Research Article

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Comparison and Evaluation of Effects of Different Impression Materials on the Marginal Fit of Metal Castings: An In Vitro Study

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ABSTRACT

Aim: The objective of this study was to evaluate the effect of different impression materials on the accuracy of marginal fit of metal castings.

Materials and Method: The master molar typhodont tooth was prepared. Sixty duplicates of the tooth were made. The duplicates were divided into three groups of 20 each. The three groups were: Group 1 (Putty and light body elastomeric impression material), Group 2 (Alginate) and Group 3 (Modelling compound). The impressions were made and marginal gap between metal crown and finish line was measured at buccal and lingual margins using scanning electron microscopy (SEM) at magnification of 60X & 400X.

Statistical Analysis: A master chart was prepared for all the data and was analyzed using Statistical Package for the Social Sciences version. Analysis of variance and Post-hoc analysis were used to make comparisons between and within the three groups respectively.

Result: Comparison of the mean and standard deviation values of marginal discrepancies (µm) on buccal and lingual margin at 60X and 400X was found to be highest for alginate and lowest for polyvinyl siloxane.

Conclusion: - The marginal discrepancies found in this study were within the clinically acceptable standard (120 µm). There were no statistically significant differences between buccal and lingual margin at both 60X and 400X magnification within the impression materials. There was no statistically significant difference between the marginal discrepancies for alginate, impression compound and polyvinyl siloxane impression material.

Keywords: Marginal fit, metal casting, impression, scanning electron microscopy.

INTRODUCTION

Marginal seal is a critical factor for successful dental restorations. The fit of a crown is very important, and many efforts have been made to reduce the distance between the prepared tooth and the crown margins. Poorly fitting restorations will render the tooth susceptible to secondary caries and pulpitis. [1-3]A smaller marginal gap will help to keep the teeth free from secondary caries and periodontal disease, thus ensuring the long-term success of the restored teeth. The size of the gap may depend on the thickness of the dental cement layer. Many factors affecting this layer, such as preparation design, die spacer, seating force, marginal configurations and surface roughness have been studied.[4]

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Precise marginal seating of fixed prosthesis over prepared abutments is crucial to fulfill biological, physical, and cosmetic requirements. Accurate fit of the restoration margins to the prepared finish line is necessary to prevent gingival inflammation, secondary caries acting as an important indicator of the overall acceptability of the cast restoration. The design of the tooth preparation can have an effect upon laboratory and clinical success of individual restorations and types of restorations. The accuracy of casting holds the key to long-term success with this restoration. Inadequate fit of a coping due to poor marginal seal can lead to a thin line of the cementing medium exposed to the action of saliva, foreign bodies, and oral fluids, encouraging problems under the restoration and finally tooth loss.[5]

It has been shown that alginate (irreversible hydrocolloid) impression material has as much dimensional accuracy as the other impression materials.[6] Alginate is easy to use because it sets rapidly, it can be mixed easily with water that is at room temperature, and it does not require the use of expensive equipment. The use of alginate impression material requires a precise step-by-step procedure that must be followed exactly as stated in order to obtain an impression and cast that are accurate.[7]

Impression compound is useful for checking cavity preparations for undercuts and for making impressions of full crown preparations where gingival tissues must be displaced. The copper band technique is used in which a copper band is placed around tooth margin, this retracts soft tissue. Impression material is then filled into the band [8-10]They are cheap, accurate, easily available but can traumatize the gingivae.[11]

Polyvinyl siloxane impression materials have the best fine detail reprodction and elastic recovery of all available materials. Because there is no by-product, they possess remarkable dimensional stability and are odorless, tasteless and pleasant for patients. They are provided in wide range of viscosities, rigidities, and working and setting times.

There are various techniques used to measure the marginal gap of metal casting such as conventional manual technique, stereomicroscope, 3D digital scanners, profilometer out of which in this study scanning electron microscope was used because according to the some authors, SEM was able to provide more appropriate and realistic observations than a light microscope particularly with complex margin morphologies.[12] Scanning Electronic Microscopy (SEM) imaging was better than light microscopy to evaluate marginal gap. Therefore, in this sudy using SEM marginal gap between metal crown and finish line was measured at buccal and lingual margins in two different magnifications.

MATERIALS AND METHOD

1. Tooth preparation

The mandibular first molar tooth was selected for study. The crown preparation of tooth was done to receive metal crown. 1.5 mm occlusal reduction was done. Chamfer finish line was given on the tooth with midproximal merging of two finish lines (buccal and lingual).

2. Impression making-

The master molar typhodont tooth was prepared. When impression was made tooth was attached to typhodont jaw set (API). 60 duplicates of this master tooth were made and were divided into three groups of 20 in each group. The three groups were:

Group 1 - Putty and light body elastomeric impression material ((3M ESPE)
Group 2 – Alginate (Marieflex Dustfree Class A Type II-Normal setting)
Group 3 - Modelling compound (Y-Dents Esquire)

Elastomeric impression was made using double mix double stage technique. Alginate was mixed, loaded into sectional impression tray and impression was made. Copper band impression was made using impression made. A copper band serves as a means of carrying the impression compound). One end of the tube was festooned or trimmed, to follow the contours of the free gingival margin, should properly fit and adapt the margins. The tube with the impression compound impression material was mechanically carried to the finish line of the prepared typhodont tooth and produce adequate impression.

3. Fabrication of die

Impressions were poured with type IV die stone (Kalrock Die stone Class IV). Then the die pins were placed with the help of pindex system. A die spacer was applied on the axial walls of die which ended 2 mm short of finish line. Wax patterns were made on stone dies in a hard inlay and crown wax (Kronen blau, Bego Germany) using a dip wax technique with a waxing instrument. The investment material was mechanically spatulated under vacuum, spatulation time was 90 seconds, and the invested patterns were placed in a hygroscopic bath at 37ºC for 60 minutes to achieve the maximum mould expansion and a standardized burn out protocol is followed.The crowns were cast in a palladium based metal ceramic alloy using an induction casting machine. The castings were cleaned by sandblasting method followed by finishing and glazing of metal crown.

4. Evaluation of marginal fit of metal crown-

The metal crowns were gold plated with JEOL JFC-1600 Auto fine coater and examined with a JEOL JSM-6390A Analytical SEM._The marginal fit was measured for each crown at a same point in the middle of the buccal and lingual surfaces, marked vertically with a marker pen. Each specimen was positioned leaning on a base at an angle of 25 degree so that the interface was positioned perpendicular to the optic axis and measurements were made at 2 magnifications i.e. 60 and 400 magnification for both buccal and lingual surface. Marginal fit was assessed by measuring the distance between the crown margin and prepared tooth margin.

RESULT

Comparison of marginal gap between restoration and tooth by three different materials exhibited similar results. One way ANOVA revealed that there was no significant difference of marginal discrepancy among various impression materials, and also when post hoc test was applied for 60X and 400X within the groups there was no statistically significant differences between buccal and lingual margins. The comparison of the mean and standard deviation values of marginal discrepancies (µm) on buccal margin at 60 X was highest for alginate (93.9150±1.46) and lowest for polyvinyl siloxane (57.8427±1.47) (table 1). Marginal discrepancy was to be highest for alginate (93.7617±1.46) and lowest for polyvinyl siloxane (57.9857±1.47) on lingual margin at 60X (table 2). At 400X, on buccal margin, discrepancy was highest for alginate (93.8683±0.57) and lowest for polyvinyl siloxane (58.4253±0.87). (table 3). Marginal discrepancy is highest for alginate (94.1440±0.57) and lowest for polyvinyl siloxane (58.0877±0.87) at 400X in lingual margins. (table 4)

Table 1: Comparison of the mean and standard deviation values of marginal discrepancies (µm) on buccal margin at 60 magnification using alginate, impression compound and polvinyl siloxane impression materials

S.No.	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	20	93.9150	2.19918	.40151	93.0938	94.7362
2	20	93.5483	1.70406	.31112	92.9120	94.1846
3	20	57.8427	2.70167	.49326	56.8338	58.8515
Total	60	81.7687	17.15709	1.80852	78.1752	85.3622

Table 2: Comparison of the mean and standard deviation values of marginal discrepancies (µm) on lingual margin at 60 magnification using alginate, impression compound and polvinyl siloxane impression materials.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	20	93.7617	2.28293	.41680	92.9092	94.6141
2	20	93.6803	1.93432	.35316	92.9580	94.4026
3	20	57.9857	2.76803	.50537	56.9521	59.0193

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	20	93.7617	2.28293	.41680	92.9092	94.6141
2	20	93.6803	1.93432	.35316	92.9580	94.4026
3	20	57.9857	2.76803	.50537	56.9521	59.0193
Total	60	81.8092	17.09926	1.80242	78.2279	85.3906

Table 3: Comparison of the mean and standard deviation values of marginal discrepancies on buccal margin at 400 magnification using alginate, impression compound and polyvinyl siloxane impression materials.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	20	93.8683	1.77688	.40151	93.2048	94.5318
2	20	93.8567	1.56348	.31112	93.2729	94.4405
3	20	58.4253	2.91876	.49326	57.3354	59.5152
Total	60	82.0501	16.93523	1.78513	78.5031	85.5971

Table 4: Comparison of the mean and standard deviation values of marginal discrepancies (µm) on lingual margin at 400 magnification using alginate, impression compound and polvinyl siloxane impression materials.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	20	94.1440	1.78872	.32657	93.4761	94.8119
2	20	94.0473	1.54108	.28136	93.4719	94.6228
3	20	58.0877	2.93110	.53514	56.9932	59.1822
Total	60	82.0930	17.20415	1.81348	78.4897	85.6963

DISCUSSION

Some of the studies conducted on copper band technique and reported the various advantages of this technique which includes (1) increased working time; (2) greater precision, especially at the cervical part of the preparation; and (3) better temperature control[9] and also reported that this technique helps to make impressions of abutments with varying degrees of taper below the finishing line easily[8]. Study concluded various disadvantages as well which showed an average reduction of the gingival crest of 0.33 mm.[7]

Studies done to evaluate the accuracy of alginate and polyvinyl siloxane concluded that the polyvinyl siloxane is a better option for the making accurate impression, as because it has good surface reproduction capacity, dimensional accuracy and better performance.[14,15]

Studies [13] compared the dimensional accuracy of the casts obtained from one step double mix, two step double mix polyvinyl siloxane putty- wash impression techniques using three different spacer thicknesses (0.5mm, 1mm and 1.5mm), in order to determine the impression technique that displays the maximum linear dimensional accuracy and drawn the conclusion that 2-step putty/light-body impression technique with 1mm spacer thickness was most dimensionally accurate impression methods in terms of resultant casts.[16,17,18,19]

A study was carried out to evaluate the effect of impression materials using different impression techniques and tested the accuracy of the marginal fit of metal castings and concluded that the differences in the gingival marginal gaps between various impression materials and techniques at both the facial and lingual surfaces were not statistically significant.[23] Few authors examined the crown marginal openings and vertical heights

before and after cementation with zinc phosphate cement and found out that the marginal opening of complete veneer gold crowns increased during cementation and the vertical heights of well-fitting crowns also increased significantly after cementation.[14,15]

Various studies were conducted on marginal discrepancies and Christensen defined two categories for the marginal fit of restorations: (1) supragingival finish lines, where discrepancies ranging from 2 to 51 µm were considered satisfactory; and (2) subgingival finish lines, where marginal discrepancies ranging from 34 to 119µm were deemed acceptable.[13] McLean and Van Fraunhofer reported similar data but accepted marginal openings of 120 µm. The laboratory experiments of Matty et al. resulted in marginal openings between 56 and 81 µm. In this study the marginal discrepancies of metal crown range from 53.3µm -96.51µm which according to above studies is clinically acceptable.

Boyde A, Knight PJ did study on SEM and reveal that the SEM was able to provide more appropriate and realistic observations than a light microscope particularly with complex margin morphologies. They provided limited results from widely separated measuring points, hence calculated means usually demonstrate large standard deviations, and the results reported might be questionable.[14] Groten et al stated that because of its great depth of focus it can be used for examination of instruments used in cavity preparation, quality of the tooth preparation & evaluation of fit of the restoration. They concluded that with its ability to examine the specimen at various angles, scanning electron microscope, should be considered in relative study of quality control in clinical dental procedures.[9] Hence scanning electron microscope was used in the study to evaluate the marginal fit of metal castings,

CONCLUSION

Within the limitations of this study, the following conclusions are drawn:

1. The marginal discrepancies (µm) on buccal and lingual margin at 60 X and 400 X was highest for alginate and lowest for polyvinyl siloxane .
2. The marginal discrepancies found in this study are within the clinically acceptable standard (120 µm).
3. There were no statistically significant differences between buccal and lingual margin at both 60 and 400 magnification for impression materials.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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