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Evaluation of the Marginal Adaptability of Indirect Composite and Monolithic Zirconia Crowns - A Stereomicroscopic Analysis

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Abstract

Marginal adaptation plays an important role in the clinical success of any prostheses. Ideal marginal adaptation can produce less gingival irritation and cement dissolution. The presence of marginal discrepancies increases plaque accumulation, secondary caries, pulpal lesions, postoperative sensitivity, periodontal disease and marginal discoloration leading to abutment failure and in turn failure of the prosthesis. A maxillary first molar typhodont tooth was prepared with an aerator handpiece. To make the monolithic zirconia crowns, the prepared tooth was scanned and the STL file was used to design a crown using CAD/CAM software. To fabricate the indirect composite crowns, a clear acrylic mould was created, in which the indirect composite was filled and the tooth was placed. The samples were then placed in a curing unit. The samples were then examined under a stereomicroscope. With the aid of imaging software, marked calibrations were calculated at four marked regions- buccal, distal, lingual and mesial margins. Monolithic zirconia adaptation showed statistically significant results when compared to that of indirect composite crowns ($p<0.05$). According to the site, results varied with zirconia crowns adapting better in buccal and mesial sites whereas indirect composite crowns adapted better in the distal and lingual sites. Overall, monolithic zirconia adapted statistically significantly better to the prepared typhodont tooth than the indirect composite crowns and should be used as a material of choice for crowns.

***Keywords**: Crowns, Indirect Composite, Monolithic Zirconia, Marginal Adaptation, Stereomicroscopy.*

Introduction

Four key characteristics are necessary for a dental restoration to be clinically successful: mechanical properties, biocompatibility, esthetics, and marginal adaptability [1,2]. Because of concerns about biocompatibility and growing expectations for aesthetically appealing restorations, all-ceramic restorations have gained popularity as an alternative to porcelain fused to metal crowns [3,4]. Since zirconia is the hardest and toughest dental porcelain available, it is being utilised more frequently to create fixed partial dentures [4]. However, marginal adaptation is just as crucial to any prosthesis's clinical effectiveness as aesthetics. Reduced gingival irritation and cement breakdown can result from ideal marginal adaptation. Crown seating will be facilitated by an excellent internal fit without sacrificing resistance or retention forms. Marginal disparities create a space between the prepared teeth and the prosthesis, accelerating the disintegration of the luting agents [5]. It also promotes secondary caries, accumulation of plaque, postoperative sensitivity, pulpal lesions, marginal discolouration and periodontal disease in the abutment tooth. This can be harmful to the abutment tooth's general health and may fail the abutment tooth [6–8]. The greatest clinically tolerable marginal discrepancy is not

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well-defined, based on the existing scientific knowledge. Values ranging from 50 to 200 µm have been recorded, although the therapeutic goal is for values to fall between 25 and 40 µm [9]. According to a study done by McLean et. al., the greatest allowed marginal discrepancy is 120 µm [9]. Increased marginal gaps also reduce the fracture resistance of the crown and the veneering porcelain [10]. Since the conventional fabrication technique involves several materials and clinical and laboratory procedures, improper marginal adaptation is bound to happen [2,11,12].

However, in comparison to conventional methods, newer technological aids like computer-aided design and computer-aided manufacturing (CAD-CAM) technology make it possible for the fabrication of uniform quality prostheses with superior mechanical characteristics in a shorter amount of time and with fewer steps. This also leads to the development of newer dental materials and systems for the production of prostheses [13]. Through the utilization of direct or indirect digitization technology, the CAD-CAM production process makes it possible to utilise a computer for restoration design, analysis, and manufacture [14]. It is usual practice to use yttria-stabilised tetragonal zirconia polycrystalline (Y-TZP) for the CAD-CAM production of all ceramic frameworks because of its special qualities, which include superior mechanical capabilities, reduced accumulation of plaque, and outstanding biocompatibility [12]. Therefore, in these restorations, it is estimated that because of the scaling down in human errors and dimensional inaccuracies of the materials involved, the acceptable marginal discrepancy was less than 100 µm [15].

A variety of techniques, including cross-sectional view, direct microscopic view, laser videography, silicon replica technique and x-ray microtomography were employed to evaluate the marginal adaptation of restorations [16–18]. In fixed prosthetic dentistry, the relationship between the CAD-CAM technique and conventional manufacturing procedures in terms of marginal adaptation has been thoroughly investigated [19–21]. However, there is a lacuna in the research comparing the marginal adaptation of monolithic zirconia and indirect composite crowns. The null hypothesis stated that no difference would be seen in the marginal adaptation of CAD/CAM monolithic zirconia and indirect composite crowns.

Materials and Methods

The marginal adaptation of monolithic zirconia and indirect composite crowns was planned to be evaluated in an in-vitro study using typhodont tooth. According to a previous study by Rayyan et. al. [22], the sample size was calculated to be six with a confidence interval of 95% and the power of the study of 80%.

A maxillary first molar typhodont tooth was prepared according to ideal dimensions. A sectioned putty index was used to evaluate the amount of tooth reduction during tooth preparation. Tooth preparation design was planned with an occlusal reduction of 1.5 mm at the centre with an axial reduction of 1 mm to maintain an axial crown height of 4 mm all around. The total occlusal convergence of 8° with a 1 mm wide smooth continuous shoulder finish line was created using an aerator handpiece.

Preparation of crowns: Group 1 Monolithic crowns: The prepared typhodont tooth was scanned using an E4 Extraoral lab scanner. The STL files were used to design anatomical monolithic zirconia crowns. Cement space thickness was set to 40 µm. The crowns were designed and the same STL file was used to fabricate all the monolithic crowns.

Group 2 Indirect composite: A clear acrylic mould was created of the monolithic crown. A spacer was coated onto the prepared abutment tooth. Indirect composite material was packed into the mould and seated on the abutment.

The tooth with the mould was placed in a light curing unit for 2 minutes according to the manufacturer's instructions. All the crowns were fabricated similarly, with the same mould and prepared tooth. Figures 1 and 2 show the monolithic zirconia and indirect composite samples respectively.

Figure 1. Monolithic Zirconia Crown

Figure 2. Indirect Composite Crown

The formed crowns were then seated onto the tooth and marginal adaptation was recorded and measured using a stereomicroscope and calibrated image software. Four points, one on each surface, buccal, mesial, distal and palatal were marked and used as reference points at which the measurements were made. Figure 3 shows the Stereomicroscopic analysis carried out.

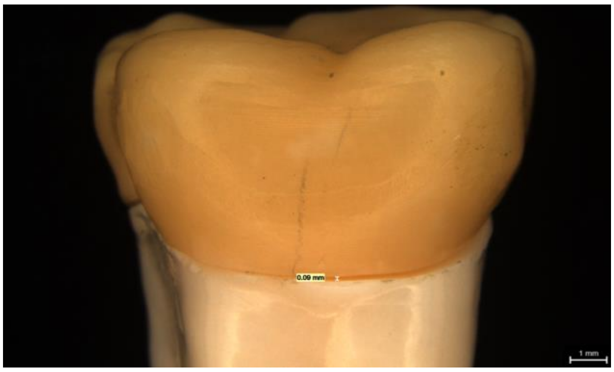

Figure 3. Stereomicroscopic Analysis

Results

Statistical analysis was done using SPSS 23.0 software. Shapiro-Wilk normality test showed that the data were normally distributed. Hence, a marginal adaptation of monolithic zirconia (Group 1) and indirect composite (Group 2) was compared using an independent t-test. The site-wise adaptation of both crowns was done using a one-way ANOVA test. Figure 4 shows the adaptation of the monolithic zirconia and indirect composite crowns. Figure 5 shows the adaptation of the monolithic zirconia crowns according to the sites. Figure 6 shows the adaptation of the indirect crowns according to the sites.

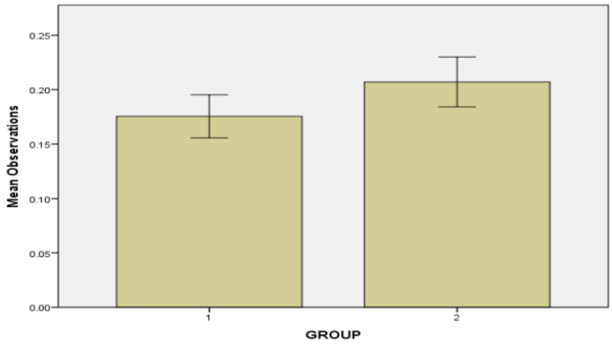

Figure 4. Adaptation of the Monolithic Zirconia and Indirect Composite Crowns

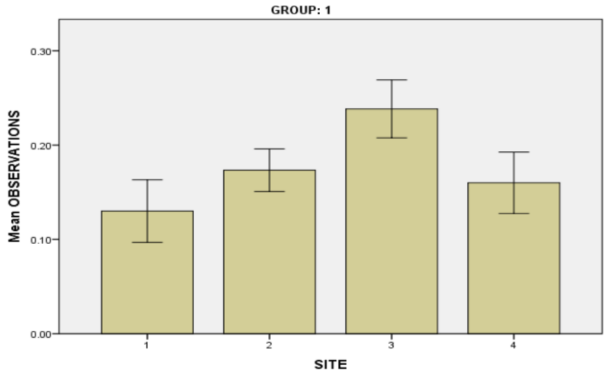

Figure 5. Adaptation of the Monolithic Zirconia Crowns According to the Sites

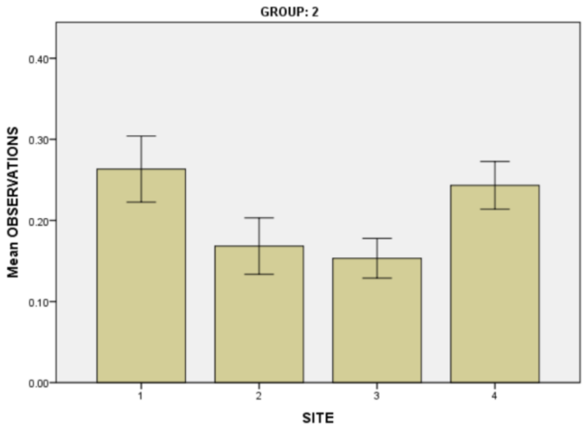

Figure 6. Adaptation of the Indirect Composite Crowns According to the Sites

According to the results obtained, it can be seen that monolithic zirconia has a lesser marginal discrepancy with a mean discrepancy of (0.175±0.048) mm as compared to that of indirect composite with a mean discrepancy of (0.207±0.056) mm. Therefore, monolithic zirconia adapted significantly better to the prepared typhodont tooth than the indirect composite crowns (p=0.042). According to the site-wise adaptation, results varied in both groups. Zirconia crowns adapted better in buccal and mesial sites with mean discrepancies of (0.130±0.031) mm and (0.173±0.021) mm, but results were statistically insignificant (p=0.296). According to Tukey's post-hoc test, the lingual site had statistically significantly worse adaptation for zirconia crowns as compared to the other sites (p=0.002). About indirect composite crowns, distal and lingual sites had a statistically significant better adaptation with a mean discrepancy of (0.168±0.033) mm and (0.153mm±0.023) mm respectively than buccal and mesial sites with values of (0.263±0.038) mm and (0.243±0.028) mm respectively (p=0.003) (Tables 1-3).

Table 1. T-Test for Equality of Means

GAP	t	df	Sig.	Mean Difference	Std. Error Difference	95% Confidence Interval Lower	95% Confidence Interval Upper
Equal variances assumed	-2.089	46	.042	-.03167	.01516	-.06219	-.00115
Equal variances not assumed	-2.089	45.002	.042	-.03167	.01516	-.06220	-.00113

Table 2. One-Way ANOVA

Group 1.00

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.038	3	.013	15.261	.000*
Within Groups	.016	20	.001		
Total	.054	23			

Group 2.00

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.053	3	.018	18.023	.000*
Within Groups	.020	20	.001		
Total	.073	23			

Table 3. Tukey's Post Hoc Multiple Comparison

Group 1.00

Comparison	Mean Difference	Std. Error	Sig.	95% Confidence Interval Lower	95% Confidence Interval Upper
1.00 vs 2.00	-.04333	.01654	.072	-.0896	.0030
1.00 vs 3.00	-.10833*	.01654	.000*	-.1546	-.0620
1.00 vs 4.00	-.03000	.01654	.296	-.0763	.0163
2.00 vs 3.00	-.06500*	.01654	.004*	-.1113	-.0187
2.00 vs 4.00	.01333	.01654	.851	-.0330	.0596
3.00 vs 4.00	.07833*	.01654	.001*	.0320	.1246

Group 2.00

Comparison	Mean Difference	Std. Error	Sig.	95% Confidence Interval Lower	95% Confidence Interval Upper
1.00 vs 2.00	.09500*	.01811	.000*	.0443	.1457
1.00 vs 3.00	.11000*	.01811	.000*	.0593	.1607
1.00 vs 4.00	.02000	.01811	.691	-.0307	.0707
2.00 vs 3.00	.01500	.01811	.840	-.0357	.0657
2.00 vs 4.00	-.07500*	.01811	.003*	-.1257	-.0243
3.00 vs 4.00	-.09000*	.01811	.000*	-.1407	-.0393

Discussion

The marginal adaptation of indirect composite crowns was assessed and compared to CAD/CAM-manufactured zirconia monolithic crowns in this study. The marginal adaptation of indirect composite and monolithic zirconia crowns differed significantly in the current investigation, hence the null hypothesis was rejected. Many studies have already been conducted to evaluate the marginal fit of crowns using various methodologies and materials. The absence of a defined methodology and the fact that various factors might impact the study's results are the key limitations of comparing the results of different research, such as the various measuring procedures employed and the location of the measuring site, both of which must be standardized.

Although numerous methods for analysing marginal precision have been offered, no recommendations to conduct the discrepancy measurements exist; hence, heterogeneity exists in the findings obtained from varied methodologies used to capture the data. To measure marginal adaptation, a stereomicroscope was utilised in this study to evaluate marginal fit since it is a dependable and non-invasive tool for determining marginal fit. The dental technician's competence plays a vital part in providing well-adapted restorations. Hence, in the current investigation, all the crowns are produced by a single technician to avoid bias. This study's findings favour the use of CAD/CAM-manufactured monolithic zirconia crowns over indirect composite crowns.

The marginal difference between the crown edge and the prepared typhodont surface was (0.175±0.048) mm for monolithic crowns and (0.207±0.056) mm for indirect composite crowns. According to previous research, these are greater than the clinically indicated values[9,15]. This can be attributed to the scanning system's limited resolution. It may result in somewhat rounded edges. A CAD software program transforms the point clouds collected during the scanning operation into a smooth and continuous surface, but it may also produce some internal discrepancies, leading to interfering contacts at the margin, which are deleterious to marginal adaptation[23]. Numerous factors influence the marginal adaptation of CAD/CAM prostheses, including the number of units in the prosthesis, anatomic location of the abutments and pontics, design of tooth preparation, physical properties of the material, type of CAM system, choice of impression materials and techniques, and CAD/CAM software versions/parameter settings [24].

For indirect composite crowns, there could exist issues in the packing and curing of the material during the production of indirect composite crowns, resulting in polymerization shrinkage and poorer marginal adaptation. In most cases, indirect composite is used as a veneering material on top of zirconia copings. It has been demonstrated that hand layering causes marginal gaps, which leads to poor marginal adaptation[25]. However, this study has a few shortcomings. This study only prepared molar crowns, but additional research is needed to compare different abutment teeth for marginal fit, as the influence of abutment tooth form on the proper fit of a crown is debatable. Furthermore, just finger pressure was utilised while placing crowns on the typhodont tooth, which could have resulted in poor adaptation. For better credibility of the study, the number of points of analysis can be increased.

Conclusion

It can be concluded that the marginal adaptation of monolithic zirconia crowns is better than indirect composite crowns and can be used as an alternative to metal-ceramic crowns. Further studies are to be carried out in terms of various other parameters like strength, colour stability, and occlusal load under oral conditions to ascertain the superiority of monolithic zirconia crowns over indirect composite crowns. Further light is to be focused on homogeneity in terms of in-vivo studies.

Conflict of Interest

The authors declare no conflicts of interest.

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