ORIGINAL RESEARCH

ASSESSMENT OF VERTICAL MARGINAL DISCREPANCIES OF THE ZIRCONIA BASED TOOTH SUPPORTED FIXED DENTAL PROSTHESIS FABRICATED USING CERAMILL, LAVA AND ZIRKONZAHN CAD CAM MILLING MATERIALS - AN IN VITRO STUDY.

M. Keerthna[1], Deepak Nallaswamy. V[2], S. Neeharika[3]
[1, 2, 3]Saveetha Dental College and Hospital, Chennai

ABSTRACT

Aim & Objective- All ceramic materials have been the most popular aesthetic restorations since the advancements in CAD CAM technology. Very limited evidence is available on marginal discrepancies of these materials when used to fabricate fixed restorations. The purpose of the study is to assess the vertical marginal discrepancies of the zirconia-based tooth supported fixed dental prosthesis, fabricated using ceramill® (M1), lava® (M2), and zirkonzahn® (M3) CAD-CAM milling materials.

Materials & Methods- The vertical marginal discrepancy of these three groups was assessed using the one-way ANOVA test using the statistical software. There was no statistically significant difference ($P \geq 0.05$) in the vertical marginal discrepancies measured among all three groups.

Results & Conclusion- Within the limitations, it is concluded that all the three CAD-CAM milling materials, when fabricated using a 5 axis CNC milling machine have provided a range of clinically acceptable vertical marginal discrepancy providing strong evidence towards their longevity.

KEYWORDS
Marginal discrepancy, CAD-CAM technology, zirconia materials, fixed dental prosthesis.

How To Cite This Article: M Keerthna et al,Assessment of vertical marginal discrepancies of the zirconia based tooth supported fixed dental prosthesis fabricated using ceramill, lava and zirkonzahn CAD CAM milling materials -an in vitro study. Int J ProsthoRehabil2022; 3: 1:1-7.

Received: 26-02-22; Accepted: 28-04-22; Web Published: 10-06-2022

Address of correspondence

Dr. M. Keerthna
Saveetha Dental College, Chennai

E-mail Address- drmkeerthna@gmail.com

Introduction

The introduction of machined all ceramics has been a great highlight in the field of dentistry as they respond to the patients demands for an aesthetic and a long-lasting restoration.[1] It is a combination of excellent mechanical and physical properties overcoming the limitations of metal ceramic restorations.[2] The longevity of the restorations fabricated using newer all ceramic materials depend on properties like biocompatibility, flexural strength, fracture toughness and marginal adaptation among which the latter plays a major role. Marginal fit is essential in maintaining the resistance, retention of the restorations along with the periodontal health of the abutment.[3] The clinically acceptable marginal discrepancy has been reported within a range of 50 to 200 μm.[3] With the advent of computer-aided designing and computer-aided machining (CAD CAM) technology, it has been proved that frameworks and restorations fabricated using this system have provided better adaptation [4] with an acceptable marginal discrepancy of 25 to 40 μm.[3] Also, when compared with conventional techniques which have limitations like machinery or manual errors, CAD CAM processing technique has demonstrated better adaptation as it is a computer-controlled processing.[1] Long term clinical studies have reported that 11% of abutments have developed secondary caries due to marginal inaccuracies.[5] This idea to provide a minimal space between the abutment and the restoration is to ensure an accurate positioning of the prosthesis and to provide an even layer of cementing material. Also, this reduced internal spacing may improve the mechanical behaviour of the ceramic restorations.[1] In general, marginal accuracy can be demarcated as marginal gap, vertical and horizontal marginal discrepancy.[3] A significant vertical marginal discrepancy exposes the luting agent to oral environment leading to its dissipation followed by biological and mechanical complications like bacterial infiltration into cement space, carries of abutment tooth or loss of resistance and retention of the prosthesis respectively. Whereas a horizontal marginal discrepancy affects the plaque control leading to food accumulation followed by compromised periodontal health.[6]

Scientific evidence on the quality of fit of the restoration when compared between CAD-CAM technology and traditional fabrication processes has been very minimal. Very few studies have been performed to analyse the vertical and horizontal discrepancies among various CAD-CAM milling materials used currently.[1,7,8] Hence this study aimed to assess the vertical marginal discrepancy of the zirconia-based tooth supported fixed dental prosthesis fabricated using three commercially available (Ceramill, Lava, and Zirkonzahn) CAD-CAM milling materials and to analyse which surface among them had the least vertical marginal discrepancy. The null hypothesis was that there is no difference in the marginal integrity of the zirconia crowns fabricated by the zirconia milling materials.

Materials And Methods

Study Design

This in-vitro study was designed meticulously to be carried out without any errors. The sample size was calculated using g power software.

Sample size calculation

A total of 18 three unit fixed partial denture samples (6 per machine) were estimated according to the software. The three materials used for the comparison were ceramill (M1), lava (M2) and zirkonzahn CAD CAM milling materials (M3)

Model preparation

To fabricate a three-unit fixed partial denture, a typhodont model was used to prepare the tooth. Tooth preparation was done on the lower right second premolar and second molar (first molar as edentulous area) with an occlusal reduction of 2 mm and a convergence angle of 6^0 taper which was standardized using a prefabricated index. The preparation was done according to the standard all ceramic preparation guidelines. [9] Following tooth preparation, the model was scanned using a lab scanner (MEDIT T 500, Seoul, South Korea) (Figure 1) and the data was then exported to an open STL file format collaborated into Trios-3 designing software (Figure 2). The scanned data was then opened in Trios-3® designing software which performs a guided workflow. The digital files of the designed restoration were transferred to a milling machine (Coritec 350® iiMes-iCore) for milling the pre-sintered zirconia blanks and further sintering in the furnace according to the manufacturer protocols scheduled at 1600^0 C for 480 minutes of holding time (Figure 3). The three CAD CAM milling materials included in the present study were,

M1: Ceramill ® zolidht + white zirconia disc
M2: Lava тм Ht zirconia disc
M3: ZirkonzahnPrettau ® Ht zirconia disc.

The two drill sizes used in the study for gross and fine milling were size 13 and 14 with dimensions of 2.5 mm and 1 mm respectively.

Measurement of marginal discrepancies

The vertical marginal discrepancy was measured using the magvision software and was evaluated under a binocular stereo microscope (Lawrence and Mayo India Pvt Ltd, Maharashtra, India) with a 100x magnification (Figure 4 & 5).

Statistical Analysis

Data was analysed using the statistical software package IBM SPSS 20. The vertical marginal discrepancies of three CAD CAM milling materials were assessed using the one-way ANOVA test where the significance level was set out at *P* value of 0.05. Post Hoc bonferroni multiple comparison test was used to compare the individual groups.

Results

The vertical marginal discrepancies of the three CAD-CAM milled zirconia fixed dental prosthesis was evaluated on four surfaces (buccal, lingual, mesial and distal) for each sample of all the groups. The mean vertical gaps ranged between 0.18 – 0.38 μm which is at clinically acceptable level. A descriptive analysis on all the three materials at the surface level showed that the distal surface of CAD-CAM milled zirconia based fixed dental prosthesis exhibited the least vertical discrepancy (Table 1) but with no significant difference on one-way Anova analysis (Table 2) and also in Bonferroni post hoc analysis (Table 3).

Discussion

The findings support the null hypothesis of the study, with least discrepancy on distal surface and no significant difference among the three CAD CAM milling materials when tested for vertical marginal discrepancy. With regards to statistical tests performed, the ANOVA, post hoc multiple comparison tests showed p values greater than 0.05 for all the group comparisons. The acceptable marginal gap for CAD CAM fabricated all ceramic restorations have been reported to be at a range of 23 - 74 μm [10] which was in correlation with a study conducted to compare vertical marginal discrepancy of zirconia restorations under cyclic loading and also its impact due to veneering process.[8] A study conducted to verify horizontal marginal discrepancy between lithium disilicate and zirconia crowns have proved that zirconia crowns have shown least amount of discrepancy.[7] Furthermore, few studies have proved that there is an increase in vertical marginal discrepancy on zirconia crowns when exposed to aging and thermo mechanical loading implying a need for long term in vivo studies.[2] Another demanding controversy is about the various CAD CAM fabricating systems and their influence on vertical marginal discrepancy, which was proved to be within clinical acceptable range but with a variation among the CAD CAM systems that were investigated.[6] With an influence of various factors, the measured vertical marginal discrepancy of the present study was lesser than (0.18 - 0.38 μm) the average of the previous studies creating stronger evidence towards the existence of vertical marginal discrepancies.

Factors influencing the study

The accuracy of the milling machine can normally affect the quality of the study and potentially influence the marginal fit of the samples. The milling machine utilized in our study was set according to standardized protocols in accordance with the previous studies for an optimal result. [11] In this study, we have used a 5 axis CNC milling machine for milling the three different CAD CAM zirconia blanks. This novel five axis milling machine provides a tilt angle of 30degree in the A axis and 25 degree in the B axis producing the most accurate zirconia based fixed dental prosthesis [12] supporting the methodology of our study. Various methods [13] have been used to measure the marginal discrepancyamong which stereomicroscope measures more accurately.[14] The current study has used a binocular stereo microscope with a 100x magnification and an inbuilt vertical illuminator (to minimize reporting errors). The microscope is also linked to a computer that provides explicit results in terms of measuring marginal discrepancies.[15] To sinter a milled crown the ideal time required is 9 hours.[16] Similarly, in this study all the pre-sintered samples milled from the three different CAD CAM materials were sintered for a period of 8 hours in the sintering furnace preventing any possible mechanical complications post sintering. Few studies have reported that post sintered milling has proved to be more acceptable for

complex frameworks, long span bridges etc as there is limited chances of firing shrinkage, but due to the hardness of post sintered zirconia blank, the milling time may be longer with an increase in wear of the milling tools.[5] In this study pre sintered stage zirconia blanks have been used as they shrink less with minimal distortion post sintering.[17] At times the armamentarium used for the process of milling may have an influence on the precision of the prosthesis. The milling machine used in the study allows five-axis milling and the milling burs used are new to avoid any possibilities of wearing out. The digital workflow of any CAD-CAM system generally begins with the use of 3D scanners followed by the designing software which are standardized for their accuracy according to the manufacturer. [18] The scanners with blue light laser technology have an advantage of longer shelf life, cooler operating temperature and a higher resistance to the other light sources in the room. This study has used a Medit T® 500 lab Scanner which employs the blue LED laser light and uses an advanced new camera system of dual 2.0MP resolution offering quick scanning and exceptional scan data quality [18] suggesting that any of the above factors may have zero to minimal influence on the results of the current study.

Limitations

The limitations of the study would be

- The results may vary when checked in an intraoral environment.
- Need to analyse the horizontal marginal discrepancy, absolute marginal discrepancy and internal fit for a complete evaluation on marginal discrepancy.
- Various other CAD CAM milling machines and fabricating systems can be tested.
- No conclusive data to justify the differences in vertical marginal discrepancies at surface level.

Areas of future scope

Long term randomized control clinical trials may be required for further research regarding the various milling machines including complex frameworks or long span bridges.

Conclusion

Within the limitations, it has been concluded that the least discrepancy was found on distal surface but with no significant difference between the vertical marginal discrepancies of tooth supported FPDs fabricated by ceramill, lava and zirkonzahn CAD CAM milling materials. Hence the study implies that these three tested CAD CAM milling materials fabricated using a 5 axis CNC milling machine have provided restorations with clinically acceptable vertical marginal discrepancies.

Author Contribution:

Dr. M Keerthna: Data curation, Investigation, Original draft preparation, Software.
Dr. Deepak Nallaswamy: Conceptualization, Reviewing, Supervision.
Dr. S. Neeharika: Visualization, Writing, Validation.

Acknowledgement:

The study was approved by the scientific review board of the university, Saveetha institute of medical and technical sciences (SIMATS), Chennai (Reference No. SRB / SDMS 03 / 18 / PRS /16). We thank Dr. Marian Anand Bennis for his help throughout the course of this work. All involved authors make no further acknowledgements.

Conflict Of Interest: None

Source of Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors

References

[1]. Boitelle P, Mawussi B, Tapie L, Fromentin O. A systematic review of CAD/CAM fit restoration evaluations. Journal of oral rehabilitation. 2014 Nov;41(11):853-74.
[2]. El-Dessouky RA, Salama MM, Shakal MA, Korsel AM. Marginal adaptation of CAD/CAM zirconia-based crown during fabrication steps. Tanta dental journal. 2015 Jun 1;12(2):81-8.
[3]. Papadiochou S, Pissiotis AL. Marginal adaptation and CAD-CAM technology: A systematic review of restorative material and fabrication techniques. The Journal of prosthetic dentistry. 2018 Apr 1;119(4):545-51
[4]. Savencu CE, Șerban C, Porojan L. Adaptability Evaluation of Metal-Ceramic Crowns Obtained by Additive and Subtractive Technologies. Applied Sciences. 2020 Jan;10(16):5563.
[5]. Triwatana P, Nagaviroj N, Tulapornchai C. Clinical performance and failures of zirconia-based fixed partial dentures: a review literature. The journal of advanced prosthodontics. 2012 May 1;4(2):76-83.
[6]. Habib SR. Digital microscopic evaluation of vertical marginal discrepancies of CAD/CAM fabricated zirconia cores. Biomedical Engineering/Biomedizinische Technik. 2019 Apr 1;64(2):207-14.
[7]. Batson ER, Cooper LF, Duqum I, Mendonça G. Clinical outcomes of three different crown systems with CAD/CAM technology. The Journal of prosthetic dentistry. 2014 Oct 1;112(4):770-7.
[8]. Zaghloul H. Vertical marginal discrepancy and microleakage of alternative veneering techniques of CAD/CAM zirconia based ceramic crowns. Egyptian dental journal 2012; 58: 3399-409.
[9]. Shillingburg HT, Hobo S. Fundamentals of Fixed Prosthodontics, https://books.google.com/books/about/Fundamentals_of_Fixed_Prosthodontics.html?hl=&id=vVxqAAAAMAAJ (1981).
[10]. Kokubo Y, Ohkubo C, Tsumita M, Miyashita A, Vult von Steyern P, Fukushima S. Clinical marginal and internal gaps of ProceraAllCeram crowns. J Oral Rehabil. 2005 Jul;32(7):526-30.
[11]. Blatz MB, Conejo J. The current state of chairside digital dentistry and materials. Dental Clinics. 2019 Apr 1;63(2):175-97..
[12]. Ohkuma K, Kameda T, Terada K. Five-axis laser milling system that realizes more accurate zirconia CAD/CAM crowns by direct milling from fully sintered blocks. Dental materials journal. 2019 Jan 28;38(1):52-60.
[13] Sannino G, Gloria F, Schiavetti R, Ottria L, Barlattani

A. Dental Wings CAD/CAM system precision: an internal and marginal fit sperimental analisys. Oral & implantology. 2009 Jul;2(3):11.
[14]. Russo LL, Caradonna G, Biancardino M, De Lillo A, Troiano G, Guida L. Digital versus conventional workflow for the fabrication of multiunit fixed prostheses: A systematic review and meta-analysis of vertical marginal fit in controlled in vitro studies. The Journal of prosthetic dentistry. 2019 Nov 1;122(5):435-40.
[15]. Winter RR, Cornell DF, Vingoren GJ, Patrick RB. Use of magnification in dental technology. Journal of Esthetic and Restorative Dentistry: Official Publication of the American Academy of Esthetic Dentistry.[et al.]. 2003 Jan 1;15(7):409-15.
[16]. Bousnaki M, Chatziparaskeva M, Bakopoulou A, Pissiotis A, Koidis P. Variables affecting the fit of zirconia fixed partial dentures: A systematic review. The Journal of Prosthetic Dentistry. 2020 May 1;123(5):686-92.
[17]. Tinschert J, Natt G, Mautsch W, Augthun M, Spiekermann H. Fracture Resistance of Lithium Disilicate--, Alumina-, and Zirconia-Based Three-Unit Fixed Partial Dentures: A Laboratory Study. International Journal of Prosthodontics. 2001 May 1;14(3).
[18]. Kang BH, Son K, Lee KB. Accuracy of five intraoral scanners and two laboratory scanners for a complete arch: A comparative in vitro study. Applied Sciences. 2019 Dec 20;10(1):74.

TABLES

Table 1: Table showing the descriptive analysis of all the three materials at the level of surface.

	N	**Minimum (values in µm)**	**Maximum values in µm**	**Mean (values in µm)**	**Standard Deviation (Values in µm)**
Buccal	36	.05	.41	.2208	.09194
Lingual	36	.09	.68	.2733	.13143
Mesial	36	.11	.80	.3897	.24418
Distal	36	.06	.49	**.1881**	.09939

Table 2: Table showing mean difference in the sum of square roots between the buccal, lingual, mesial and distal surfaces of the three CAD CAM milling material groups using one way ANOVA analysis with no statistically significant difference ($p<0.05$)

		Sum of squares	**Df values**	**Mean Square values**	**F values**	**Significance**
Buccal	Between groups	.009	2	.005	.531	.593
	Within groups	.287	33	.009		
	Total	.296	35			

Lingual	Between groups Within groups **Total**	.006 .598 .605	2 33 35	.003 .018	.171	.844
Mesial	Between groups Within groups **Total**	.024 2.063 2.087	2 33 35	0.012 0.063	.191	.827
Distal	Between groups Within groups **Total**	.034 .311 .346	2 33 35	.017 .009	1.825	.177

Table 3: Bonferroni post hoc analysis comparing the mean difference in the buccal, lingual, mesial and distal surfaces among the 3 groups.

	Material (I)	**Material (J)**	**Mean Difference (I - J)**	**Std. Error**	**Sig.**
Buccal	Ceramill	Lava Zirkonzahn	.02083 -.01833	.03805 .03805	1.000 1.000
	Lava	Ceramill Zirkonzahn	-.02083 -.3917	.03805 .03805	1.000 .932
	Zirkonzahn	Ceramill Lava	.01833 .03917	.03805 .03805	1.000 .932

Lingual	Ceramill	Lava	.00500	.05497	1.000
		Zirkonzahn	-.02500	.05497	1.000
	Lava	Ceramill	-.00500	.05497	1.000
		Zirkonzahn	-.03000	.05497	1.000
	Zirkonzahn	Ceramill	.02500	.05497	1.000
		Lava	.03000	.05497	1.000
Mesial	Ceramill	Lava	.03833	.10208	1.000
		Zirkonzahn	.06250	.10208	1.000
	Lava	Ceramill	-.03833	.10208	1.000
		Zirkonzahn	.02417	.10208	1.000
	Zirkonzahn	Ceramill	-.06250	.10208	1.000
		Lava	-.02417	.10208	1.000
Distal	Ceramill	Lava	.00583	.03965	1.000
		Zirkonzahn	.06250	.03965	.374
	Lava	Ceramill	-.00583	.03965	1.000
		Zirkonzahn	.-06833	.03965	.283
	Zirkonzahn	Ceramill	.06250	.03965	.374
		Lava	.06833	.03965	.283

FIGURE LEGENDS

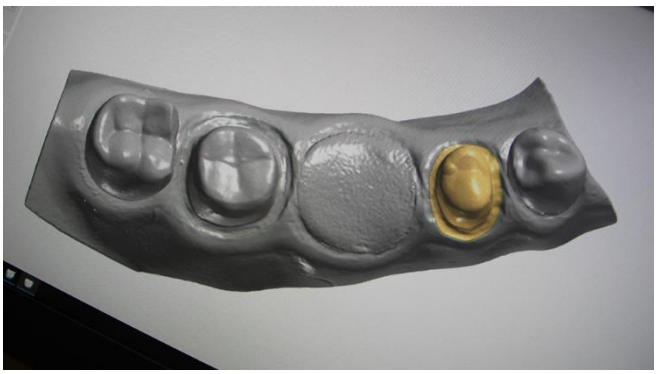

Figure 1: Typhodont models scanned after tooth preparation.

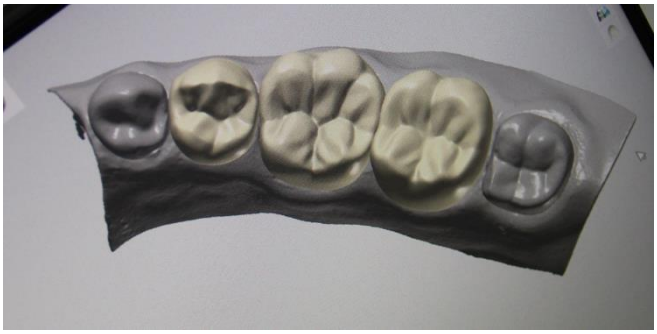

Figure 2: Fixed prosthesis after designing.

Figure 3: CAD CAM fixed prosthesis after milling.

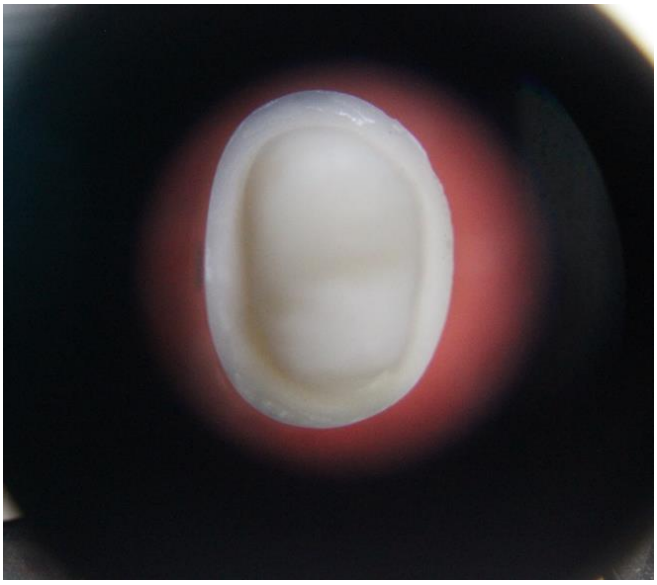

Figure 4: Examination of the finish lined under binocular stereomicroscope.

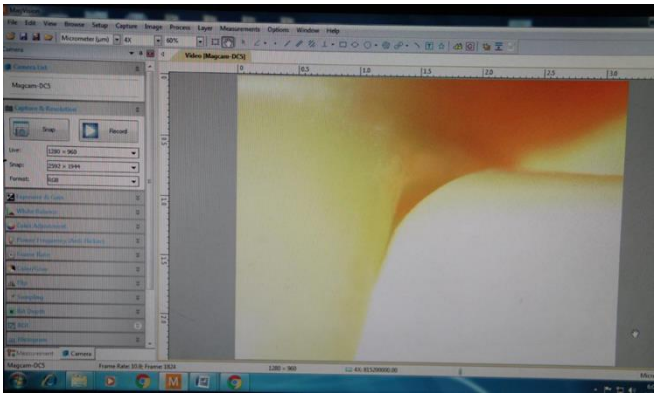

Figure 5: Measurement of vertical marginal discrepancy under stereomicroscope using magvision software,