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.

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

Digital techniques have often been implied for measuring the accuracy of fixed dental restoration precisely around the tooth and error in extension of the crown edge. 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.

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

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.

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

Thus, making the marginal adaptation one of the important criteria that determines the quality and long-term clinical success of the restoration. 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.

Developments in CAD/ CAM have facilitated the design and the processing of monolithic zirconia crowns and fixed partial dentures. 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.

The marginal opening is the most important factor in enhancing the reliability of the newly developed CAD/CAM systems. Sulaiman et al. 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. 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. 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. 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

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. Therefore, making the marginal adaptation one of the important criteria that determines the quality and long-term clinical success of the restoration.
### 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 (µm) | 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        |
were drawn from the data obtained in this study: Within the limitation of the study the following conclusion

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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