ISSN 2664-4177 (Print) & ISSN 2664-7931 (Online)
South Asian Research Journal of Oral and Dental Sciences
Abbreviated Key Title: South Asian Res J Oral Dent Sci

| Volume-7 | Issue-2 | May-Jun- 2025   **DOI: https://doi.org/10.36346/sarjods.2025.v07i02.005**

Original Research Article

Strength Characteristic of Different Layers of Zirconia Discs Manufactured Using Various Multilayering Methods and Sintered at Variable Final Temperature

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Article History
Received: 11.04.2025
Accepted: 17.05.2025
Published: 23.05.2025

Abstract: ***Background***: Nowadays, yttria stabilized ZrO2 is the most commonly used esthetic material in fixed dental prosthodontics. The vast majority of full contour monolithic fixed dental restorations were made from multilayered translucent zirconia. ***The Aim of this Research***: Was to study the flexural strength of three different layers of multilayered zirconia discs manufactured with two multilayering technologies (yttria graded and shade graded) and sintered at different temperatures. ***Method***: Ninety bars were divided into 3 groups (n=30) made from three different zirconia discs manufactured with various multilayering techniques, Zircad PRime, Super Translucent Multilayered and Zolid FX, each main group subdivided into three subgroups (n=10) in accordance with the multilayered zirconia materials that were used and three different layers were utilized from each disc: Zircad PRime Cervical ZPRC, Zircad PRime Middle ZPRM, Zircad PRime Incisal ZPRI, STM Cervical STMC, STM Middle STMM, STM Incisal STMI, Zolid FX Cervical ZFXC, Zolid FX Middle ZFXM and Zolid FX Incisal ZFXI. After milling the specimens were separated from zirconia discs, then fully sintered conventionally for 2 hours according manufacturer instructions regarding final temperature and the strength evaluated with three point's flexural strength bending test utilizing the universal testing equipment. ***Result:*** Non significant differences among layers of shade graded zirconia STM and Zolid FX while a difference was observed between layers of yttria graded zirconia Zircad PRime. Highest result was for ZPRC and lowest flexural strength result was for ZFXC. ***Conclusion***: Neither all multilayered zirconia discs nor the variable layers are the same**.** Incisal layer of varying yttria concentrations multilayered zirconia demonstrates much lower flexural strength than cervical layer at the same disc, while shade graded multilayered disc variable layers have same strength, yttria content greatly influence strength of zirconia materials and sintering temperature has no effect on flexural strength of layers have the same yttria content.

Keywords: Flexural, Multilayer, Shade Gradient, Strength, Yttria, Zirconia.

INTRODUCTION

Yttria stabilized tetragonal zirconia polycrystal (Y TZP) represent the earliest and most commonly used ceramic in metal free indirect restorations since the 1990s [1]. In comparison to other dental ceramic materials, it has exceptional biocompatibility and strength characteristics, making it an excellent restorative material for the production of fixed dental prostheses (FDPs) [2, 3]. First introduced zirconia was 3% yttria (3Y TZP) which consisted predominantly from tetragonal (t) phase, high strength of 3Y TZP results from transitional toughening mechanism through transformation of t phase to monoclinic (m) phase, as when cracks start it trigger neighboring t crystal to transform to a larger size and more volume m crystals causing a compressive stress on crack that impeding its propagation. Unfortunately esthetic results of 3Y TZP was inferior, it has been reported that the existence of a tetragonal crystal phase is responsible for the zirconia material's poor optical characteristics [1, 4], because light is refracted and reflected at boundaries of the grain [4]. Due to the considerable opacity of the first introduced zirconia, it was only utilized as a frame for fixed dental prostheses and must be subsequently covered with a more esthetic porcelain materials [4].

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Achievement of a higher translucency of zirconia allowing us for making a full contour monolithic fixed dental restorations to overcome the challenges of chipping and fracturing of porcelain veneering material [5, 6]. In order to get a better esthetic, more cubic crystal (c) phase was incorporated into zirconia disc because of its isotropic characteristics, rendering the refractive index independent and free from the influence of the direction in which light travels result in reduction of light scattering and enhancement of translucency [7–9]. In addition to the increasing amounts of the esthetically pleasant cubic phase, the translucency improvement was accomplished by means of modifying the chemical formulation through the use of a higher concentration yttria oxides stabilizers, in comparison to the 3Y opaque conventional zirconia the new zirconia was four and five yttria partially stabilized zirconia 4Y and 5Y PSZ [7–9]. However, zirconia containing more yttria concentration and a significant proportion of cubic phase have a compromised mechanical properties as it contains less t phase, consequently strength reduced resulting from reduced tetragonal–monoclinic (t-m) transformation so diminished advantages of transitional phase toughening mechanism due to efforts to increase their translucency [7–9].

Fortunately manufacturers innovating a multilayering method for zirconia material designed for high yttria 4Y and 5Y full contour monolithic restorations, multilayers discs made from same yttria content translucent zirconia with different layers were varies from one another on the basis of the shading technology, these discs consists of an identical chemical formulation of all layers, but they utilize a gradient tint approach [10, 11]. This method utilize zirconia with varying additional substances of color pigments applied in each layer to enhance a progressive translucency in a gradual manner from the cervical to incisal region. The illusion mechanism of being multilayering is attained by regulating the pigments color modifiers for each layer, whereas variations of diminishing light transmittance indirectly possess an effects on material translucency. Color pigments are not present in the incisal translucent layer, but are highly saturated in the cervical layer [10, 11].

The major challenges arises when attempting to achieve an acceptable balance between the mechanical and optical properties of multilayered zirconia through the use of shade gradient technology. The amount of yttria present in the material has a significant impact on this equilibrium [7]. For instance, multilayered zirconia discs containing low yttria 3Y manufactured using shade graded technique has good strength, however their translucency may be diminished. On the other hand, when employing the identical procedure for multilayered discs containing high yttria 4 and 5Y PSZ resulting in a higher esthetic but with a lower flexural strength [8, 9].

In order to overcome this problem a novel multilayering technology have been invented, different layers of zirconia disc made from different chemical compositions through incorporating a varying yttria amount present in each layer, producing a material with excellent strength and high esthetic [12]. Top part of the zirconia disc representing the incisal/occlusal region constructed from translucent zirconia with a high yttria concentration, while the inferior bottom section representing cervical region made from low translucency opaque zirconia with a 3Y concentration. Consequently, the mechanical characteristics of zirconia are anticipated to be vary per layer [7, 12]. Thus throughout restoration manufacturing process using CAD/CAM system, the dental professionals must possess sufficient understanding and handle such multilayered zirconia materials with care. Furthermore the dentist must have scientific knowledge about strength, ranges of indications and type of multilayered zirconia used during fabrication of each fixed prosthesis inside dental laboratory, understanding strength of material and how different layers behave under stress can help dentists to anticipate potential issues related to fractures or failures, enabling them to offer more predictable restorative solutions and select best multilayered disc according case specifications. A wide range of new generations of translucent zirconia discs made using various multilayering methods exists in the dental market, additionally these product sintered at different temperatures, few researchs focusing on this subject and a further investigations are needed to assess how those variable parameters affect the zirconia material's flexural strength at each layer and study if the difference in sintering temperature have an effect on the strength of layers located at same level when comparing discs manufactured using different multilayering methods. The first null hypothesis assumed that the flexural strength of zirconia discs fabricated using various multilayering methods and sintered at different temperatures are same, the second null hypothesis stated that strength of zirconia at different layers of each disc are same.

MATERIALS AND METHODS

Samples Preparation

Three different zirconia discs 98.5mm diameter and color A2 manufactured using various multilayering technologies were used in this study: Zircad PRime ZPR (Ivoclar, USA), Super Translucency Multilayer STM (Kuraray Noritake Dental, Japan) and Zolid FX ZFX (amanngirrbach, Germany). According to manufacturer's information, Zircad PRime ZPR made using yttria gradient method and consists of three layers with a different yttria contents of each layer: The top incisal layer forms 18% of entire disc height made from 5Y stabilized material, the middle transitional layer 25% from 3Yand 5Y , and the bottom cervical dentin layer forming 57% of the entire disc which synthesized from 3Y stabilized material, the STM disc consists of four layers of same yttria content 4Y zirconia utilizing a shade graded multilayering technique: The incisal esthetic translucent layer comprises 35%, intermediate transitional two layers forming 30%, while the bottom cervical dentin layer constitutes the remaining 35% of disc height, whereas according to manufacturer data Zolid FX ZFX consists of four equal layers each one comprises 25% of disc height, all layers made from zirconia material having the same amount of yttria 5Y, ZFX disc multilayering achieved similarly using gradient shading technique (Figure1and Table 1).

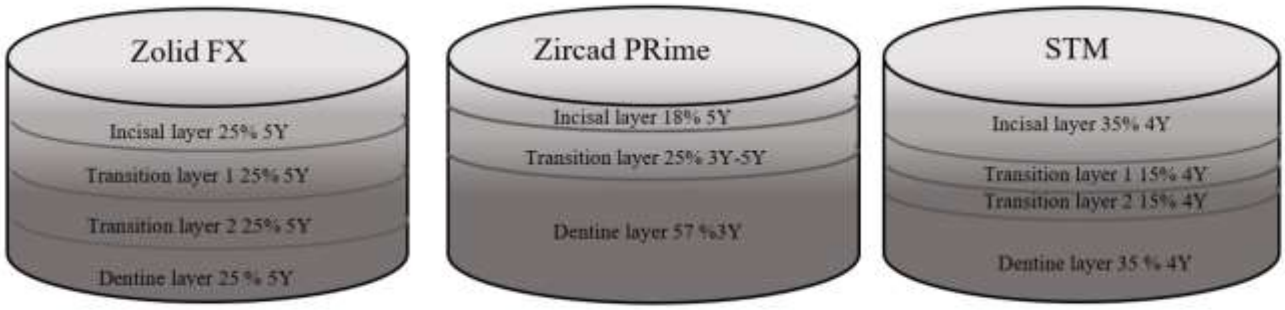

Figure 1: Schematic diagram shows three different multilayered zirconia discs of the study and their individual layers features

Table 1: Multilayering method and final sintering temperature of tested materials

Material tested	**Abbreviation**	**Multilayering method**	**Final sintering temperature**
Zircad PRime from ivoclar	ZPR	Zirconia materials with varying yttria concentrations arranged in three layers 3Y- 5Y	1500° C
Super Translucent Multilayer from katana	STM	Four layers of a single zirconia material using gradient shading technique with each layer having the same amount of yttria 4Y	1550° C
Zolid FX from amanngirrbach	ZFX	Four layers of a single zirconia material using gradient shading technique with each layer having the same amount of yttria 5Y	1450° C

Computer assisted design and manufacturing was utilized to prepare the specimens, a standard tessellation file STL of bar using Autodesk meshmixer software (Autodesk, Inc. USA) was made, the standard dimensions of bar were 1.2 mm thickness, 4.0 mm width and 15.0 mm length (Figure 2) according to ISO standard 6872:2015 [13].

A total of ninety specimens categorized into 3 main groups (n=30) according to type of multilayered zirconia utilized, each main group subdivided into 3 subgroups according to the specific layers of the discs have been tested: ZPR Cervical (ZPRC), ZPR Middle (ZPRM) and ZPR Incisal (ZPRI). STM Cervical (STMC), STM Middle (STMM) and STM Incisal (STMI). ZFX Cervical (ZFXC), ZFX Middle (ZFXM) and ZFX Incisal (ZFXI). The sintered groups and sintering temperatures were summarized in Tables 2.

Table 2: Groups' classification depending on specimen layers and sintering temperature

Group	**Material type**	**Layers of sample**	**Yttria content**	**Sintering temperature**
ZPRC	Zircad PRime from ivoclar	Cervical	3%	1500° C
ZPRM	Zircad PRime from ivoclar	Middle	3%-5%	1500° C
ZPRI	Zircad PRime from ivoclar	Incisal	5%	1500° C
STMC	Super Translucent Multilayer from katana	Cervical	4%	1550° C
STMM	Super Translucent Multilayer from katana	Middle	4%	1550° C
STMI	Super Translucent Multilayer from katana	Incisal	4%	1550° C
ZFXC	Zolid FX from amanngirrbach	Cervical	5%	1450° C
ZFXM	Zolid FX from amanngirrbach	Middle	5%	1450° C
ZFXI	Zolid FX from amanngirrbach	Incisal	5%	1450° C

Then STL files send to the milling machine, the specimens were dry milled using a Roland machine DWX-52DC (DG SHAPE, JAPAN), during the nesting process of samples within disc the outermost upper and lower 1 mm of the zirconia discs were omitted to exclude effects of manufacturers finishing and printed labels placed at the surfaces of zirconia disc, in CAM software incisal specimens were placed 1 mm below highest point of incisal part of disc, middle specimens were positioned at center of middle third and cervical bar specimens were placed I mm above lowest point of zirconia disc bottom (Figure 2), in this way the middle and two extreme positions were selected so different three layers were covered. All preparations for zirconia bars were made by the same person, after milling the specimens were separated from the zirconia discs using a diamond cutting bur, then polished with 800 and 1200 grit silicon carbide coated abrasive paper (Grit flex, Italy) to ensure same initial surface smoothness. To eliminate any remaining dusts as a result of milling and polishing procedures each specimen was thoroughly cleaned with a compressed dry air.

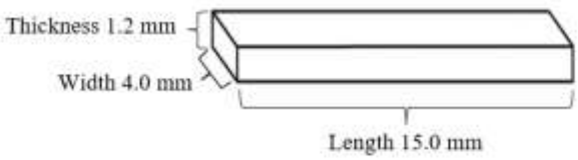

Figure 2: Illustration of specimen geometry and location of bar were cut from the individual layers of multilayered disc

Conventional sintering protocol of samples was done using a calibrated HTS furnace (MIHM VOGT, GERMANY). Standard sintering programs as stated by the manufacturer served as the basis for the sintering conditions. The Final sintering temperature for STM samples was 1550° C, 1500° C for Zircad PRime and 1450° C for Zolid FX specimens. According manufacturer instructions, for all specimens heat increasing rate was +10°C/minute, holding time 2 hours and cooling rate was -10°C/minute. After sintering the dimensions of all specimens were checked using a digital caliper micrometer (Digimatic, Mitutoyo Corp, Japan), later on samples were ultrasonically washed with distilled water and isopropyl alcohol for five minutes before the test.

Strength Test

Flexure strength was calculated using a universal testing machine (Instron Corp, MA, USA) according to the International Organization for Standardization (ISO) 6872:2015 standard [13]. A static three points bending test was performed to assess the strength of each one of three individual layers of the different zirconia discs. Every single zirconia bar sample was positioned on two beams that provided support as in (Figure 3), then the universal testing machine piston applied load on the center of bar at a cross head speed of 0.5 millimeter per minute until the fracture occurred. All of the specimens were examined in a dry state at room temperature. The following standard formula shown below was used to obtain flexural strength data in megapascals (MPa):

$\sigma = 3Nl/2bd^2$

In this equation, the flexural strength (σ) is measured in megapascals (MPa), the maximum load causing fracture load is measured in Newtons (N), the distance between the support beams is measured in millimeters (l), the width of the specimen is measured in millimeters (b), and the thickness of the specimen is measured in mm (d).

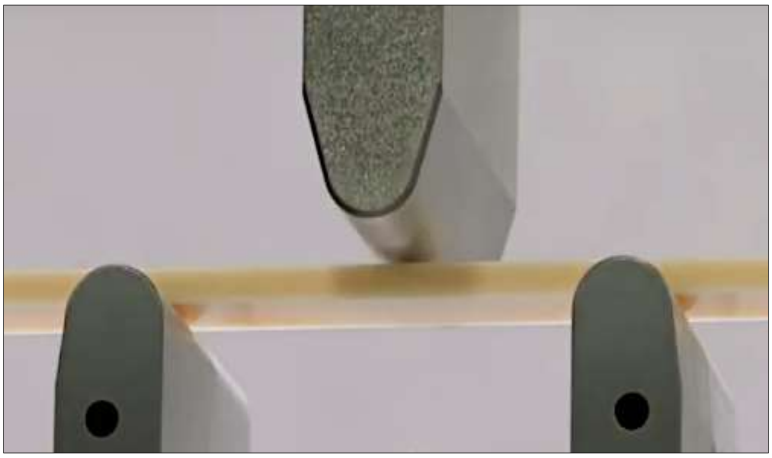

Figure 3: Picture shows piston on bar specimen with 2 beams support for flexural strength test of zirconia.

Statistical Analysis

Using SPSS program (IBM SPSS Statistics; SPSS Inc. USA), a two-way analysis of variance was conducted in order to get a better understanding impact of zirconia material layers and the temperature and effect of their interaction on flexural strength, For the purpose of determining which of the nine layers exhibited significant differences from one another, a primarily one-way analysis of variance (ANOVA) and Tukey comparison tests were used with a significance level of P≤0:05. Previous researchs possess a similar study design were served as the basis for the analysis [12, 14].

RESULTS

Table 3 shows Means, Standard Deviation SD and significance levels for all tested groups. Figure 4 shows the bar graph of strength data of nine groups. Results of 2 way ANOVA in Table 4 showed the significant effect of zirconia material layers, sintering temperature and influence of their interaction on strength. A significant difference was noticed among the means of the main three groups of different multilayered discs which manufactured using various multilayering technology have been tested in this study (P≤0:05). Mean flexural strength of all Zircad PRime zirconia samples was higher than that of STM, while mean of all specimens were made from Zolid FX materials exhibits the least flexural strength result. Highest mean flexural strength was for ZPRC group (1169 ±28.2 MPa) followed by ZPRM (1158.9±13.4) while the lowest mean strength value was belong to ZFXC group (597±8.3MPa).

Zircad PRime groups demonstrated a significant differences in strength results between its 3 layers. In contrast, both STM and Zolid FX material did not exhibit strength differences among all their three layers within same disc. Results showed a non significant difference between ZPRC and ZPRM but these two groups were significantly differed regarding strength with ZPRI specimens which made from same discs. A slight differences in mean strength values appeared within three groups made from STM discs but comparative tests revealed that these 3 layers did not exhibit a statistically significant difference in strength from each other, and this same for all layers made from Zolid FX discs. Additionally, analysis revealed a non significant difference (P>0:05) was observed between ZPRI and all three group made from Zolid FX.

Table 3: Means and standard deviation SD for flexural strength for all tested groups

GROUP	Flexural Strength Mean (MPa)	SD	Minimum	Maximum
ZPRC	1169.6[a]	28.21426	1121.00	1215.00
ZPRM	1158.9[a]	13.46972	1146.00	1189.00
ZPRI	622.6[b]	22.35670	591.00	660.00
STMC	746.9[c]	7.26407	733.00	756.00
STMM	755.0[c]	8.65384	741.00	769.00
STMI	765.9[c]	9.91576	749.00	785.00
ZFXC	597.5[b]	8.35663	585.00	612.00
ZFXM	610.0[b]	7.74597	595.00	625.00
ZFXI	621.6[b]	11.95547	601.00	641.00

Means that do not share the same letter (a, b, c) are significantly different. ZPRC: Zircad PRime Cervical layer from ivoclar. ZPRM: Zircad PRime Middle layer from ivoclar. ZPRI: Zircad PRime Incisal layer from ivoclar. STMC: Super Translucent Multilayer Cervical layer from katana Noritake. STMM: Super Translucent Multilayer Middle layer from katana Noritake. STMI: Super Translucent Multilayer Incisal layer from katana Noritake. ZFXC: Zolid FX Cervical layer from amanngirrbach. ZFXM: Zolid FX Middle layer from amanngirrbach. ZFXI: Zolid FX Incisal from amanngirrbach.

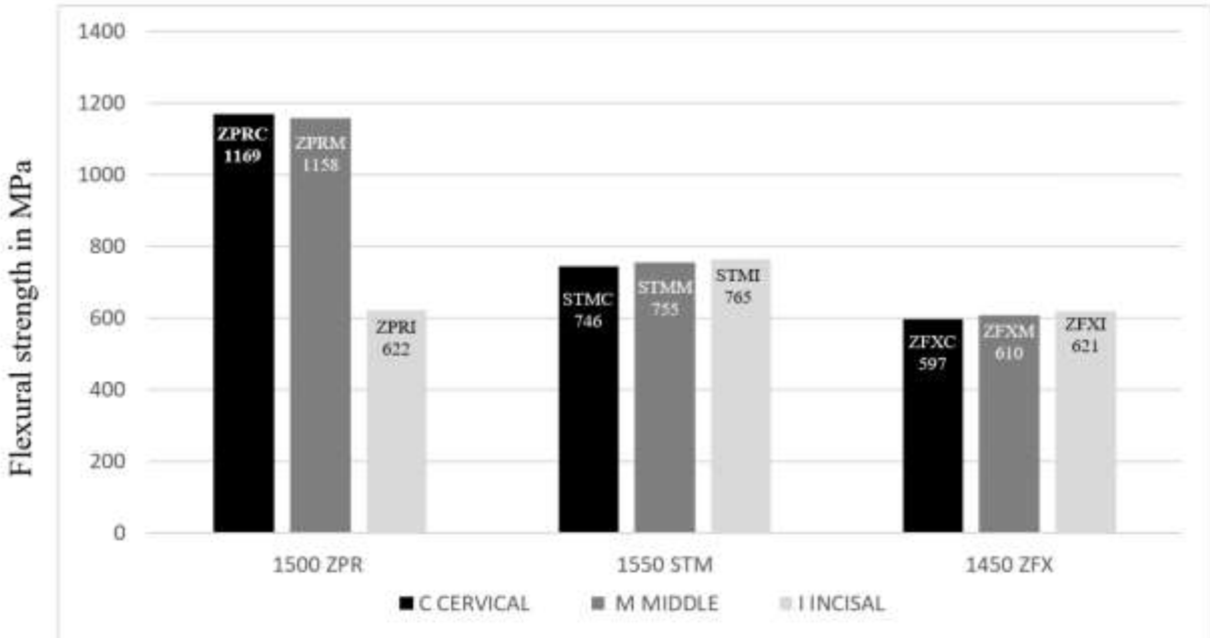

Figure 4: Flexural strength data of all tested groups

Table 4: Two-way ANOVA results of zirconia material layers, sintering temperature and effect of their interaction on strength

Source	Type III Sum of Squares	Degree of Freedom	Mean Square	F	Sig.
Corrected Model	4092572.489a	8	511571.561	2329.980	.000
Intercept	55193671.111	1	55193671.111	251382.524	.000
layer	575559.622	2	287779.811	1310.709	.000
Temperature	2131378.422	2	1065689.211	4853.738	.000
layer * Temperature	1385634.444	4	346408.611	1577.737	.000
Error	17784.400	81	219.560		
Total	59304028.000	90			
Corrected Total	4092572.489a	89			

DISCUSSION

Flexural strength was studied in the current research since it is regarded a validated test to assess the mechanical property of brittle materials such as ceramics, it is measured in several ways, with the three points flexural bending being one of the most popular tests [15]. The study showed that the flexural strength measurements of the different levels at multilayered zirconia having a variable quantities of yttria in each layer were significantly differs from those of the zirconia manufactured using gradient shade multilayering method, furthermore both 4Y and 5Y PSZ shade gradient zirconia have a significant differences in strength between them although both were made with same multilayering technology so the first null hypothesis was rejected. The second null hypothesis was partially accepted, as current research revealed that the strength of the different layers of the zirconia discs did not vary significantly from one another within same discs made with gradient shading method, on the other hand material with variable yttria concentrations individual layers were differ in strength when compared to each other.

Despite fact that the recently introduced multilayered highly esthetic zirconia materials are more translucent than 3% yttria earlier standard zirconia [4, 9], the clinical success of these materials is greatly affected by the harmonious relationship between their strength and translucency qualities. To improve the material's translucency and match the optical qualities of natural teeth the manufacturers used a variety of methods. This study explored three multilayered zirconia discs were manufactured using different multilayering techniques and measured their flexural strength at different layers. The STM is made up of the same translucent zirconia material that has been stabilized by 4% mol yttria in each layer, the translucency graduation of this material is controlled by different color additives. Using the same manufacturing process Zolid FX was produced but each layer composed of 5% mol yttria. Conversely, Zircad PRime is constituted of two zirconia materials were stabilized with different concentrations of yttria (3% and 5% yttria) at the same disc, cervical layer comprised of 3% mol yttria, incisal layer made from 5%mol yttria and an intermediate layer that consists of a mixture of the two ingredients for improving gradual smooth transitional change regarding esthetic and strength characteristics. The preferred technique of multilayering is the one that more effectively balances the mechanical properties of strength and esthetic outcome irrespective of the technology that is implemented.

According to the current research, ZPRC group showed the greatest flexural strength, then the ZPRM, additionally a non-statistically significant difference in strength values between these two layers, the explanation why ZPRC has the greatest strength because the ZPR dentin bottom layer is made from 3% mol yttria zirconia, which consists entirely of a strong tetragonal crystal phase which can undergo transformation toughening upon stress [1, 16]. This mechanism involves t-m phase conversion, by increasing the grains volume causing a compression on the surface and this procedure encounters the cracks were occurred during restoration fabrication stage and prevents further cracks spreading resulting in enhancing the strength characteristics [15, 16]. The ZPRM specimens strength exhibits approximately the same flexural strength of ZPRC and difference was not significant, this related to the manufacturing issue as ZPRM specimens located midpoint positions between two extremities of discs and because of bottom dentine layer of Zircad PRime comprises 57% of discs so bulk of these bar specimen were made from 3Y zirconia layers (figure 1) this explain why it has same strength as that of ZPRC. This agree with other study results [17], stated that the yttria amount at Zircad PRime middle and cervical layers were consistent mainly with a 3Y% material, while the yttria amount at incisal layers was 5Y% materials, the incisal layer of Zircad PRime material is made of zirconia material that is more esthetic but had the lowest values for flexural strength in the same discs, it stabilized with a greater yttria concentration 5mol% and have greater amount of weak non transformable cubic phase, increasing yttria concentration lead to reduction of created metastable tetragonal phase at the microstructural level [7, 8, 18, 19], as a consequence transformation toughness will affected for cubic containing zirconia materials so strength will be less in this layer [18, 19]. Therefore, the strength characteristics of the incisal translucent layer may adversely affected by an increased the amount of yttria in comparison to the cervical layer. Strength differences of the variable layers of Zircad PRime coincide with other studies showed that this material with a bottom layer strength comparable to data previously reported for 3Y materials, as well as a top translucent layer has strength comparable to that of 5Y zirconia [17]. The reasons mentioned earlier explained why ZPR specimens all layers mean strength was higher than that of STM and the ZFX samples showed lowest mean flexural strength as they vary in c phase and yttria content whereas most of ZPR disc made from 3Y while STM and ZFX were manufactured from 4Y and 5Y respectively.

Mean flexural strength of STM and Zolid FX were below 800 MPa this coincide with other studies results [20, 21], these two multilayered shade gradient zirconia material (STM and Zolid FX) exhibited no significant differences in mean readings of flexural strength test among the various layers within same discs. A flexural strength investigation found similar strength characteristics in STM data with no significant differences among three different layers within same discs, this consistent with results of other studies [17, 22], showing that the mechanical properties of the various layers of STM material not different from one another, these multilayer zirconia discs consist of homogeneous same yttria content 4Y throughout all layers [23], with no variations in microstructure and grain size among layers when undergo conventional sintering [24]. Each layer of these multilayered discs contain a same amount of yttria and the only difference in the translucency properties was the quantity of color additives. These findings align with prior researchs indicating no differences in the flexural strength of same amount yttria stabilized zirconia materials exposed to various coloring techniques [25, 26]. Although our study revealed a non significant differences among layers of STM specimens but results showed that the cervical bottom layer (STMC) strength slightly lower than others especially if compared with incisal layers this in harmony with results of another study [27], this somewhat surprising as most of companies manufacturing zirconia discs aims to make cervical part of multilayer disc have a higher strength than other layers, the explanation is that the cervical part of shade gradient discs has more amounts of iron and titanium color modifying additives affecting phase transformation mechanism, this adversely affects the mechanical characteristics, resulting in an physically unstable solid material that more prone to fracture under heavy load circumstances [28], on the contrary regarding with cervical layer strength results of our research, the strength characteristic of the cervical bottom layers in a descending order was ZPRC, STMC then ZFXC which has the lowest strength, this mostly not due to amount of color tints but these results from fact that ZPRC has higher tetragonal phase and less yttria content than STMC and ZFXC group has the least amount of t phase and highest yttria content.

According to manufacturer information's the Zolid FX multilayer zirconia has a uniform yttria content within all layers with a high yttria 5% this explains why all layers have same strength and flexural characteristics less than that of STM, this confirmed by another study [21], showed significantly a higher strength results for STM than that of Zolid FX after conventional sintering, this might be associated to the variation in composition of these two zirconia discs. This was in harmony with another research [29], which stated that the microstructural composition of CAD CAM material significantly influence their strength. The yttria amount present in STM is 4% while it is 5% in Zolid FX according to the information from the manufacturer, although the increase of the amount of yttrium oxide beneficial regards improvement of zirconia translucency, it lead to a reduction in the mechanical strength of the material [30].

Our study results demonstrated a high correlation between zirconia strength and yttria content, so from scientific point of view the effect of final sintering temperature may be relevant only when comparing ZPRC layers and all layers of Zolid FX as all these 4 layers have the same yttria content (5Y) and all sintered for 2 hours but former one sintered 1500° C while the latter three groups were sintered at 1450° C. Current investigation data showed a non significant differences between strength of ZPRC and all layers of Zolid FX, this agrees with result of [31], study which stated that regarding mechanical behavior, the best strength for 5Y PSZ ceramics when sintered at temperature of 1450°C (variant 5Y PSZ-1450° C), and an increase in sintering temperature above 1450° C did not cause a significant increase in strength. This may be clarified by a greater stabilization of crystal structure with an increased Y_2O_3 content at 1450° C leading to an optimum balance between different tetragonal, monoclinic and cubic phases of zirconium oxide [32].

Fixed dental restorations were manufactured in dental laboratories from tested presintered multilayered zirconia discs utilizing computer-aided design and manufacturing (CAD/CAM) technology [33], with this technique, the dental technician may use the CAM software to move the planned prosthesis up and down within CAM software inside the mounted zirconia disc. This research found that Zircad PRime varying yttria contents variable layers strength significantly differed in comparison with the STM and Zolid FX material which made with shade gradient method and possess same yttria contents in all layers which have same strength. However, dental professional must be more aware at the stage of dental prosthesis positioning inside zirconia disc during milling procedure when using yttria graded disc compared to the material with gradient shade technology. These processes have a significant impact on the clinical outcome of dental prostheses, this is particularly true when sensitive components, such connectors are located in transitional or incisal layers [11, 34-36].

Based upon the results of this study, different manufacturing techniques can significantly affect the zirconia strength, the importance of studying the flexural strength of different layers of multilayered zirconia lies in understanding how variations in multilayering manufacturing technologies influence the material's mechanical properties which crucial for both dentist and technician: Understanding the mechanical properties of multilayered zirconia allows dentists to make informed decisions for improved treatment planning, knowledge of the strength and aesthetics of various zirconia options enables them to experience the most suitable material for each patient's specific needs. At same time technicians need to be knowledgeable about the flexural strengths of different zirconia layers to choose appropriate materials for individual cases. Furthermore the nested positions of restorations within yttria graded blocks will influence their translucency and strength indicated that the technician must perform precise positioning of designed restoration within these discs which is essential for attaining maximum strength without compromising final results of restoration translucency. Better communication and collaboration between dentists and dental technicians promotes powerful teamwork to achieve durability and longevity of dental restorations for optimal patient outcome.

Bar Shape of specimens have been tested was one of the limitations of our study, thus in order to replicate the failures in clinical situations it is advised to do such researches on samples similar to dental restorations like full anatomic crowns and 3 units bridges samples for better understanding the strength of the various multilayered zirconia. More researches are required to assess how placement procedures and positioning within discs affect strength of prosthesis composed of multilayered zirconia materials with varying yttria concentration. Furthermore, grain sizes and material composition of the each layers should be examined.

CONCLUSIONS

The following conclusions can be drawn from the study:

1. Yttria graded zirconia displayed differences in flexural strength results throughout the 3 different layers while various layers of color graded material have same strength. Yttria content variation more influencing strategy than color shading factor regarding strength characteristics.
2. The cervical dentine layer of zirconia with yttria graded technology was substantially stronger than all other layers of multilayered zirconia.
3. Multilayered discs manufactured utilizing varying concentrations of yttria per layer exhibits great reduction in flexural strength at incisal part compared to those created using gradient shading technique with uniform yttria content across all layers, thus positioning of prostheses within the zirconia disc during nesting in CAM software and the required aesthetic criteria must be taken into account when choosing this multilayered zirconia materials.
4. Flexural strength of cervical layer of yttria graded zirconia disc much higher than that of incisal layer while for color graded discs the strength of cervical layer slightly lower than that of incisal layer.
5. Flexural strength of 5Y PSZ did not affected when raising sintering temperature from 1450° C to 1500° C at holding time 2 hours.

Funding: This research received no external funding.

Conflicts of Interest: The author s declare no conflicts of interest in this work.

Acknowledgments: We would like to thank Dr. whaled Khaled and Dr. Ali Saad for their valuable insights and guidance in the development of this article.

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