex system, Multi-step system and Identoflex points. The samples were then analyzed by a 3-D surface profiler to obtain roughness average (Ra), root mean square value (rms), greatest distance peak-valley (PV), measure of profile about the center line (Rsk) and measure of steepness of the amplitude density curve of the roughness profile (Rku) directly from

the tested area. Results of the study showed that the Enhance and Multi-step systems gave the best finish and polish for both materials.[73]

43. **Huan Lu , Leslie B Roeder, John M Powers (2003)** examined the effect of three different polishing systems on surface roughness of five newly developed resin composites which included three microhybrid composites (Point 4, Kerr, Orange, CA; Esthet-X, Dentsply/Caulk, Milford, DE; Vitalescence, Ultradent, South Jordan, UT, USA), one microfilled composite (Renamel Microfill, Cosmedent, Chicago, IL, USA), and one experimental microhybrid composite (FZB, Ivoclar Vivadent, Schaan, Liechtenstein). Specimens in each group were finished with a carbide bur (16 fluted) and three polishing systems (Astropol, Ivoclar Vivadent; Diagloss, Axis Dental, Irving, TX, USA; Sof-Lex, 3M, ESPE, St. Paul, MN, USA). Results showed that for Astropol, Ra ranged from 0.10 to 0.15 microm and Sm ranged from 24 to 40 microm for the five composites; for Diagloss, Ra ranged from 0.24 to 0.34 microm and Sm from 38 to 74 pm; for Sof-Lex, Ra ranged from 0.06 to 0.10 microm and Sm ranged from 16 to 22 microm.[74]

44. **Deniz Sen , Gültekin Göller, Halim Işsever (2002)** compared the surface roughness of 3 different bis-acryl composite-based and 3 different methyl methacrylate-based provisional crown and fixed partial denture resins after being polished with aluminum oxide and diamond paste. Results of the study concluded that single-phase polishing of the bis-acryl composites tested and the methacrylate resins tested with diamond-based paste produced a smoother surface than when polished with aluminum oxide paste.[75]

45. **Halim Nagem Filho , Maria Tereza Fortes Soares D'Azevedo, Haline Drumond Nagem, Fernanda Pátaro Marsola (2003)** evaluated the effect of surface finishing methods on the average surface roughness of resin composites using seven composites and two polishing systems. The results showed no statistical difference in average surface roughness between the polyester strip and aluminum oxide discs ($p > 0.05$). However, finishing with diamond burs showed a statistically higher average roughness for all composites ($p < 0.05$).[76]

46. **Alessandra Bühler Borges [1], Ana Lucia Marsilio, Clóvis Pagani, José Roberto Rodrigues (2004)** evaluated surface roughness of packable composites polished with various systems and found out that packable composite resins display variable roughness depending on the polishing system used; the Sof-Lex disks and Jiffy points resulted in the best Ra values for the majority of the materials tested.[77]

47. **Tamayo Watanabe, Masashi Miyazaki, Toshiki Takamizawa, Hiroyasu Kurokawa, Akitomo Rikuta, Susumu Ando (2005)** conducted a study to investigate the influence of polishing duration on surface roughness of light-cured resin composites. Four polishing systems, Compomaster (Shofu), Silicone Points C Type (Shofu), Super Snap (Shofu) and Enhance Finishing and Polishing System (Dentsply/Caulk), were used to polish two commercially available resin composites, Clearfil AP-X (Kuraray Medical) and Lite-Fil. In this study, the surface roughness was measured every 10 s during polishing procedures using profilometer. Results showed that the mean Ra values ranged from 0.07 to 0.50 for Clearfil AP-X, and from 0.11 to 0.57 for Lite-Fil II A.[78]

48. **Daniela Venturini [1], Maximiliano Sérgio Cenci, Flávio Fernando Demarco, Guilherme Brião Camacho, John M Powers (2006)** evaluated the effects of immediate and delayed polishing on the surface roughness, microhardness and microleakage of a microfilled (Filtek A110) and a hybrid (Filtek Z250) resin composite. They concluded that the flexicups exhibited the highest Ra of the three systems (Flexicups, Jiffy Polishing Brush, Flexibuffs). Generally, immediate polishing produced no detrimental effect compared to delayed polishing.[79]

49. **M Jung, K Sehr, J Klimek (2007)** evaluated the surface geometry of four nanofilled composites (Premise, KerrHawe; Tetric EvoCeram, Ivoclar Vivadent; Filtek Supreme, 3M ESPE; Ceram X Duo, Dentsply) and one hybrid composite (Herculite XRV, KerrHawe). It was concluded that the composite materials and the finishing methods had a significant effect on

surface roughness (*p*<0.001 for Ra and LR). Compared to Herculite XRV, three of the nanocomposites were significantly smoother after finishing, according to FM 1-3 and after application of the Sof-Lex discs. Ceram X Duo and Herculite XRV had similar surface roughness in terms of Ra and LR. Compared to a single 30 µm diamond and a sequence of two diamonds (FM 2), significantly lower roughness values on all composites were achieved by using a 30 µm diamond followed by a tungsten carbide instrument (*p*<0.001 for Ra and LR). Evaluation by SEM revealed that the use of a 30 µm diamond caused detrimental surface alteration on all types of composites. A remarkable number of porosities were detected on 1 of the nanofilled composites.[80]

50. **Juliana da costa, Jack Ferracane, Rade d. paravina, Rui fernando mazur, Leslie roeder (2007)** evaluated the surface finish and gloss of five direct resin composites polished with six polishing systems. The study concluded that there was no significant interaction between the composite and the polishing systems for surface roughness (*p* = 0.059). The order of surface roughness ranked according to composite was: Durafill < Esthet-X < Supreme < Z250 < Z100; and the ranking for the polishing system was: Pogo < Sof-Lex < Diacomp/Enamelize < Diacomp < ComposiPro brush < Jiffy. Also, the highest gloss value was recorded for Supreme + Pogo; the lowest was recorded for Z100 + Jiffy. Pogo showed the highest gloss values for all composites.[81]

51. **Maximiliano Sérgio Cenci , Daniela Venturini, Tatiana Pereira-Cenci, Evandro Piva, Flávio Fernando Demarco (2008)** evaluated the effects of immediate (IM) and delayed (DE) polishing on the surface roughness (Ra), microhardness (KHN) and microleakage (ML) of microfilled (Filtek A110) and hybrid (Filtek Z250) resin composites after one-year storage. After one year, microfilled resin composite specimens showed the lowest Ra and KHN (p<0.05). No difference in microleakage was observed among the different groups (p>0.05). The sequential technique provided the lowest roughness and Sof-Lex the lowest hardness (p<0.05). Thus, aging increased the composites Ra and ML in all experimental conditions.[82]

52. **Karla Zanini Kantorski [1], Roberto Scotti, Luiz Felipe Valandro, Marco Antonio Bottino, Cristiane Yumi Koga-Ito, Antonio Olavo Jorge (2009)** evaluated the surface roughness and the in vitro adherence of Streptococcus mutans to indirect aesthetic restorative materials that are uncoated with saliva and concluded that the microhybrid and microfilled resin composites were similar and the leucite-reinforced feldspathic ceramic was rougher and presented higher bacterial adherence than the microparticulate feldspathic ceramic.[83]

53. **Tatsuo Endo , Werner J Finger, Masafumi Kanehira, Andreas Utterodt, Masashi Komatsu (2010)** investigated polishability of one nanofill (Filtek Supreme XT/FIL) and three nanohybrid materials (Grandio/GRA, Tetric EvoCeram/TET, Venus Diamond/VED) using surface profilometry and SEM. Study concluded that the surface textures of the polished nanofill FIL and nanohybrid TET were uniformly smooth, whereas relief polishing effects and filler extrusion of varying extents were seen on the nanohybrid composites GRA and VED.[84]

54. **Sandrine Bittencourt Berger, Alan Rodrigo Muniz Palialol, Vanessa Cavalli, Marcelo Giannini (2011)** investigated the influence of filler size and finishing systems on the surface roughness and staining of three composite resins evaluated with a profilometer. Results showed no significant differences in surface roughness among the composites treated with Enhance + PoGo. In addition, no differences were observed when the Filtek Supreme Plus composite was submitted to surface staining evaluation. In general, the composites polished with the finishing systems from the same company demonstrated lower surface roughness and staining. The results of this study recommend that composite resins could be finished and polished with finishing systems supplied by the composite's manufacturer. The surface rough- ness and staining of composite resins were not influenced solely by filler size.[85]

55. **Cesar Penazzo Lepri [1], Regina Guenka Palma-Dibb (2012)** evaluated the influence of beverages and brushing on the surface roughness(SR) and color change(ΔE) of a composite resin. Through this study, it was found out that red wine promoted the highest alteration, followed by soft drink=sugar cane spirit and finally saliva. At 30th day, specimens exhibited ΔE higher than 15th day; after repolishing, ΔE was similar to 15th day. Beverages and brushing negatively influenced the SR. Therefore, ΔE and SR can be influenced by beverages and brushing.[86]

56. **Duygu Tuncer , Emel Karaman , Esra Firat (2013)** investigated the effect of beverages' temperature on the surface roughness, hardness, and color stability of a composite resin. They concluded that high-temperature solutions caused alterations in certain properties of composites, such as increased color change, although they did not affect the hardness or roughness of the composite resin material tested.[87]

57. **Esra Can Say , Haktan Yurdagüven, Batu Can Yaman, Füsun Özer (2014)** investigated surface roughness (Ra) and morphology of supra-nanofilled [Estelite Omega (EO), Estelite ∑ Quick (EQ)], micro-hybrid [Esthet.X HD (EHD), G-aenial (GAE)] and nano-hybrid [Clearfil Majesty Posterior (CMP), Charisma Diamond (CD), Beautifil II (BII)] composites polished with two-step polishing systems [Enhance/PoGo (EP); Venus Supra (VS)]. Results demonstrated that except for GAE, CD and BII, the differences in Ra between EP and VS in each composite group were significant, showing smoother surfaces for EP. Supra-nanofilled composites created smoother surfaces than nano-hybrids, and their performance was similar or slightly better than that of micro-hybrids.[88]

58. **Jasmina Bijelic-Donova , Sufyan Garoushi, Lippo V J Lassila, Pekka K Vallittu (2015)** assessed the thickness of the oxygen inhibition layer of short-fiber-reinforced composite in comparison with conventional particulate filling composites. Four different restorative composites were selected: everX Posterior (a short-fiber-reinforced composite), Z250, SupremeXT, and Silorane. Equal amount of each composite was polymerized in air between

two glass plates and the thickness of the oxygen inhibition layer was measured using a stereomicroscope. Through this assessment, it was found out that the inhibition depth was lowest (11.6 μm) for water-sprayed Silorane and greatest (22.9 μm) for the water-sprayed short-fiber-reinforced composite. The shear bond strength ranged from 5.8 MPa (ground Silorane) to 36.4 MPa (water-sprayed SupremeXT).[89]

59. **Fernanda Carvalho Rezende Lins , Raquel Conceição Ferreira , Rodrigo Richard Silveira, Carolina Nemésio Barros Pereira , Allyson Nogueira Moreira , Claudia Silami Magalhães (2016)** evaluated the effect of immediate or delayed finishing/polishing using different systems on the surface roughness, hardness, and microleakage of a silorane-based composite. After considering roughness, microhardness, and microleakage together, this study concluded that the immediate finishing/polishing of a silorane-based composite using aluminium oxide discs may be recommended.[90]

60. **Gloria Cazzaniga , Marco Ottobelli , Andrei C Ionescu , Gaetano Paolone *et al* (2017)** evaluated the influence of surface treatments of different resin-based composites (RBCs) on S. mutans biofilm formation. 4 RBCs (microhybrid, nanohybrid, nanofilled, bulk-filled) and 6 finishing-polishing (F/P) procedures (open-air light-curing, light-curing against Mylar strip, aluminium oxide discs, one-step rubber point, diamond bur, multi-blade carbide bur) were evaluated using scanning electron microscopy morphological analysis (SEM). A morphological evaluation of S. mutans biofilm was also performed using confocal laser-scanning microscopy (CLSM). It was observed that F/P procedures as well as RBCs significantly influenced surface roughness and gloss while F/P procedures did not significantly influence S. mutans biofilm formation. Hence, F/P procedures of RBCs may unexpectedly play a minor role compared to that of the restoration material itself in bacterial colonization.[91]

61. **T Aslan, H Koccagaolu, A Gurbulak, H Albayrak, Z Tasdemir, H Gumus (2017)** evaluated the surface roughness and color stability of four different composites resins. Result of the regression analysis indicated

statistically significant correlation between Ra and ΔE values ($P < 0.05$, $r2 = 0.74$). The findings of the study showed clinical relevance in the choice of polishing kits used.[92]

62. **Hande Kemaloglu , Gamze Karacolak , L Sebnem Turkun (2017)** evaluated the effects of various finishing and polishing systems on the final surface roughness of a resin composite by fabricating ninety discs of a nano-hybrid resin composite. Enamel Plus Shiny, Venus Supra, One-gloss, Sof-Lex Wheels, Super-Snap, Enhance/PoGo, Clearfil Twist Dia, and rubber cups were used for polishing the subgroups and the surface roughness was measured under scanning electron microscope. It was found out that the smoothest surfaces were obtained under Mylar strips and the results were not different than Super-Snap, Enhance/PoGo, and Sof-Lex Spiral Wheels. The group that showed the roughest surface was the rubber cup group and these results were similar to those of the One-gloss, Enamel Plus Shiny, and Venus Supra groups.[93]

63. **V C Ruschel, V S Bona, L N Baratieri, H P Maia (2018)** evaluated the effect of surface sealants and polishing delay time on a nanohybrid resin composite roughness and microhardness. It was observed that surface smoothness similar to polishing with rubber points was achieved when surface sealants were used, except for PermaSeal surface sealant, which resulted in a less smooth resin composite surface. However, surface sealant application did not significantly improve composite resin microhardness.[94]

64. **Karan Bansal, Sachin Gupta, Vineeta Nikhil, Shikha Jaiswal, Akanksha Jain etal. (2019)** compared the effect of different finishing and polishing systems for the change in surface roughness of resin composites and enamel. Thirty extracted human maxillary central incisors were selected, decoronated, and molded in self-cure acrylic molds. A box-shaped cavity was prepared in all the teeth. A nanohybrid composite resin (Filtek Z250) was then used to restore the prepared cavities. The mean surface roughness values demonstrated by Mylar matrix was the lowest followed by Sof-Lex polishing

system. Shofu polishing system demonstrated the highest surface roughness values.[95]

65. **Lippo Lassila, Eija Säilynoja, Roosa Prinssi, Pekka K. Vallittu, and Sufyan Garoushi (2020)** conducted an *in vitro* study to determine the effects of different polishing protocols on the surface gloss (SG) of different commercial dental resin composites (RCs) by making 147 block-shaped specimens (40 mm length × 10 mm width × 2 mm thick) from conventional RCs (G-aenial Ant. and Flo X), bulk-fill RC (Filtek Bulk Fill), fluoride-releasing RCs (BEAUTIFIL II, ACTIVA-Restorative) and discontinuous microfiber-reinforced RCs (Alert and everX Flow). Laboratory-machine polishing with different siliconcarbide paper grits (G1: 320) → (G2: 800) → (G3: 1200) → (G4: 2000) → (G5: 4000) were used for polisihing and evaluation was done using a glossmeter. Significant differences in SG (ranged 3–93 GU) were found according to the type of polishing protocol and RC ($p < .05$). Specimens polished with 4000 grit paper showed the highest SG (93 GU) values among all the groups tested.[96]

66. **Vincenzo Tosco, Riccardo Monterubbianesi, Giulia Orilisi, Maurizio Procaccini, Simone Grandini etal. (2020)** evaluated the effect of four different finishing and polishing systems on resin composites. Twelve Filtek XTE Supreme discs were prepared and divided into 4 groups of finishing and polishing systems. The roughness and gloss were evaluated and examined by SEM. SEM showed the abrasion of the samples with an increase in the surface roughness in Sof-Lex Extra-Thin XT and Sof-Lex Coarse black disc.[97]

67. **Lu Zhang, Peng Yu, Xiao-Yan Wang (2021)** evaluated the polishability of nanofilled and nanohybrid composites by measuring surface roughness and gloss values and explore the surface qualities of composite before and after polishing observed by scanning electron microscope. Results showed that the Ra values of polished surfaces were significantly higher than negative control and lower than positive control ($P < 0.05$). After polishing, the microhybrid resin composite showed lower GU values than nanofilled and nanohybrid

resin composite groups. The SEM images showed surface textures and irregularities were corresponded to the results of surface roughness and gloss. There was no significant difference noted on surface roughness among nanofilled, nanohybrid, and microhybrid composites after polishing with Sof-Lex disc system. Microhybrid composite presented lower gloss values than nanofilled and nanohybrid resin composites.[98]

68. **Riccardo Monterubbianesi, Vincenzo Tosco, Giulia Orilisi, Simone Grandini, Giovanna Orsini, and Angelo Putignano (2021)** evaluated the effects of different finishing and polishing (F/P) systems on gloss and surface morphology of Filtek Universal Restorative material (3 M, ESPE). Six groups were created in which Group A and B followed F/P protocols for anterior restorations, whereas Group C and D for posterior ones. Group E represented the control (covered by Mylar strip) and Group F represented the nanocomposite placement by means of clinical hand instruments; Groups E and F did not undergo F/P procedures. Among the polished groups, Group B showed the highest values (68.54 ± 7.54 GU), followed by Group A and D (46.87 ± 5.52 GU; 53.76 ± 2.65 GU). Finally, Group C (37.38 ± 4.93 GU) displayed the lowest results. Overall, Group E showed the highest gloss values (93.45 ± 8.27 GU), while Group F presented the lowest ones (1.74 ± 0.64 GU). It was concluded that the clinicians might use the protocols of Group B and Group D, for anterior and posterior restorations, respectively.[99]

69. **Giovanna Gisella Ramírez-Vargas, Marysela I Ladera-Castañeda, Carlos López-Gurreonero, Alberto Cornejo-Pinto (2022)** compared the surface roughness in nanoparticle resin composites subjected to two polishing systems. The study consisted of thirty-two samples divided equally into four groups. When polished with the Sof-lex and Super Snap polishing systems, the surface roughness of the Filtek Z350 XT and Palfique LX5 nanoparticle resin composites did not differ significantly.[100]

70. **Marta Ewa Szczepaniak, Michal Krasowski and Elzbieta Boltacz-Rzepkowska (2022)** investigated the effect of various polishing systems on

the surface roughness of composites. The Filtek Z250 and Filtek Ultimate were put to the test. Each material was made into Forty samples. Five samples from each group's polymerization process were tested for surface roughness under a Mylar strip. After polishing, the Super Snap groups have the lowest Ra coefficient. The Enamel Shiny group's FU, Sof-Lex, Sof-Lex Diamond Polishing System, and Jiffy Polishing Kit have the lowest Rlr coefficients, while FZ and Super Snap are only marginally higher.[101]

71. **Kana Hayashi , Hiroyasu Kurokawa , Makoto Saegusa , Ryota Aoki , Toshiki Takamizawa , Atsushi Kamimoto *et al* (2023)** determined the influence of surface roughness of the color adjustment potential restoration of universal resin composites namely omnichroma and Beautifil unishade. It was concluded that color adjustment potential of universal resin composites was affected by the surface roughness of the restorations and Omnichroma has a more stable color adjustment than Beautifil unishade.[102]

72. **HaticeTepe, Ayse Dina Erdilek, Merve Sahin, Begum Guray Efes, Batu Can Yaman (2023)** compared the effect of different polishing systems and speeds on the surface roughness of resin composites. The mean roughness was 0.07 to 0.41 micrometres. Super-Snap and OptiDisc both worked at 20,000 RPM to produce the smoothest surfaces. The group of Bisco Finishing Discs displayed the greatest surface roughness values at 2,000 RPM. The roughness at 20,000 RPM was lower than that at other speeds for all polishing systems.[103]

# MATERIALS AND METHODOLOGY

# MATERIALS AND METHODS

The present *in-vitro* study was conducted 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. The study was done to evaluate the surface roughness different composite resins using confocal laser scanning microscope.

# INCLUSION/ EXCLUSION CRITERIA

The following inclusion/exclusion criteria were set for the sample preparation:

1. All microscopic slides with uniform dimensional of 2mm by 2mm by 1mm composite resin will be used for the Confocal laser scanning microscope analysis.
2. All microscopic slides with intact composite resin on the slide.

# MATERIALS AND ARMAMENTARIUM

## MATERIALS

| S.NO. | MATERIAL & ARMAMENTARIUM | MANUFACTURER |
|---|---|---|
| 1. | Microscopic slides | G Lab, India |
| 2. | Composite filling instruments | GDC, India |
| 3. | Omnichroma | Tokuyama, Japan |
| 4. | Charisma Topaz ONE | Kulzser, Japan |
| 5. | Ceram.x® SphereTEC™ one | Dentsply sirona |
| 6. | Tetric N-Ceram Composite | Ivoclar vivadent |
| 7. | Beautifil II composite | Shofu, Japan |
| 8. | Curing light unit | Woodpecker, USA |
| 9. | Tweezer | GDC, India |
| 10. | Brush | Faber Castell |
| 11. | Dental Microscope | Labomed, USA |

**TABLE 1: MATERIALS**

## FOR FINISHING AND EVALUATION

| S.NO. | MATERIAL & ARMAMENTARIUM | MANUFACTURER |
|---|---|---|
| 1. | Micromotor | NSK, Japan |
| 2. | 3M ESPE Sof-lex Mandrel | 3M dental products, St. Paul Minn USA |
| 3. | 3M ESPE Sof-lex Polishing disc (Coarse, Medium, Fine, Super fine) | 3M dental products, St. Paul Minn USA |
| 4. | Confocal laser scanning microscope | Carl Zeiss, Germany |

**TABLE 2: ARMAMENTARIUMFOR FINISHING AND EVALUATION**

## DETAILS OF POLISHING MATERIALS USED IN THIS STUDY

| Polishing system | Composition | Particle size (µm) | Application time | Manufacturer |
|---|---|---|---|---|
| SofLex | Aluminum oxide | Medium (29) Fine (14) Superfine (5) | Multi-step 20 seconds, each step | 3M ESPE, St. Paul, MN, USA |

**TABLE 3: DETAILS OF POLISHING MATERIAL**

# CHARACTERISTICS OF THE COMPOSITE RESINS USED IN THIS STUDY

| MATERIAL | MANUFACTURER | RESIN COMPOSITION | TYPE OF FILLER |
|---|---|---|---|
| OMNICHROMA | Tokuyama Dental, Tokyo, Japan | UDMA<br>TEGDMA | Nano-spherical |
| Charisma Topaz ONE | Kulzer, Hanau, Germany | TCD-DI-HEA | Nano-hybrid |
| Beautifil II | Shofu Co. Kyoto, Japan | bis-GMA, TEGDMA, urethane diacrylate nano-hybrid<br>(UDA) | Nano-hybrid |
| Ceram.x Sphere TEC | Dentsply, Konstanz, Germany | Polyurethane methacrylate, Bis-EMA and TEGDMA, Methacrylic polysiloxane nanoparticles | Nano-hybrid |
| Tetric N-Ceram | Ivoclar Vivadent, Schaan, Liechtenstein | Bis-GMA<br>Bis-EMA<br>UDMA | Nano-hybrid |

**TABLE 4: DETAILED DESCRIPTION OF COMPOSITE RESINS**

# METHODOLOGY

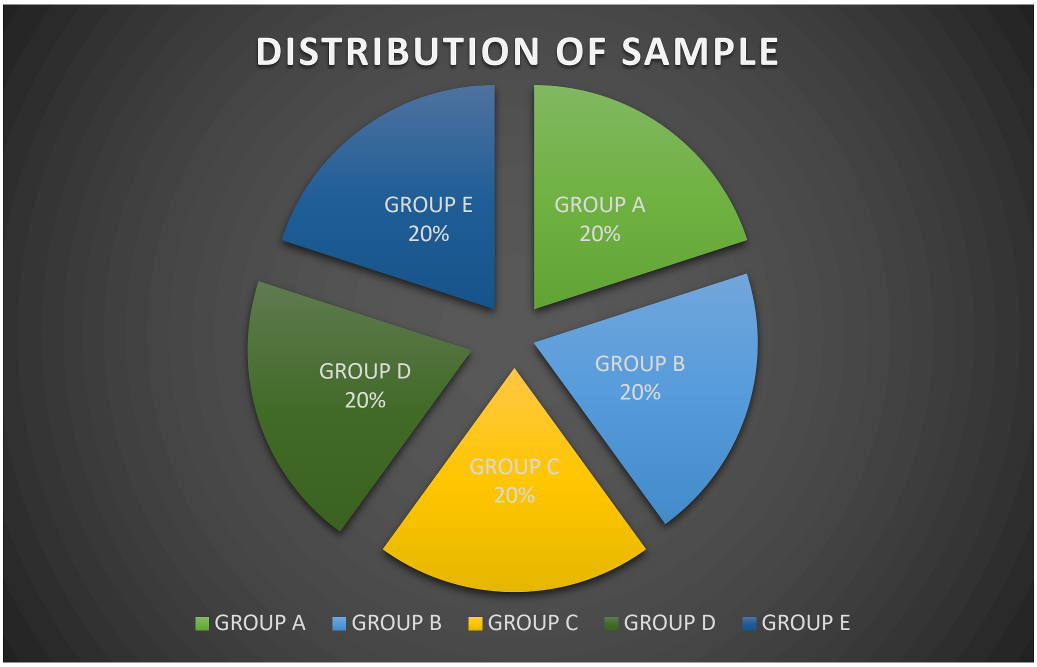
Following the computation of the statistically suitable sample size (n=25 per group), the investigation was planned with the goal of examining distinct composite resins using standardized polishing regimens.

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

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

**TABLE 5: DISTRIBUTION OF SAMPLES**




**GRAPH 1: SAMPLE DISTRIBUTION**

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.

The material was compressed under pressure to create a smooth surface over the mold while minimizing the inclusion of pores into the created resin layer. The composite resin was condensed in a single increment, and bottom surfaces of the mold were placed on the glass slides.

This was followed by light activation of the material using light curing unit (Woodpecker, USA) by keeping the curing unit head at standardised 1mm distance from the surface of the restorative material and activating each sample for 40 seconds. The samples were polished chairside in the manner described below:
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.

During the polishing process, fresh Sof-Lex discs in each grit size were utilised for each sample. Using a slow-speed handheld device (Slow Speed Hand Piece, NSK, Nakanishi, Japan) at a moderate pace, all of the Sof-Lex discs were applied to the composite specimens in one direction for 20 seconds each, for a total of 60 seconds. It was ensured that only light intermittent pressure was applied. For every sample, the pressure was maintained as consistently as feasible.

Scanning was done using a confocal laser scanning microscope (CLSM, Confocal Laser Scanning Microscope, Carl Zeiss, Germany. To evaluate the surface roughness, samples from each group were placed on the stage of the CLSM. The polished surfaces were placed upright, and the scan was carried out for complete surface of each sample.

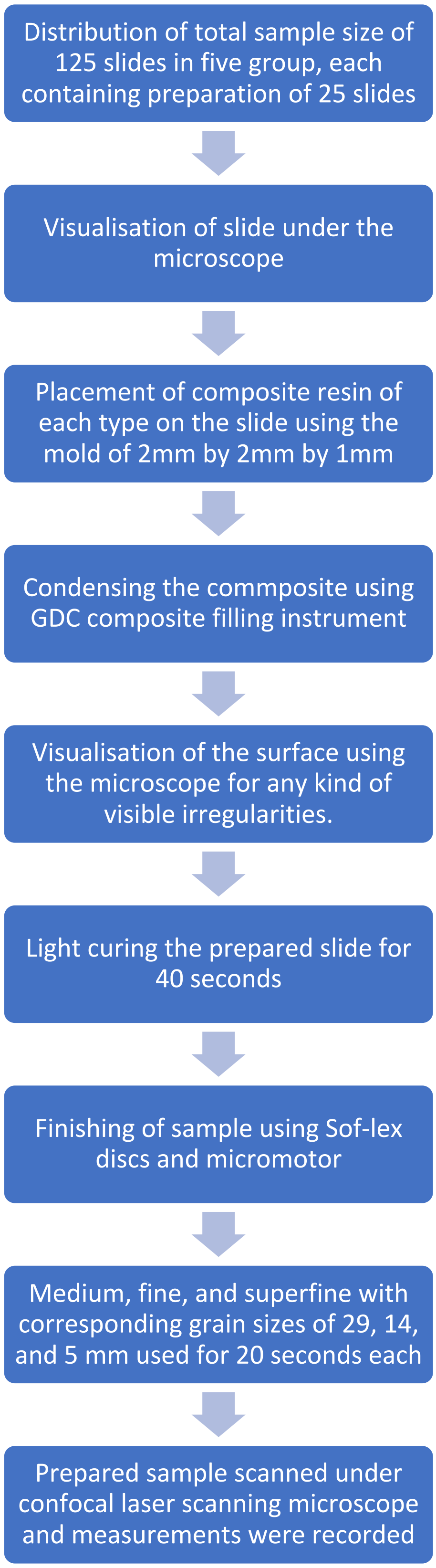
For scanning of each specimen, 5/0.15 objective lens in xyz scan mode was used which created the reflected image of the samples with the help of Argon/Krypton laser. Scan speed of 450 Hz and file format of 512 x 512 pixels were generated. The reading section was moved in z axis direction between the first detected and the last detected reflex. Because this lens offers a scanned surface area of 9 $mm^2$, which is greater than the necessary assessment area of 4 $mm^2$, an objective magnification of 5/0.15 was chosen.

A sequence of photographs was created by taking optical sections 10 mm apart along the z-axis. Using confocal processing software, the image series was transformed into a topographical image and a roughness profile was created which forms the average surface roughness (Ra).

After obtaining the values of each group, the following tests were performed using SPSS (Statistical Package for Social Sciences) Version 20.0 (IBM Corporation, Chicago, USA) keeping the significance level $p = 0.05$

- One-way analysis of variance (ANOVA)
- Post hoc Tukey's HSD analysis.

## FLOW CHART DEPICTING THE METHOD OF THE STUDY

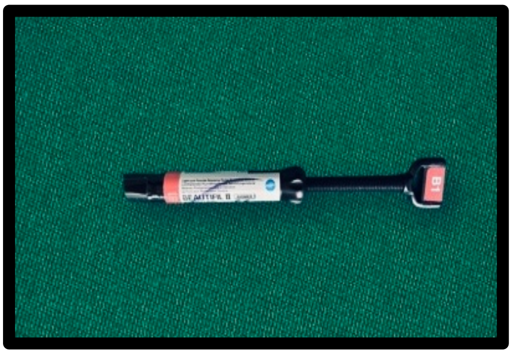



**FLOWCHART 1: METHODOLOGY OF THE STUDY**



**FIGURE 1: OMNICHROMA**

**FIGURE 2: CHARISMA TOPAZ ONE**



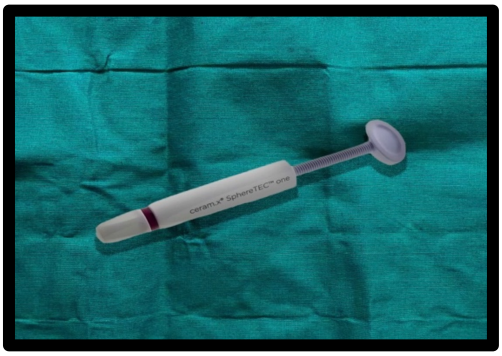


**FIGURE 3: BEAUTIFIL II**

**FIGURE 4: CERAM.X SPHERETEC**

**FIGURE 5: TETRIC N CERAM**

# PLATE I

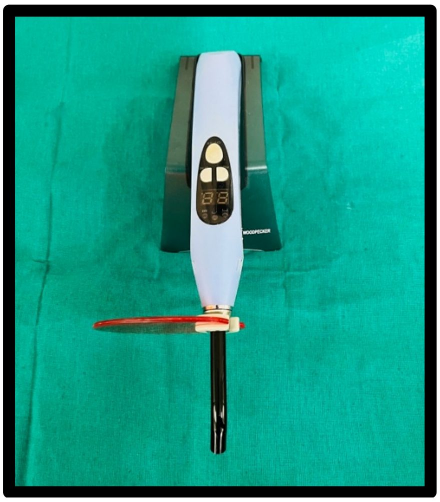
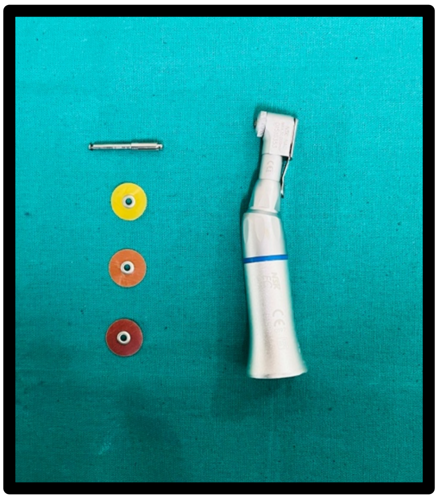


**FIGURE 6: CURING LIGHT**

**FIGURE 7: TWEEZER AND BRUSHES**



**FIGUR 8: MICROMOTOR**

**FIGURE 9: SOF-LEX DISCS**

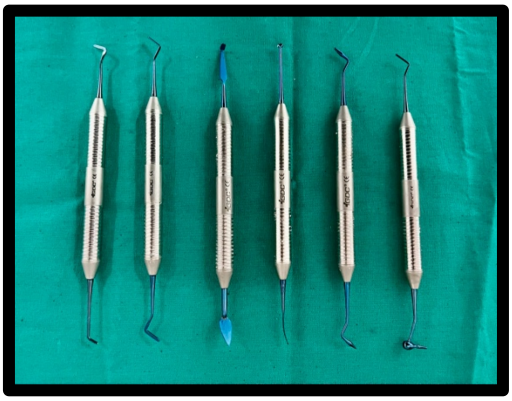


**FIGURE 10: GDC FILLING INSTRUMENTS**

# PLATE II

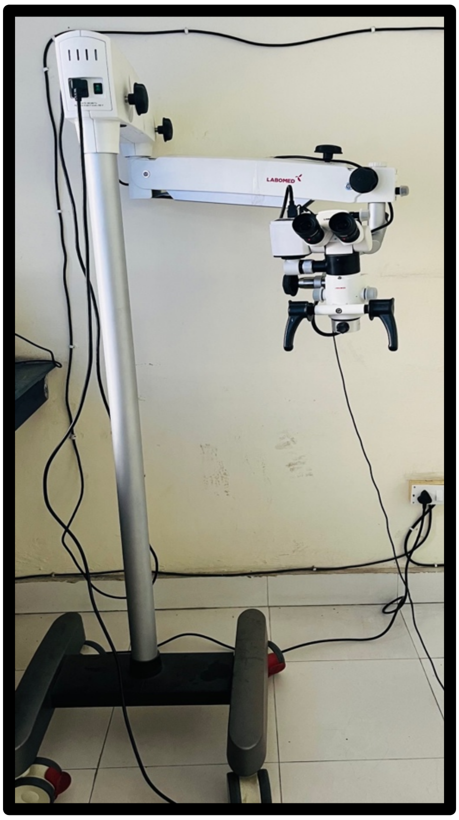




FIGURE 11 & 12: DENTAL MICROSCOPE

FIGURE 13: CONFOCAL LASER SCANNING MICROSCOPE (CLSM)

# PLATE III

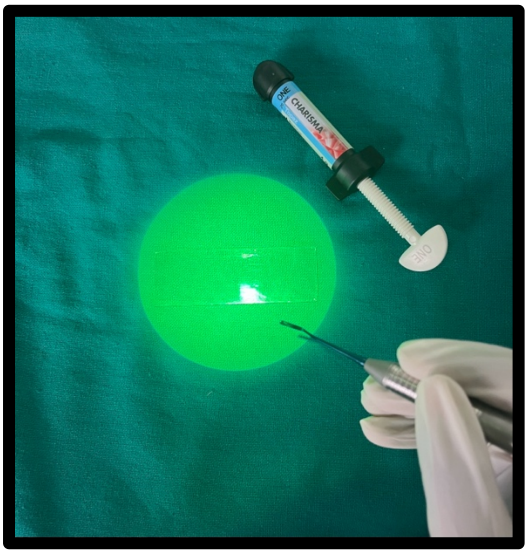



**FIGURE 14: VISUALISATION OF SLIDE**

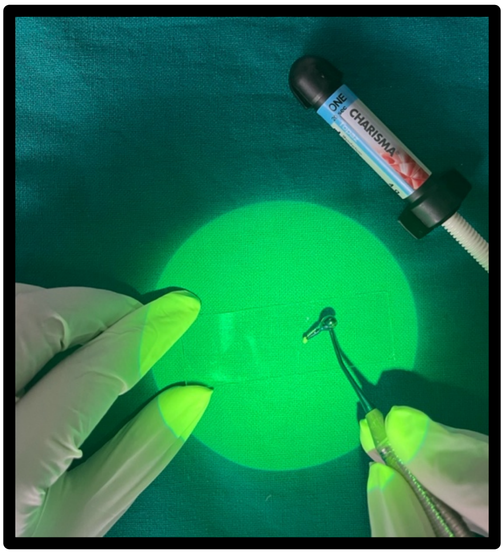



**FIGURE 15: PLACEMENT OF SAMPLE ON INSTRUMENT**

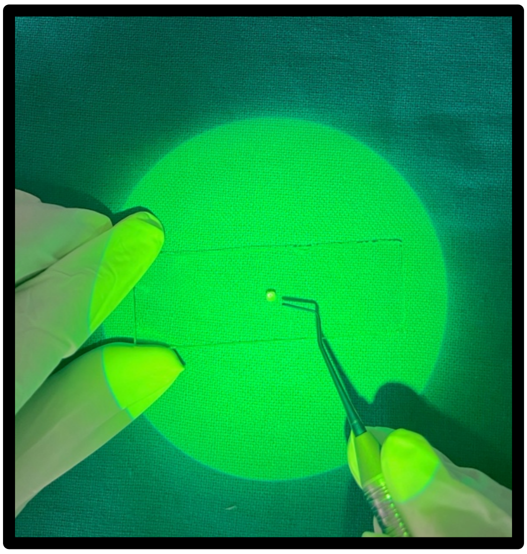


**FIGURE 16: PLACEMENT OF SAMPLE ON THE SLIDE**

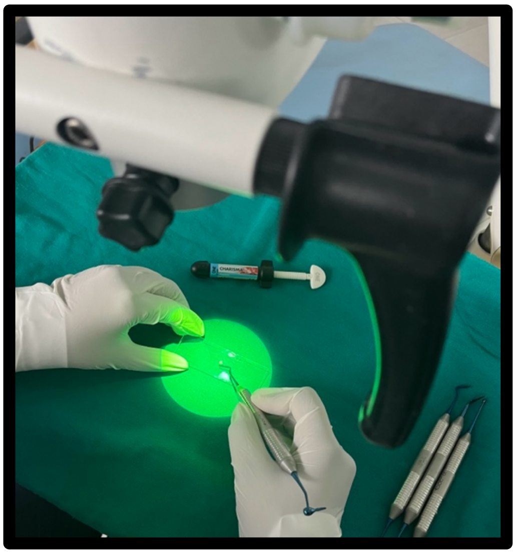


**FIGURE 17: CONDENSATION OF SAMPLE IN THE MOLD**

# PLATE IV

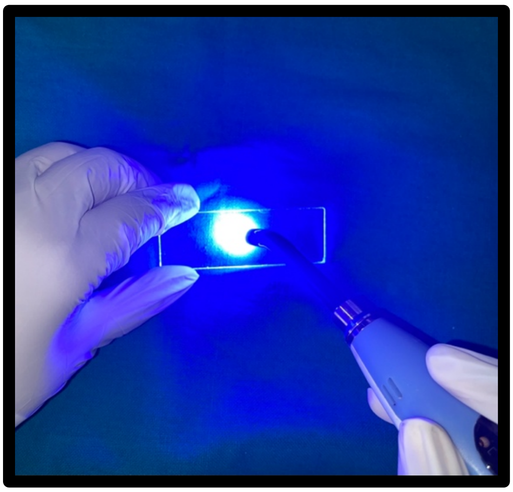


FIGURE 18: LIGHT CURING FOR 40 SECONDS

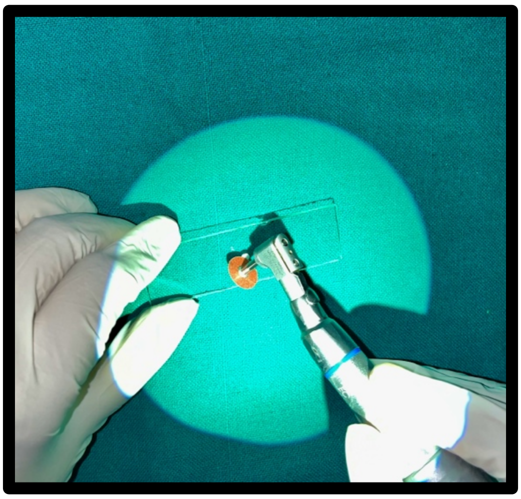


FIGURE 19: FINISHING WITH MEDIUM SOF-LEX DISC

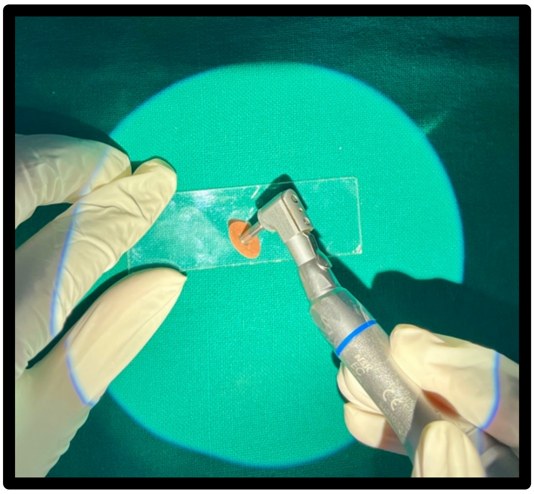


FIGURE 20: FINISHING WITH FINE SOF-LEX DISC

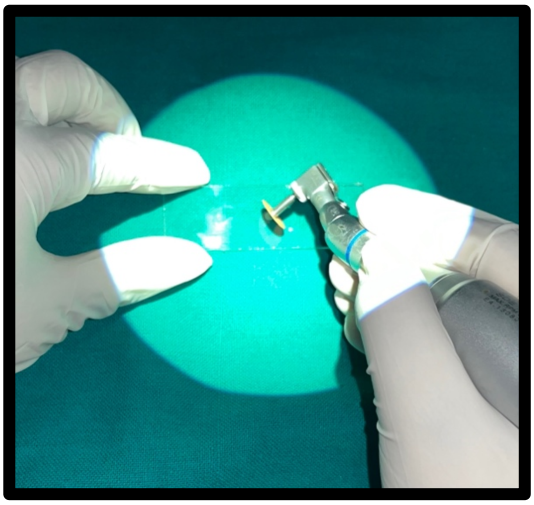


FIGURE 21: FINISHING WITH SUPER FINE SOF-LEX DISC

# PLATE V

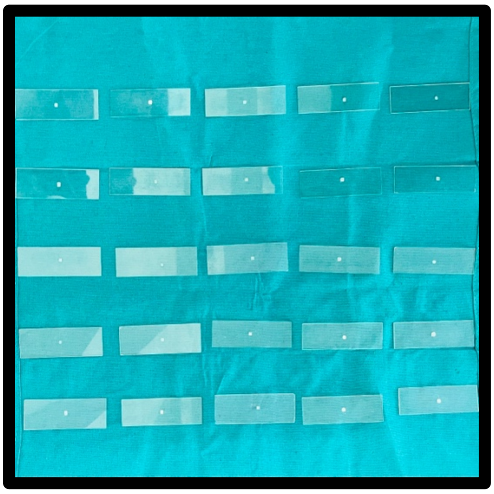


FIGURE 22: OMNICHROMA

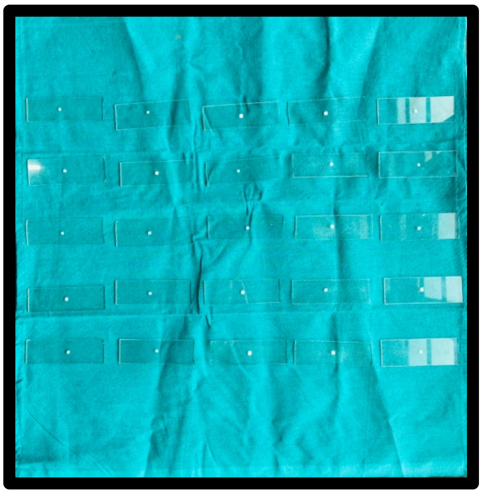


FIGURE 23: CHARISMA TOPAZ (N=25)

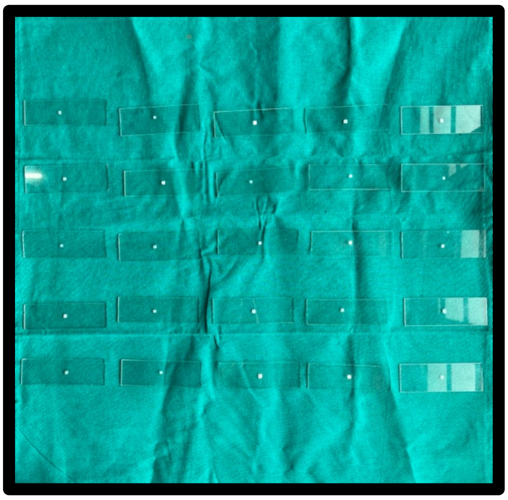


FIGURE 24: BEAUTIFIL II (N=25)

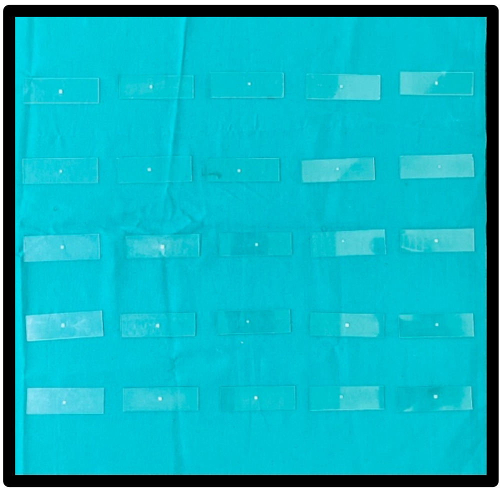


FIGURE 25: CERAM.X SPHERE TEC

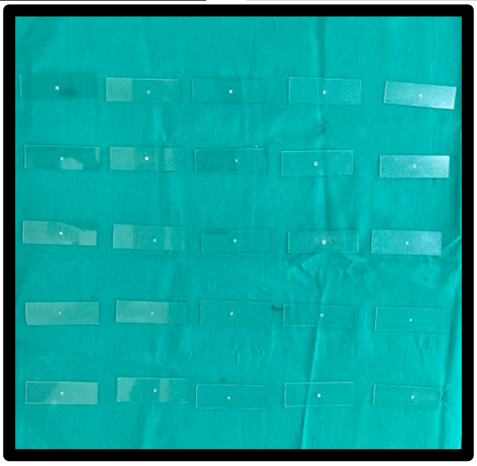


FIGURE 26: TETRIC N CERAM

# PLATE VI

# RESULTS

# RESULTS

## STATISTICAL ANALYSIS

Data were summarized as Mean ± SE (standard error of the mean). Groups were compared by one factor analysis of variance (ANOVA) and the significance of mean difference between the (inter) groups was done by Tukey's HSD (honestly significant difference) post hoc test. A two-tailed ($\alpha$=2) $P < 0.05$ was considered statistically significant. Analysis was performed on SPSS software (Windows version 20.0).

**1) Arithmetic mean:**

It is the simplest measure of central tendency. It is obtained by adding the individual observations and then divided by the total number of observations. Mean is calculated using the formula,

$$EXi/n$$

Where, I (sigma), means the sum of, Xi is the value of each observation in the data, n is the number of observations in the data.

**2. Mean deviation**

It is the average of the deviations from the arithmetic mean. It is given by,

$$M.D = E(X-Xi)/ n$$

Where, £ (sigma), is the sum of, X is the arithmetic mean, Xi is the value of each observation in the data, n is the number of observations in the data

**3. Standard Deviation**

The standard deviation is the most important and widely used measure of studying dispersion. It is also known as root mean square deviation because it is the square root of the mean of the squared deviations from arithmetic mean. Greater the standard deviation, greater will be the magnitude of dispersion from the mean. A small standard deviation means a higher degree of uniformity of the observations.

$$S.D = \sqrt{\frac{(X - X_i)^2}{n}}$$

## ANALYSIS OF VARIANCE

Analysis of variance (ANOVA) is used when we compare more than two groups simultaneously. The purpose of one-way ANOVA is to find out whether data from several groups have a common mean. That is, to determine whether the groups are actually different in the measured characteristic. One way ANOVA is a simple special case of the linear model. For more than two independent groups, simple parametric ANOVA is used when variables under consideration follows Continuous exercise Group 4istribution and groups variances are homogeneous otherwise non parametric alternative Kruskal-Wallis (H) ANOVA by ranks is used. The one-way ANOVA form of the model is

$$Y_{ij} = \alpha_{.j} + \varepsilon_{ij}$$

where;

- $Y_{ij}$ is a matrix of observations in which each column represents a different group.
- $\alpha_{.j}$ is a matrix whose columns are the group means (the "dot j" notation means that α applies to all rows of the $j^{th}$ column i.e. the value $\alpha_{ij}$ is the same for all i).
- $\varepsilon_{ij}$ is a matrix of random disturbances.

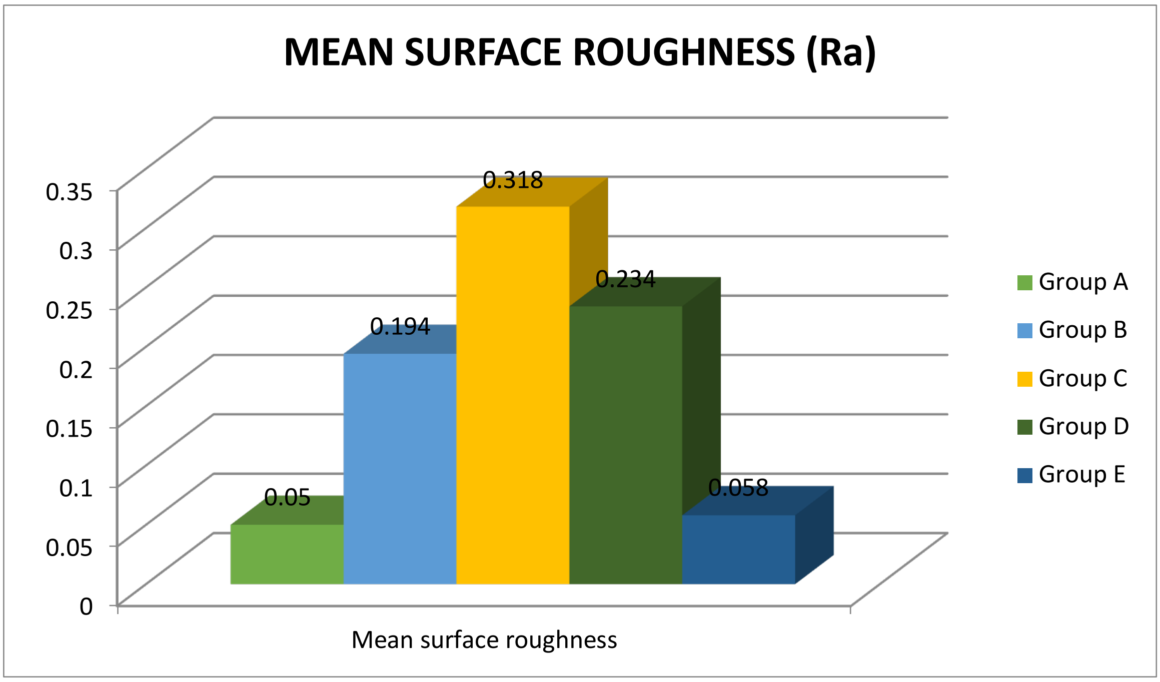
The model posits that the columns of Y are a constant plus a random disturbance. We want to know if the constants are all the same.

## TABLES

| GROUPS | MEAN (µm) | 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 | |

**TABLE 6: RESULTS OF ALL GROUPS**

The above table 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.




**GRAPH 2: COMPARISON OF MEAN SURFACE ROUGHNESS OF DIFFERENT GROUPS**

## TUKEY MULTIPLE COMPARISON TEST

After performing ANOVA, Tukey HSD (honestly significant difference) post hoc test is generally used to calculate differences between group means. The rationale behind the hsd technique comes from the observation that, when the null hypothesis is true, the value of the *q* statistics evaluating the difference between Groups *a* and *a0* is equal to

$$q = \frac{M_{a+} - M_{a'+}}{\sqrt{\frac{1}{2} MS_{S(A)} \left( \frac{1}{S_a} + \frac{1}{S_{a'}} \right)}}$$

and follows, a studentized range *q* distribution with a range of *A* and *N¡A* degrees of freedom. The ratio *t* would therefore be declared significant at a given ® level if the value of *q* is larger than the critical value for the ® level obtained from the *q* distribution and denoted *qA; α* where *υ* = *N* - *A* is the number of degrees of freedom of the error, and *A* is the range (*i.e.,* the number of groups). This value can be obtained from a table of the Studentized range distribution.

### Statistical significance

**Level of significance** "*P*" is the probability signifies level of significance. The mentioned p in the text indicates the following:

$P > 0.05$ -Not significant (ns)

$P < 0.05$- Just significant (*)

$P < 0.01$- Moderate significant (**)

$P < 0.001$- Highly significant (***)

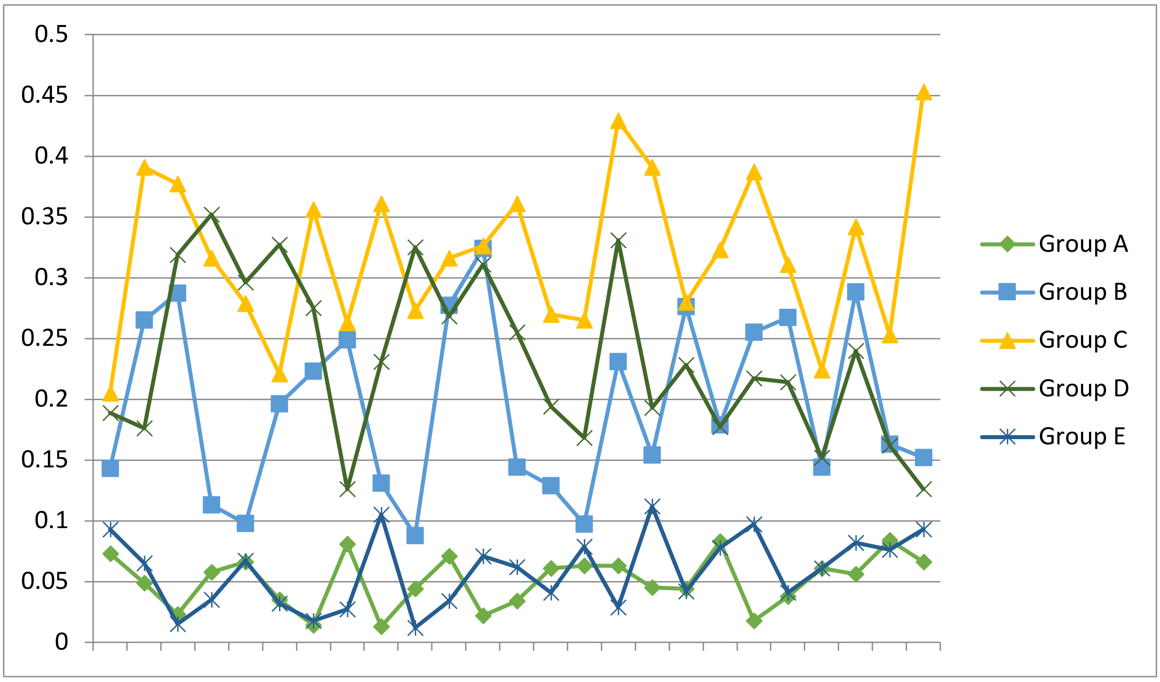
## INTERGROUP COMPARISON RESULTS

| Group I | Group II | Mean Difference | 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** |

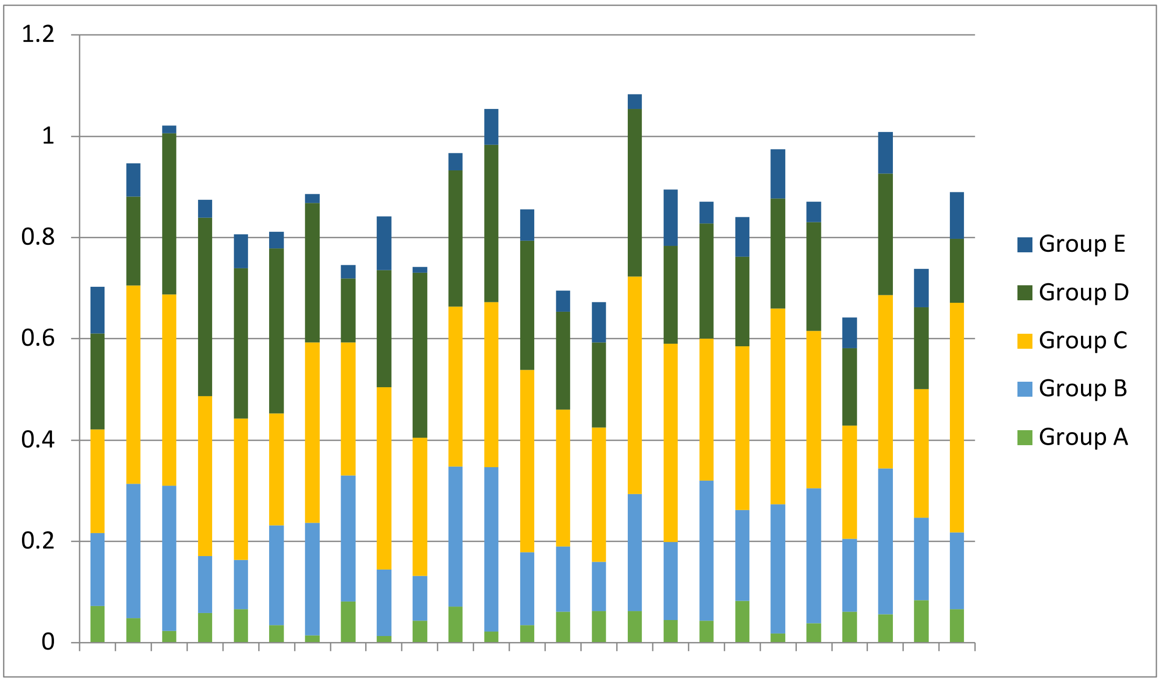
**TABLE 7: INTERGROUP COMPARISON TABLE**

The above table shows the intergroup comparison 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 ($p>0.05$).

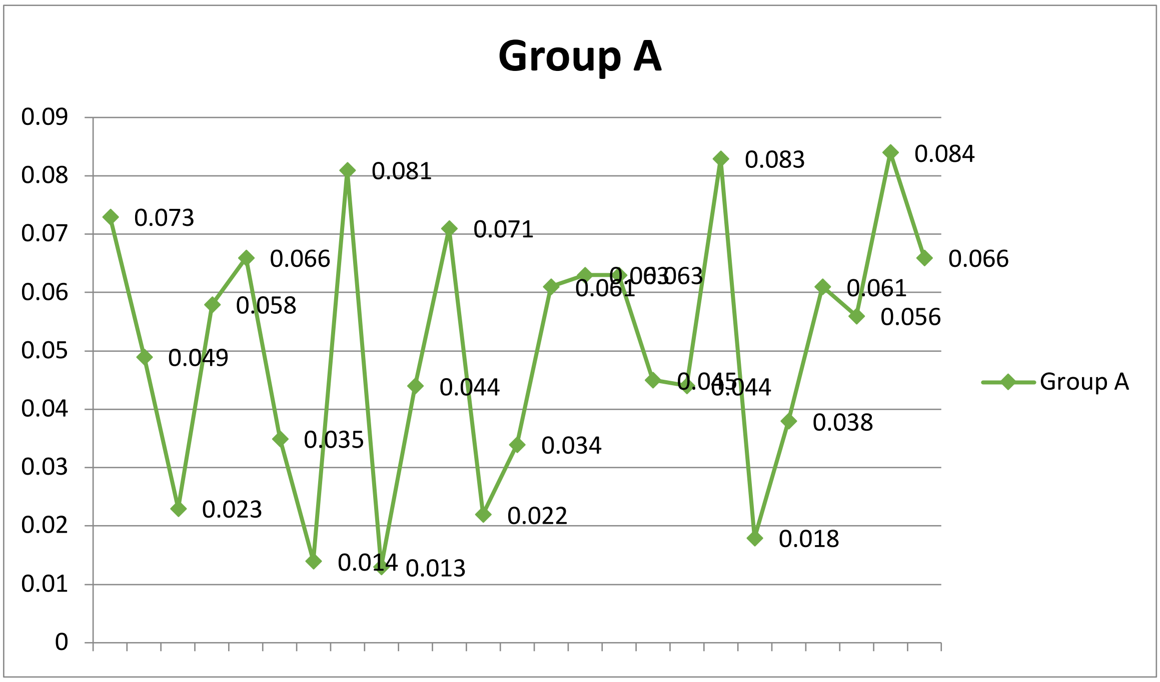
## INTERGROUP COMPARISON



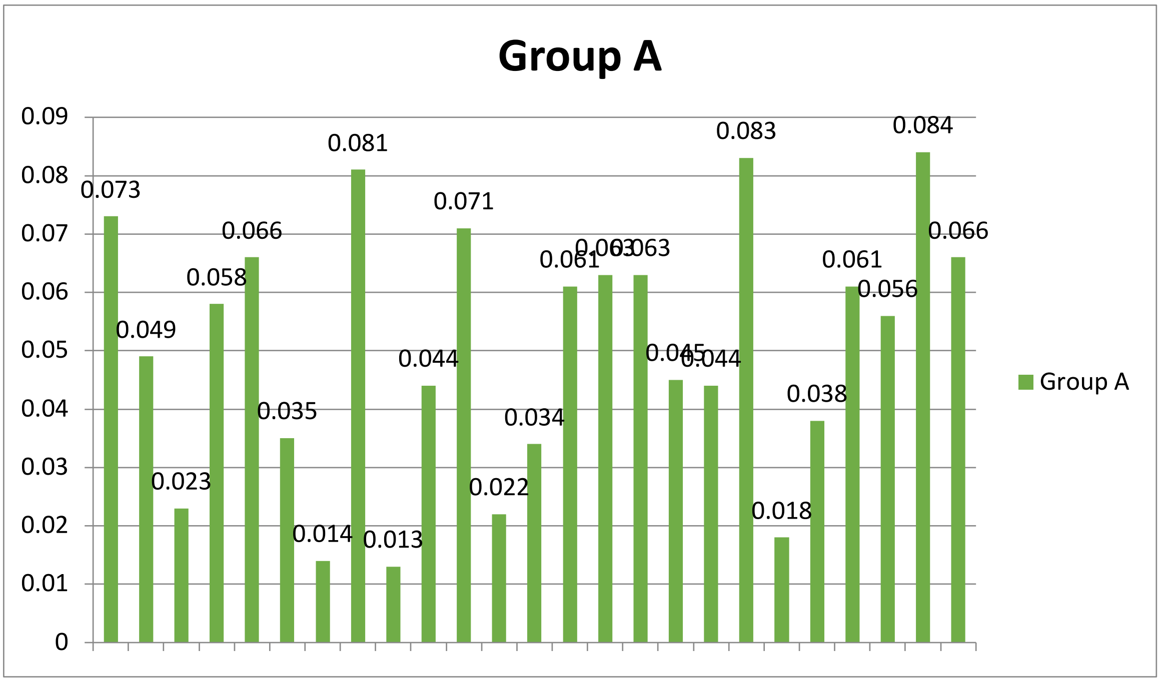

**GRAPH 3: MULTIPLE LINE GRAPH COMPARING ALL THE GROUPS**



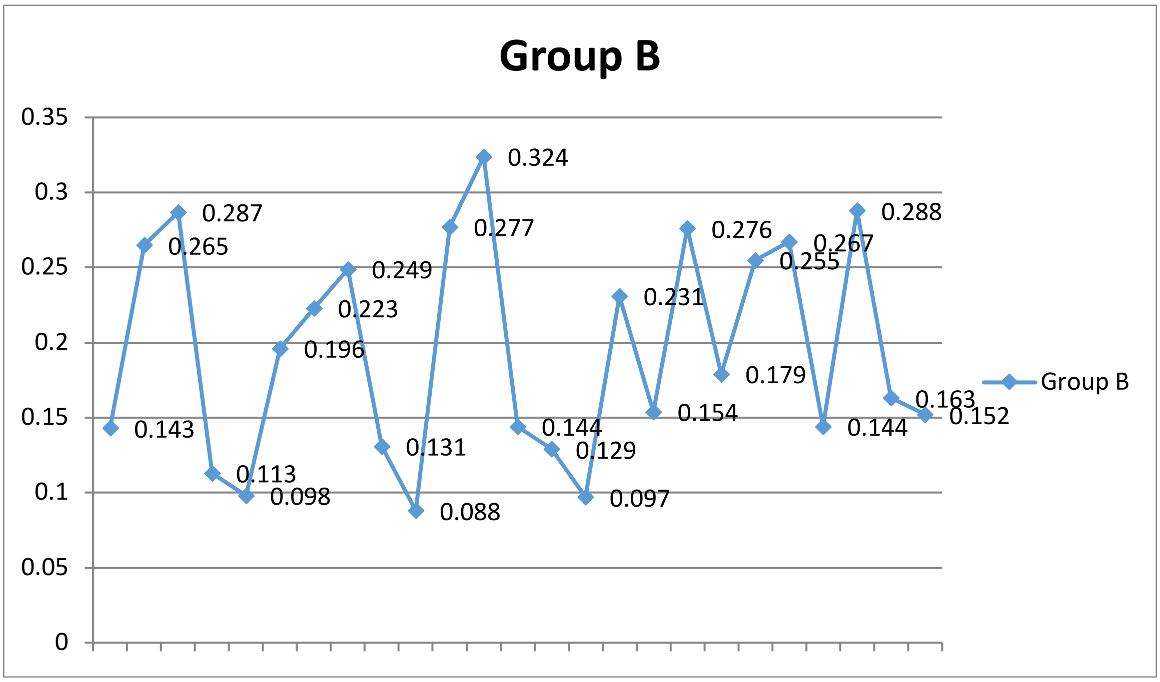

**GRAPH 4: BAR GRAPH COMPARING ALL THE GROUPS**



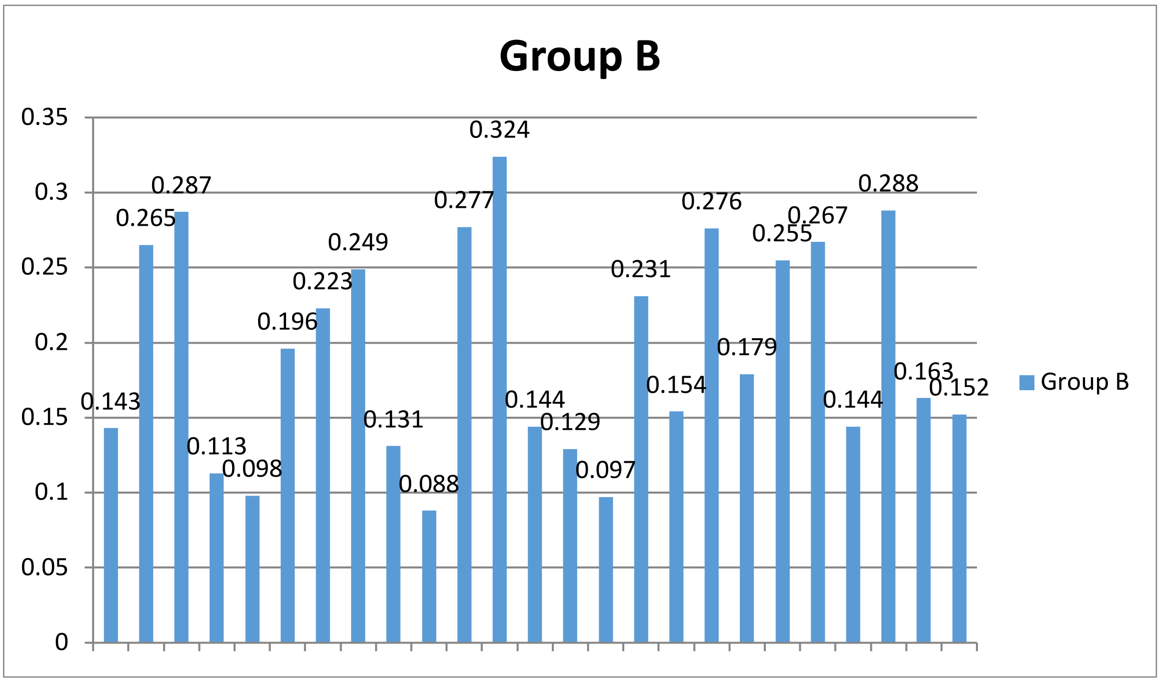

**GRAPH 5: SIMPLE LINE GRAPH DEPICTING GROUP A RESULTS**



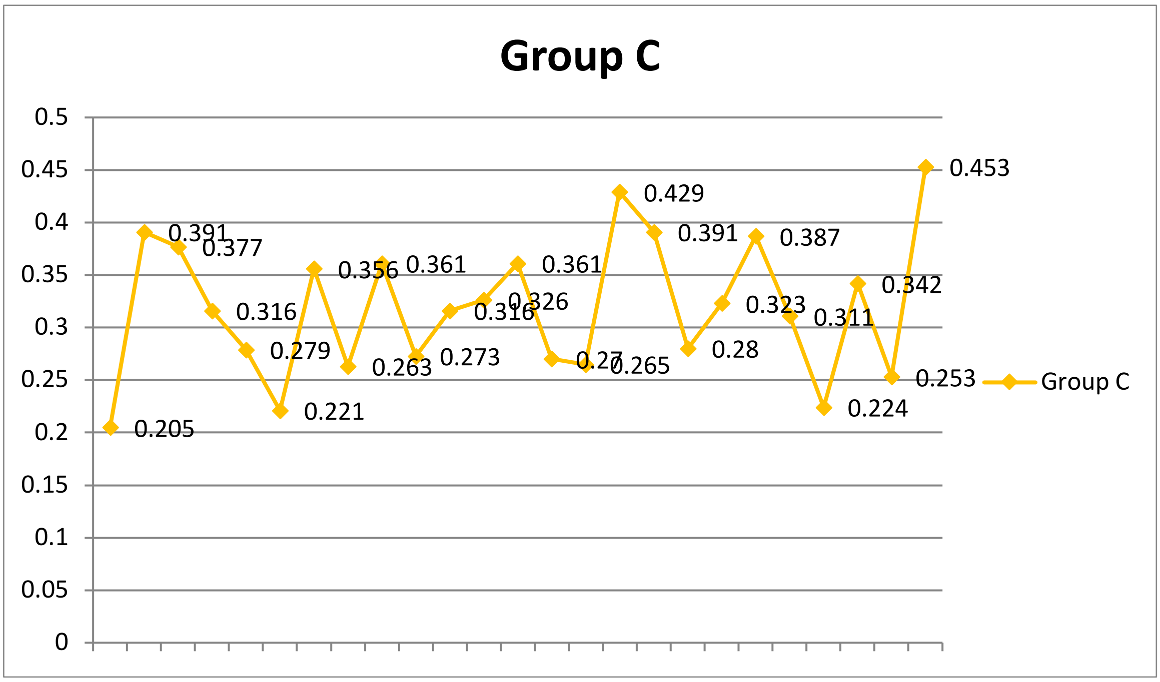

**GRAPH 6: BAR GRAPH DEPICTING GROUP A RESULTS**



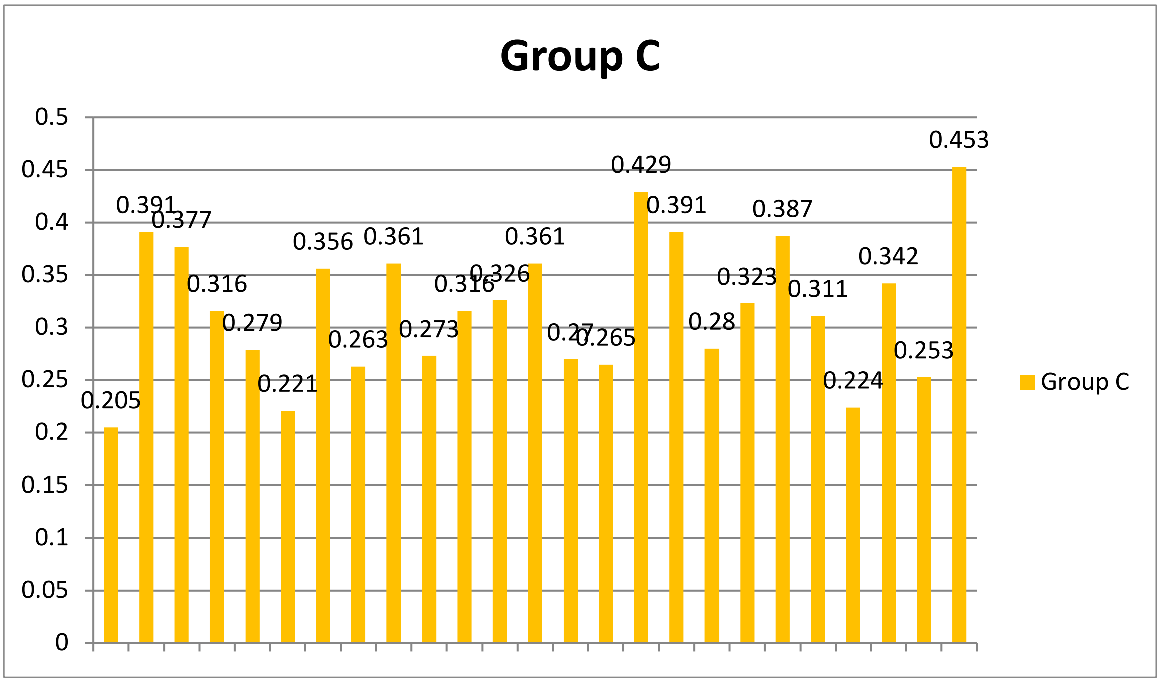

**GRAPH 7: SIMPLE LINE GRAPH DEPICTING GROUP B RESULTS**



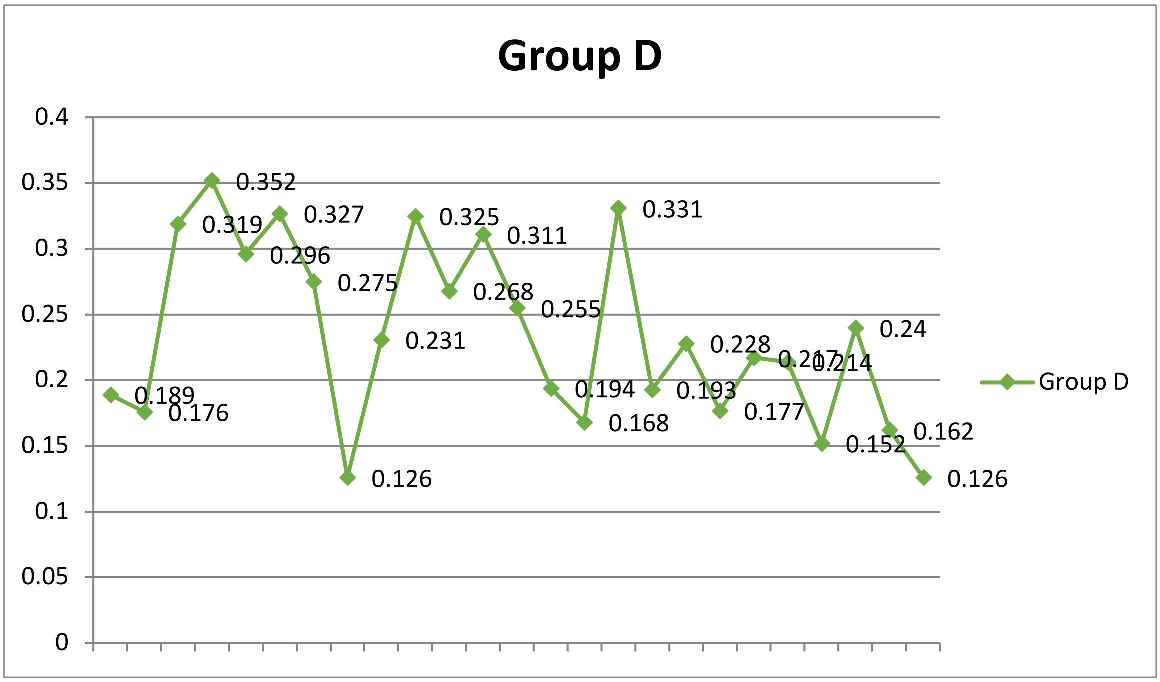

**GRAPH 8: BAR GRAPH DEPICTING GROUP B RESULTS**



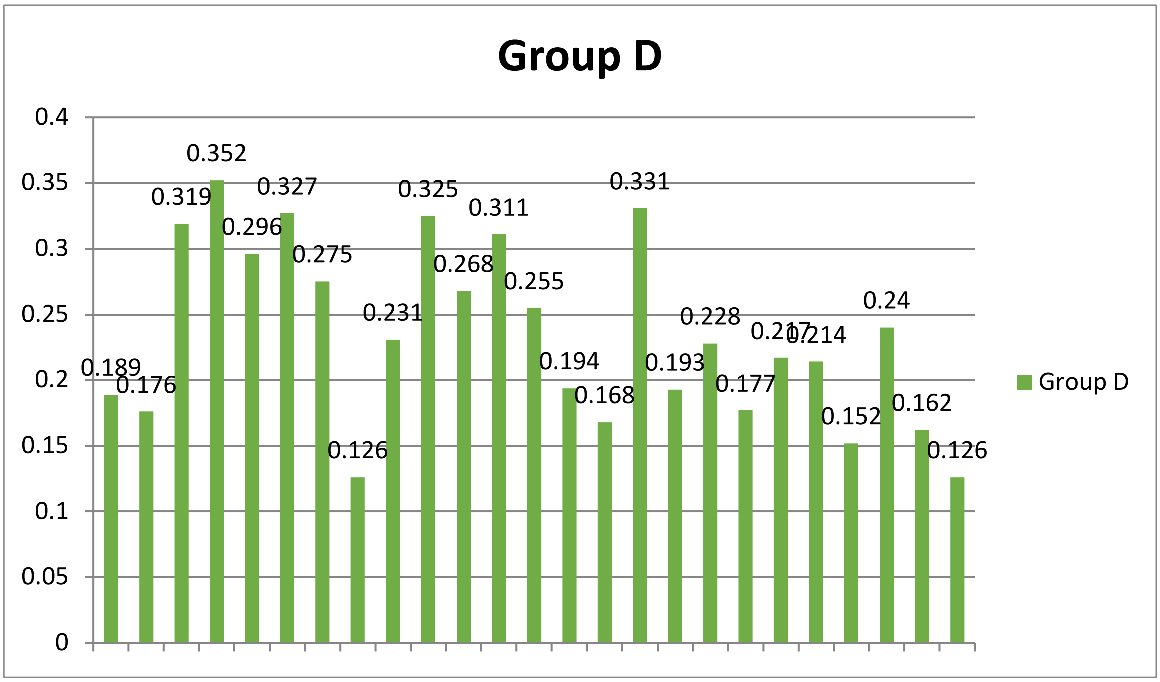

**GRAPH 9: SIMPLE LINE GRAPH DEPICTING GROUP C RESULTS**



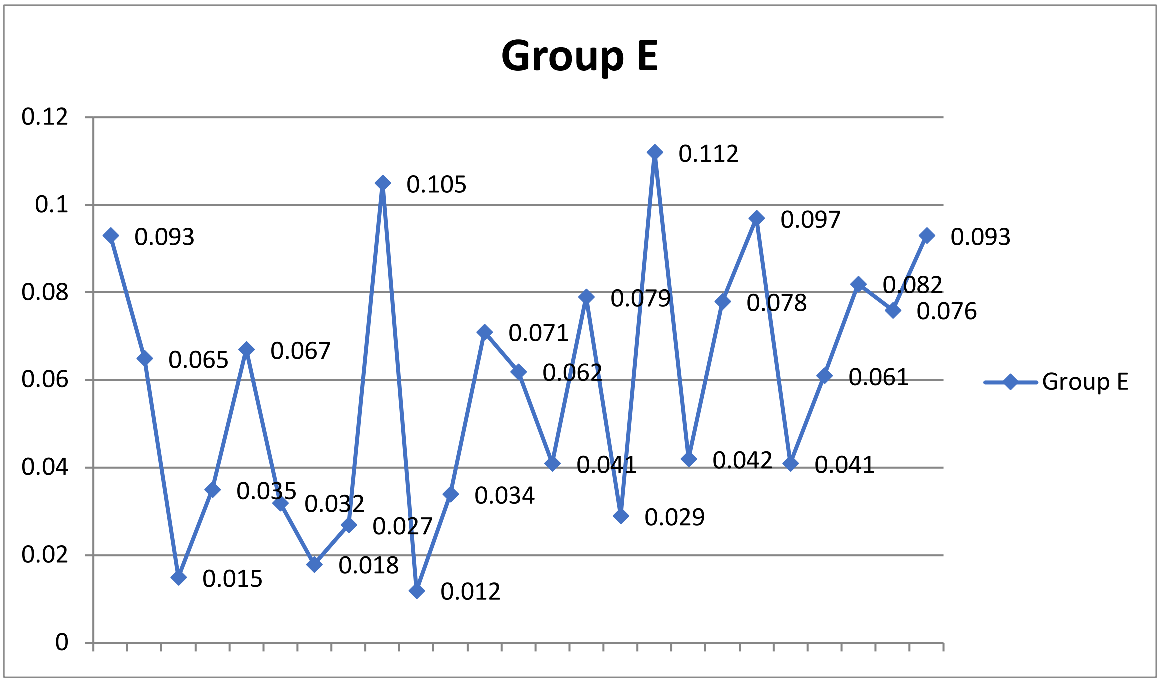

**GRAPH 10: BAR GRAPH DEPICTING GROUP C RESULTS**



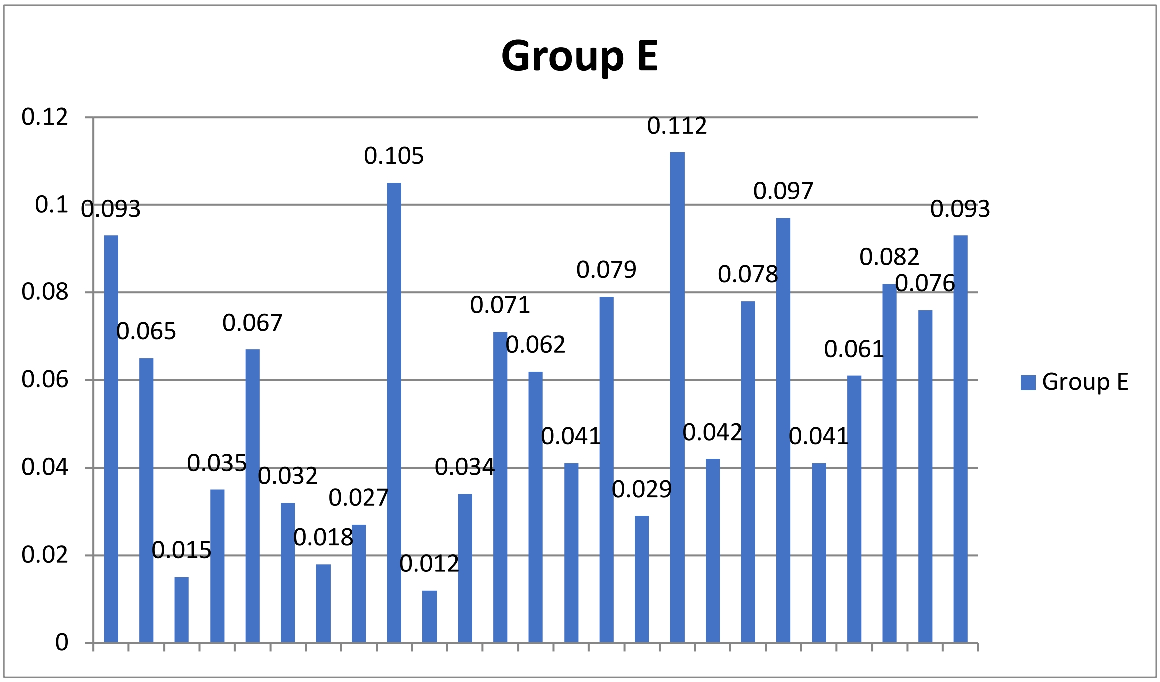

GRAPH 11: SIMPLE LINE GRAPH DEPICTING GROUP D RESULTS




GRAPH 12: BAR GRAPH DEPICTING GROUP D RESULTS




**GRAPH 13: SIMPLE LINE GRAPH DEPICTING GROUP E RESULTS**




**GRAPH 14: BAR GRAPH DEPICTING GROUP E RESULTS**

# DISCUSSION

# DISCUSSION

In aesthetic dentistry, restorative materials should duplicate the appearance of a natural tooth. A resin composite restoration could be imperceptible to the naked eye when its surface closely resembles the surrounding enamel surface. Thus, polished restorations should demonstrate an enamel-like surface texture and gloss.[4]

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.[31] The clinical significance of surface roughness is related to the aesthetic appearance of the restoration (discoloration and wear), the biological consequences regarding periodontal health and the development of secondary caries due to increased plaque accumulation.[38] 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.[104]

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. Harder filler particles are left protruding from the surface during polishing, as the softer resin matrix is preferentially removed in hybrid composites.[65] Filler particles should be situated as close together as possible in order to protect the resin matrix from abrasives. Hence, the application of nanotechnology to composite research is of great benefit. Due to reduced dimension of the particles and wider distribution, an increased filler load can be achieved, which results in reducing polymerization shrinkage and increasing mechanical properties. [105]

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*[106] who compared the surface roughness of three composite materials – Omnichroma, Tetric N Ceram and Z350XT from 3M . When the collected Ra values were analysedf using One-way ANOVA, there were no significant differences between the groups.

In a study conducted by Haesong Kim *et al*[107] ,who compared the surface roughness of Omnichroma, a novel composite resin developed using "smart chromatic technology", with those of two other conventional composite resins with different filler compositions- Omnichroma (nano-spherical), Filtek Z350 XT (nanofill), and Tetric N-Ceram (nanohybrid) Surface roughness was analysed quantitatively and qualitatively using an atomic force microscope and a scanning electron microscope. The surface roughness (Ra) of Omnichroma was 0.123 µm after finishing, and it exhibited a smooth surface compared to the other resins. However, there were no significant differences in the surface roughness between the three composite 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[108] on the surface roughness of three 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[109] *et al,* which showed the lowest surface roughness values with the nanofill resin composite (Omnichroma) as compared to nanohybrid Composites (Charisma Topaz One). In the study done by Endo *et al*[110] similar results were obtained regarding to the roughness of nanofill composite. A study was conducted by Cao *et al* [111] on the filler morphology of different resin based composite materials and the surface properties and it was concluded that the spherical shaped fillers showed lower surface roughness than other different shape.

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 was that the clusters of the particles wear off instead of taking out the whole particles.[112]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* [113].

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*[114] 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[115] *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*[116] 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[117]. 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. Also, the Charisma

Diamond One composite has the lowest filler ratio (65 vol%) between the composites used in this study and has the highest surface roughness between the groups. This result may be related to the low filler ratio of this resin composite. The increase in the filler volume/weight ratio in the material increases the wear resistance against the exposed external factors and reduces the surface roughness[118]

In the present study the surface roughness of Group C (Beautifil II) was highest with mean value of 0.318 μm. The surface roughness of Beautifil II was highest in the present study and significant difference was observed from all other groups. The results of the present study are in line with the study conducted by Yumiko Hosoya[119] *et al* who evaluated the effects of polishing on surface roughness, gloss, and color of regular, opaque, and enamel shades of three resin composites. The authors reported that the surface roughness was highest and gloss was lowest for the Beautifil II as compared to Estelite and Clearfil Majesty. They attributed the high surface roughness in Beautifil II to shape of filler particles in the Beautifil II composite resin which are difficult to polish. According to the manufacturer, Beautifil II is considered a giomer because it has a high content of surface pre-reacted glass ionomer (S-PRG) particles with 0.01–4 μm, able to release and recharge fluoride. The giomer material, Beautifil, has susceptibility to deterioration by weak acids. Furthermore, Gonulol *et al*.[120] reported that more surface gaps could be observed in giomer composites compared with conventional composites due to the fluoride ion releasing property.

The present study found the surface roughness of Ceram.x Sphere TEC (Group D) to be high and comparable to Charisma One. The study conducted by Anindita Chakraborty[129] *et al* reported surface roughness of Ceram.x Sphere TEC to be high and comparable with bulk fill composites.

In the present study, the surface roughness of Group E (Tetric N Ceram) was comparable to Omnichroma and significantly lower than the surface roughness of Beautifil II composite material and Charisma Topaz one. Indhira Melo[115] and Gunce Ozan *et al*[121] also found the surface roughness of Tetric N Ceram to be significantly lower as compared to Beautifil with and without sealant application. Özyurt E, *et al*[12] evaluated the surface roughness of three bulk-fill (Beautifil, Tetric N-Ceram, Filtek One) composite resin and one conventional (Z250) composite resin material in which the surface roughness of Beautifil was found to be highest and statistically significant from Tetric N Ceram.

The low surface roughness of Tertic N ceram can be attributed to nano-filler dimensions in Tetric N-Ceram. While the material contains only a small quantity of inorganic nano-particles, nano additives, known as rheological modifiers, have been incorporated in a targeted fashion[123] which contribute to, high tensile strength, reduced shrinkage, and low surface roughness[124,125,126]. Also because Tetric N-Ceram Bulk Fill contains alternative photoinitiators intended to enhance photopolymerization, such as ivocerin (a dibenzoyl germanium derivative) and monoacylphosphine oxide (TPO), which are stimulated by different wavelengths. Gutierrez A[127] *et al* study also showed that ivocerin acts as a polymerization enhancer, allowing it to be efficient material. The low surface roughness found in Tetric N Ceram in the present study has been contradictory to the results of the study conducted by Hassan, *et al*.[128] who found the surface roughness of Tetric N ceram to be very high.

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[130] 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).[49]

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.[33] 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.[32]

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 present study was conducted to comparatively evaluate the surface roughness of five different composite resin materials using confocal laser scanning microscope (CLSM). Composite resin from five different manufacturers were selected 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 of dimensions 2mm by 2mm by 1mm and light cured for 40 seconds.

The five groups were

**Group A (**n=25): Omnichroma (Tokuyama, Japan)
**Group B** (n=25): Charisma Topaz ONE (Kulzser, Japan)
**Group C** (n=25): Beautifil II composite (Shofu, Japan)
**Group D** (n=25): Ceram.x® SphereTEC™ one (Dentsply sirona)
**Group E** (n=25): Tetric N-ceram Composite IVA (Ivoclar vivadent)

Each sample was polished with 3M ESPE Sof-lex Polishing discs (Medium, Fine, Super fine) for 20 seconds each 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.

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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# ANNEXURES

# ANNEXURE 1

**BABU BANARASI DAS UNIVERSITY**
**BBD COLLEGE OF DENTAL SCIENCES, LUCKNOW**

BBD UNIVERSITY

**BBDCODS/IEC/09/2022** **Dated: 16th September, 2022**

**Communication of the Decision of the Xth Institutional Ethics Sub-Committee Meeting**

**IEC Code: 02**

**Title of the Project:** Comparative Evaluation Of Surface Roughness Of Different Composite Resins Using Confocal Laser Scanning Microscope: An In Vitro Study.

**Principal Investigator:** Dr Aayush Anand Poddar **Department:** Conservative Dentistry and Endodontics

**Name and Address of the Institution:** BBD College of Dental Sciences Lucknow.

**Type of Submission:** New, MDS Project Protocol

Dear Dr Aayush Anand Poddar,

The Institutional Ethics Sub-Committee meeting comprising following members was held on 15th September, 2022.

| | | |
|---|---|---|
| 1. | Dr. Lakshmi Bala<br>Member Secretary | Prof. and Head, Department of Biochemistry, BBDCODS, Lucknow |
| 2. | Dr. Praveen Singh Samant<br>Member | Prof. & Head, Department of Conservative Dentistry & Endodontics, BBDCODS, Lucknow |
| 3. | Dr. Jiji George<br>Member | Prof. & Head, Department of Oral Pathology, BBDCODS, Lucknow |
| 4. | Dr. Amrit Tandan<br>Member | Professor, Department of Prosthodontics and Crown & Bridge, BBDCODS, Lucknow |
| 5. | Dr. Rana Pratap Maurya<br>Member | Reader, Department of Orthodontics, BBDCODS, Lucknow |

The submitted documents of the current MDS Project Protocol is exempted for review in the meeting.

**Decision: The MDS Protocol is exempted for review by the Institutional Ethics Sub-Committee.**

Forwarded by:

**Prof. Dr. Puneet Ahuja**
Principal
BBD College of Dental Sciences
BBD University, Lucknow

16/9

PRINCIPAL
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Lakshmi Bala
16/09/22

**Dr. Lakshmi Bala**
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Faizabad Road, Lucknow-226028

**ANNEXURE 2**

# BABU BANARASI DAS UNIVERSITY

## BBD COLLEGE OF DENTAL SCIENCES, LUCKNOW

BBD UNIVERSITY

## INSTITUTIONAL RESEARCH COMMITTEE APPROVAL

The project titled **"Comparative Evaluation Of Surface Roughness Of Different Composite Resins Using Confocal Laser Scanning Microscope: An In Vitro Study"** submitted by **Dr Aayush Anand Poddar** Postgraduate student in the **Department of Conservative Dentistry and Endodontics** for the Thesis Dissertation as part of MDS Curriculum for the academic year 2021-2024 with the accompanying proforma was reviewed by the Institutional Research Committee in its meeting held on **14th September, 2022** at BBDCODS.

The Committee has granted approval on the scientific content of the project. The proposal may now be reviewed by the Institutional Ethics Committee for granting ethical approval.

**Prof. Dr. Puneet Ahuja**
Chairperson

**Dr. Mona Sharma**
Co-Chairperson

## ANNEXURE 3

## SAMPLE SIZE CALCULATION

To calculate the sample size using the means, considering 5.0% margin of error (*α=0.05 i.e. type I error*), 80.0% power (*1-β=0.80 i.e. type II error*), the formula is,

$$\text{Sample size, N} = 2\ SD^2\ (Z_{\alpha/2} + Z_{\beta})^2/d^2$$

SD – Standard deviation = From previous studies

$Z_{\alpha/2} = Z_{0.05/2} = Z_{0.025} = 1.96$ (From *Z* table) at type 1 error of 5%

$Z_{\beta} = Z_{0.20} = 0.84$ (From *Z* table) at 80% power

d = effect size = difference between mean values

So now formula will be,

$$\text{Sample size} = 2\ SD^2\ (1.96+0.84)^2/d^2$$
$$= 2\ (0.02)^2\ (1.96+0.84)^2/\ (0.011)^2$$
$$= 51.83\ \sim 50$$

As the sample size formula is for 2 groups,
So, for five groups the sample size will be 125 and
for each group the sample size will be 25.

**FINAL OUTCOME**

**TOTAL SAMPLE SIZE: 125**

**GROUP SIZE: 25**

## ANNEXURE 4

| Group A | | | Group B | |
|---|---|---|---|---|
| Omnichroma | Ra (µm) | | Charisma Topaz ONE | Ra (µm) |
| 1 | 0.073 | | 1 | 0.143 |
| 2 | 0.049 | | 2 | 0.265 |
| 3 | 0.023 | | 3 | 0.287 |
| 4 | 0.058 | | 4 | 0.113 |
| 5 | 0.066 | | 5 | 0.098 |
| 6 | 0.035 | | 6 | 0.196 |
| 7 | 0.014 | | 7 | 0.223 |
| 8 | 0.081 | | 8 | 0.249 |
| 9 | 0.013 | | 9 | 0.131 |
| 10 | 0.044 | | 10 | 0.088 |
| 11 | 0.071 | | 11 | 0.277 |
| 12 | 0.022 | | 12 | 0.324 |
| 13 | 0.034 | | 13 | 0.144 |
| 14 | 0.061 | | 14 | 0.129 |
| 15 | 0.063 | | 15 | 0.097 |
| 16 | 0.063 | | 16 | 0.231 |
| 17 | 0.045 | | 17 | 0.154 |
| 18 | 0.044 | | 18 | 0.276 |
| 19 | 0.083 | | 19 | 0.179 |
| 20 | 0.018 | | 20 | 0.255 |
| 21 | 0.038 | | 21 | 0.267 |
| 22 | 0.061 | | 22 | 0.144 |
| 23 | 0.056 | | 23 | 0.288 |
| 24 | 0.084 | | 24 | 0.163 |
| 25 | 0.066 | | 25 | 0.152 |

## ANNEXURE 4

| Group C | | | Group D | |
|---|---|---|---|---|
| Beautil II | Ra (µm) | | Ceram.x SphereTEC | Ra (µm) |
| 1 | 0.205 | | 1 | 0.189 |
| 2 | 0.391 | | 2 | 0.176 |
| 3 | 0.377 | | 3 | 0.319 |
| 4 | 0.316 | | 4 | 0.352 |
| 5 | 0.279 | | 5 | 0.296 |
| 6 | 0.221 | | 6 | 0.327 |
| 7 | 0.356 | | 7 | 0.275 |
| 8 | 0.263 | | 8 | 0.126 |
| 9 | 0.361 | | 9 | 0.231 |
| 10 | 0.273 | | 10 | 0.325 |
| 11 | 0.316 | | 11 | 0.268 |
| 12 | 0.326 | | 12 | 0.311 |
| 13 | 0.361 | | 13 | 0.255 |
| 14 | 0.27 | | 14 | 0.194 |
| 15 | 0.265 | | 15 | 0.168 |
| 16 | 0.429 | | 16 | 0.331 |
| 17 | 0.391 | | 17 | 0.193 |
| 18 | 0.28 | | 18 | 0.228 |
| 19 | 0.323 | | 19 | 0.177 |
| 20 | 0.387 | | 20 | 0.217 |
| 21 | 0.311 | | 21 | 0.214 |
| 22 | 0.224 | | 22 | 0.152 |
| 23 | 0.342 | | 23 | 0.24 |
| 24 | 0.253 | | 24 | 0.162 |
| 25 | 0.453 | | 25 | 0.126 |

## ANNEXURE 4

| Group E | |
|---|---|
| Tetric N-Ceram | Ra (µm) |
| 1 | 0.093 |
| 2 | 0.065 |
| 3 | 0.015 |
| 4 | 0.035 |
| 5 | 0.067 |
| 6 | 0.032 |
| 7 | 0.018 |
| 8 | 0.027 |
| 9 | 0.105 |
| 10 | 0.012 |
| 11 | 0.034 |
| 12 | 0.071 |
| 13 | 0.062 |
| 14 | 0.041 |
| 15 | 0.079 |
| 16 | 0.029 |
| 17 | 0.112 |
| 18 | 0.042 |
| 19 | 0.078 |
| 20 | 0.097 |
| 21 | 0.041 |
| 22 | 0.061 |
| 23 | 0.082 |
| 24 | 0.076 |
| 25 | 0.093 |

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### Submission Information

| | |
|---|---|
| Author Name | AAYUSH ANAND PODDAR |
| Title | COMPARATIVE EVALUATION OF SURFACE ROUGHNESS OF DIFFERENT COMPOSITE RESINS USING CONFOCAL LASER SCANNING MICROSCOPE : AN IN VITRO STUDY. |
| Paper/Submission ID | 1412980 |
| Submitted by | amarpal.singh056@bbdu.ac.in |
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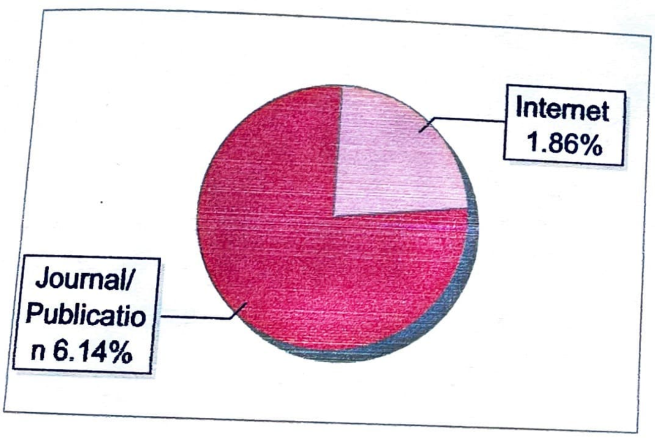


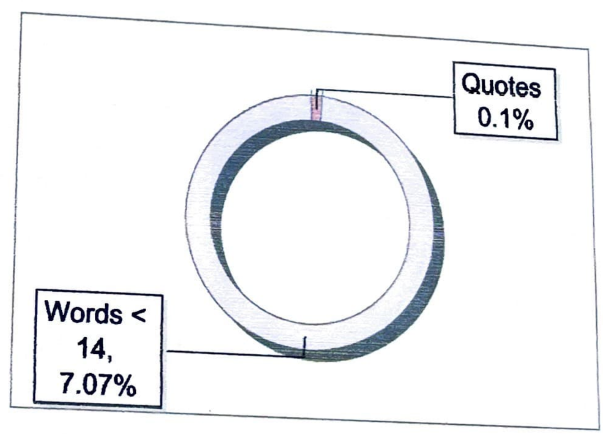


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