Journal of Applied Dental and Medical Sciences
NLM ID: 101671413 ISSN:2454-2288
Volume 2 Issue3 July- September 2016

Meta -Analysis

Marginal Discrepancy of All Ceramic Complete Veneers Processed From Cad-Cam And Conventional Processing Technique – Sytematic Review And Meta-Analysis

Vikas Punia [1], Vivek Sharma [2], Meenakshi Khandelwal [3], Sandhya Kapoor Punia [4]

[1] Ph.D. Scholar, Faculty of Dental Sciences, Pacific Academy of Higher Education and Research University, Udaipur(Raj.)
[2] Professor & Head, Department of Prosthodontics, Darshan Dental College & Hospital, Loyara, Udaipur (Raj.)
[3] Professor, Department of Prosthodontics, Darshan Dental College & Hospital, Loyara, Udaipur (Raj.)
[4] Reader, Department of Conservative & Endodontics, Darshan Dental College & Hospital, Loyara, Udaipur (Raj.)

ARTICLE INFO

Keywords:
CAD/CAM techniques, Ceramic veneers, Marginal discrepancy

ABSTRACT

Statement of problem: Various studies has been conducted to evaluate and compare the accuracy of marginal fit by digital Cad-Cam Technique and Conventional Lost wax technique. But the result varied in each studies. Hence to determine the best of either there is a need for evidence based report.

Purpose: To systematic review and meta-analysis was to compare the marginal discrepancy induced by CAD/CAM technique and conventional ceramic processing techniques in all ceramic complete veneer

Material and method: A search strategy was completed using PubMed, Science Direct, Ebsco-host, Google Scholar, CENTRAL (Cochrane Central Register of Controlled Trials) based on a Population, Intervention, Comparison, and Outcome (PICO) framework using suitable keywords. The studies were screened and independently reviewed by two researchers against predetermined criteria for eligibility. As a result of this screening studies were included for meta-analysis. For the statistical analysis, the mean marginal fit values of each study were extracted and categorized according to the technique of All Ceramic copping fabrication and then meta-analysis were performed.

Result: Ten studies were included in the meta-analysis from the 157 identified records after database searching. A random effect model and fixed effect model was used for analysis. The results for marginal discrepancy demonstrate statistically significant heterogeneity with Q = 43.637 and d.f. = 9, which gives a p-value < 0.0001. For fixed effect model the estimated MD = 0.111 and the 95% CI is [0.174; 0.609] .From the random- effects model, the estimated MD = -0.264 and the 95% CI is [-0.197; 0.836] which indicates a statistically significant difference between the conventional lost wax technique and digital CAD CAM technique in terms of absolute marginal discrepancy.the result showed that the Digital technique of fabricating All ceramic fixed prosthesis can significantly reduce the absolute marginal discrepancy when compared with the conventional lost wax technique.

Conclusion: A significant reduction in absolute marginal discrepancy was observed with digital CAD CAM technique for fabrication of All-ceramic fixed prosthesis when compared with the marginal discrepancy. Though all the values extracted from various studies were under the clinical acceptable range of marginal discrepancy.

Introduction

The amount of the marginal discrepancy between a restoration and tooth preparation is an plays a major role in determining the life of a ceramic fixed prosthesis. Marginal discrepancy can lead to ceramic fracture, plaque retention, micro leakage, carious lesion, periodontal pathology and can ultimately lead to failure of the prosthesis by minimizing it's clinical life.1-7 Hence precise marginal adaptation an key to success by reducing the risk factors and hence increasing the clinical life of the prosthesis. The adaptation of a restoration is determined by measurements of its marginal and internal gaps, which are important factors for the long-term clinical success of restorations. An ideal internal adaptation improves the mechanical properties, such as retention, strength, and resistance.8 McLean et al showed that crown marginal discrepancies ranging up to 120 μm were

* Corresponding author: Dr. Vikas Punia, Ph.D. Scholar, Faculty of Dental Sciences, Pacific Academy of Higher Education and Research University, Udaipur (Raj.)

clinically acceptable.9 There is no consensus in literature on the limits of clini¬cally acceptable marginal adaptation, some support a value lower or equal to 120 μm, others concluded that it should be lower than 100 μm10 and there are still those who argue for a maladjustment lower than 75 μm or between 20-45 μm11, however, these last ones are rarely found in clinic.12

Dental computer-aided design and computer-aided manufacturing (CAD-CAM) systems are now commonly used in dental offices and are highly sophisticated, allowing marginal discrepancy measurements. These digital techniques afford several advantages in the dental practice The adaptation of restorations may be improved by combining intraoral scanning and digital milling. Furthermore, CAD/CAM technology enables the use of a wide range of esthetic dental materials to restore both anterior and posterior teeth. The adaptation of conventionally-fabricated all-ceramic restorations in the laboratory is a sensitive technique that may be affected by several factors such as the impression material and technique, disinfection, the storage time and conditions of the impression before pouring the stone cast, application of the die spacer, and the investment and casting or pressing process.8 There are also inherent factors affecting the adaptation of milled restorations: the accuracy of the scanner, the software design, spacer setting, the precision of the milling unit, and the properties of milled material in CAD/CAM technology However, recent CAD/CAM systems use highly accurate scanners, advanced software, and precise milling devices with advanced technology. The accuracies of scanners and precision of milling devices have been confirmed by recent studies. Therefore, restorative material properties have gained interest for the accuracy of the CAD/CAM fabrication process. A wide range of esthetic CAD/CAM ceramic materials has recently been introduced ranging from relatively weak feldspathic and leucite-reinforced glass ceramics to high-strength lithium disilicate glass ceramics, zirconia, and new hybrid ceramics.

The conventional method requires the meticulous securing of a negative replica of the dentition with a stable recording medium, for example, an elastomeric impression material, to minimize errors in crown fabrication. Transporting the impression to a commercial dental laboratory subjects an impression to significant variation in temperature, which has been shown to result in a 1- to 18-micrometer dimensional change when temperatures vary from 4 degree C to 40 degree C. Moreover, the length of time between securing an impression and the pouring of the stone cast, the ambient temperature, the surface wettability of the gypsum product, and disinfection may result in additional distortion. The application of a die hardener and die spacer, the fabrication of a wax pattern of the intended crown, and the investment and casting or pressing process may also induce error. Margin inaccuracy could lead to the accumulation of dental plaque, the dissolution of luting material, and/or the inflammation of the periodontium. The marginal fit of cemented restorations ranges from 25 to 40 mm, with some researchers suggesting that a marginal opening of_120 mm is clinically acceptable. Little evidence is available with regard to the marginal fit afforded by the latest digital method in comparison with the conventional method.13

MATERIAL AND METHOD:

This review was based on the PRISMA guidelines (Table 1)

1.1.1. PICOS	
1.1.2. P: Participants *1.1.3.*	*1.1.4. All Ceramic copings*
1.1.5. I: Interventions *1.1.6.*	*1.1.7. Different manufacturing techniques*
1.1.8. C: Comparison *1.1.9.*	*1.1.10. CAD CAM technique and conventional technique*
1.1.11. O: Outcomes *1.1.12.*	*1.1.13. Marginal discrepancy*
1.1.14. S: Study Design *1.1.15.*	*1.1.16. Networking Meta-Analysis*

Table 1: PICOS search strategy

Search strategy:

All literature that investigated the marginal accuracy of All Ceramic opping using Cad/Cam and the conventional techniques were included in Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines with a predetermined search strategy. The search strategy was based on a Population, Intervention, Comparison, Outcome and Study design (PICOS) framework and included an electronic search of studies published in PubMed (www.ncbi.nlm.nih.gov./entrez/query.fcgi), Science Direct (www.sciencedirect.com), Google Scholar (http://scholar.google.com), CENTRAL (Cochrane Central Register of Controlled trials, (http://www.mrw.interscience.wiley.com/cochrane/cochrane_clcentral_articles_fs.htm) and Ebsco-host till 2014. Search terms were a combination of the appropriate Medical Subject Headings (MeSH) terms and free-text words in simple or multiple conjunctions and were grouped into PICOS.

The search methodology applied was a combination of MESH terms and keywords included are, Metal ceramic crowns, All ceramic crowns, Porcelain fused

metal crowns, Zirconia crowns, Marginal accuracy of metal ceramic crowns, Marginal accuracy of all ceramic crowns, Marginal accuracy of porcelain fused crowns, Marginal accuracy of zirconia crowns, Marginal fit of all ceramic crowns,Marginal fit of acrylic crowns, Marginal fit of zirconia crowns,Marginal fit of porcelain fused crowns, Marginal discrepancy of metal ceramic crowns.Marginal discrepancy of all ceramic crowns, Marginal discrepancy of porcelain fused crowns, Marginal discrepancy of zirconia crowns, All ceramic restorations, All ceramic veneers, All ceramic fixed partial denture, All ceramic crowns, Metal free crowns, All ceramic bridges. Alumina crowns, Zirconia crowns,Lithium disilicate crowns, Dicor crowns, Cerestore crowns,,Emax press crowns, Empress crowns, CAD/CAM TECHNIQUE, CAD/CAM crowns, Copymilling technique, Sintered crowns, Luting agents, Luting ceramic crowns, CAD/CAM. Heat pressing, Copy milling, Slip casting, Marginal exposure, Secondary caries.

Review articles as well as references from the different studies were also used to identify the relevant articles. Further the manual search was conducted and additional articles could not be identified.

Inclusion and exclusion criteria:

Two reviewers read the titles and abstracts of the studies independently to decide whether the studies met the inclusion criteria. Full articles were examined if necessary. Any disagreement between the reviewers was resolved by an interviewer consensus with a third reviewer

Inclusion criteria:

- It should be an original study
- It should be a complete study
- Study should be on All Ceramic complete veneers.
- Study must include comparison of both techniques.

Exclusion criteria:

- Review articles
- Incomplete studies
- Studies between same techniques.
- Finite element analysis studies.
- Case reports and case series.
- Porcelain labial margins.
- Marginal discrepancy in porcelain fused metal restorations.
- Marginal discrepancy with partial veneer retainers.
- Marginal discrepancy with labial veneers.
- Porcelain repair systems creating marginal discrepancy.

RESULT:

A total of 157 records were identified through database searching (Pub Med, Ebsco-Host, and Google scholar) out of which 83 records excluded as either they were irrelevant or data was unavailable or due repetition. Remaining 74 full text articles were assessed for eligibility out of which 58 articles were excluded due to either of the reasons: comparison between digital techniques, comparison between conventional techniques, case reports and/or case history, finite

element studies, comparison between all ceramic and metal ceramic restorations, studies using Porcelain labial margins, studies on labial veneers or partial veneer, porcelain repair systems creating marginal discrepancy. Of the 16 full text articles selected for marginal discrepancy of all ceramic fixed prosthesis 6 full-text articles were excluded with reasons: absolute marginal discrepancy was not mentioned, standard deviation was not mentioned, studies comparing values after application of luting agents. Thus 10 studies were included in the present meta-analysis.

Figure 1 shows the flowchart of the same.

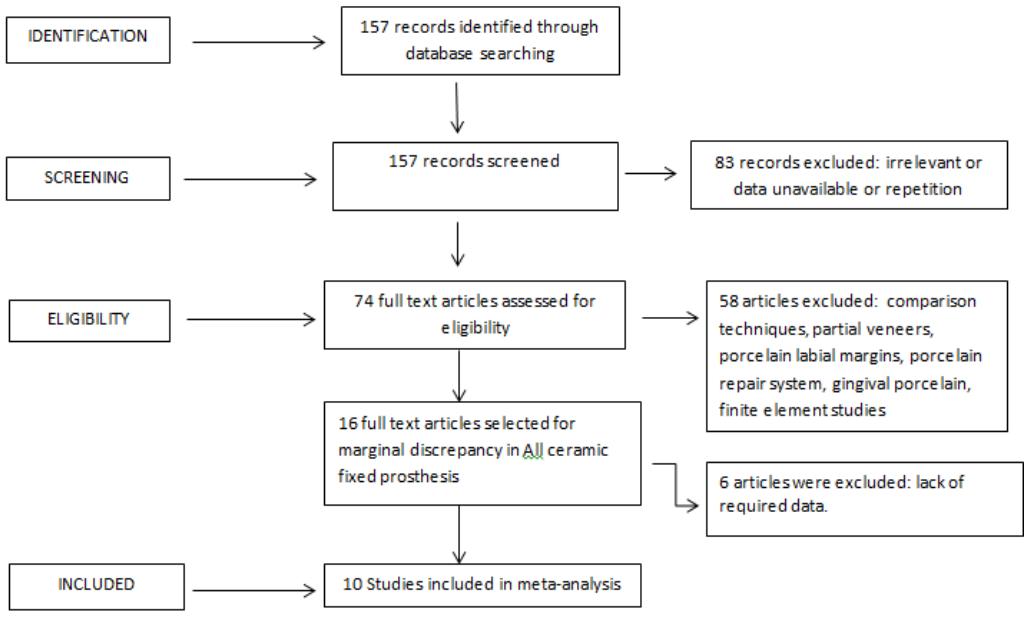


Figure 1: Search strategy based on inclusion and exclusion criteria

META-ANALYSIS:

The meta-analysis was performed on the selected 10 studies[12-21] on marginal discrepancy comparing the absolute marginal discrepancy found in all ceramic fixed prosthesis when either of the fabrication technique is used i.e. digital CAD-CAM technique or conventional lost wax technique. The data was extracted and tabulated as shown in the following table 2.

A random effect model and fixed effect model was used for analysis. The results for marginal discrepancy demonstrate statistically significant heterogeneity with Q = 43.637 and d.f. = 9, which gives a p-value < 0.0001. For fixed effect model the estimated MD = 0.111 and the 95% CI is [0.174; 0.609] .From the random- effects model, the estimated MD = -0.264 and the 95% CI is [-0.197; 0.836] which indicates a statistically significant difference between the conventional lost wax technique and digital CAD CAM technique in terms of absolute marginal discrepancy. The result showed that the Digital technique of fabricating All ceramic fixed prosthesis can significantly reduce the absolute marginal

discrepancy when compared with the conventional lost wax technique. The forest plot was drawn as shown in figure 2.

DISCUSSION

Marginal fit is a key criteria used in the clinical evaluation of fixed restorations. The importance of marginal fit for clinical success of ceramic complete coverage restorations has been reported in several clinical trials.[16]The size of the marginal discrepancy between a restoration and tooth preparation is an important predictor of future ceramic fracture, periodontal health, plaque retention, caries, pulpal pathology, and bone resorption.[21] Precise marginal adaptation is essential to ensure long-term prosthetic success. Absolute marginal discrepancy is the result of many combinations between horizontal and vertical discrepancies in 3 dimensions. Heavy chamfers and rounded shoulder finish lines have been advocated for all-ceramic crowns. There are all-ceramic systems that generate ceramic copings using either the lost wax technique (IPS Empress; Ivoclar Vivadent, Schaan, Liechtenstein), the slip casting method (InCeram; Vita Zahnfabrik, Bad Sackingen, Germany) or by machining densely sintered alumina (Procera; Nobel Biocare, Gothenburg, Sweden). [22]

The demand for esthetic dental restorations with good biocompatibility has made ceramic crowns a popular form of metal-free restorations. Well-made ceramic restorations can be indistinguishable from unrestored natural teeth. Over the years, several ceramic systems have been developed and introduced, using various materials and techniques for crown fabrication.Two areas of concern have been fracture strength and marginal fit[16] All-ceramic crowns can be fabricated through computer aided design/computer aided manufacturing (CAD/CAM) or can be heat-pressed (HP). The HP technique is based on the lost-wax principle. Prefabricated ceramic ingots are heated and then pressed into the lost-wax form of a crown coping. Dental CAD/CAM systems such as CEREC (Sirona Dental, Charlotte, NC, USA) use a scanning and milling process to fabricate all-ceramic copings from prefabricated ceramic blocks.[19]

Computer-aided design (CAD) and computer-aided manufacturing (CAM) have been popular in recent years. These digital techniques afford several advantages in the dental practice. Capturing images of prepared, adjacent, and opposing teeth, which is the first step in the CAD/CAM process, eliminates the need for making an impression using elastomeric impression material. Therefore, concerns about the dimensional stability of impression materials and the pouring of stone cast can be eliminated, and the impression process can be significantly simplified. The design and milling stages of the CAD/CAM process would decrease manufacturing costs by reducing the time spent in the laboratory by technicians and allowing clinicians to fabricate chair-side restorations. Milling the restoration from an industrially sintered ceramic block with a very homogenous structure improves the quality of the material compared with conventional ceramic processing techniques. The adaptation of restorations may be improved by combining intraoral scanning and digital milling. Furthermore, CAD/CAM technology enables the use of a wide range of esthetic dental materials to restore both anterior and posterior teeth.[8]
The adaptation of conventionally-fabricated all-ceramic restorations in the laboratory is a sensitive technique that may be affected by several factors such

as the impression material and technique, disinfection, the storage time and conditions of the impression before pouring the stone cast, application of the die spacer, and the investment and casting or pressing process. There are also inherent factors affecting the adaptation of milled restorations: the accuracy of the scanner, the software design, spacer setting, the precision of the milling unit, and the properties of milled material in CAD/CAM technology. However, recent CAD/CAM systems use highly accurate scanners, advanced software, and precise milling devices with advanced technology. The accuracies of scanners and precision of milling devices have been confirmed by recent studies. Therefore, restorative material properties have gained interest for the accuracy of the CAD/CAM fabrication process.[8]

With CAD-CAM production of crowns, the cement space is typically set in the software to 50 mm, as 30 to 50 mm has been found to deliver the best marginal fit. However, Beschnidt and Strub demonstrated that the evaluation of the marginal adaptation of restorations depends on factors such as the type of die material used during marginal fit evaluations, whether the specimens were cemented, the effects of aging procedures, the type of microscope, and the location and quantity used for measurements. The factors that have been documented to influence the marginal fit of a dental restoration are the preparation design, location of the preparation finish line (subgingival or supragingival), restorative material, fabrication method, and impression material and technique. McLean and von Fraunhofer stated that a restoration is considered clinically successful when the marginal discrepancy and the luting space are less than

120 mm, a range that has been considered clinically acceptable.[21]

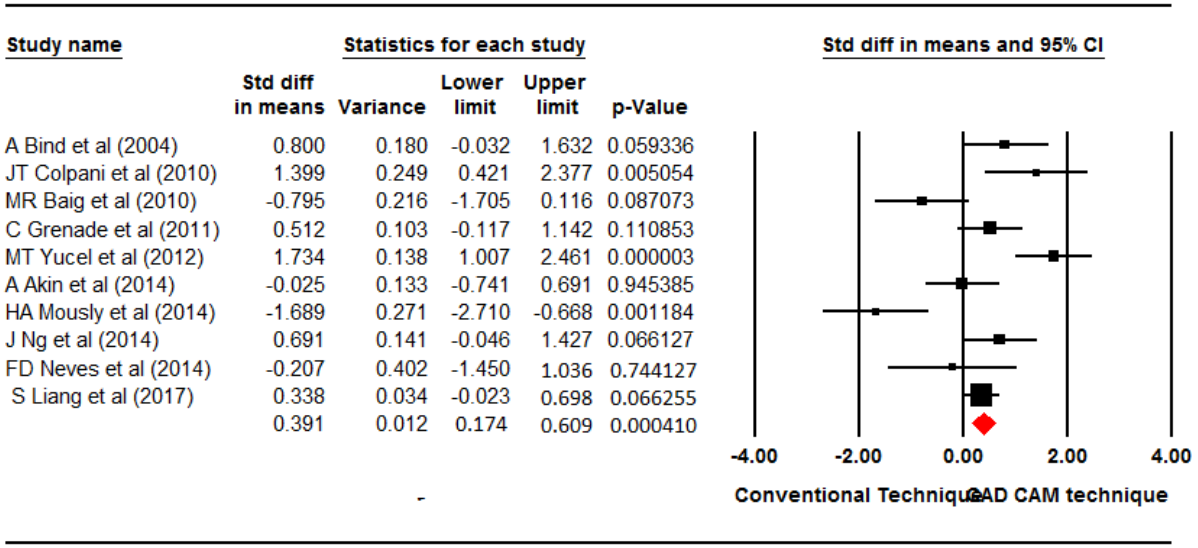
The digital method improves the quantitative evaluation accuracy for absolute marginal discrepancy and can evaluate the quality of the prosthesis objectively and accurately. However, the method involves many interactive operations, making it difficult for dentists. It may be not clinically feasible for each restoration. In the future, the process should be simplified and the evaluation function improved to establish an automatic evaluation method.[21]

CONCLUSION:

A significant reduction in absolute marginal discrepancy was observed with digital CAD CAM technique for fabrication of All-ceramic fixed prosthesis when compared with the conventional lost wax technique. Apart from the fabrication technique various other factors also affect the marginal discrepancy like impression technique, thickness of die spacer, type of finish line and type of luting agent. Hence more studies are required to determine the best possible combination for reducing the marginal discrepancy. Although all the values extracted from various studies were under the clinical acceptable range of marginal discrepancy and hence will not significantly affect the clinical life of prosthesis.

1.1.17. r. No.	*1.1.18. Study*	*1.1.19. Sample Size (Conventional Technique)*	*1.1.20. MD Conventional (mean)*	*1.1.21. MD Conventional (SD)*	*1.1.22. sample size (CAD-CAM technique)*	*1.1.23. MD CAD-CAM (mean)*	*1.1.24. MD CAD-CAM (SD)*
1.1.25.	*1.1.26. A Bind et al (2004)[14]*	*1.1.27. 12*	*1.1.28. 44 µm*	*1.1.29. 33*	*1.1.30. 12*	*1.1.31. 23 µm*	*1.1.32. 17*
1.1.33.	*1.1.34. JT Colpani et al (2010)[15]*	*1.1.35. 10*	*1.1.36. 35.6 µm*	*1.1.37. 7.3*	*1.1.38. 10*	*1.1.39. 25.8 µm*	*1.1.40. 6.7*
1.1.41.	*1.1.42. MR Baig et al (2010)[16]*	*1.1.43. 10*	*1.1.44. 36.6 µm*	*1.1.45. 32.1*	*1.1.46. 10*	*1.1.47. 66.4 µm*	*1.1.48. 42.2*
1.1.49.	*1.1.50. C Grenade et al (2011)[17]*	*1.1.51. 20*	*1.1.52. 81 µm*	*1.1.53. 66*	*1.1.54. 20*	*1.1.55. 51 µm*	*1.1.56. 50*
1.1.57.	*1.1.58. MT Yucel et al (2012)[18]*	*1.1.59. 20*	*1.1.60. 29.3 µm*	*1.1.61. 5.1*	*1.1.62. 20*	*1.1.63. 21.5 µm*	*1.1.64. 3.8*
1.1.65.	*1.1.66. A Akin et al (2014)[19]*	*1.1.67. 15*	*1.1.68. 130.2 µm*	*1.1.69. 71*	*1.1.70. 15*	*1.1.71. 132.2 µm*	*1.1.72. 88*
1.1.73.	*1.1.74. HA Mously et al (2014)[20]*	*1.1.75. 10*	*1.1.76. 41.05 µm*	*1.1.77. 11.16*	*1.1.78. 10*	*1.1.79. 100.92 µm*	*1.1.80. 48.87*
1.1.81.	*1.1.82. J Ng et al (2014)[13]*	*1.1.83. 15*	*1.1.84. 74 µm*	*1.1.85. 47*	*1.1.86. 15*	*1.1.87. 48 µm*	*1.1.88. 25*
1.1.89.	*1.1.90. FD Neves et al (2014)[12]*	*1.1.91. 5*	*1.1.92. 36.8 µm*	*1.1.93. 13.9*	*1.1.94. 5*	*1.1.95. 39.2 µm*	*1.1.96. 8.7*
1.1.97.0	*1.1.98. S Liang et al (2017)[21]*	*1.1.99. 60*	*1.1.100. 115 µm*	*1.1.101. 15.2*	*1.1.102. 60*	*1.1.103. 110 µm*	*1.1.104. 14.4*

Table 2: Comparison of mean values of conventional lost wax technique and digital CAD-CAM technique for absolute marginal discrepancy.



Meta Analysis

Model	Effect size and 95% confidence interval						Test of null (2-Tail)		Heterogeneity				Tau-squared			
Model	Number Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed	10	0.391	0.111	0.012	0.174	0.609	3.533	0.000	43.637	9	0.000	79.375	0.520	0.355	0.126	0.721
Random	10	0.319	0.264	0.069	-0.197	0.836	1.211	0.226								

Figure 2: Forest plot for comparison of absolute marginal discrepancy between conventional lost wax technique and digital CAD-CAM technique for fabrication of all ceramic fixed prosthesis.

REFERENCES:

1. Felton DA, Kanoy BE, Bayne SC, Wirthman GP. Effect of in vivo crown margin discrepancies on periodontal health.J Prosthet Dent 1991;65:357-64.

2. Hamza TA, Ezzat HA, El-Hossary MM, Katamish HA, Shokry TE, Rosenstiel SF. Accuracy of ceramic restorations made withtwo CAD/CAM systems. J Prosthet Dent 2013;109:83-7.

3. Beschnidt SM, Strub JR. Evaluation of the marginal accuracy of different all-ceramic crown systems after simulation in the artificial mouth. J Oral Rehabil 1999; 26:582-93.

4. Beuer F, Neumeier P, Naumann M. Marginal fit of 14-unit zirconia fixed dental prosthesis retainers. J Oral Rehabil 2009;36:142-9.

5. Gonzalo E, Suárez MJ, Serrano B, Lozano JF. Comparative analysis of two measurement methods for marginal fit in metal-ceramic and zirconia posterior FPDs. Int J Prosthodont 2009;22:374-7.

6. Groten MS, Girthofer S, Probster L. Marginal fit consistency of copy-milled all- ceramic crowns during fabrication by light and scanning electron microscopic analysis in vitro. J Oral Rehabil 1997;24:871-81.

7. Euan R, Figueras-Alvarez O, Cabratosa- Termes J, Oliver-Parra R. Marginal adaptation of zirconium dioxide copings: influence of the CAD/CAM system and the finish line design. J Prosthet Dent 2014; 112:155-162.

8. Gungor MB, Dogan A, Bal BT, Nemli SK. Evaluation of marginal and internal adaptations of posterior all-ceramic crowns fabricated with chair-side CAD/CAM system**:** an in vitro study**.** Acta Odontol Turc 2015;35(1):1-8.

9. McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an in vivo technique. Br Dent J 1971;131:107-11.

10. Keshvad A, Hooshmand T, Asefzadeh F, Khalilinejad F, Alihemmati M, Van Noort R. Marginal gap, internal fit, and fracture load of leucite-reinforced ceramic inlays fabricated by CEREC inLab and hot-pressed techniques. J Prosthodont 2011;20:535-40.

11. Council adopts American Dental Association Specification No. 8 (dental zinc phosphate cement) and 11 (agar impression material). Council on Dental Materials and Devices.J Am Dent Assoc 1967;74:1565-73.

12. Neves FD, Prado CI, Prudente MS, Carneiro TA, Zancopé K, Davi LR et al. Micro-computed tomography evaluation of marginal fit of lithium disilicate crowns fabricated by using chairside CAD/CAM systems or the heat-pressing technique. J Prosthet Dent 2014;112:1134-40.

13.Ng J, Ruse D, Wyatt C. A comparison of the marginal fit of crowns fabricated with digital and conventional methods. J Prosthet Dent 2014;112:555-60.

14.Bindl A & Mormann WH. Marginal and internal fit of all-ceramic CAD/CAM crown copings on chamfer preparations. J of Oral Rehabil 2005;32: 441–447.

15. Colpani JT, Borba M, Bona AD**.** Evaluation of marginal and internal fit of ceramic crown copings. Dent Mater 2013; 29: 174–180.

16. Baig MR, Tan KB, Nicholls JI**.** Evaluation of the marginal fit of a zirconia ceramic computer-aided machined (CAM) crown system. J Prosthet Dent 2010;104:216-227.

17. Grenade C, Mainjot A, Vanheusden A**.** Fit of single tooth zirconia copings: comparison between various manufacturing processes. J Prosthet Dent 2011;105:249-255.

18. Yucel MT, Aykent F, Avunduk MC. In vitro evaluation of the marginal fit of different all-ceramic crowns. Rev Bras Odontol. 2014;74(3):229-31.

19. Akın A, Toksavul S, Toman M. Clinical Marginal and Internal Adaptation of Maxillary Anterior Single All-Ceramic Crowns and 2-year Randomized Controlled Clinical Trial**.** J of Prosthodont 2014; 12:1–6.

20. Mously HA, Finkelman M, Zandparsa R, Hirayama H. Marginal and internal adaptation of ceramic crown restorations fabricated with CAD/CAM technology and the heat-press technique. J Prosthet Dent 2014;112:249-256.

21. Quintas AF, Oliveira F, Bottino MA.Vertical marginal discrepancy of ceramic copings with different ceramic materials, finish lines, and luting agents: An in vitro evaluation. J Prosthet Dent 2004;92:250-7.