Original Article

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Dentistry Section

An In-vitro Evaluation of Grinding and Polishing on Surface Roughness and Flexural Strength of Monolithic Zirconia

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ABSTRACT

Introduction: For a dentist, it is a matter of concern to restore the original luster or glaze on a Monolithic Zirconia (MZ) restoration after clinical adjustments. For a long time, the gold standard for surface restoration was reglazing; however, with advancements in technology, new polishing kits optimised for zirconia have become available for chairside polishing.

Aim: To examine the effects of grinding, reglazing, and polishing techniques on the surface roughness and flexural strength of MZ specimens.

Materials and Methods: This in-vitro study was conducted in the Department of Prosthodontics at MM College of Dental Sceiences and Research in Mullana, Haryana, India from April to December 2019 and 32 specimens of MZ, each measuring 20 mm×5 mm×3 mm, were fabricated and divided into four groups, with each group consisting of eight specimens. Group C was considered the Control group. Specimens in Group G were only Ground, specimens in Group GR were Ground and Reglazed, and specimens in Group GP were Ground and Polished using a zirconia polishing kit. All specimens were then analysed for surface roughness and flexural strength using a profilometer and a Universal Testing Machine (UTM), respectively. Statistical analysis was performed using Analysis of Variance (ANOVA), Honest Significant Test (HSD) post-hoc test, Pearson's correlation, and other methods using International Business Machine (IBM) Statistics version 25.0 (Armonk, USA).

Results: The surface roughness (Ra) of the control group (C) was 0.4403 μm, followed by the Polished Group (GP) at 0.656 μm and the Reglazed Group (GR) at 0.809 μm. The difference between the polished (GP) and reglazed (GR) groups, was statistically insignificant (p=0.53). There was a statistically significant increase in flexural strength in the reglazed samples (GR) when compared to the polished samples (GP). No significant correlation (p=0.58 and r=-0.1) was found between surface roughness and flexural strength.

Conclusion: Chairside polishing can be an effective alternative to reglazing for restoring the surface finish of MZ. Additionally, polishing increases the strength of zirconia after adjustments.

Keywords: Glaze, Mechanical properties, Post-processing

INTRODUCTION

In the modern era, there has been an increase in the application of ceramics in dentistry and biomedical fields. Martin Heinrich Klaproth accidentally discovered zirconium dioxide (ZrO_2) in 1789 while working with gems [1]. In 1969, zirconium oxide (ZrO_2) was first used for medical purposes in orthopaedics, replacing aluminum or titanium for femoral head replacement [1]. Recently, Y-TZP ceramics (Yttrium-stabilised Tetragonal Zirconia Polycrystalline) have gained popularity due to their superior mechanical, aesthetic, and biocompatibility properties compared to conventional dental ceramics [1].

Zirconia Veneered with feldspathic Porcelain (ZVP) offers better aesthetics, while MZ provides greater strength [2]. Fracture and chipping of the veneering layer are common clinical complications associated with ZVP. MZ restorations do not require veneering with aesthetic materials, thereby eliminating the chipping problem [2].

Zirconia can exist in three allotropic forms. At room temperature and up to 1170°C, the monoclinic (m) structure is observed. Upon heating between 1170°C and 2370°C, the tetragonal (t) structure appears. The cubic (c) structure is formed when heated above 2370°C and upto its melting point [2]. The metastable tetragonal phase is stabilised by incorporating oxides such as CaO, MgO, Y_2O_3, or CeO2 into pure zirconia. The phase transformation from tetragonal to monoclinic can be induced by temperature changes, stress, or surface treatments. This phase transformation results in an increase in volume that slows and halts crack propagation by forming a compressive layer, thus enhancing fracture toughness [3].

Currently, Computer-aided Design (CAD)/Computer-aided Manufacturing (CAM) applications for zirconia include the fabrication of veneers, full coverage crowns, Fixed Partial Dentures (FPDs), implants, and customised abutments. The fabrication of zirconia restorations is done either by soft machining of pre-sintered blanks or hard machining of fully sintered blocks. Restorations obtained through soft machining must be sintered after all formation steps are completed. After sintering, a superficial treatment known as glazing is applied to zirconia surfaces, which enhances their appearance, making them look more like natural teeth. Glazing seals any open pores on the surface, resulting in a smooth finish with good optical properties [4].

The benefit of glazing ceramics is that it may increase fracture resistance and reduce potential abrasiveness. In the majority of cases, it is essential to make adjustments to occlusion, interproximal contacts, and axial contour during the intraoral trial of the final prosthesis. In common practice, fine-grained diamond burs are used to modify or adjust the zirconia surfaces. However, these adjustments disrupt the glaze layer, and if the surface of the restoration is left rough, it can lead to plaque accumulation, dental caries, gingival inflammation, periodontal problems, and abrasion of opposing teeth [3].

Thus, an abraded surface should be either polished or reglazed. However, reglazing requires an additional clinical session. Numerous finishing and polishing systems are available in the market for zirconia restorations, such as diamond rotary instruments of different sizes and shapes, as well as silicone cups, points, and wheels that are diamond-impregnated and made from natural or synthetic diamond grit grades [4,5]. Huh YH et al., found that various zirconia polishing systems significantly smoothed surfaces compared to other systems, but it was also noted that all systems were clinically acceptable [6]. The use of a ceramic polishing kit ensured a smooth surface, yielding durable and cost-effective outcomes [7]. Therefore, chairside polishing of the prosthesis can be performed, which is supported by several studies stating that polishing is a good alternative to reglazing [8,9]. However, various studies also suggest that reglazing is superior. This remains a controversial topic, with various authors expressing differing opinions when comparing glazing and polishing.

In a study conducted by Papanagiotou HP et al., it was observed that the polishing procedure helps increase the strength of dental ceramics and reduces surface roughness [10]. It was also found that there is a negative correlation between surface roughness and zirconia strength [11].

It is a known fact that grinding zirconia has two counteracting effects: it can either produce surface compressive stress that enhances crack healing and increases the strength of the material through transformation toughening, or it may induce surface flaws that exceed the depth of the compressive layer, potentially decreasing the strength of the material [12]. There is still controversy regarding the effects of grinding, polishing, and glazing on the properties of zirconia [3,11,13-15]. Thus, the present study was conducted to investigate the effects of the proposed polishing or surface restoration method on the strength and surface roughness of the restoration.

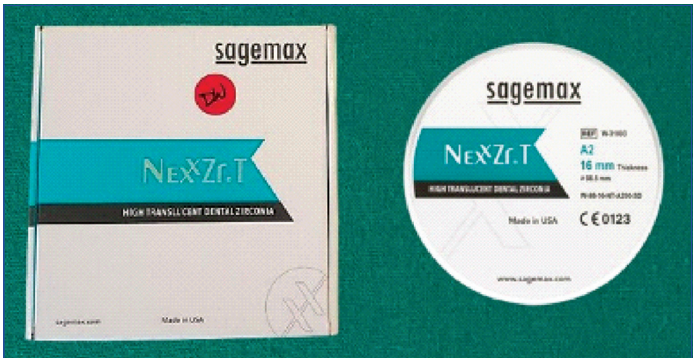
The null hypothesis states that there are no differences in mean roughness or flexural strength among ground, polished, and glazed MZ, and that there is no correlation between flexural strength and roughness.

MATERIALS AND METHODS

This in-vitro study was conducted in the Department of Prosthodontics at MM College of Dental Sciences and Research in Mullana, Haryana, India, from April to December 2019. Ethical clearance was obtained from the Institutional Ethical Committee (IEC 1923). In present study, 32 bar-shaped samples were fabricated.

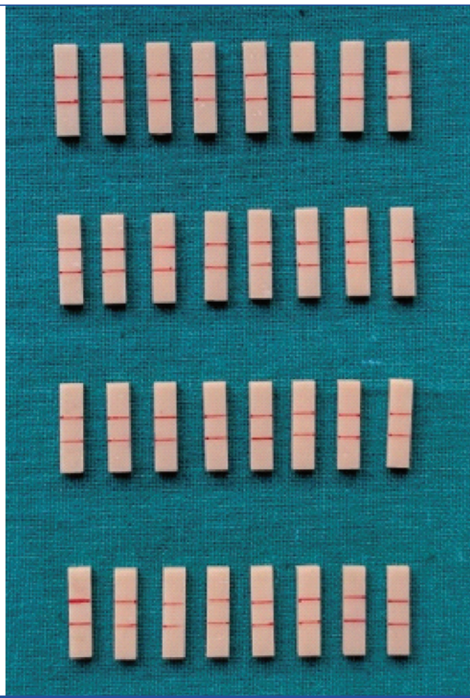
Study Procedure

A total of thirty-two standardised MZ blocks [Table/Fig-1] were constructed from presintered high-translucent MZ blanks (NexxZr T, Sagemax) using CAD/CAM technology. The composition of the material is as follows: ZrO_2 ≥89%, Y_2O_3 4-6%, HfO_2 ≤5%, and Al_2O_3 <1%. The length, width, and thickness of each zirconia block were maintained at 20 mm, 5 mm, and 3 mm, respectively, in accordance with American Dental Association (ADA) Specification Number 69. The blocks were then sintered according to the manufacturer's instructions. The dimensions of the samples were checked using a digital caliper, after which each specimen was glazed in a ceramic furnace.



[Table/Fig-1]: Monolithic Zirconia (MZ) blank.

Grouping of specimens: A total of 32 specimens were fabricated and divided into four groups, with each group consisting of eight specimens [Table/Fig-2].



[Table/Fig-2]: Zirconia specimens.

Group C- Glazed (Control)

Group G- Grinded

Group GR- Grinded and Reglazed

Group GP- Grinded and Zirconia Polishing Kit

Group C- There are eight glazed samples that were kept as a control, meaning they were not ground. The remaining 24 samples were ground to simulate the adjustments made in a clinical setting.

Grinding procedure: Bars were marked at 5 mm intervals at the center of each specimen. Grinding was performed for 20 seconds with a 10-second interval, using a sweeping motion with a 40-grit diamond point (TR-25F, Mani Inc, Japan) and an air rotor handpiece with water coolant to simulate adjustments in a clinical setting. The diamond point was changed after every five samples. Grinding was conducted by a single operator. The samples were then ultrasonically cleaned for 15 minutes. After cleaning, the samples were treated according to their respective groups.

- Group G- Eight ground samples were ultrasonically cleaned for 15 minutes and then air-dried.
- Group GR- Eight samples were subjected to reglazing according to the manufacturer's instructions. A layer of glaze (IPS Ivocolour, Ivoclar, USA) was applied to the ground surface, and the specimens were fired at a temperature of 900°C without vacuum, following the manufacturer's instructions.
- Group GP- The ground surfaces of the eight specimens were polished using a Zirconia polishing kit (Kenda Zircovis Diamond, Liechtenstein) [Table/Fig-3]. Polishing was performed in two steps with a diamond-impregnated polisher that had two rotary

[Table/Fig-3]: Zirconia polishing kit.

points: a blue rubber (medium) and a red rubber (fine) polisher, operated at low speed for two minutes. First, the medium grit polisher was used for one minute at 10,000 rpm. Thereafter, the fine grit polisher was used for another one minute at the same speed [Table/Fig-4]. Polishing was conducted in a sweeping motion, moving both forward and backward. The samples were then cleaned ultrasonically for 15 minutes in distilled water and air-dried.

[Table/Fig-4]: Polishing of specimens.

Surface roughness evaluation: The surface roughness of the specimens was measured using a profilometer. Ra was the parameter calculated during the test, which was conducted using a physical probe that traced the surface. Ra represents the surface roughness and is calculated as the average roughness of the surface, measured by the microscopic spikes and valleys during the stylus tracing. The profilometer determines the roughness of the specimen surface, and Ra can be described as the arithmetical average of all absolute distances of the surface profile from the centerline within the measuring length [Table/Fig-5].

[Table/Fig-5]: Surface roughness evaluation.

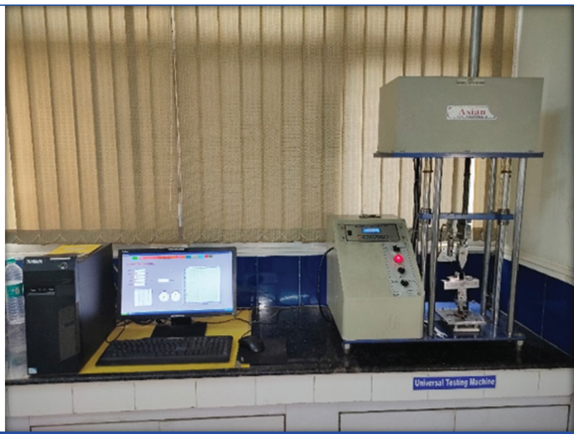
A pick-up with a diamond stylus (5 μm tip radius) was used under a constant pressure force of 4 mN, with a tip angle of 90 degrees. Calibration of the instrument was performed using a standard reference specimen (ISO 1997) at a speed of 0.5 mm/s and a traversing length of 0.25 mm.

The surface roughness of each sample was measured at three locations to obtain the mean surface roughness. The surface roughness of the ground, reglazed, and chairside polished surfaces was recorded. For each sample, the stylus was run in three different directions: horizontally, vertically, and obliquely. This method was consistently applied to obtain three values for each sample. A larger Ra value indicates greater surface roughness, while a lower Ra value signifies a smoother surface.

Flexural strength evaluation: Flexural strength was determined using a 3-point bending test conducted on a Universal Testing Machine (UTM) at a crosshead speed of 0.5 mm/min, with a span length of 15 mm [Table/Fig-6]. The maximum load that caused the fracture of the specimen was recorded. The mean fracture strength was calculated using the following formula, as recommended by the ISO 6872 standard, 1995.

$M=3Wl/2bd^2$ [16]

M=Flexural strength (Mpa)



[Table/Fig-6]: Universal Testing Machine (UTM) for flexural strength evaluation.

W=Fracture load (N)

l=Distance between support points (mm)

B=Breadth of specimen (mm)

D=Thickness of specimen

STATISTICAL ANALYSIS

The statistical analysis was conducted using One-way ANOVA, HSD post-hoc test, and Pearson's correlation to analyse the mechanical properties of zirconia. The analysis was performed using IBM SPSS Statistics version 25.0 (Armonk, USA). A p-value of less than 0.05 was considered statistically significant.

RESULTS

The mean and standard deviation of the surface roughness (Ra) for all four groups were calculated. Group C, the control group (0.4403), demonstrated the minimum value for surface roughness, followed by Group GP (Polished) at 0.656, Group GR (Reglazed) at 0.809, and Group G (Ground) specimens, which exhibited the maximum value at 1.467 [Table/Fig-7].

Groups	Mean±SD	Maximum	Minimum
Control (C)	0.4403±0.096	0.58	0.30
Ground (G)	1.467±0.327	2.03	1.02
Ground and Glazed (GR)	0.809±0.215	1.19	0.56
Ground and Polished (GP)	0.656±0.163	0.84	0.38

[Table/Fig-7]: Mean surface roughness (Ra) and standard deviation of specimens according to different surface treatments.

In the intergroup analysis, statistically significant differences were found between Group C and Group G (p<0.01), Group C and Group GR (p=0.01), Group C and Group GP (p=0.008), Group G and Group GP (p<0.01), and Group G and Group GR (p<0.01). However, there was no statistically significant difference between Group GP and the other groups (p=0.53) [Table/Fig-8].

Tukey's HSD post-hoc test			
Groups	Mean difference	95% CI	p-value
Control (C) vs Ground (G)	1.03	0.7317 to 1.3283	<0.01*
Control (C) vs Ground and Glazed (GR)	0.37	0.0717 to 0.6683	0.01*
Control (C) vs Ground and Polished (GP)	0.22	-0.0783 to 0.5183	0.008*
Ground (G) vs Ground and Glazed (GG)	-0.66	-0.9583 to -0.3617	<0.01*
Ground (G) vs Ground and Polished (GP)	-0.81	-1.1083 to -0.5117	<0.01*
Ground and Glazed (GR) vs Ground and Polished (GP)	-0.15	-0.4483 to 0.1483	0.53

[Table/Fig-8]: Intergroup analysis of surface roughness (Ra) of specimens according to groups.
*:statistically significant (p<0.05)

When assessing the flexural strength (MPa) of all four groups, it was found that the reglazed zirconia sample (Group GR) had the highest flexural strength value at 599.859 MPa, followed by Group C at 524.043 MPa [Table/Fig-9].

Groups	Mean	SD	Minimum	Maximum
Control (C)	524.043	56.834	428.06	605.56
Ground (G)	478.809	99.951	355.98	657.05
Ground and Relazed (GR)	599.859	57.371	486.41	651.65
Ground and Polished (GP)	491.864	87.773	358.93	592.32

[Table/Fig-9]: Mean Flexural Strength (MPa) and Standard Deviation of specimens according to different surface treatments.

In the intergroup analysis of flexural strength, no statistically significant differences were found between Group C and Group G (p=0.66), Group C and Group GR (p=0.23), or Group C and Group GP (p=0.84). However, a statistically significant difference was observed between Group G and Group GR (p=0.02), as well as between Group GR and Group GP (p=0.04) [Table/Fig-10].

Tukey's HSD post-hoc test			
Group	Mean difference	95% CI	p-value
Control (C) vs Ground (G)	-45.23	-151.45 to 60.99	0.66
Control (C) vs Ground and Glazed (GR)	-75.82	-30.39 to 182.04	0.23
Control (C) vs Ground and Polished (GP)	-32.18	-0.078 to 0.518	0.84
Ground(G) vs Ground and Glazed (GR)	121.05	-0.958 to -0.362	0.02*
Ground (G) vs Ground and Polished (GP)	13.05	-1.108 to -0.512	0.98
Ground and Glazed (GR) vs Ground and Polished (GP)	-108.00	-0.448 to 0.148	0.04*

[Table/Fig-10]: Intergroup analysis of flexural strength (MPa) of specimens according to groups.
*:statistically significant (p<0.05)

The correlation between surface roughness and flexural strength was assessed using Pearson's correlation analysis [Table/Fig-11]. A weak positive linear relationship was found in the Ground and Reglazed groups. Overall, a significant relationship was established.

Pair	r value	p-value
Control (C) (Surface Roughness) and Control (C) (Flexural strength)	-0.13	0.77
Ground (G) (Surface Roughness) and Ground (G) (Flexural strength)	0.12	0.79
Ground and Glazed (GR) (Surface Roughness) and Ground and Glazed (GR) (Flexural strength)	0.35	0.39
Ground and Polished (GP) (Surface Roughness) and Ground and Polished (GP) (Flexural strength)	0.22	0.60
Overall	-0.1	0.58

[Table/Fig-11]: Pearson correlation between surface roughness and flexural strength.

DISCUSSION

In the present study, no correlation was found between flexural strength and roughness; however, the type of surface restoration did impact the surface roughness and flexural strength of MZ. The results revealed that occlusal adjustments significantly influenced surface roughness values. Surface roughness values (Ra) increased with grinding and decreased with polishing. Therefore, the null hypothesis- that there are no differences in mean roughness or flexural strength among the ground, polished, and reglazed samples, and that there is no correlation between flexural strength and roughness- was partially rejected.

Sabrah AH et al., evaluated the wear behaviour and surface roughness of polished, glazed, and ground MZ [17]. Their findings revealed that although glazed zirconia has a smoother surface, it is not preferred over unglazed MZ. Heintze SD et al., found that glazed surfaces (glazed at 820°C for two minutes) cause more wear to the opposing tooth than polished surfaces (polished in a two-step procedure with a zirconia polishing kit for 60 seconds) [18]. Thus, while reglazing results in greater smoothness, its longevity cannot be established when the restoration is in function. Therefore, appropriate polishing can reduce antagonist abrasion.

In present study, a high-speed handpiece was used to grind the specimens under water cooling. A similar procedure was followed in the studies by Hmaidouch R et al., Chougule KJ et al., and Aboushelib MN and Wang H, [3,16,19]. To standardise the parameters, all surface treatments were conducted by the same operator. Surface roughness was evaluated using a profilometer, as employed by Mohammadi-Bassir M et al., Caglar I et al., and Azeez SM and Salih SA, [8,20,21]. The contact profilometer used in present study is advantageous for its accuracy, being less influenced by surface material properties such as colour or transparency compared to non contact profilometers.

In the present study, ground samples exhibited the highest surface roughness (1.467 µm), while polishing (0.656 µm) and reglazing (0.809 µm) reduced roughness, with the smoothest surface observed in the control group (0.4403 µm). The results of present study are consistent with the findings of Mohammadi-Bassir M et al., and Khayat W et al., who also reported greater roughness in ground zirconia compared to the reglazed and polished groups [8,22]. Various equipments can be used for surface characterisation, including profilometers, mechanical surface roughness testers, Scanning Electron Microscopy (SEM) for morphological characteristics, and total reflection Fourier-transform infrared spectroscopy for surface chemical composition.

Azeez SM and Salih SA, found that polished zirconia was smoother than reglazed zirconia, which is consistent with our findings [21]. Hmaidouch R et al., Mitrov G et al., and Janyavula S et al., also reported lower surface roughness with polishing compared to glazing [3,23,24]. However, Sabrah AH et al., found different results, likely due to variations in polishing and glazing techniques or study protocols, as noted by Özkurt-Kayahan Z [17,25]. Polishing often yields better results because it may remove loosely attached surface grains and grinding trace lines, as highlighted by Dupriez ND et al., [26]. Anusavice KJ noted that polishing might be more effective than reglazing due to the insufficient thickness of the glaze to fill micro-cracks and grooves [27].

Studies by Aboushelib MN and Wang H, and Al-Haj Husain N and Ozcan M, indicate that abrading introduces compressive stress, hindering crack propagation and increasing flexural strength, possibly due to a phase transformation of zirconia from tetragonal to monoclinic [19,28]. However, Iseri U et al., Khayat W et al., and Al-Haj Husain N et al., found that grinding reduces zirconia's strength [12,22,28]. In present study, the mean flexural strength after grinding (478.809 MPa) was lower than that of the control group (524.043 MPa), though the difference was not statistically significant, likely because the surface flaws resulting from grinding exceeded the depth of the compressive layer.

The flexural strength of the control group (524.043 MPa) was lower compared to that of the reglazed group (599.859 MPa), although the difference was not statistically significant, similar to the findings by Chougule KJ and Wadkar AP, [16]. The increase in flexural strength in the reglazed group may be attributed to the reglaze layer filling surface flaws and creating compressive stress upon cooling, thereby enhancing strength. Polishing increased the flexural strength of abraded MZ specimens, consistent with studies by Mohammadi-Bassir M et al., and Aboushelib MN and Wang H, although not statistically significant [8,19]. Traini T et al., found that fine polishing reduced surface roughness but also decreased fracture toughness and induced microcracks, similar to our findings, where the polished group (491.864 MPa) exhibited a lower mean flexural strength than the control group [29]. Guazzato M et al., explained that polishing might remove the monoclinic phase and the layer of compressive

Author's name and year	Place of study	Number of subjects	Materials compared	Parameters assessed	Conclusion
Chougule KJ and Wadkar AP, 2017 [16]	Maharashtra	30	1. No alteration 2. Grounded and polished 3. Grounded and reglazed	Flexural strength	Reglazing increased the flexural strength compared to polishing
Azeez SM and Salih SA, 2019 [21]	Iraq	36	The control was not modified while the next 27 samples were grinded with a coarse diamond bur and then divided into 1. Grinded 2. Polished 3. Reglazed	Surface roughness	Polished surface showed least surface roughness and glazing restores the smoothness
Mohammadi-Bassir M et al., 2017 [8]	Iran	50	1. Standard polishing without any surface treatment 2. Grinding 3. Grinding and overglazing, 4. Grinding and polishing with intraoral zirconia polishing kit 5. Grinding and polishing with polishing kit	1. Flexural strength 2. Surface roughness	1. Roughness increased after grinding and reduced equally with polishing and glazing 2. Flexural strength significantly decreased after glazing
Khayat W et al., 2018 [22]	Boston	44	1. Grinding 2. Grinding and polishing with Brasseler Zirconia polishing kit 3. Grinding and polising with Komet polishing kit 4. The control	1. Flexural strength 2. Surface roughness	1. There was no difference found in the flexural strength 2. Grinding increased the surface roughness while polishing decreased the surface roughness
Mitov G et al., 2012 [23]	Austria	64	1. Polished 2. Glazed 3. Fine grit diamond grinding 4. Coarse grit diamond grinding	Surface roughness	Polishing decreased the surface roughness
Janyavula S et al., 2013 [24]	Birmingham	8	1. Polished 2. Glazed 3. Polished and then reglazed 4. Veneering porcelain 5. Enamel	Surface roughness	Polished surface showed least surface roughness
Traini T et al., 2012 [29]	Italy	30	1. As received by milling centre 2. Coarsely polished 3. Fine polished	Surface roughness	Decrease surface roughness was seen with fine polishing
Nakamura Y et al., 2010 [31]	Japan	120	1. Control (original glazed) 2. After grinding with 100 grit 3. After grinding with 600 grit 4. After grinding with 1000 grit	1. Surface roughness 2. Flexural strength	Glazed surface showed highest flexural strength As the surface roughness increased, flexural strength decreased
Present study	India	32	1. Control 2. Grinding 3. Grinding and overglazing 4. Grinding and polishing with polishing kit	1. Surface roughness 2. Flexural strenrth	Decrease surface roughness was seen with polishing Glazed surface showed highest flexural strength

[Table/Fig-12]: Discussion of various studies from the literature [8,16,21-24,29,31].

stress, thereby reducing flexural strength [30]. Nakamura Y et al., found that the flexural strength of the reglazed samples was the highest when compared with polished samples, consistent with our study [31]. However, Kumchai H et al., found that external glazing decreased flexural strength [9]. Findings from similar studies in the literature are presented in [Table/Fig-12] [8,16,21-24,29,31].

There was no overall correlation between surface roughness and flexural strength, consistent with studies by Khayat W et al., and Luthardt RG et al., [22,32]. Hmaidouch R et al., Azeez SM and Salih SA, Mitrov G et al., and Janyavula S et al., demonstrated that chairside polishing is equal to or better than glazing in terms of surface roughness [3,21,23,24], while Chougule KJ and Wadkar AP, argued that glazing is superior [16].

Variations in flexural strength after different surface treatments have been noted by various authors [9,14], likely due to differences in zirconia specimen dimensions. This study followed American Dental Association (ADA) specification no. 69, using medium grit diamond points for clinical adjustments and fine grit diamond points for grinding the glazed surface, which makes direct comparisons difficult. Manual surface grinding and polishing are challenging to standardise; thus, the same operator performed all treatments to minimise variations.

Chairside polishing, which eliminates the need for an extra appointment, can be an effective alternative to reglazing, as it increases zirconia strength post-adjustment. However, if a second visit is possible, reglazing is recommended, as it significantly increases strength compared to polishing.

Limitation(s)

The present in-vitro study utilised fabricated samples (zirconia bars) that may not resemble those used clinically, and therefore, the findings may not accurately reflect real clinical performance. Additionally, the present study focused exclusively on one brand of MZ. For these reasons, the results may not represent what occurs in the oral cavity. Further studies should include various brands of zirconia and different polishing kits to validate the results observed in present research.

CONCLUSION(S)

Both polishing and reglazing were effective in achieving a smoother surface, with statistically significant findings. However, grinding led to a reduction in the flexural strength of zirconia. Among the surface treatments, the order of effectiveness for achieving smoothness was Control>Polished>Reglazed>Ground, while the order for flexural strength was Reglazed>Control>Polished>Ground. Notably, there was no significant correlation between surface roughness and flexural strength. Therefore, chairside polishing is a viable option for restoring the surface smoothness of zirconia restorations. However, for a more substantial improvement in flexural strength, reglazing is preferable to polishing.

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