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Original Research Article

Evaluation of marginal adaptation of CAD/CAM vs conventional all-ceramic crowns on an implant abutment: An in vitro study

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ABSTRACT

Background: The survival of fixed prosthodontic restorations depends on the state of the marginal adaptation. Marginal gaps can create a favourable condition for biofilm deposition, thereby contributing to the development of caries and periodontal disease. The longevity of fixed prosthodontic restorations depends on the condition of the marginal adaptation to the abutment teeth.

Aim: The presented work aimed to study, evaluate and compare the marginal adaptation of All-Ceramic crowns fabricated using conventional laboratory procedures with those fabricated using the CAD/CAM technology.

Objectives: To compare the marginal fit and adaptation of All- Ceramic crowns obtained by conventional techniques and crowns obtained by CAD/CAM technique.

Materials and Methods: The presented study focused on a total of 20 samples divided into two groups viz. Group I (Conventional) and Group II (CAD/CAM) having 10 sample each. The samples were prepared with the straight abutment having a standardized collar height of 2mm, HIOSSEN that was mounted on acrylic blocks using implant analogue, HIOSSEN. A set of crowns was produced by 5-axis milling lithium disilicate using glass-ceramic blocks with laboratory fabrication methods. Another set of zirconia crowns was produced using CAD/CAM technology. Circumferential marginal gap measurements were taken at 12 measurement locations on the hexagonal die marked equidistant to each other. Both the samples were measured for marginal discrepancy at under the stereomicroscope.

Results: The results obtained showed that the mean vertical gap for the group II samples showed the least variation in the marginal discrepancy. Although the mean obtained for both the groups showed that the mean vertical marginal discrepancy was within the clinically acceptable level.

Conclusion: It can be concluded that within the limitation of the study the data obtained showed that The Mean vertical gap was the maximum for Group I (Conventional group) i.e. 49.25 μm showing maximum variation in marginal fit. While the CAD/CAM Group had shown least vertical marginal discrepancy which depicts statistically significant better marginal fit than those fabricated using conventional laboratory procedures.

1. Introduction

The goal to achieve a successful restoration has improved over the last decade through new and specific treatment modalities, steadily enhanced and more aesthetic dental materials, and novel techniques and technologies has evolved with time. Metal-Free prostheses are considered as the gold-standard in dentistry, with reasonable esthetics.

Over the years implant dentistry has gained recognition from "survival" to "quality of survival." The long-term success of any restoration depends on its marginal and internal fit. The term marginal gap cannot be outlined in a simple way. The literature often describes marginal gap as the quantitative value; a space discrepancy that is found between the edge of the crown and the demarcation (margins) of the preparation on the tooth. A significant

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explanation of the term was given by Holmes, who believes that the discrepancy between the crown and the tooth is a combination of discrepancy between the edge of the crown and the tooth and error in extension of the crown edge. [1]

Emulating the esthetic look of natural teeth is something that all dental technicians aspire to, but achieving this is by no means a simple task. The marginal accuracy of all ceramic crowns is mainly affected by the production system. Continuous development and restorations have entailed extensive studies to determine the accuracy of final restoration. The modern dentistry, enables us to use the 3D scanning and modeling capabilities allowing design work to be done digitally chairside instead of in a traditional laboratory setting. The combination of digital design and machine manufacturing techniques is termed computer-aided design/computer- aided manufacturing (CAD CAM). Digital techniques have often been implied for measuring the accuracy of fixed dental restoration precisely around the margins because they are relatively accurate and do not cause destruction of the sample. They are easier to use, allows for lesser chairside time with realistic result outcomes.

2. Aim

The aim of the study is to evaluate the marginal fit and adaptation of All-Ceramic crowns obtained by using CAD/CAM technique with the All-Ceramic crowns prepared using the conventional fabrication methods.

3. Objectives

1. To evaluate the marginal fit and adaptation of All-Ceramic crowns obtained by Conventional inlay wax pattern using conventional techniques.
2. To evaluate marginal fit and adaptation of All-Ceramic crowns obtained by CAD/CAM technique.
3. To compare the marginal fit and adaptation of All-Ceramic crowns obtained by conventional techniques and crowns obtained by CAD/CAM technique.

4. Materials and Methods

Twenty samples were prepared using the master die with the straight abutment having a standardized collar height of 2mm, HIOSSEN that was mounted on acrylic blocks using implant analogue, HIOSSEN. This mounted block had a standard dimension of 30mm x 15 mm. All the abutments were torqued to 35Ncm according to manufacturer's recommendations using the torque control system.

The standardized abutment on the premolar region was taken for an All- ceramic crown. A set of crowns was produced by 5-axis milling lithium disilicate using glass-ceramic blocks with laboratory fabrication methods. Another set of zirconia crowns (Sagemax Dental Zirconia) was produced using CAD/CAM technology.

The samples were then divided into two groups, Group I (Conventional) and Group II (CAD/CAM). The group I crowns were fabricated using the conventional laboratory procedures which included fabrication of wax pattern, Sprueing, investing, pressing, divesting and removal of reaction layer. While the group II crowns were fabricated using digital impressions and CAD/CAM (VHF K4 Milling) technology. The VHF K4 milling system with software Exocad was used to design the copings. Each sample was scanned using the Medit T500 scanner. All crowns were definitively placed on the abutments with finger pressure to simulate clinical situation. Both the samples were measured for marginal discrepancy at under the stereomicroscope (Olympus BX43). Circumferential marginal gap measurements were taken at 12 measurement locations on the hexagonal die marked equidistant to each other. The marginal gap measurements were made to determine the vertical component of marginal gap, according to the definition of marginal fit.

4.1. Inclusion criteria

The samples that will have standardized dimensions, exhibiting no distortion or porosities will only be selected for this study.

4.2. Exclusion criteria

1. If any of the samples exhibit porosity will be excluded.
2. If pressing procedure is interrupted exhibiting non-standardized dimensions will be excluded.

5. Results

The results obtained showed that the mean vertical gap for the group II samples showed the least variation in the marginal discrepancy. Table 1 shows the mean vertical marginal gap and standard deviation of Group I samples while Table 2 shows the mean vertical marginal gap and standard deviation of Group II samples. Table 3 and Table 4 depicts various measurements for vertical marginal gap of Group I and Group II samples at various sites all together. Figure 1 represents the data Showing Mean discrepancy for Group I samples at various sites. Figure 2 represents the data Showing Mean discrepancy for Group I samples at various sites while Figure 3 shows the mean vertical marginal gap and standard deviation of Group I and Group II samples at various sites. Where Group II showed least variation in marginal discrepancy with maximum mean at point P5 - P5´i.e 28.90 with standard deviation of 8.58 and minimum mean at point P12 -P12´i.e 23.30 with standard deviation of 4.95. The maximum mean for Group 1 sample was found to be 55.70 at P6-P6´with standard deviation of 14.97 and minimum mean being 42.60 at P1-P1´with standard deviation of 11.35. The CAD/CAM Group had shown

least vertical marginal discrepancy which shows statistically significant better marginal fit than those fabricated using conventional laboratory procedures.

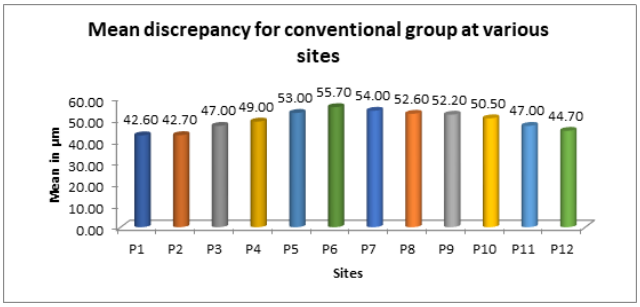

Fig. 1:

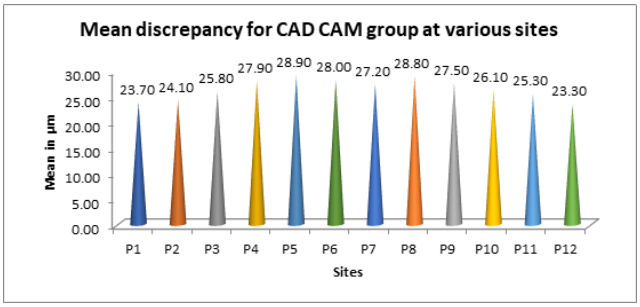

Fig. 2:

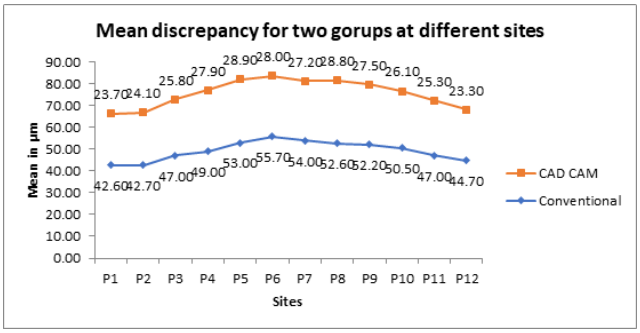

Fig. 3:

6. Discussion

All-ceramic dental restorations possess an outstanding advantage of excellent aesthetics and high degree of biocompatibility, seldom rivaled by metal ceramic restorations. The cervical marginal misfit can lead to exposure of cement by oral fluid, which can result in the dissolution of the cement material. The space formed by the dissolution of the cement material can be a site of plaque accumulation that causes caries as well as changes in the microflora, which can lead to periodontal disease.[2,3] Thus, making the marginal adaptation one of the important criteria that determines the quality and long-term clinical success of the restoration.[4] The field of dental prosthetics has progressed into numerous ultra-modern technologies and procedures that allows the manufacture to make accurate, custom-made and optimal dental restorations. Since the traditional way of manual manufacture is prone to numerous subjective errors, last some years have shown tremendous advancement of modelling and manufacture of dental restorations with introduction of modern Computer-Aided equipment, state-of-the-art materials and machining technologies. 3D digitization systems, Computer-Aided Design and Reverse Engineering, Computer-Aided Manufacturing, Rapid Manufacturing, Rapid Prototyping, etc are one of the modern Computer-Aided systems, which have found broad application in this area. The development and implementation of such technologies and systems have opened the way towards significant evolution of conventional modeling, manufacture and inspection of dental restorations.[1,5,6] Developments in CAD/ CAM have facilitated the design and the processing of monolithic zirconia crowns and fixed partial dentures.[7] It also, helps provide the proper emergence profile, and allowing corrections of implant angulations and finally CAD/CAM abutments provide optimal esthetics for the surrounding soft tissues and optimum optical properties of a natural dentition.[8]

The marginal opening is the most important factor in enhancing the reliability of the newly developed CAD/CAM systems. Sulaiman et al.[9] compared the marginal fit of three different production techniques (Procera, IPS Empress, and In-Ceram). The results showed that the mean marginal gap of the Procera group was 82.88 μm; for the IPS Empress group, it was 62.77 μm; and for the In-Ceram group, it was 160.66 μm. The Procera and IPS Empress crowns displayed the smallest marginal gap within the clinically acceptable range. In another study, the marginal accuracy of the conventional lost-wax technique (heat-pressed IPS Empress) and the CAD/CAM approach (Cerec 3D) was compared.10 The mean (±standard deviation [SD]) marginal gaps were 56 (±31) μm for the former and 70 (±32) μm for the latter; there was no significant difference between the groups. In a similar study, Lee et al.[10] compared the marginal fit of all-ceramic crowns fabricated using two CAD/CAM systems (single-layer system Cerec 3D and double-layer system Procera). The results showed a clinically acceptable marginal fit with both the system. Meanwhile, Baig et al.[11] studied the influence of two different CAD systems on the marginal fit of full-veneer all-ceramic restorations. The mean marginal gaps were 66.4 μm for the Cercon system, 36.6 μm for IPS Empress II, and 37.1 μm for the full-veneer metal control group. The Cercon CAD system showed a statistically significant, larger marginal gap than that produced by the latter two

Table 1:

Site	Minimum	Maximum	Mean	Std. Deviation
P1	29	63	42.60	11.35
P2	29	61	42.70	10.58
P3	30	65	47.00	11.57
P4	29	69	49.00	13.08
P5	34	74	53.00	13.30
P6	37	79	55.70	14.97
P7	29	73	54.00	14.60
P8	36	72	52.60	13.13
P9	39	68	52.20	10.88
P10	36	66	50.50	10.14
P11	35	61	47.00	9.74
P12	33	60	44.70	10.00

Table 2:

Site	Minimum	Maximum	Mean	Std. Deviation
P1′	17	34	23.70	5.46
P2′	18	32	24.10	4.77
P3′	20	34	25.80	4.21
P4′	17	39	27.90	6.44
P5′	17	44	28.90	8.58
P6′	20	41	28.00	7.18
P7′	19	43	27.20	7.57
P8′	20	47	28.80	8.48
P9′	21	42	27.50	7.06
P10′	19	36	26.10	5.30
P11′	19	37	25.30	5.72
P12′	17	32	23.30	4.95

Table 3:

Readings Pressable (μ m)	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
P1	34	42	29	51	46	35	36	33	57	63
P2	37	40	29	49	43	39	33	37	59	61
P3	42	44	34	56	47	44	30	44	64	65
P4	40	49	37	59	52	40	29	48	67	69
P5	41	54	44	64	56	41	34	52	70	74
P6	39	57	40	69	61	46	37	56	73	79
P7	42	50	42	71	59	49	29	54	71	73
P8	40	49	37	66	57	51	36	49	69	72
P9	44	47	39	63	60	47	41	47	66	68
P10	43	50	36	60	56	43	44	44	63	66
P11	38	46	35	57	52	40	42	39	60	61
P12	36	44	33	54	48	37	39	37	59	60

Table 4:

Readings CAD (μm)	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18	Sample 19	Sample 20
P1'	18	21	24	17	34	25	22	19	30	27
P2'	20	21	26	23	32	21	23	18	32	25
P3'	23	26	29	27	34	26	20	20	28	25
P4'	24	29	33	28	39	24	17	22	34	29
P5'	25	33	35	31	44	19	22	17	37	26
P6'	20	30	29	28	41	21	26	24	39	22
P7'	19	26	24	33	43	25	24	24	35	19
P8'	22	22	24	37	47	27	29	25	35	20
P9'	23	25	22	34	42	23	27	21	35	23
P10'	25	27	20	30	36	19	24	23	32	25
P11'	21	23	23	25	37	19	22	25	34	24
P12'	17	20	22	19	31	22	23	21	32	26

groups. In another study, Yeo et al[12] studied the marginal discrepancies of all-ceramic crowns fabricated with the Celay In-Ceram, Conventional In-Ceram, and IPS Empress II layering techniques, in com- parison with a metal ceramic crown as a control group.

In the present study, zirconia copings created by CAD/CAM had similar values 23.70±5 μm. The differences between the two groups of copings in mean vertical marginal gap created by CAD/CAM and conventional laboratory procedures could be due to different sintering procedures for the zirconia blanks and precision of the wax pattern fabrication. Master models were prepared with a customizable die and divided into 10 samples for each Group I and Group II. Crowns were fabricated for group I using conventional laboratory procedures while Group II crowns were prepared digitally by scanning the samples with an intra-oral scanner, designing the crown and then finally milling it using the VHF K4 milling machine. The measurements were carried out using the stereomicroscope. 12 measurements were taken for each sample at 12 different points determining the variation in marginal discrepancy. In this study it was found that the mean marginal gap was of 49.25 μm for Group I samples while the mean marginal gap for Group II samples was found to be 26.38 μm which appeared to be statistically significant (P<0.05).

7. Conclusion

Within the limitation of the study the following conclusion were drawn from the data obtained in this study:

1. The marginal fit of crowns obtained by using the conventional laboratory techniques showed maximum variations. The Mean vertical gap was the maximum for Group I (Conventional group) i.e 49.25 μm.
2. The marginal fit of crowns obtained by using the CAD/CAM technology showed least variations in the marginal fit. The Mean vertical gap for Group II samples (CAD/CAM) was 26.38 μm.
3. CAD/CAM Group had shown least vertical marginal discrepancy and statistically significant better marginal fit than that fabricated by conventional laboratory procedures.

8. Source of Funding

None

9. Conflict of Interest

None

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