"EVALUATION AND COMPARISON OF FRACTURE STRENGTH AND MARGINAL FIT OF TWO INDIAN BRANDS OF ZIRCONIA"

Dissertation

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BABU BANARASI DAS UNIVERSITY LUCKNOW, UTTAR PRADESH

In the partial fulfillment of the requirements for the degree

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MASTER OF DENTAL SURGERY

In

PROSTHODONTICS, CROWN & BRIDGE

By

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Under the guidance of

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(Faculty of Babu Banarasi Das University)

BATCH : 2021-2024 **ENROLLMENT NO : 12103292956**

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I hereby declare that this dissertation entitled **"EVALUATION AND COMPARISON OF FRACTURE STRENGTH AND MARGINAL FIT OF TWO INDIAN BRANDS OF ZIRCONIA"** is a bonafide and genuine research work carried out by me under the guidance of **DR. SWATI GUPTA**, Professor and Head, Department of Prosthodontics, Babu Banarasi Das College of Dental Sciences, Lucknow, Uttar Pradesh.

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DR. DEEKSHA

CERTIFICATE BY THE GUIDE

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DR DEEKSHA

DEDICATED TO MY PARENTS

Mrs. Meenakshi Chaudhary

Dr. Dinesh Kumar Chaudhary

AND

MY GRANDFATHER

Late (Shri) Ram Ji Lal

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LIST OF ABBREVIATIONS

CAD	Computed aided designing
CAM	Computer aided machining
Zr	Zirconia
MG	Marginal gap
HT	High translucency
LT	Low translucency
Y-TZP	Yttrium tetragonal zirconia polycrystals

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ABSTRACT

STATEMENT OF PROBLEM – There is still "in progress search" for evidence to access the quality of Indian brands zirconia for fabrication of fixed prosthesis when it comes to mechanical properties as compared with established zirconia brands.

PURPOSE – The purpose of this in vitro study was to compare the marginal fit and fracture strength of established zirconia CAD/CAM blocks with the economical Indian commercial brands.

MATERIALS AND METHODS – A typodont acrylic resin left mandibular first molar was prepared for an all ceramic crown. Zirconia discs for two Indian brands were milled and sintered for different time at a constant temperature to compare marginal fit and fracture resistance.

RESULT – Sintering duration did not affect the fracture resistance of the samples. Fracture toughness of Jyodent was 4673.03 and Upcera was 3602.02 which was better as compared to Vita with fracture resistance 2921.87 ± 349.67 N. The marginal fit was found within the clinically acceptable range of 100µm

CONCLUSION – The monolithic zirconia CAD-CAM Indian zirconia brand Jyodent crowns showed better fracture strength than Vita YZ T, as it withstood fracture loads greater than the maximum masticatory force. The marginal fit was seen to be within the acceptable range for both Jyodent and Upcera brands.

KEYWORDS – Fracture resistance, marginal fit, all ceramic crown, zirconia, CAD/CAM

INTRODUCTION

The name 'Zirconium' comes from an Arabic word 'zargon' which means golden in colour was accidently identified by a German chemist Martin Heinrich Klaproth in 1789. Due to its many advantages, it became popular in dentistry in 2000s though cost is a major deterrent when compared to porcelain fused to metal crowns [1].

Yttria-stabilized tetragonal zirconia polycrystals (Y-TZP) are the strongest ceramic materials now on the market, while partially yttrium stabilized zirconia has been proved to be stronger than other dental ceramic materials [2]. They are similar to metal-ceramic crowns, which are the gold standard of dental crown restorations to date, and have the highest fracture strength of any material. Both anterior and posterior restorations have been made using these crowns.

Zirconium dioxide is a polymorphic material and occurs in three forms: monoclinic, tetragonal and cubic. Monoclinic phase is stable from room temperature to 1170 °C, tetragonal in 1170–2370 °C and cubic over 2370 °C [2]. During cooling, a T-M transformation takes place at the temperature range of about 100 °C below 1070 °C. The phase transformation, which takes place during cooling, is associated with volume expansion of approximately 3–4% [1,3]. This results in compressive stresses that resist crack generation, as well as enhancing crack propagation resistance, and is named the "transformation toughening" process [3]. This toughening process results in high fracture resistance by creating compression stresses around flaws to prevent their catastrophic propagation. From a clinical perspective, a precise marginal fit of zirconia restorations is essential for maintaining periodontal health, preventing cement dissolution, secondary caries and ensuring optimal retention and stability of the prosthesis. It is possible to adjust sintering temperature of porous YSZ to control the pore size and thus the compressive strength for potential applications in restorative dentistry.[4]

The interpretation of strength parameters and the probability of failure during clinical trials could assist in selecting the optimum materials while planning treatment. When evaluating the properties of a crown material, marginal discrepancies and fracture resistance govern the longevity of the restoration. It represents the surface of the cement that is exposed to the oral environment and can be dissolved, resulting in microleakage. [5] The marginal discrepancy ranging upto 120 micro meter were clinically acceptable [6]. Processing techniques novel to dentistry such as computer aided design computer aided machining (CAD-CAM) or copy milling techniques have developed a straightforward approach and also the speed of construction can be delineated.

One important feature of fracture toughness is its ability to indicate a material's serviceability in the oral cavity. The application of the indentation fracture technique (IF) in studying the behavior and properties of brittle materials is specifically appropriate because only small dimensional specimens are required and the crack growth parameter is similar to those cracks expected in clinical condition.[7][8]

Fracture toughness is the ability to indicate a material's serviceability in oral cavity [9]. The microstructure and properties of the material are directly impacted by variations in the zirconia sintering process. The growth and size of the grains in the zirconia microstructure have been found to be impacted by variations in the sintered-holding time during the sintering process[8]. With an increase in grain size, zirconia may be more vulnerable to spontaneous t-to-m-phase transitions, which could lead to a gradual change in strength.

Zirconia of Indian brands are available in the market but have not been proven literature wise and so, the study will explore two areas of important concern namely fracture resistance and marginal fit of these brands. With the advent of intraoral scanners, chairside milling unit and improved materials, the use of zirconia is becoming quite popular. The study will compare the marginal fit and fracture strength of established zirconia (Vita YZ T) CAD/CAM generated full coverage restorations with the economical Indian brands.

AIMS AND OBJECTIVES

AIM- The aim of this study was to evaluate the marginal fit and fracture strength of economical Indian brands Jyodent and Upcera.

OBJECTIVES-

1. Evaluation of marginal fit of Jyodent and Upcera and comparison with Vita YZ T
2. Evaluation of fracture strength of Jyodent and Upcera and comparison with Vita YZ T

HYPOTHESIS –

Null hypothesis for this experiment states that the Indian brands will have no difference when compared to the established zirconia in terms of marginal fit and fracture resistance.

Working hypothesis states that the Indian brands will exhibit comparable properties – like vita brand zirconia.

MATERIAL AND METHODOLOGY

The current research was carried out in the Postgraduate Department of Prosthodontics and Crown and Bridge, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, with the aim to evaluate and compare the marginal fit and fracture strength of zirconia crowns of different brands using two sintering times. Attempts were made to standardize the procedures throughout the study to minimize effect of the variable factors on the observation and final result.

Ethical Committee Approval:

Prior to the study, approval was taken from the Ethical Committee Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow **(IEC Code:11)**

Sample Study, Size and Distribution:

The in vitro study will be performed on the mandibular left first molar tooth of API typhodont model (32 teeth), a total of 24 samples; 12 samples of each brand to compare marginal fit and fracture strength.

Total 24 samples from 2 brands of zirconia discs (98 x 14mm) were fabricated using two different sintering methods; 6 samples each of long cycle and short cycle.

Group JL- JYODENT long sintering cycle; 1550°C for 6 hours

Group JS- JYODENT short sintering cycle; 1550°C for 2.5 hours

Group UL- UPCERA long sintering cycle; 1550°C for 6 hours

Group US- UPCERA short sintering cycle; 1550°C for 2.5 hours

ARMAMENTARIUM FOR THE STUDY:

- API Typodont teeth set [Fig.1]
- Metal thickness gauge [Fig. 2 (a)]
- Tooth preparation burs [Fig. 2 (c)]
- Airotor [Fig. 2 (b)]
- Intra oral scanner (Omnicam, Cerec) [Fig. 3 (a) and (b)]
- Zirconia discs of two brands (JYODENT and UPCERA) [Fig. 6 (a) and (b)]
- Lab sintering unit (HTS-2/M/Zirkon-120) [Fig. 10]

- Universal testing machine (INSTRON) [Fig. 13]
- Stereomicroscope (Leica stereozoom) [Fig. 11]

Armamentarium for tooth preparation

Fig. 1- API typhodont teeth set

Fig. 2 - (a) Metal thickness gauge; (b) Airotor; (c) Tooth preparation burs

Figure 3- Intraoral scanner system (CEREC); (a) display screen (b) scanning device

METHODOLOGY

For convenience and clarity of the study methodology have been described under the following headings:

A. Inclusion criteria
B. Exclusion criteria
C. Reference model preparation and dataset
D. Digital impression making
E. Assessment of marginal fit
F. Assessment of fracture strength
G. Groups and dataset
H. Statistical analysis of data

A. **INCLUSION CRITERIA:**

- Biomechanically prepared mandibular first molar tooth.
- Complete scans of typhodont with fully prepared mandibular left molar.

B. **EXCLUSION CRITERIA:**

- Faulty tooth preparation
- Incomplete scans

C. REFERENCE MODEL PREPARATION:

A typodont containing acrylic resin teeth was used and mandibular first molar was prepared following biomechanical principles with 1mm shoulder finish line, axial convergence of 6 degrees and 1.5 to 2mm of occlusal reduction to receive zirconia restoration.

Figure 4: Tooth preparation of mandibular left first molar using biomechanical principles:

(a) 1mm shoulder finish line preparation with tapered flat end diamond bur

(b) Buccal view of prepared tooth

(c) Occlusal view of prepared tooth. Note the shoulder finish line margin for zirconia restoration.

(d) Occlusal clearance of 1.5 - 2mm to receive zirconia restoration.

D. DIGITAL IMPRESSION MAKING

- Intraoral scanning for the prepared tooth was done using Omnicam Cerec intraoral scanner.

E. ASSESSMENT OF MARGINAL FIT

- Zirconia discs of the two brands were then milled into 12 crowns for each disc. These Indian brands are not included in the chair side and lab milling machine because so far there haven't been any studies that confirm their performance inspite of them having appropriate certification (Fig 8).
- Sintering was done for the milled crown samples using two different sintering time duration; long and short sintering time (1550°C for 6 hours and 2.5 hours respectively).
- Once we get the ideal fit of the zirconia crown specimens the design was evaluated for proper contacts and contours.
- No luting cement was used between tooth and the crown interface.
- Using Scanning electron microscopy, photomicrographs will be obtained from the center of each sample with magnification upto 5x and then assessed.
- The marginal gap at the restoration-abutment interface was measured at the buccal (B), lingual (L), mesial (M), and distal (D) aspects.
- For each side, the point at minimum radial distance between the circumference and the corresponding aspect was identified, resulting in B, L, M and D points
- Descriptive statistics were presented as mean and standard deviations.
- The statistical analyses were performed using a software package.

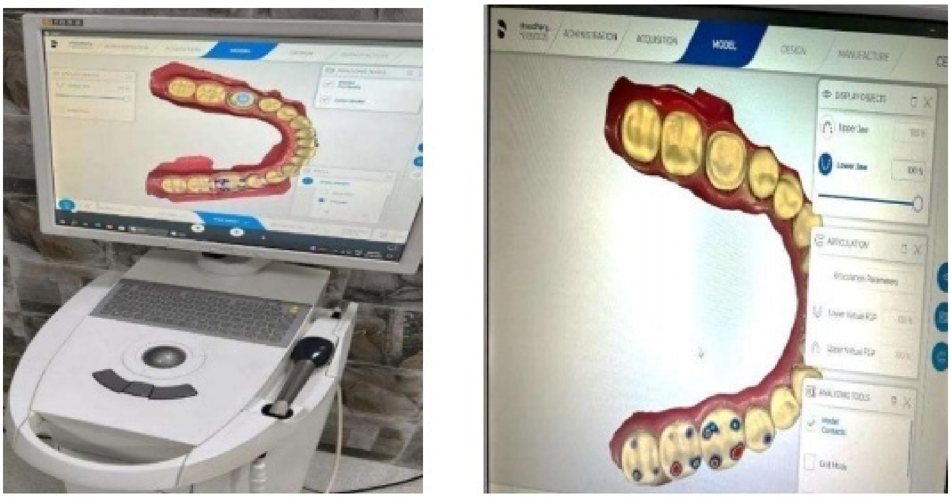


Fig 5 Intraoral scanning (CEREC)

Fig. 6 Zirconia discs (a) Jyodent (b) Upcera

Fig 7- Designed crown samples in zirconia disc

Fig 8 a) Milling unit (DGSHAPE, DWX- 52D)

b) Milling under process

Fig 9- a) Milled Jyodent specimens with connectors

b) Milled Upcera specimens with connectors

Fig. 10- Sintering unit (HTS-2/M/Zirkon-120)

Fig 11 – Stereomicroscope (Leica stereozoom)

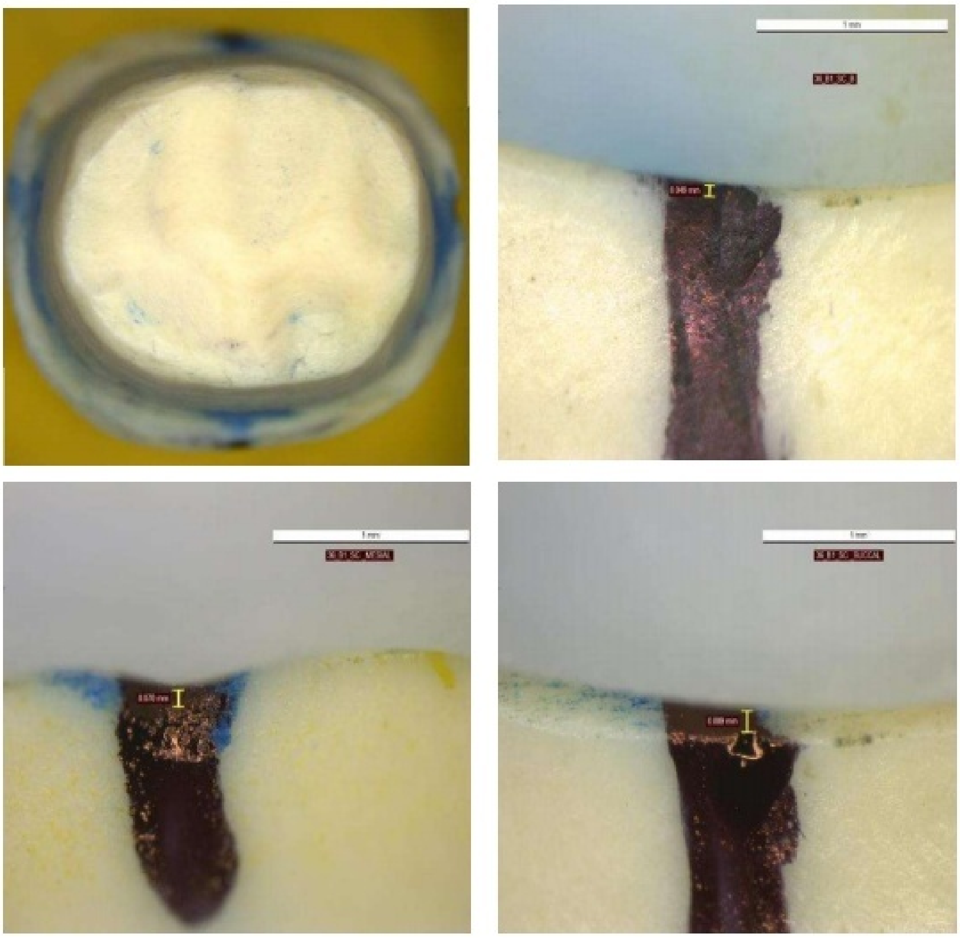


Fig 12 – a) Prepared typhodont mandibular left molar

b), c) and d) Marginal fit as seen under stereomicroscope

F. ASSESSMENT OF FRACTURE RESISTANCE

These specimens without cementing will be placed on the abutment and tested.

The fracture resistance (N) was tested using a measured universal testing machine with a 90° angle at a ramp rate of 1mm/min.

The samples were placed into a platform and the forces were applied onto the crowns until the crown fractured.

The values were recorded at the time of fracture, and the Instron was reset after each value was recorded.

Furthermore, the load was balanced, and the disc attached was returned to its starting position to ensure standardization.

Following this a statistical analysis was performed.

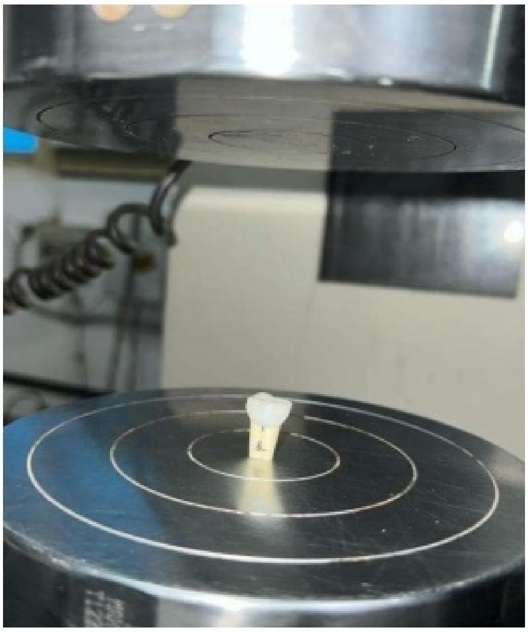


Fig 13 (a) Universal Testing Machine (b) Abutment along with coping sample

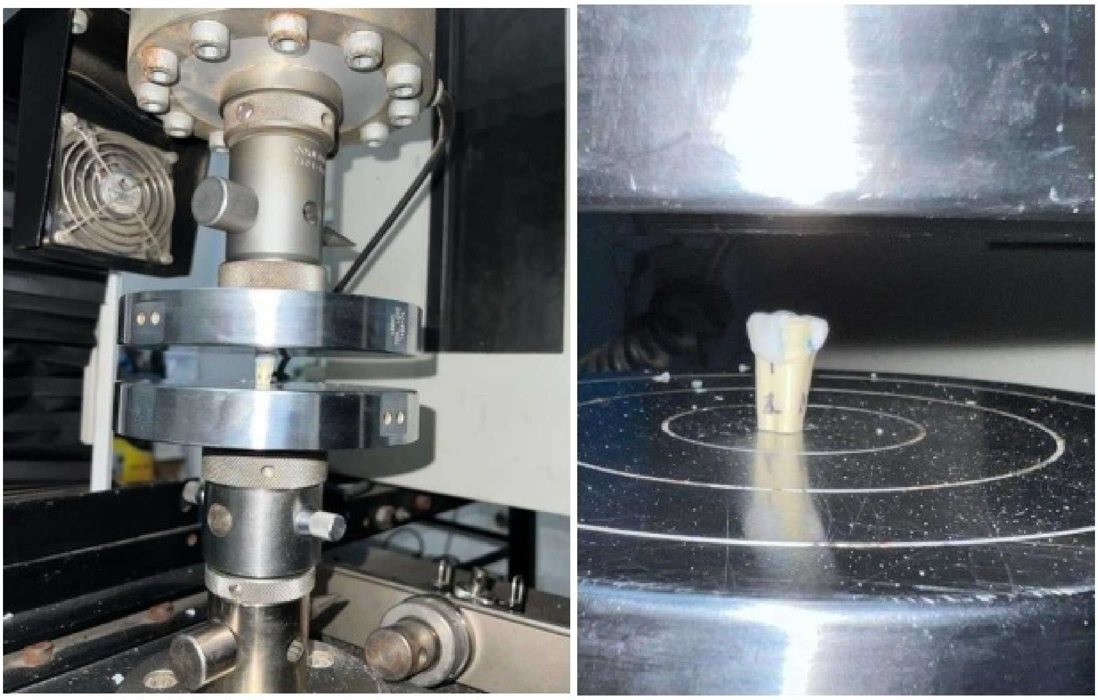


Fig 14 (c) Testing in progress (d) Fractured sample

G. GROUPS AND DATA SETS

A comparative evaluation between Group JS and group US was done to access the fracture resistance and marginal fit during short sintering cycle.

A comparative evaluation between Group JL and group UL was done to access the fracture resistance and marginal fit during long sintering cycle.

A comparative evaluation between Group JS and group JL was done to access the fracture resistance and marginal fit in same brand during short and long sintering protocol.

A comparative evaluation between Group US and group UL was done to access the fracture resistance and marginal fit in same brand during short and long sintering protocol.

H. STATISTICAL ANALYSIS OF DATA

The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation frequency and percentage. The level of the significance for the present study was fixed at 5%.

The intergroup comparison will be done using the independent t tests and intragroup comparison will be done using the Paired t test The Shapiro–Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables.

1. **John A. Sorensen (1990)** [7] conducted a study on a standardized method for determination of crown margin fidelity and concluded for the seven crown systems measured, the interobserver variance was 10 pm. This article presents a biologic rationale for a standardized method of measurement of vertical and horizontal marginal discrepancies.

2. **Handan Yilmaz, Cemal Aydin and Basak E. Gul (2007)**[8] assessed flexural strength and fracture toughness of dental core ceramics and concluded Cercon Zirconia core material showed high values of biaxial flexural strength and indentation fracture toughness when compared to the other ceramics studied.

3. **Jenni Hjerppe, Pekka K. Vallittua, Kaj Fröbergc, Lippo V.J. Lassila (2008)**[2] studied the effect of sintering time on biaxial strength of zirconium dioxide and concluded shorter sintering time does not affect on the static biaxial flexural strength of zirconia but it has meaning to the surface composition of the samples. As some amount of monoclinic phase exist on the surface of zirconia after water exposure, it should be also noted that zirconia on dental application is covered with porcelain and thus clinical situation is not equal as in this study.

4. **M Comlekoglu, M Dundar, M Özcan M Gungor, B Gokce and C Artunc (2008)**[9] studied the influence of cervical finish line type on the marginal adaptation of zirconia ceramic crowns and concluded Shoulder and mini-chamfer finish lines showed comparable AMO (absolute marginal opening) and MO (marginal opening) values and therefore both can be recommended in the clinical application of zirconia crowns. The chamfer type of finish line resulted in the highest AMO and MO values. From a technical standpoint, although the feather-edge finish line resulted in lower AMO and MO values, it cannot be recommended in the clinical application of zirconia FPDs. This group was involved only to test the null hypothesis.

5. **M. Laurent, P. Scheer, J. Dejou & G. Laborde (2008)** [10] evaluated the marginal fit of cast crowns – validation of the silicone replica method and concluded that the measurement of a silicone replica of the cement space between tooth and cast restoration allows comparison of adaptation whatever the silicone used. The use of this

technique with appropriate materials, such as zinc phosphate cement and S4i Bisico silicone, allows accurate prediction of the actual size of the cement thickness in vivo, after cementation. – The method is valid whatever the measurement location (cervical, axial or occlusal).

6. **Wael Att, Futoshi Komine, Thomas Gerds, Dr Rer Nat and Jörg Rudolf Strub (2009)** [11] conducted a study to evaluate the marginal adaptation of different zirconia 3-unit fixed dental prostheses at different fabrication stages and after artificial aging and concluded that VITA YZ-Cerec showed significantly smaller marginal gap values than Procera and DCS.

7. **LiangFa Hu, Chang-An Wang (2010)** [4] conducted a study to assess the effect of sintering temperature on compressive strength of porous yttria-stabilized zirconia ceramics and concluded that the compressive strength increased remarkably from 3 to 27 MPa with increasing sintering temperature from 1350 to 1550 °C, which was related to the corresponding change of linear shrinkage, porosity, pore size and microstructure.

8. **Moustafa N. Aboushelib (2011)** [12] compared the fatigue and fracture resistance of zirconia crowns prepared with different finish line designs and concluded that within the limitations of this study, the finish line design did not influence the fatigue or the fracture resistance of veneered zirconia crowns. Selection of any of the finish line designs should be based on the clinical condition of the restored tooth.

9. **Bogna Stawarczyk, Mutlu Özcan, Lubica Hallmann, Andreas Ender, Albert Mehl and Christoph H. F. Hämmerlet (2011)** [13] assessed the effect of zirconia sintering temperature on flexural strength, grain size, and contrast ratio and concluded zirconia ceramic tested showed the highest flexural strength at final sintering temperatures between 1,400°C and 1,550°C. Contrast ratio of the tested zirconia increased with the increase in final sintering temperatures above 1,300°C. Enlarged grains of the zirconia microstructure were observed with the increase in sintering temperatures above 1,300°C. Sintering temperatures above 1,600°C resulted in grain growth and hollow holes in the zirconia microstructure.

10. **Li Jiang, Yunmao Liao, Qianbing Wan, Wei Li (2011)** [14] conducted a study to evaluate the effects of sintering temperature and particle size on the translucency of yttrium stabilized tetragonal zirconia polycrystals (Y-TZP) dental ceramic and concluded that that the sintering temperature and particle size could influence the transmittance of Y-TZP. The sintering temperature determines the properties of ceramics by effect on the microstructure and the crystalline phases.

11. **Abdulredha A. Almazdi, Hasan M. Khajah, Edward A. Monaco Jr and Hyeongil Kim (2012)** [15] conducted a study on applying microwave technology to sintering dental zirconia and concluded that under the conditions of this study, it appears that either microwave or conventional zirconia sintering may be used for processing zirconia for dental use. However, microwave energy provides uniformity of heating, allowing the use of higher heating rates, which can increase productivity and save energy.

12. **Mi-Jin Kim, Jin-Soo Ahn, Ji-Hwan Kim, Hae-Young Kim, Woong-Chul Kim (2013)** [16] conducted a study to identify the effects of the sintering conditions of dental zirconia on the grain size and translucency and concluded that different sintering conditions resulted in differences in grain size and light transmittance. To obtain more translucent dental zirconia restorations, shorter sintering times should be considered. There was no significant difference in density between brands and sintering conditions.

13. **Shinyoung An, Sungtae Kim, Hyunmin Choi, Jae-Hoon Lee and Hong-Seok Moon (2014)** [17] evaluated the marginal fit of zirconia copings with digital impressions with an intraoral digital scanner and concluded the marginal gap between the restoration and definitive cast base metal die was greater in the groups that used the digital impression method than in the group that used the conventional impression method. However, the marginal discrepancies of all of the groups were clinically acceptable.

14. **Kamal Ebeida, Sebastian Wille, Amina Hamdy, Tarek Salahb, Amr El-Etreby , Matthias Kerna (2014)** [18] assessed effect of changes in sintering parameters on monolithic translucent zirconia and concluded increasing the sintering temperature and

time will lead to enhanced color reproduction and translucency of shaded monolithic nanozirconia ceramic. There is a direct relation between zirconia grain size and the sintering temperature and time. Changing the sintering parameters within the selected range will not cause any tetragonal-monoclinic phase transformation of zirconia ceramic. Changing the sintering parameters within the range selected will have no effect on the surface roughness, biaxial flexural strength, and surface hardness of monolithic nanozirconia ceramic.

15. **Jonathan Ng, Dorin Ruse and Chris Wyatt (2014)** [19] compared and determined the marginal fit of crowns fabricated with digital and conventional methods and concluded that fully digital fabrication method provided better margin fit than the conventional.

16. **Deborah Pacheco Lameira, Wilkens Aurélio Buarque e Silva, Frederico Andrade e Silva and Grace M. De Souza (2015)** [20] conducted a study to evaluate the effect of design and surface finishing on fracture strength of yttria-tetragonal zirconia polycrystal (Y-TZP) crowns in monolithic (1.5 mm thickness) and bilayer (0.8 mm zirconia coping and 0.7 mm porcelain veneer) configuration after artificial aging and concluded that Y-TZP monolithic crowns (polished and glazed) present higher fracture strength than bilayered veneered Y-TZP crowns. There was no evidence of yttrium depletion after 2.5 million cycles in artificial aging.

17. **Nuri Murat Ersoy, Hasan Murat Aydoğdu, Beyza Ünalan Değirmenci, Neslihan Çökük and Müjde Sevimay (2015)** [21] conducted a study to evaluate the effects of sintering temperature and duration on the flexural strength and grain size of zirconia and concluded that zirconia samples tested showed the highest flexural strength when sintering was carried out at 1580°C for 10 min.

18. **Y. Sravanthi, Y.V. Ramani, Asha M. Rathod, Sabita M. Ram, Hetal Turakhia (2015)** [22] evaluated and compared the translucency of crowns fabricated with three different commercially available all-ceramic materials and concluded that Lithium disilicate – Pressable IPS e.max Press is having better translucency in comparison with Alumina – CAD-CAM Procera, Zirconia – CAD-CAM Lava.

19. **Niklas Nordahl, Per Vult von Steyern, and Christel Larsson (2015)** [23] conducted a study to evaluate fracture strength of ceramic monolithic crown systems of different thickness and concluded that the load at fracture decreased from thicker to thinner within the same material for all groups. Two types of fracture were recorded: partial crack-like and complete fractures through the crown. For the LTZ group, crack type fractures dominated, although for the thicker crowns (1.0 mm and 1.5 mm) the majority of the fractures were complete. For the HTZ and LDS groups, the crack type fractures were predominant irrespective of crown thickness

20. **Tamer Abdel-Azim, Kelly Rogers, Eiad Elathamna, Amirali Zandinejad, Michael Metz and Dean Morton (2015)** [24] conducted a study to compare of the marginal fit of lithium disilicate crowns fabricated with CAD/CAM technology by using conventional impressions and two intraoral digital scanners and concluded that the average (±SD) gap for the conventional impression group was 112.3 (±35.3) mm. The digital impression groups had similar average gap sizes; the Lava group was 89.8 (±25.4) mm, and the iTero group was 89.6 (±30.1) mm. No statistically significant difference was found in the effects among impression techniques.

21. **Hamid Jalali, Leyla Sadighpour, Ali Miri, Ahmad Reza Shamshiri (2015)** [25] compared and evaluated marginal fit and fracture strength of a CAD/CAM zirconia crown with two preparation designs and concluded less aggressive preparation of proximal and lingual finish lines for the preservation of tooth structure in all-ceramic restorations does not adversely affect the marginal adaptation or fracture strength of the final restoration.

22. **Rinet Dauti (2016)** [26] compared the marginal fit of cemented zirconia copings manufactured after digital impression with Lava™ C.O.S and conventional impression technique and concluded that copings manufactured after digital impression with Lava™ C.O.S. show comparable marginal parameters with the copings manufactured after conventional impression with polyvinyl siloxane. The mean MG values of both groups fit in the clinically acceptable range.

23. **Panagiotis Tsirogiannis, Daniel R. Reissmann and Guido Heydecke (2016)** [27] evaluated the marginal fit of single-unit, complete-coverage ceramic restorations fabricated after digital and conventional impressions and concluded that no significant difference was observed regarding the marginal gap of single-unit ceramic restorations fabricated after digital or conventional impressions.

24. **Christian Schriwer, Anneli Skjold, Nils Roar Gjerdet and Marit Øilo (2017)** [28] conducted a study on monolithic zirconia dental crowns internal fit, margin quality, fracture mode and load at fracture and concluded that production method and material composition of monolithic zirconia crowns affect the above factors. The hard-machined Y-TZP zirconia crowns had the best margin quality and the highest load at fracture. Reduction of margin flaws will improve fracture strength of monolithic zirconia crowns and thereby increase clinical success.

25. **Philippe Boitelle, Laurent Tapie, Bernardin Mawussi and Olivier Fromentin (2017)** [29] evaluated the marginal fit of CAD-CAM zirconia copings using 2D and 3D measurement methods and concluded that although both methods showed good repeatability, the triple-scan method was more reliable. Both assessment methods allowed comparison of the marginal fit between the zirconia CAD-CAM copings studied. The triple-scan method provided quantitative values of marginal fit significantly lower than those obtained with the replica method with less data dispersion.

26. **Sung-Sook Kim, Ji-Hye Jeong and Hye-Won Cho (2018)** [30] conducted a study to assess effect of digital scans on marginal and internal discrepancies of zirconia crowns and concluded zirconia crowns made by using the IOS CS3600 and the laboratory scanner with a conventional impression showed significantly better internal discrepancies than those made by using TRIOS3 and CEREC Omnicam.

27. **Niwut Juntavee, Surawut Attashu (2018)** [31] conducted a study to compare effect of different sintering process on flexural strength of translucency in monolithic zirconia and concluded that increasing sintering temperature and prolonged sintered-

holding time lead to enhancing flexural strength of translucency monolithic zirconia, and are suggested for sintering process to achieve durable restoration.

28. **Amir Ali Reza Khaledi, Mahroo Vojdani, Mitra Farzin, Soudabeh Pirouzi (2018)** [32] conducted a study that aimed to assess the effects of sintering time on compressive strength of Yttria Tetragonal Zirconia Polycrystal (Y-TZP) copings and concluded that compressive strength of the zirconia copings is affected by the sintering time. High compressive strength of zirconia copings can be obtained by shortening the sintering time.

29. **Walaa Magdy Ahmed et al (2019)** [33] conducted a study to evaluate marginal discrepancies of monolithic zirconia crowns: The influence of preparation designs and sintering techniques and concluded that there was a significant interaction between the finish line widths, the crown thickness, and the sintering protocol on the vertical marginal gap. All vertical marginal gaps measurements were, however, within the clinically acceptable range. The combination of 1.0 mm finish line preparations with either 0.8 or 1.5mm crown thickness had better marginal fit in both sintering protocols (standard or fast) compared to crowns with 0.5 or 1.2mm finish lines. Standard sintering showed lower vertical marginal gaps values compared to the corresponding combinations of fast sintering, except at 0.5 mm finish line. Smaller marginal discrepancies were observed for standard sintering for zirconia crown preparations with a 0.5 mm finish line and 1.5 mm occlusal reduction. Conservative occlusal reduction should be accompanied with a 1.2 mm finish line to obtain better marginal fit for zirconia crowns.

30. **Artak G. Heboyan (2019)** [34] conducted a study to access the marginal and internal fit of fixed prosthodontic constructions and concluded that marginal fit affects the clinical success and longevity of restoration, and the type of the finish line is a crucial factor affecting the marginal fit of fixed prosthetic constructions. Regardless the type of cement, large gaps contribute to its dissolution. Currently used methods of restoration fabrication, including constructions fabricated by CAD/CAM system can ensure clinically acceptable marginal fit.

31. **Avi Meirowitz, Yoli Bitterman, Sharon Levy, Eitan Mijiritsky and Eran Dolev (2019)** [35] evaluated marginal fit zirconia crowns fabricated by a CAD-CAM dental laboratory and a milling center and concluded: The CEREC inLAB system demonstrated significantly better marginal fit in relation to the absolute marginal discrepancy. However, no difference between the systems was found in the MD. Monolithic zirconia crowns fabricated by the CAD-CAM CEREC inLAB system and the LAVA system milling center showed marginal discrepancy values of less than 120 μm, which is within the clinically acceptable range.

32. **Walaa Magdy Ahmed, Batoul Shariati, Arwa Z. Gazzaz, Mohammed E. Sayed, Ricardo M. Carvalho (2020)** [36] compared the fit of tooth-supported zirconia single crown and concluded that shoulder finish line preparations had slightly better marginal fit compared to chamfer finish lines. Crowns obtained from digital impressions had comparable to superior marginal adaptation compared to conventional impressions. Increasing cement space showed to improve zirconia crown adaptation. Cementation and veneering zirconia frameworks found to increase the marginal and internal gaps.

33. **Eleana Kontonasaki, Panagiotis Giasimakopoulos, Athanasios E. Rigos (2020)**[3] conducted a study to review strength and aging resistance of monolithic zirconia and concluded that a significant reduction of mechanical properties has been correlated to high translucent zirconia formulations while regarding aging resistance, the findings are contradictory, necessitating more and thorough investigation. Composition, sintering method and temperature, may affect both strength and aging resistance.

34. **Yadel Hazır Tekin, Yeliz Hayran(2020)** [37] study aimed to evaluate the clinical applicability of monolithic zirconia (MZ) crowns of different thickness via determination of fracture resistance and marginal fit and concluded that the monolithic zirconia exhibited high fracture resistance and good marginal fit even with the 0.5 mm thickness, which might be used with reduced occlusal thickness and be beneficial in challengingly narrow interocclusal space.

35. **Niwut Juntavee and Sasiprapa Kornrum (2020)** [5] conducted a study to evaluate effect of marginal designs on fracture strength of high translucency monolithic zirconia

crowns and concluded that design of heavy chamfer margins provided a stronger and more durable zirconia crown than light chamfer margin. Nevertheless, both heavy and light chamfer margins were capable of withstanding a fracture load that is higher than the maximum masticatory force of humans.

36. **Min Xue, Songbai Liu, Xin Wang, Kuo Jiang (2020)** [38] conducted a study to evaluate high fracture toughness of 3Y-TZP over a wide sintering range and concluded that the fracture toughness values of the 3Y-TZP ceramics were determined to be in the range of 4.0–6.2 MP $m^{1/2}$, and these values did not vary significantly over a wide sintering range.

37. **Yasser Haddadi, Bahram Ranjkesh, Flemming Isidorand Golnosh Bahrami (2021)** [39] conducted a study to assess the marginal and internal fit of crowns manufactured by additive and sub-tractive manufacturing technique and concluded that the marginal fit of additively manufactured crowns is comparable to crowns manufactured with chair-side subtractive technique and within the clinically acceptable range. As regards the internal fit no one technique was consistently superior.

38. **Liya Zacharias, Rajesh Shetty, Mohammad Zahid (2021)** [40] evaluated and compared marginal gap / fit of zirconia copings & full contoured monolith zirconia crowns (CAD / CAM) and concluded CAD/CAM milled full contoured zirconia crowns showed least marginal discrepancy when compared to zirconia copings. All samples had marginal gap within the clinically acceptable range of 120 µm.

39. **Mina Mohaghegh, Sajjad Baseri, Mohammad Hassan Kalantari, Rashin Giti, Seyed Ahmad Ghoraishian (2021)** [41] conducted a study that aimed to evaluate the effect of sintering temperature on the marginal fit and compressive strength of monolithic zirconia crowns and concluded that although increasing the sintering temperature would not affect the marginal gap of monolithic zirconia crowns, it could significantly improve the compressive strength of zirconia restorations because higher sintering temperature and extended dwell time yielded greater grain size, and consequently, greater micropores, which diminished the mechanical properties of the material.

40. **Yunus Emre Ozden, Mustafa Baris Guncu, Guliz Aktas and Senay Canay Quired (2022)** [42] conducted a study to investigate the effect of shortened sintering time on the marginal and internal fit of 3Y-TZP and 4Y-TZP monolithic crowns and concluded that all groups showed clinically acceptable gap values, altering the sintering time had an effect on marginal fit of the crowns manufactured from 4Y-TZP zirconia.

41. **Nadin Al-Haj Husain, Mutlu Özcan, Nataliya Dydyk and Tim Joda (2022)** [43] conducted a study to provide an overview of the technical and clinical outcomes of conventional, speed sintering and high-speed sintering protocols of zirconia and concluded that mechanical and precision results were similar or higher when speed or high-speed sintering methods are used for 3-, 4- and 5-YTZP zirconia. Translucency is usually reduced when 3 Y-TZP is used with speed sintering methods. All types of zirconia using the sintering procedures performed mechanically better compared to lithium disilicate glass ceramics. However, glass ceramics showed better results regarding translucency.

42. **Andrea Ordoñez Balladares, Cristian Abad-Coronel, Joao Carlos Ramos and Benjamín José Martín Biedma(2022)** [44] conducted a study to compare the fracture strength of monolithic zirconium dioxide subjected to a sintering process in two different furnaces and concluded that there were no significant differences between the two groups, and the mechanical strength of the material was not affected.

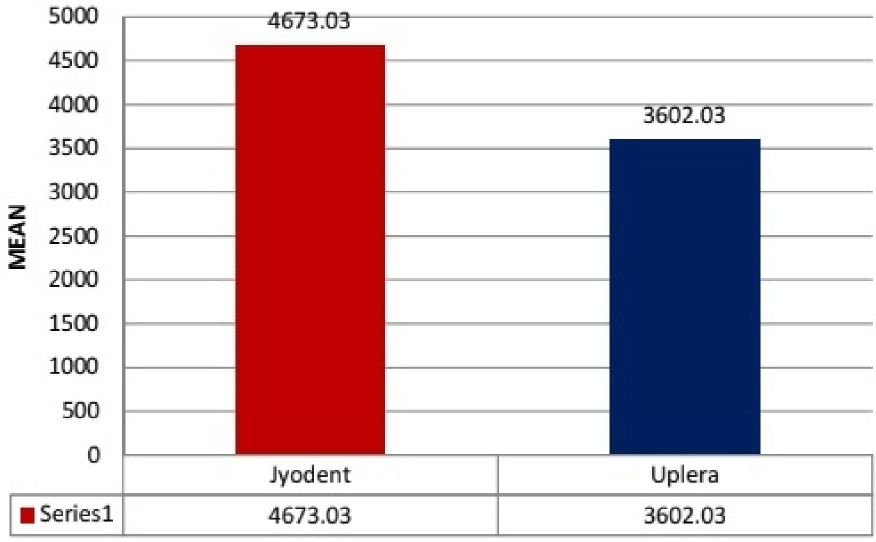
43. **Seulgi Lee, Gyujin Choi, Jinhyeok Choi, Youngjun Kim and Hee-Kyung Kim (2023)** [45] conducted a study and compared the marginal and internal fit of zirconia crowns fabricated using conventional and high-speed induction sintering and concluded zirconia crowns subjected to high-speed sintering exhibited better marginal and internal fit than those subjected to conventional sintering especially concerning the marginal and internal gaps of fixed zirconia restorations because higher sintering shrinkage in the zirconia crowns fabricated using the conventional sintering method, leading to a greater misfit.

OBSERVATIONS AND RESULTS

Table -1 INTERGROUP COMPARISON IN SHORT CYCLE SINTERING

Zirconia	Mean	Std. Deviation	Std. Error	Minimum	Maximum	P value	Significant
Jyodent	4673.03	214.990	87.769	4350.30	4884.08	0.001	Significant
Upcera	3602.03	73.237	29.899	3504.43	3674.24		

The mean fracture resistance in the Jyodent was 4673.03 N/mm^2 (sd=214.99) and in the Upcera Group was 3602.03 N/mm^2 (sd=73.237). The fracture strength was significantly higher in Jyodent compared to Upcera

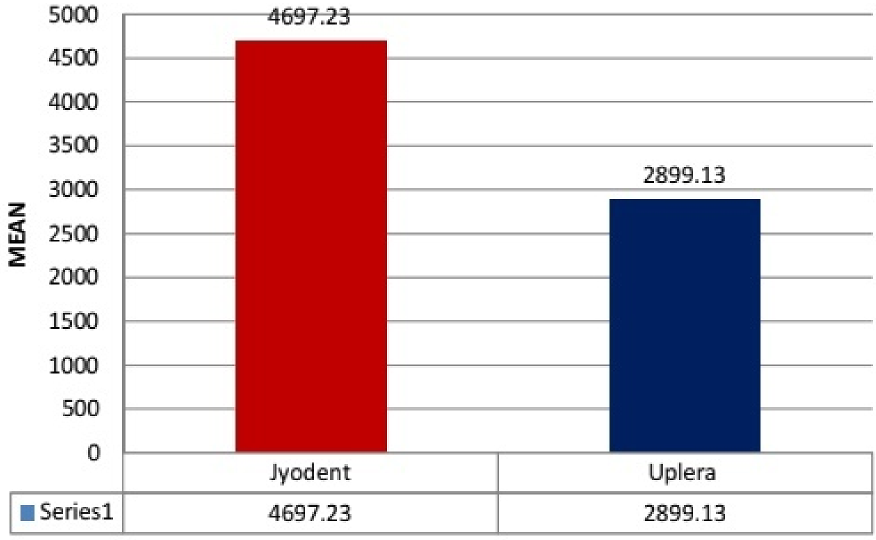


Graph 1 – Graphical representation of fracture resistance in Jyodent and Upcera in short sintering

Table -2 INTERGROUP COMPARISON IN LONG CYCLE SINTERING

Zirconia	Mean	Std. Deviation	Std. Error	Minimum	Maximum	P value	Significant
Jyodent	4697.23	260.749	106.45	4452.45	5045.96	0.001	Significant
Upcera	2899.13	507.375	207.13	2352.42	3539.52		

The mean fracture resistance in the Jyodent was 4697.23 N/mm^2 (sd=260.749) and in the Upcera Group was 2899.13 N/mm^2 (sd=507.375). The fracture strength was significantly higher in Jyodent compared to Upcera

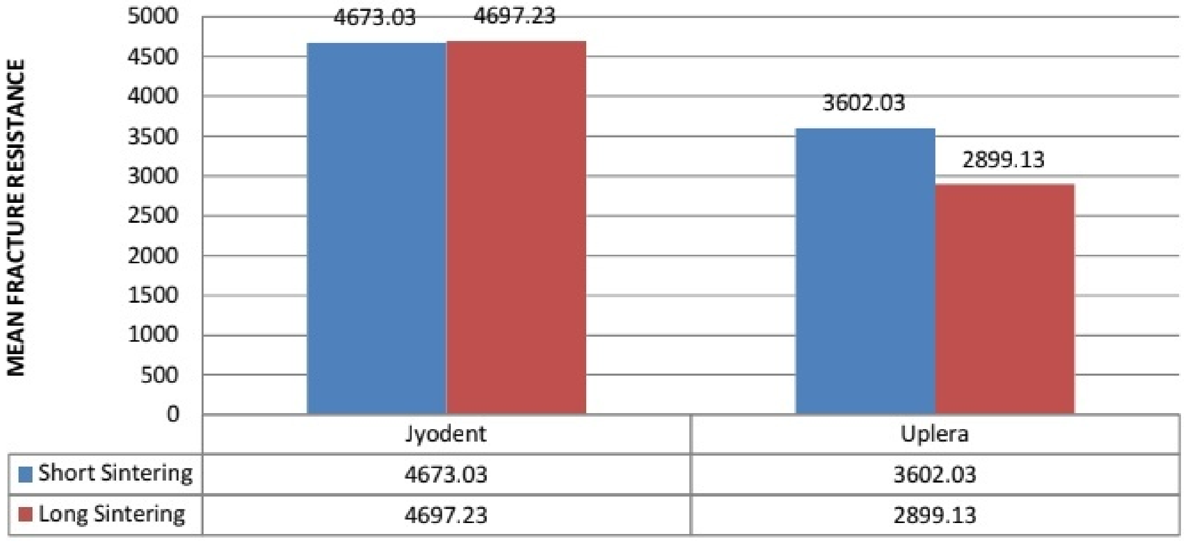


Graph 2- Graphical representation of fracture resistance in Jyodent and Upcera in long sintering

OBSERVATIONS AND RESULTS

Table -3 **<u>INTRAGROUP COMPARION BETWEEN SHORT AND LONG SINTERING IN THE GROUPS</u>**

Zirconia crown	Sintering duration	Mean	Std. Deviation	Std. Error	Minimum	Maximum	P value	Significant
Jyodent	Short Sintering	4673.03	214.990	87.769	4350.30	4884.08	0.821	Non-Sig
	Long Sintering	4697.23	260.749	106.45	4452.45	5045.96		
Upcera	Short Sintering	3602.03	73.237	29.899	3504.43	3674.24	0.023	Significant
	Long Sintering	2899.13	507.375	207.13	2352.42	3539.52		



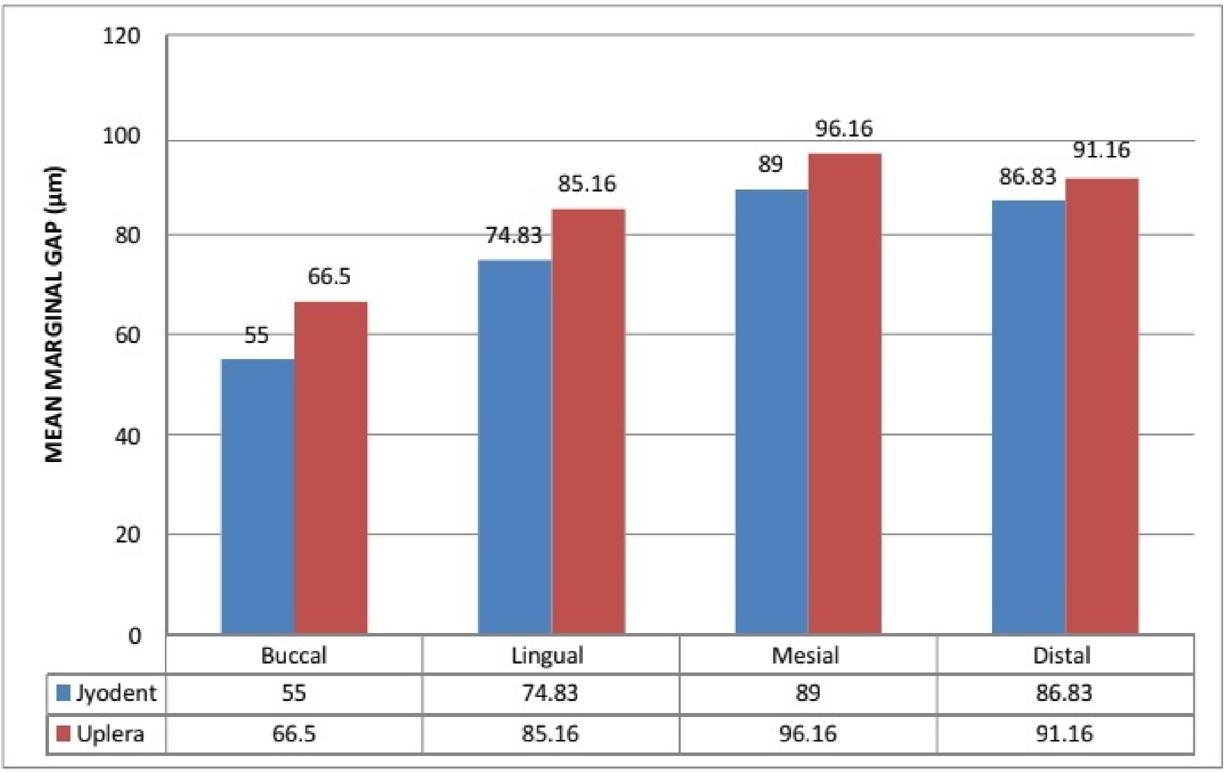
Graph 3 - Graphical representation of fracture resistance in both the groups in short and long sintering

At the short sintering cycle, the mean fracture resistance in the Jyodent was 4697.23 N/mm^2 (sd=260.749) and in the Upcera Group was 2899.13 N/mm^2 (sd=507.375). At the long sintering cycle the mean fracture resistance in the Jyodent was 4697.23 N/mm^2 (sd=260.749) and in the Upcera Group was 2899.13 N/mm^2 (sd=507.375). The intragroup change in the fracture resistance was significant in the Upcera Group as compared to Jyodent Group where the intragroup comparison was statistically non-significant.

Table -4 <u>INTERGROUP COMPARISON OF MARGINAL GAP BEWTEEN THE GROUPS IN SHORT SINTERING</u>

Tooth Surface	Zirconia crown	Mean (µm)	Std. Deviation	Std. Error	Minimum	Maximum	P value	Significant
Buccal	Jyodent	55.00	5.176	2.113	48.00	59.00	0.001	Non-Sig
	Upcera	66.50	1.870	0.763	64.00	68.00		
Lingual	Jyodent	74.83	11.478	4.686	59.00	87.00	0.001	Significant
	Upcera	85.16	4.915	2.006	80.00	94.00		
Mesial	Jyodent	89.00	3.847	1.570	86.00	96.00	0.001	Significant
	Upcera	96.16	1.602	0.654	94.00	98.00		
Distal	Jyodent	86.83	2.316	0.945	84.00	90.00	0.001	Significant
	Upcera	91.16	3.188	1.301	87.00	96.00		

On the Buccal side, the mean marginal gap was 55.00 µm in the Jyodent group and 66.50 µm in the Upcera group. At the Lingual side the mean marginal gap was 74.83 µm in the Jyodent group and 85.16 µm in the Upcera Group. At the mesial side the mean marginal gap was 89.00 µm in the Jyodent and 96.16 µm in the Upcera Group. At the distal side the mean marginal gap was 86.83 µm in the Jyodent and 91.16 µm in the Upcera. The mean marginal gap was significantly higher in the Upcera group as compared to the Jyodent Group.

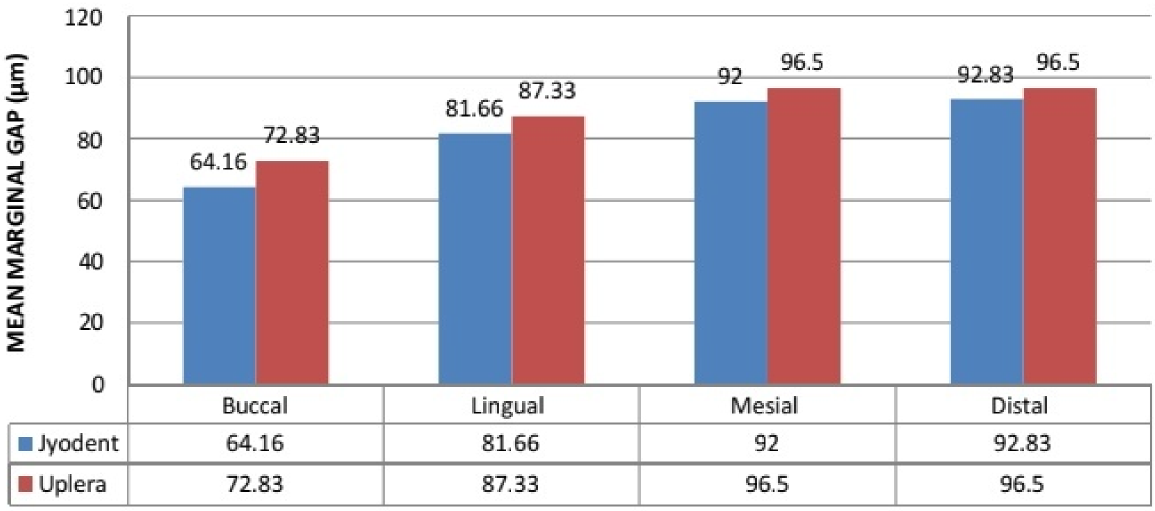


Graph 4- Graph representing intergroup comparison of marginal gap in short sintering

Table -5 <u>INTERGROUP COMPARISON OF MARGINAL GAP BETWEEN THE GROUPS IN LONG SINTERING</u>

Surface	Zirconia	Mean	Std. Deviation	Std. Error	Minimum	Maximum	P value	Significant
Buccal	Jyodent	64.16	6.112	2.495	54.00	70.00	0.001	Non-Sig
	Upcera	72.83	4.167	1.701	67.00	78.00		
Lingual	Jyodent	81.66	1.751	0.714	79.00	84.00	0.017	Significant
	Upcera	87.33	3.011	1.229	82.00	91.00		
Mesial	Jyodent	92.00	6.511	2.658	73.00	99.00	0.023	Significant
	Upcera	96.50	4.806	1.962	82.00	99.00		
Distal	Jyodent	92.83	8.424	3.439	72.00	95.00	0.047	Significant
	Upcera	96.50	3.089	2.077	92.00	99.00		

On the Buccal side, the mean marginal gap was 64.16 µm in the Jyodent group and 72.83 µm in the Upcera group. At the mesial side the mean marginal gap was 92.0 µm in the Jyodent and 96.50 µm in the Upcera Group. At the distal side the mean marginal gap was 92.83 µm in the Jyodent and 96.50 µm in the Upcera . The mean marginal gap was significantly higher in the Upcera group as compared to the Jyodent Group.



Graph 5- Graph representing intergroup comparison of marginal gap in long sintering

Table -6 <u>INTRAGROUP COMPARISON BETWEEN SHORT AND LONG SINTERING – JYODENT AND UPCERA</u>

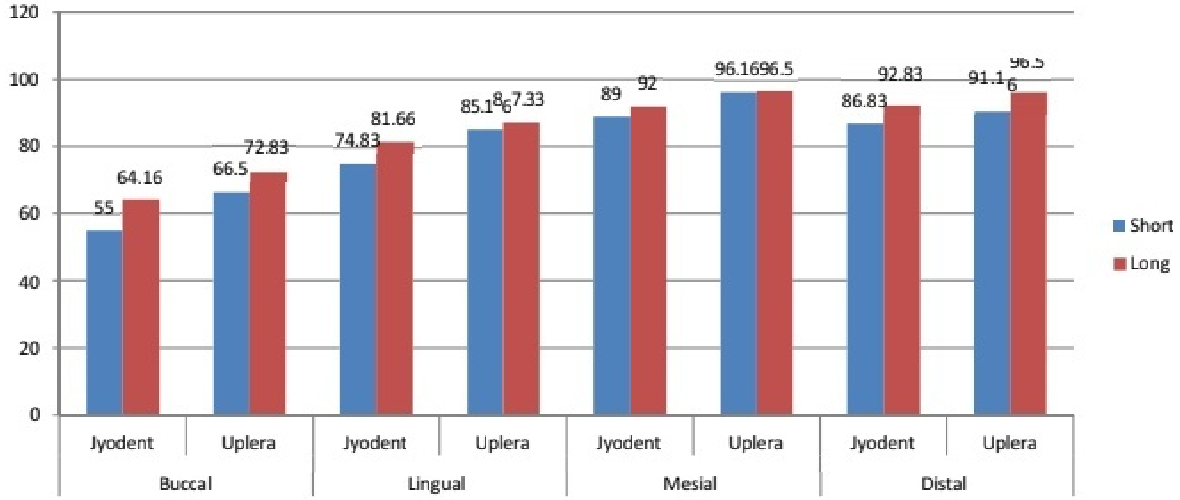
		Short Sintering		Long Sintering		
Surface	Zirconia	Mean	Std. Deviation	Std. Error	Minimum	P value
Buccal	Jyodent	55.00	5.176	64.16	6.112	0.001 (Sig)
	Upcera	66.50	1.870	72.83	4.167	0.001 (Sig)
Lingual	Jyodent	74.83	11.478	81.66	1.751	0.001 (Sig)

	Upcera	85.16	4.915	87.33	3.011	0.210 (Non-Sig)
Mesial	Jyodent	89.00	3.847	92.00	6.511	0.012 (Sig)
	Upcera	96.16	1.602	96.50	4.806	1.00 (Non- Sig)
Distal	Jyodent	86.83	2.316	92.83	8.424	0.001 (Sig)
	Upcera	91.16	3.188	96.50	3.089	0.001 (Sig)

In the short sintering cycle on the Buccal side, the mean marginal gap was 55.00 µm in the Jyodent group and 66.50 µm in the Upcera group. At the Lingual side the mean marginal gap was 74.83 µm in the Jyodent group and 85.16 µm in the Upcera Group. At the mesial side the mean marginal gap was 89.00 µm in the Jyodent and 96.16 µm in the Upcera Group. At the distal side the mean marginal gap was 86.83 µm in the Jyodent and 91.16 µm in the Upcera .

In the long sintering cycle, on the Buccal side, the mean marginal gap was 64.16 µm in the Jyodent group and 72.83 µm in the Upcera group. At the Lingual side the mean marginal gap was 81.66 µm in the Jyodent group and 87.33 µm in the Upcera Group. At the mesial side the mean marginal gap was 92.00 µm in the Jyodent and 96.50 µm in the Upcera Group. At the distal side the mean marginal gap was 92.83 µm in the Jyodent and 96.50 µm in the Upcera

The intragroup increase in the marginal gap from short to long sintering cycle was significant in both the groups at the buccal, lingual, mesial and distal side except for the Upcera group on the mesial and lingual side where the intragroup change was statistically non-significant.



Graph 6- Graph representing intragroup comparison of marginal gap between short and long sintering

STATISTICAL ANALYSIS

The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation frequency and percentage. The level of the significance for the present study was fixed at 5%.

The intergroup comparison will be done using the independent t tests and intragroup comparison will be done using the Paired t test The Shapiro–Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables.

Mean

$$\overline{X} = \frac{\Sigma X}{N}$$

Where:

$\overline{X}$ = the data set mean

$\sum$ = the sum of

X = the scores in the distribution

N = the number of scores in the distribution

Range

$$range = X_{highest} - X_{lowest}$$

Where:

$X_{highest}$ = largest score

X_{lowest} = smallest score

Variance

$$SD^2 = \frac{\Sigma(X - \overline{X})^2}{N}$$

The simplified variance formula

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$$SD^2 = \frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N}$$

Where:

SD^2 = the variance

$\sum$ = the sum of

X = the obtained score

$\overline{X}$ = the mean score of the data

N = the number of scores

Standard Deviation (N)

$$SD = \sqrt{\frac{\Sigma(X - \overline{X})^2}{N}}$$

The simplified standard deviation formula

$$SD = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N}}$$

Where:

SD = the standard deviation

$\sum$ = the sum of

X = the obtained score

$\overline{X}$ = the mean score of the data

N = the number of scores

Independent t-test

Independent t Test can be used to determine if two sets of data are significantly different from each other, and is most commonly applied when the test statistic would follow a normal distribution. The independent samples *t*-test is used when two separate sets of independent and identically distributed samples are obtained, one from each of the two populations being compared

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\left(\frac{(N_1 - 1)s_1^2 + (N_2 - 1)s_2^2}{N_1 + N_2 - 2}\right)\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}}$$

Where X1 =Mean of the first Group, X2 =Mean of the Second Group

Paired t test

$$t = \frac{\overline{x} - 0}{SE(d)} = \frac{\overline{x}}{SD(x)/\sqrt{n}}$$

A paired t-test is used to compare two population means where you have two samples in which observations in one sample can be paired with observations in the other sample. Examples of where this might occur are: - Before-and-after observations on the same subjects (e.g. students' diagnostic test results before and after a particular module or course) or a comparison of two different methods of measurement or two different treatments where the measurements/treatments are applied to the same .

DISCUSSION

The study evaluates the fracture strength and marginal fit of two Indian zirconia brands and compares with an established brand i.e. Vita (Zahnfabrik, Bäd Sackingen,Germany).

Choice of a suitable dental crown material plays a pivotal role in the success and longevity of dental restoration. Each material has distinct mechanical properties like marginal adaptation and fracture toughness that can influence the restoration's durability, aesthetic purpose, and the patient's overall oral health.

Ideal properties that contribute to the success of fixed prosthesis are-

Durability -The durability of a crown is a vital consideration in its success. Durable materials like metal and zirconia can withstand the forces of biting and chewing, reducing the risk of the crown becoming damaged or having loose crown. This durability can mean a longer lifespan for the crown, potentially reducing future dental visits and associated costs.

Aesthetic Appeal -The appearance of a dental crown is another significant factor to consider. This natural look can enhance a patient's smile and boost their self-esteem. The position of the tooth can also influence the choice of material.

Cost - Cost is a critical factor in the decision-making process for many patients. While some materials may have a higher upfront cost, their durability and longevity could make them a more cost-effective choice in the long run.

Within the last ten years, there has been a substantial evolution in dental ceramics and processing technology; novel microstructures and CAD-CAM techniques have played a major role in this progression. Zirconium dioxide (ZrO_2) has been introduced for use in restorative dentistry because of their biocompatibility and aesthetics outcomes. A monolithic zirconia dental crown is made from one piece of zirconia i.e. a solid block of pure zirconium dioxide (ZrO_2), one of the strongest materials available in dentistry. Other features of zirconia include resistance to cracks, chipping, and discoloration, biocompatible and safe, it does not cause any metal sensitivity in patients, the smooth exterior protects against abrasion to adjacent teeth and gingiva, gives the most natural look to the tooth.[46]

The production of all-ceramic dental prostheses has also been altered by a tendency toward the use of monolithic restorations, as multilayered restorations, although more aesthetically pleasing, are more prone to chipping or delamination [47]

Reducing the work required for chairside adjustments and the difficulties related to cracked restorations would be possible with accurate impression processes, precise manufacturing, and lab finishing procedures.

DISCUSSION

To fabricate a zirconia restoration, the zirconia disc or block is milled (subtractive manufacturing) to achieve the desired configuration of the restoration. In India, many foreign brands available to the dentist/lab to choose from and the milling units; be it lab milling or chairside milling units have inbuilt company specific programmes in them so as to perform the process.

Research has created new microstructures to provide ceramic and composite materials with optimum qualities, such as adequate wear behaviour, good mechanical capabilities, and acceptable aesthetic features. Therefore, materials such as zirconium dioxide, with high fracture strength due to their fully crystalline microstructure and due to the presence of a resistive transformation mechanism, exhibit superior fracture strength values in relation to other ceramic materials by preventing fracture propagation [48].

According to a market research and competitive intelligence report on zirconia-based dental ceramics published by future market insights, the market value of this product category is expected to rise at a compound annual growth rate of approximately 8.5% between 2017 and 2021. The market for dental crowns alone is expected to expand at the fastest rate possible between 2022 and 2032—more than 10.7%. Estimates for the size of the zirconia-based dental material market in 2022 and 2023 range from US$ 235.1 million to US$ 577.9 million, respectively. This report clearly emphasises on the elevating demand of zirconia in the future in the dental market.[49]

Zirconia when compared to porcelain fused to metal restorations are quite higher in cost and it is one of the limitations of zirconia. There are couple of commercially available Indian zirconia available in Indian market but so far no studies have been conducted using the Indian brand zirconia to establish their effectiveness as acceptable zirconia. Keeping all this in mind, the study has been conducted with the aim to look for an economical alternative instead of established foreign brands.

The study investigated the most basic of zirconia composition; based on yttria content opaque zirconia was used in the study which contains 3 mole % yttria to partially stabilize the tetragonal phase i.e. UPCERA ST WHITE, JYODENT IS ZD, VITAYZ T; for fracture strength and marginal fit of two Indian brands (Jyodent and Upcera). The composition and properties of these materials are given in **Table no. 7 and 8** as mentioned on the respective company's website.

Table No.7- PHYSICAL CHARACTERISTICS:

PROPERTIES	UPCERA	JYODENT	VITA YZ T
Sintering Temperature	1530°C	1450°C	1450°C
CTE	$10.5 \pm 0.5 \times 10^{-6} K^{-1}$	-	$10.5 \times 10^{-6} K^{-1}$
Density after sintering	6.07 ± 0.01 g/cm^2	6.1	6.05
Accelerated ageing surface monoclinic phase content	<15%	-	-
Chemical solubility after sintering	<100µg/cm^2	-	<20
Radioactivity	<0.1Bq/g		
Transmittance % as per Shimadzu spectrophotometer UV2600	-	35.0	-
Transmittance % as per Haze meter	-	41.6	-
Bending Strength (MPa)	-	1200	1200
Fracture toughness N/mm^2	-	-	4500
Hardness	-	-	12
Modulus of elasticity[GPa]	-	-	210
Weibull modulus	-	-	14

Table no. 8 - CHEMICAL COMPOSITION:

UPCERA	JYODENT	VITA YZ T
ZrO2 + HfO2 +Y2O3 (>99%)	ZrO2+Hf2+Y2O3+Al2O3 (>99.9)	ZrO2 (90-95)
Y2O3 (4.5 – 6%)	Y2O3 [5.15(±0.20)]	Y2O3 (4-6)
Al2O3 (<0.5%)	Al2O3 [0.25 (±0.10)]	HfO2 (1-3)
Other oxides (<0.5%)	SiO2 (<0.02)	Al2O3 (0-1)
	Fe2O3 (<0.01)	Pigments (0-1)
	Na2O (<0.04)	

Natural teeth exhibit wide variety of dimensions which might affect the restoration dimensions fabricated [50] and thus any test performed wouldn't have relevant and comparable results, therefore in the present study only one tooth (mandibular left molar) of typhodont was selected and prepared following all ceramic restoration preparation guidelines.

1. PREPARATION DESIGN:

A mandibular left molar was biomechanically prepared on typodont using a 1mm shoulder finish line, 6 degrees of axial convergence, and 1.5-2mm of occlusal reduction to receive zirconia restoration.

It is believed that the preparation design may contribute to the fracture strength and durability of final restorations and also there is a direct relationship between crown lifetime and the quality of marginal fit. Fracture strength is a measure of the stress that a crack-free metal can bear before deforming or breaking under a single applied load. Fracture strength is a measure of the amount of energy required to fracture a material that contains a crack. The tougher the material, the more energy required to cause a crack to grow to fracture. Fracture strength would be affected by the different composition of each material. However, if these properties exceed the masticatory forces, they are clinically favourable for application in the posterior region.

Maximum bite force is highest in the molar region [51]. Unilateral measurement of maximum bite force in the molar region averages between 300 and 600 Newtons (N) in healthy adults with natural teeth [52].

FINISH LINE-

For all ceramic crowns, two main finish lines i.e. round shoulder and the deep chamfer are suggested [53], while bevel is contraindicated for these restorations. However, the round shoulder finish line presents better values of a marginal gap than the deep chamfer and the addition of ceramic effect the final gap values of marginal fit [54]. Scanning electron photomicrographs revealed that the crack generally originates from the cervical margin [55]. Therefore, the design of the margins in restorations has a significant influence on the fracture strength of the ceramic restoration.

A study revealed, that at different stages of fabrication, differences in marginal fit were observed in the chamfer group ($p=0.0042$) but there were no differences in the crowns with shoulder margins ($p=0.4335$) [42]. A well-defined supra gingival finish line is critical for optical impressioning. The design of the finish line is one of the most investigated factors, with some studies reporting no significant differences between horizontal and vertical finish lines [56], while others reporting that shoulder results in a more accurate one with advantage of maximum fracture strength and biomechanical performance of prosthesis [57-62]. The shoulder preparation for zirconia had a mean breaking load of 2286 N, the shoulderless preparation 2041 N, the beveled shoulder 1722 N, the pronounced deep chamfer 1752 N, and the slight chamfer 1624 N [57]. A shoulder finish line offers a larger rest area for margins, which was suggested to ensure more favourable stress distribution pattern during occlusal loading81 therefore in this study, shoulder finish line was prepared. When dealing with monolithic zirconia crowns in a purely digital method, it is critical to design and produce a restoration that perfectly fits and closes on marginal lines of prosthetic abutments. Although the clinical precision of a monolithic crown is determined by a succession of following procedures (data acquisition, design, milling, sintering).

1. OPTICAL IMPRESSION:

The intraoral scanner has advantages of superior convenience, fast acquisition time of the virtual model, and superior accuracy as compared with the conventional method [63-66]. A study evaluated 3-unit zirconia fixed dental prostheses fabricated using an intraoral scanner and reported a better marginal fit (AMD) in the digital group (64 ± 16 μm) than in the conventional group (76 ± 18 μm) [67]

Due to established superiority of optical scanning as discussed above, the study recorded an optical impression.

2. MILLING AND SINTERING:

Different sintering time helps to compare the mechanical parameters of the two brands at different holding time in furnace. Such temperature deviations have an optical and mechanical influence on the final restoration. The ideal mechanical properties can be achieved following the sintering temperature which is according to the manufacturers recommendations, any increase in this temperature causes grain growth, deteriorating the mechanical properties of

To fabricate standardized zirconia crowns, the milling and sintering of the final crown were controlled by a single i.e. experienced dental technician which was done using lab milling unit after which the restorations were fabricated by two different sintering times (6 hours and 2.5 hours) at a constant temperature of 1550°C. The ideal sintering temperature for VITA YZ is 1450 °C and equally good results can be achieved with both conventional sintering (17 °C/min, 2 h holding time) and high speed sintering, with regard to structure, mechanical properties and fit.

Different types of sintering include conventional sintering, speed sintering and super speed sintering. Super-speed (SS, 1580 ◦C, dwell time 10 min), Speed (S, 1510 ◦C, dwell time 25 min), and Long-term (LT, 1510 ◦C, dwell time 120 min). When single abutment teeth were investigated, speed sintering (1500°C for 20 mins) showed significantly better fit compared to the conventional sintering in the marginal gap and occlusal surface. This was explained by the higher predictability of the shrinkage of zirconia during speed-sintering processes. However, all values were within the clinically acceptable range [68]. On the other hand, found no significance in the marginal gap high-speed sintered monolithic zirconia crowns compared to conventionally fabricated ones after aging [69].

With an increase in sintering temperature, the ZrO2 grain size was found to grow, and the flexural strength decreased [70]. With an increase in the sintering temperature and holding time, the grains grow and the number of micropores increases. Thus, after microwave sintering at 1500 °C for 20 min, the average grain size was 347 nm, and after traditional sintering at the same temperature of 1500 °C, but with a longer holding time of 40 h, the grain size was 1512 nm. This decreased the strength of zirconia stabilized with 3 mol% Y2O3 [70] Therefore, the sintering temperature should be restricted to below 1550 °C. Therefore, the sintering temperature should be restricted to below 1550 °C. It was documented that higher sintering temperature and extended dwell time yielded greater grain size, and consequently, greater micropores, which degraded the mechanical properties of the material. This difference can be attributed to the varying brands (and therefore composition) of zirconia [71]. It has been shown that the holding time during sintering causes grain growth in the material [71].

The transformation from tetragonal to mono-clinic zirconia decreases with tensile stress [72]. Higher sintering temperatures as well as longer sintering time yield larger grain size. [73-75]. Zirconia is generally sintered between 1,350 and 1,600°C [13] Higher sintering temperatures were found to migrate yttrium to the grain boundaries [76]. The grain size of zirconia increased with higher sintering temperatures above 1,300°C and with the highest results at 1,700°C. The specimens with a final sintering temperature above 1,600°C were accompanied by hollow opening in the zirconia microstructure. Sintering temperatures at 1,400°C and 1,550°C presented the highest Weibull modulus, whereas at 1,700°C, the lowest Weibull modulus. The increase in sintering temperature above 1,300°C enlarged grain size and increased contrast ratio [13].

3. ASSESSEMENT OF MARGINAL FIT:

The amount of space between the prepared tooth's finish line and the restoration's margin determines the marginal fit of fixed dental prosthesis. Marginal fit that is clinically acceptable can be achieved with the restorative manufacturing techniques currently in use, including constructs made using computer-aided design and computer-aided manufacturing systems. The material utilized, the type of finish line, and the characteristics of different restoration manufacturing techniques are the most significant elements determining the marginal and internal fit of fixed dental prosthesis. It reported that the fracture load of zirconia was between 2700 N and 4100 N. [73]

Long-term success of crowns highly depends on their marginal fit. As reported by studies, the marginal gap between 40 and 120 μm is clinically acceptable [77,78]. Poor marginal fit also decreases the fracture strength and jeopardizes the restoration strength. [79]

However, gaps of less than 80 μm were proven to be very difficult to detect clinically [80] and several authors have considered that marginal discrepancies between 100-150 μm to be clinically acceptable [81] . Ranges of 100-250 μm have been deemed clinically acceptable for the marginal fit in numerous prior investigations, despite the fact that values may vary based on parameters such restoration design, materials, imprint processes, fabrication procedures, and cement types [82]. While some specialists consider the value lower or equal to 120μm to be acceptable, while others believe it should be less than 100μm [83].

Marginal fit of Vita- value lower or equal to 120µm to be acceptable, while some studies state that it should be less than 100µm [84]. Vita In-Ceram YZ frameworks showed mean marginal gaps of 38.9±8.2 µm [40], in a similar study mean marginal gap was 64 µm for VITA In-Ceram YZ, which is considerably higher [11].

Based on the results of a study, zirconia crowns subjected to high-speed sintering exhibited better marginal and internal fit than those subjected to conventional sintering. Therefore, high-speed induction sintering can be considered a valid option for single-visit dental treatments, especially concerning the marginal and internal gaps of fixed zirconia restorations [34].

Evaluating the marginal fit of crowns can be challenging, many techniques have been used in the past by authors including direct view with microscope [85], indirect view on resin replicas [85], microcomputed tomography [86] and silicone replica technique [86-88]. These evaluation measures have some shortcomings and can be technique-sensitive. One of the shortcomings of this technique is a limited number of measurement points for each restoration, therefore it may not represent the true circumferential fit of a crown [41].

This study evaluated the marginal gap by using a direct microscopic view of the non-cemented specimen on the prepared typhodont, this technique is non invasive [34]. Hence, the marginal fit of the crowns was carefully evaluated in the laboratory by means of a stereomicroscope [29,89-91] (Leica stereozoom) at 5x magnification at the restoration-abutment interface was measured at the buccal (B), lingual (L), mesial (M), and distal (D) aspects for each coping samples of two different brands. For each side, the point at minimum radial distance between the circumference and the corresponding aspect was identified [33,90], resulting in the B, L, M, and D points.

In this study, the marginal gap of zirconia single crowns was reported to range between 92.83 -64.16µm in Jyodent, 96.5-72.83µm in Upcera in long cycle sintering and 83.83-55µm in Jyodent, 91.16- 66.5µm in Upcera for short sintering cycle which was under acceptable range when compared with mean marginal gap in Vita YZ i.e. 40-100 µm. The mean marginal gap was statistically significantly higher in the Upcera group as compared to the Jyodent Group in the short sintered and long sintered cycle cycle except the buccal surface where the difference was statistically non-significant. Different sintering temperatures are likely to alter the marginal fit as the ceramic materials shrink when cooling down to room temperature [92]. This shrinkage depends on various factors including the material composition, density, and factors of sintering procedure [13,20,27,40].

4. ASSESSEMENT OF FRACTURE STRENGTH:

The fracture strength is the ability of a material to resist fracture, maximum stress it can withstand before fracture. Fracture strength would be affected by the different composition of each material. However, if these properties exceed the masticatory forces, they are clinically favourable for application in the posterior region. Maximum bite force is highest in the molar region [93]. Unilateral measurement of maximum bite force in the molar region averages between 300 and 600 Newtons (N) in healthy adults with natural teeth [94].

The evaluation of fracture strength was done using Universal testing machine (INSTRON, PTC/083/ME). Earlier studies have concluded that the occlusal thickness and the type of cement significantly affected the fracture strength of the crowns, but the occlusal thickness was more significant [95]. The difference in grain size caused by different sintering procedures as seen in SEM images is generally small and it is difficult to see if there is a difference [21].

In the study, cementation was not done because the there is no micromechanical interlocking between a typhodont and resin modified glass ionomer cement which is only possible in case of a natural tooth.

Each specimen was tested at a speed of 1mm/min, parallel to the long axis of tooth applying an initial load of 10N on the occlusal surface until the specimen fracture. The data on load to fracture was procured and the values were noted in Newton(N). Utilizing compressive strength on the zirconia crown as a conventional single-fracture load test, the load value at fracture was determined in this work. In this study, the maximum load values at the time of crown fracture were compared.

The fracture strength of the long sintering cycle restorations varied between 4697.23 ± 260.49 N/mm2 in Jyodent and 2899.13 ± 507.37 N/mm2 in Upcera and values for short sintering cycle were 4673.03 ± 214.99 N/mm2 and 3602.03 ±73.23 N/mm2 respectively in comparison with Vita YZ T which was tested to have 4500 N/mm2 fracture strength.

There was no significant variation in the fracture strength of Jyodent as seen in long and short sintering cycles this means that at 1550°C temperature there was no increase in grain size significantly so it did not alter the fracture strength of zirconia, as seen in the other brand i.e. Upcera there is significant variation in fracture of short and long dwell times of sintering ,a high sintering temperature and a long dwelling time increased the grain size and thus, the number of micropores, resulting in a material with reduced mechanical properties, also an excessive dwell time decreases the light transmittance mainly by inducing grain growth. If the temperature is too low, the structure cannot be completely densely sintered. If the temperatures are too high, the material reveals a tendency to grain growth. Phase composition and microstructure analysis results indicate that the high fracture toughness over a wider range of sintering conditions can be attributed to the cooperativity between the transformation toughening mechanism and the critical grain size effect of the transition from the tetragonal to monoclinic phase of the 3Y-TZP [38]

Ideal sintering temperature for Vita YZ is 1450 °C according to manufacturer's instructions, equally good results can be achieved with both conventional sintering (17 °C/min, 2 h holding time) and high speed sintering, with regard to structure, mechanical properties and fit. If this temperature exceeded leads to grain growth, deteriorating the mechanical properties of zirconia. With an increase in the sintering temperature and holding time, the grains grow and the number of micropores increases so the sintering should be restricted below 1550 °C. The ideal sintering temperature for VITA YZ is 1450 °C. According to a study sintering at 1510 °C at 120 min micropits in the wear crater were less frequent when compared with sintering at 1510 °C at for 25 mins and sintering at 1580 °C at 10 mins, though tetragonal to monoclinic phase transformation was seen in all the three groups of 3 YTZP [96].

Different sintering temperatures are likely to alter the marginal fit as the ceramic materials shrink when cooling down to room temperature. This shrinkage depends on various factors including the material composition, density, and factors of sintering procedure. Sintering temperature higher than 1550°C and extended dwell time yielded greater grain size, and consequently, greater micropores, which degraded the mechanical properties of the Zirconia.(most common sintering method of zirconia -Conventional furnaces at temperatures between 1350 and 1600°C and holding times ranging from 2 to 4 hours)

Upcera ISO certificate

CERTIFICATE

This is to Certify that the Management System of

Jyoti Ceramic Industries Pvt. Ltd.
(Bio Ceramic division)

Plot No. C-21, NICE, Satpur, Nashik-422 007, Maharashtra, India

has been audited and found to comply with the requirements of:

ISO 13485:2016
(Medical Devices – Quality Management System)

For the Scope of activities described below:

Manufacture and distribution of Jyodent Zirconia Ceramic Dental Blanks and Zirconia Ceramic Dental Restorative

Director

Jyodent ISO certificate

Limitations of the study -

Typhodont used in this study is a constraint because intraorally the tooth is well hydrated which imparts strength to the restoration and presence of luting cement adds to the strength of prosthesis. The use of natural teeth would be ideal to stimulate clinical procedure. Also, finger pressure used clinically to access marginal fit of crowns on prepared typhodont tooth was not standardized. Therefore, the use of a loading device is needed to apply uniform load on all crowns. The samples were not subjected to thermocycling. Only two properties were evaluated; more research is required on analysing the remaining properties of the materials.

Future scope of the study -

Future research needs to be done using a natural tooth, as well as to analyse the material cemented with different adhesive techniques.

Clinical implications of the study-

Fracture strength of Jyodent was found to be significantly greater than Vita and the marginal gap (< 100) was also seen within the acceptable range which makes it an acceptable material for full coverage restorations in posterior region and is economical too.

As we know the maximum bite force in the molar region averages between 300 and 600 Newtons (N) in healthy adults with natural teeth and the fracture strength for Jyodent and Upcera was evaluated to be 4697.23 N/mm^2 and 4673.03 N/mm^2 which was statistically greater than that of Vita which is 4500 N/mm^2.

CONCLUSION

Within the limitations of study, the following conclusions were drawn –

1.The mean fracture resistance in Jyodent group was 4673.03 ± 214.99 N/mm^2 and in the Upcera group was 3602.03± 73.237 N/mm^2. The fracture strength was statistically significantly higher in Jyodent compared to Upcera in the short sintered cycle.

2. The mean fracture resistance in the Jyodent was 4697.23± 260.749 N/mm^2 and in the Upcera Group was 2899.13 ± 507.375 N/mm^2. The fracture strength was statistically significantly higher in Jyodent compared to Upcera in the long sintered cycle.

3. The intragroup difference in the fracture resistance was statistically significant in the Upcera Group as compared to Jyodent Group where the intragroup comparison was statistically non-significant.

4. The mean marginal gap was statistically significantly higher in the Upcera group as compared to the Jyodent Group in the short sintered and long sintered cycle except the buccal surface where the difference was statistically non-significant.

5. Jyodent group exhibited higher fracture resistances as compared to Vita YZ T.

6. The marginal gap in Jyodent and Upcera was found to be within acceptable range of 40-100um.

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ANNEXURE -I

BABU BANARASI DAS UNIVERSITY
BBD COLLEGE OF DENTAL SCIENCES, LUCKNOW

OBO UNIVERSITY

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

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

IEC Code: 11

Title of the Project: Evaluation And Comparison Of Flexural Strength And Marginal Fit Of Zirconia Crown Of Three Different Brands: An In Vitro Study.

Principal Investigator: Dr Deeksha Department: Prosthodontics & Crown and Bridge

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

Type of Submission: New, MDS Project Protocol

Dear Dr Deeksha,

The Institutional Ethics Sub-Committee meeting comprising following members was held on 1 September, 2022.

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

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:

ANNEXURE -II

BABU BANARASI DAS
UNIVERSITY
BBD COLLEGE OF DENTAL SCIENCES,
LUCKNOW

Lakshmi Bala
16/09/22

Prof. Dr. un t Ahuja PrincipalMember-Secretary	Dr. Lakshmi Bala
BBD Universit Lucknow PR!NdiPAL Babu Banarasi Das College of Dental Sciences (Babu Banarasi Das University) BBD City, Faizabad Road, Lucknow-226028 BBD Coll ge f Dental Sciences	BBD College of Dental Sciences BBD University, Lucknow Member-Secretary Institutional Ethic Committed BBD College of Dental scienq Institutional Ethics Sub-Committee (IFC) BBD University Faizabad Road, Lucknow-226028

EBO UNIVERSITY

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

Communication of the Decision of the Institutional Ethics Sub-Committee Meetin

IEC Code: 11

Title of the Project: Evaluation And Comparison Of Flexural Strength And Marginal Fit Of Zirconia Crown Of Three Different Brands: An In Vitro Study.

Principal Investigator: Dr Deeksha Department: Prosthodontics & Crown and Bridge

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

Type of Submission: New, MDS Project Protocol

Dear Dr Deeksha,

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

ANNEXURE -III

BABU BANARASI DAS UNIVERSITY

BBD COLLEGE OF DENTAL SCIENCES, LUCKNOW

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

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 Coll ge f Dental Sciences
BBD Universit Lucknow
PR!NdiPAL
Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD Cith Faizabad Road, Lucknow-226028

Lakshmi Bala
16/05/22
Dr. Lakshmi Bala
Member-Secretary
Institutional Ethics Sub-Committee (IBC)
BBD College of Dental Sciences
BBD University, Lucknow
Member-Secretary
Institutional Ethic Committea
BBD College of Dental Scienq
BBD University
Faizabad Road, Lucknow-226028

ANNEXURE -IV

BABU BANARASI DAS
UNIVERSITY
BBD COLLEGE OF DENTAL SCIENCES,
LUCKNOW

ao UNIVERSITY

INSTITUTIONAL RESEARCH COMMITTEE APPROVAL

The project titled "Evaluation And Comparison Of Flexural Strength And Marginal Fit Of Zirconia Crown Of Three Different Brands : An In Vitro Study" submitted by Dr Deeksha Postgraduate student in the Department of Prosthodontics & Crown and Bridge 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. P n t Ahuja
Chairperson

Dr. Mona Sharma
Co-Chairperson

ANNEXURE -V

INSTITUTIONAL RESEARCH COMMITTEE APPROVAL

The project titled "Evaluation And Comparison Of Flexural Strength And Marginal Fit Of Zirconia Crown Of Three Different Brands : An In Vitro Study" submitted by Dr Deeksha Postgraduate student in the Department of Prosthodontics & Crown and Bridge 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. P n t Ahuja
Chairperson

Dr. Mona Sharma
Co-Chairperson

ANNEXURE -VI

MASTER CHART

			Short sintering (**marginal gap**)				Long sintering (**marginal gap**)			
	Short cycle (Fracture resistance)	Long cycle (Fracture resistance)	BUCCAL	LINGUAL	MESIAL	DISTAL	BUCCAL	LINGUAL	MESIAL	DISTAL
Jyodent	4350.3	4452.45	49	82	91	93	68	88	84	82
Jyodent	4764.53	4581.81	56	87	96	92	54	87	84	93
Jyodent	4884.08	5045.96	59	84	87	89	70	91	75	96
Jyodent	4488.07	4574.49	59	84	87	90	63	89	73	87
Jyodent	4678.42	5010.28	48	80	87	96	69	87	89	92
Jyodent	4872.52	4518.25	59	94	86	87	61	82	87	87
Uplera	3674.24	3539.52	84	59	94	84	70	81	87	82
Uplera	3532.63	3041.69	89	87	98	87	78	84	94	77
Uplera	3656.1	2551.6	87	82	96	90	76	82	82	90
Uplera	3504.43	3418.83	85	62	95	86	71	81	90	72
Uplera	3580.26	2490.51	88	79	96	85	75	79	82	81
Uplera	3664.2	2352.42	86	80	98	89	67	83	84	95

ANNEXURES

ANNEXURE -VII

DrillBit

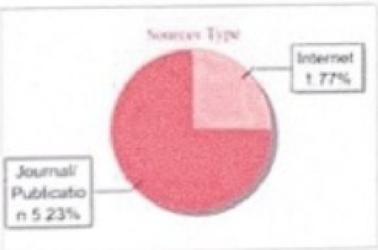
The Report is Generated by DrillBit Plagiarism Detection Software

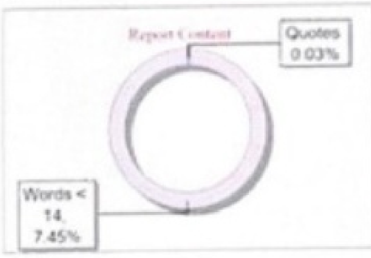
Submission Information

Author Name	DEEKSHA
Title	"EVALUATION AND COMPARISON OF FRACTURE STRENGTH AND MARGINAL FIT OF TWO INDIAN BRANDS OF ZIRCONIA"
Paper/Submission ID	1511917
Submitted by	amarpal.singh05@bbdu.ac.in
Submission Date	2024-02-29 14:21:58
Total Pages	35
Document type	Dissertation

Result Information

Similarity 7 %





Exclude Information

Quotes	Excluded
References/Bibliography	Excluded
Sources: Less than 14 Words %	Excluded
Excluded Source	0 %
Excluded Phrases	Not Excluded

Database Selection

Language	English
Student Papers	Yes
Journals & publishers	Yes
Internet or Web	Yes
Institution Repository	Yes

For Manuj 29/02/24