IMPACT OF VARIOUS SURFACE MODIFICATIONS ON FLEXURAL STRENGTH OF MONOLITHIC ZIRCONIA : AN IN-VITRO STUDY

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Abstract:

Background: Monolithic zirconia have been developed with high strength and better esthetics. However studies on their strength and surface roughness after occlusal adjustment and subsequent modification are few.
Aim: The aim of this invitro study was to evaluate the effect of different surface modifications on the flexural strength of monolithic zirconia.
Materials and Methods: A total of 30 monolithic zirconia specimens were fabricated from zirconia discs with the aid of CAD/ CAM, followed by sintering. Samples were randomly allocated into three Groups (n = 10) each. Group G: Glaze, Group GGR :Glaze-Grind-Reglaze, Group-PGR: Polish-Grind-Repolish. Samples of Group GGR and PGR were mounted on customized apparatus for grinding and surface modifications were performed for each Group according to the group allocated. Flexural strength of all the groups were determined by using Universal testing machine. The collected data was statistically analysed using unpaired "t" test and One way ANOVA- F test. P values less than 0.05 were considered to be statistically significant in all tests.
Results: The mean flexural strength of the Group G was higher followed by Group PGR and GGR.
Conclusion: Grinding decreased the flexural strength. Repolishing subsequently seems to be better than reglazing in terms of strength. However, it is impossible to create a original surface after grinding by reglazing or repolishing.

Keywords: Monolithic zirconia, surface modification, Glazing, polishing

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1. INTRODUCTION

The recuperation of edentulous space with substances that resemble natural teeth is the pivotal intention of prosthetic dentistry. To be able to "restore" those undesirable tooth voids, clinicians have used an expansion of restorative substances and with the useful resource of advancements consisting of CAD/ CAM milling, 3-D printing that have undergone big research and development.[1,2] One in all them is, using zirconia, a metal-free substance. Zirconia can be used as a core for anterior restorations that consist of veneering ceramics or as a totally anatomical structure (monolith) for posterior restorations. The perks of monolithic zirconia encompass more aesthetics, accelerated mechanical strength, no veneering, and less reduction in tooth preparation for the requirement for excessive interocclusal area. Also it has brilliant biocompatibility, reduced plaque retention, and accurate radiopacity. Monolithic zirconia exhibited greater fracture resistance than bilayered ones, even after mechanical cycling and aging.[1]

However, in the course of final cementation of the prosthesis, minor occlusal correction may be required. This grinding process can result in removal of initial glaze or polish layer, which can also affect the surface characterization and mechanical properties of the material. So ceramic surfaces must to be smoothened as viable by using reglazing or repolishing.[.3] In order to decide whether these restorations can resist larger masticatory stresses following grinding and surface modifications, an invitro study was performed to examine the flexural strength of monolithic zirconia after surface modifications including grinding followed by reglazing and repolishing. The null hypothesis was that the surface alteration like reglazing and repolishing does not affect the flexural strength of monolithic zirconia.

2. MATERIALS AND METHODS

A total of 30 monolithic zirconia samples (Cercon HT, Dentsply) were fabricated. Each sample was created using a wax replica of dimension (20 mm(l)*5 mm(b)*3 mm(d) (l=length, b=width, d=thickness) through CAD/CAM technology. [4] A digital scanner was used to scan the wax replica, followed by milling of the cercon disc with the help of Computer assisted machine. The samples were then sintered for eight hours at 1500°C to achieve full density. Since the porous zirconia shrinks by 1.24%, the final dimensions were determined using a digital calliper instrument, and damaged samples were discarded. Based on surface modifications three Groups of samples were created (n=10).
Group G: Specimens with Glazed surface
Group GGR: Specimens with Glazed surface followed by grinding and reglazing.
Group PGR : Specimens with Polished surface followed by grinding and repolishing.
For standardization of samples, a specially built apparatus was used to mount the specimens for grinding. (Figure-1 and 2) It had two perpendicular planes, a horizontal guide with a slot for specimen placement and a handle attached to it for movement of specimens continuously in a straight line forward and backward and a vertical plane to clamp the micromotor and straight handpiece. Grinding was performed for Groups GGR and PGR and specimens were reduced by 1 mm.
The specimens were then tested for flexural strength using UTM, (ACME Engineers, Model no. UNITEST-10)) Each specimen was placed centrally in a self-aligning fixture (Figure-3) and the load was applied perpendicular to the longitudinal axis of the specimen (1 mm/minute)
The flexural strength of specimens were calculated in megapascals (MPa) using the following formula.
Flexural strength: $3FL/2bh^2$
Where, F: Maximum load, L: Distance between supports h: Height of specimens, b: Width of specimens .
The results obtained were statistically analysed with the SPSS software. All the Groups were individually evaluated and compared with each other using unpaired "t" test and One way ANOVA-F test.

3. RESULTS

Individual specimen was tested for flexural strength and result is tabulated. [Table 1]. The measurement of flexural strength showed varied results. The results showed maximum flexural strength in Group G (1059.49 MPa) followed by Group PGR (937.44 MPa) and least strength in Group GGR (805.57 MPa) [Graph 1]

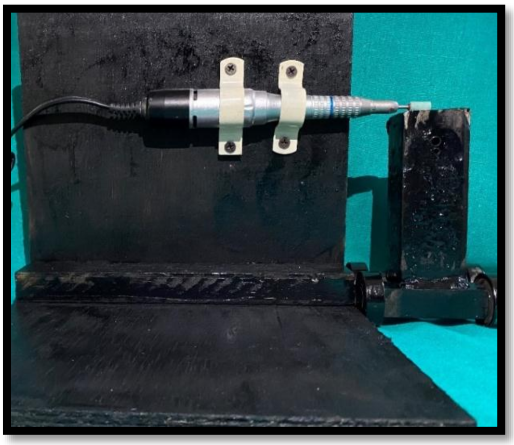
Statistical analysis
values of unpaired "t" test between different pair of groups comparing the significant differences in flexural strength (MPa) among all the three groups. It showed a high significant difference is in strength among all the groups at $p<.05$. [Table 2].
The combination of different Groups using One way ANOVA- F test also showed a significant difference for Flexural strength (P =.0001*). [Table 3]

4. DISCUSSION

The use of zirconia has increased due to its high flexural strength, bio compatibility with acceptable esthetics. However, Some clinical problems emerged with the use of zirconia, such as chipping and delamination of veneering as these veneering layers are prone to fracture. In order to eliminate the weak veneering layer, monolithic zirconia restorations with higher translucency were developed by means of adding different dopants, coloring liquids, and changing the sintering temperatures. Monolithic zirconia that is, solid zirconia does not require veneering. It is a unique ceramic system with multiple clinical applications, including those with, high esthetic demands (anterior restorations), easy processing than bilayered ones resulting in lower final cost and also significantly reduced thickness (only 0.5 mm for posterior restorations).[5]

Monolithic restorations are manufactured using computer-aided design/computer-aided manufacturing technology either using pre sintered or fully sintered blocks. In this study Pre sintered blocks are manufactured with soft machining, which results in a homogenous product. It is easier to mill, reducing production times, machinery wear and surface flaws; furthermore, soft machining generates negligible internal porosities (about 20–30 nm) as compared to hard machining.[6] Zirconia's mechanical strength can be compromised when the surfaces are left rough. Clinical occlusal adjustments could initiate subcritical flaws or larger defects. Under clinical loading and presence of moisture, rough surfaces might eventually yield to catastrophic failure. In addition, the level of surface roughness created during different finishing and polishing procedures can cause stress concentrations and consequently, decreases the strength. For these reasons, the superficial roughness must be minimized by employing effective polishing and glazing techniques resulting in a smoother surface which is well tolerated by oral tissues.[7]
The present study evaluated the effect of grinding, reglazing and repolishing on the flexural strength of monolithic zirconia. Based on the results obtained, there were significant difference present between the groups. Thus null hypothesis was rejected that surface modification does not affect flexural strength of monolithic zirconia. In the study two different surface treatments were employed onto the specimens, one was reglazing and other was repolishing.

Various studies have shown the negative influence of grinding on the strength, indicating that grinding affects mechanical characteristics negatively.
The current study's findings demonstrated that grinding considerably reduced the flexural strength. Işeri et al. and Hamid Neshandar Ali also demonstrated same in their study.[8,9] Reglazing was found to significantly reduce the flexural strength of ground zirconia. A probable explanation could be that the glaze layer does not effectively seal the defects produced during grinding due to its high viscosity and low wettability. The study's findings suggest that the production of bubbles inside the glaze layer during the mixing and sintering of the glaze material, as well as the thickness of the glaze layer, may also be factors in the strength drop that occurs after reglazing. Contrary to the result of present study **Mohammadi-Bassir et al.** stated that when comparing overglazing and polishing, polishing improved the strength while glazing had negative impact. They explained it by negligible removal of monoclinic phase in their study.[10] Repolishing also reduced the strength but significantly less compared to glazing. **Aboushelib et al.** also concluded that polishing increased the strength by eliminating fine surface flaws, thus improving the strength of ceramics.[11] Repolishing subsequently seems to be better than reglazing and these results will be helpful in the long term survival of zirconia crowns and FPDs. The purpose of this study was to evaluate the effect of different surface modifications on monolithic zirconia. However there are certain limitations such as grinding would have been performed by high speed hand piece with coolant leading to temperature variations. In addition, variable speed of the micromotor has not been taken into consideration. Nonetheless, the study has given sufficient information regarding the strength of monolithic zirconia.



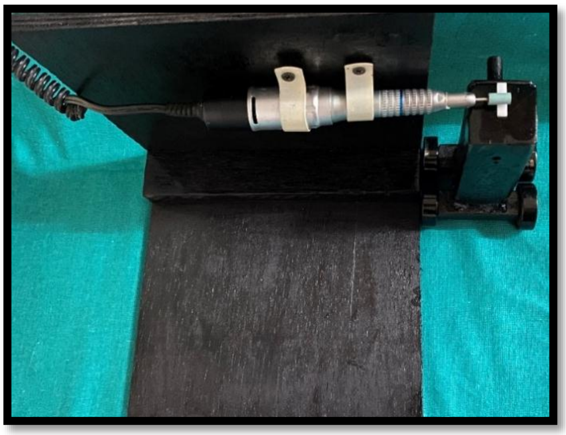


Figure-1and 2

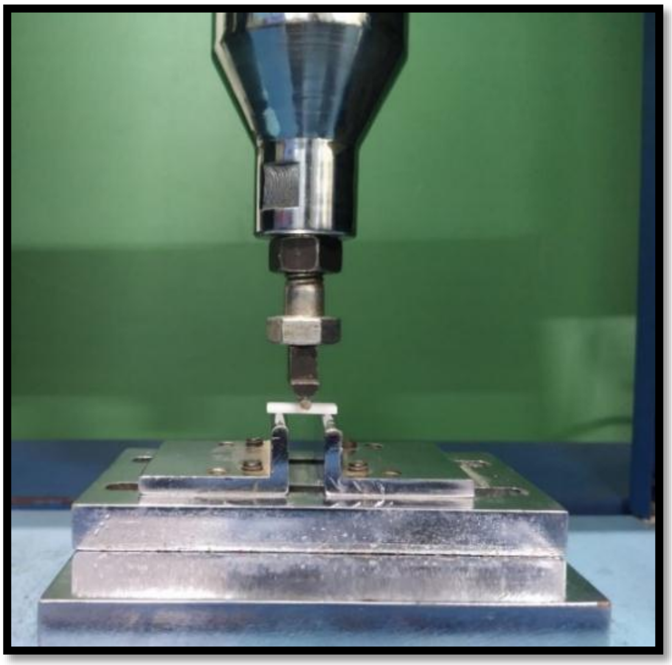


Figure- 3

Table 1: Represent maximum, minimum, mean and SD for flexural strength between the three experimental groups

FLEXURAL STRENGTH (MPa)			
S.NO.	**GROUP-G (GLAZED)**	**GROUP-GGR (GLAZED-GRINDED-REGLAZED)**	**GROUP-PGR (POLISHED-GRINDED-REPOLISHED)**
1	1098.50	839.50	942.50
2	1027.70	825.70	955.70
3	1017.70	783.50	933.70
4	1052.70	816.00	922.70
5	1077.00	801.20	929.50
6	1043.70	784.70	895.70
7	1061.70	795.20	938.00
8	1078.50	810.20	960.70
9	1049.20	806.50	938.20
10	1088.20	793.20	957.70
MEAN	**1059.49**	**805.57**	**937.44**
S.D.	**26.198**	**17.919**	**19.287**
MAXIMUM	**1098.50**	**839.50**	**960.70**
MINIMUM	**1017.70**	**783.50**	**895.70**
C.V.	**2.473**	**2.224**	**2.057**
MEDIAN	**1057.20**	**803.85**	**938.10**

Graph 1: Represents bar diagram for average scores of strength between three groups

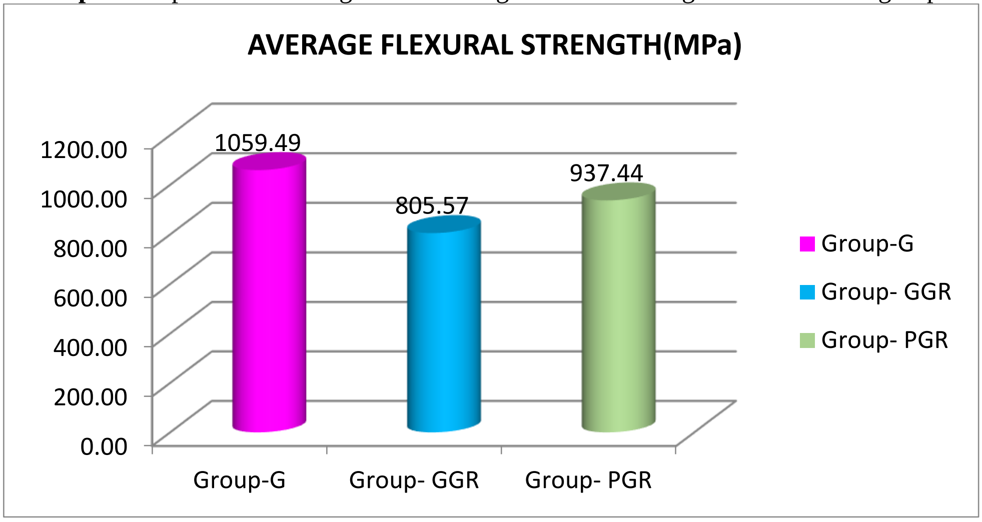


Table- 2 Comparative study of flexural strength between the three groups using unpaired "t" test

S.NO.	PAIR OF GROUPS	PROBABLE VALUES OF UNPAIRED "t" TEST B/W DIFFERENT PAIR OF GROUPS	
1	**GROUP G and GROUP GGR**	P=.0007*	P<.05 (SIGNIFICANT DIFFERENCE)
2	**GROUP GGR and GROUP PGR**	P=.0003*	P<.05 (SIGNIFICANT DIFFERENCE)
3	**GROUP G and GROUP PGR**	P=.0002*	P<.05 (SIGNIFICANT DIFFERENCE)

Table- 3 Comparative Study of Flexural Strength between the Three Groups Using One- Way Anova F-Test

S.NO.	COMBINATION OF GROUPS	PROBABLE VALUES OF ONEWAY ANOVA-F TEST AMONF ALL GROUPS	
1	**GROUP G, GROUP GGR , GROUP PGR**	P=.0001*	P<.05 (SIGNIFICANT DIFFERENCE)

5. CONCLUSION

Within the limitations of this study, it can be concluded that

- Grinding significantly decreased the flexural strength
- Reglazing markedly decreased the flexural strength of ground zirconia surfaces
- Repolishing of reground surfaces significantly decreased the flexural strength. However, the mean flexural strength was significantly higher than that of the reglazed group.

6. REFERENCES

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