

AN IN-VITRO STUDY COMPARING THE MASS OF TOOTH STRUCTURE REMOVED FOLLOWING DIFFERENT RESTORATIVE PROCEDURES IN ANTERIOR TEETH – AN ORIGINAL RESEARCH

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Abstract

Purpose – The aim of this study was to measure the mass of tooth structure removed in - Porcelain Laminate Veneers, Metal ceramic and All-ceramic crown preparation. To compare the mass of tooth structure removed from maxillary and mandibular incisors with canine teeth.

Material and Methods – The study was conducted on a sample size of sixty teeth, selected based on the criteria that they had a single intact root, was free of caries, attrition, abrasion, erosion and had no sign of dental restoration. The bucco-lingual and mesio-distal dimensions of each specimen was measured at the cemento-enamel junction by using a thickness gauge and weighed. The specimen teeth were then prepared for receiving Porcelain laminate veneer, conventional metal ceramic and all-ceramic restoration according to pre-determined standardized preparation design.

Results – There was statistically significant difference in mean final weight between laminate veneer & metal ceramic. (P value <0.05). In laminate veneers there was significantly less loss of weight as compared to the other types of preparations. Percentage of weight loss in laminate veneer was minimum followed by all ceramic & metal ceramic. The percentage of loss of tooth structure for incisor and canine group for all selected types of restorations were not significantly difference. (P value >0.05).

Conclusions – Though the metal ceramic restorative procedure is most widely practiced across the world it demands highest amount of tooth structure removal. So, when clinical condition permits, considering this restorative procedure, the clinician may think over the other modalities of treatment once more.

Keywords: Gravimetric, Porcelain Laminate Veneers, Conventional Metal ceramic crown, All-ceramic full veneer

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Introduction

The focus of dentistry in the present times is not only preservation of health and treatment of disease but also on meeting the demands for better aesthetics. Aesthetic restoration is reproducing of natural tooth form, its color, transparency and other optical and physical properties by means of modern filling materials. Nowadays dentists have various materials and technologies that allow to imitate original appearance of natural tooth. These dental restorations irrespective of the material have a specific space requirement. Understanding the individual materials requirement for aesthetics and long-term durability is of paramount concern for successful restoration.^{1,2}

Due to their excellent clinical performance, outstanding aesthetics, and minimal invasiveness, resin-bonded veneers and fixed partial dental restorations offer an excellent treatment option with an ever-expanding range of indication.^{3,4} However, the tooth preparation requires careful and meticulous technique. Although clinicians may believe that innovative preparation designs are less invasive than conventional aesthetic preparations, there is still lack of supporting scientific studies that have quantified the tooth structure removal associated with these preparations.⁵

The purpose of this study was to gravimetrically quantify the amount of tooth structure removed for anterior preparations for single tooth restoration and fixed partial dental retainers. This study attempts to find the importance of measuring the difference in amount of tooth structure removed for different restorative procedure for two different groups, which might have a clinical significance with regard to subsequent longevity of the tooth and the associated dental restoration. The aim of this study was –

1. To measure the mass of tooth structure removed in - porcelain laminate veneers, conventional metal ceramic crown and all-ceramic crown preparation.

2. To compare the mass of tooth structure removed from maxillary and mandibular central and lateral incisor with maxillary and mandibular canine teeth.

Methodology

This study was conducted in the Department of Prosthodontics and Crown & Bridge. A sample size of 150 teeth were selected based on the criteria that they had a single intact root, was free of caries, attrition, abrasion, erosion and had no sign of dental restoration.⁷ Informed consent was obtained following the Helsinki declaration. (Annexures 1, annexure 2 and annexure 3)

They were then divided into the following groups –

A. INCISOR GROUP –

1. Upper Central Incisor – 25 specimens
2. Upper Lateral Incisor – 25 specimens
3. Lower Central Incisor – 25 specimens
4. Lower Lateral Incisor – 25 specimens

B. CANINE GROUP –

1. Upper Canine – 25 specimens
2. Lower Canine – 25 specimens

TOTAL – 150 specimens

The selected teeth were stored in 4% formalin saline solution for four weeks. (Fig – 1) Teeth were made free from stain, calculus and soft tissue, by using an ultrasonic scaler, polishing brush, and pumice water mixture. They were then examined under microscope at 2.5× magnification to ensure that they are free from fracture, caries, restoration, crazing.⁵

The bucco-lingual and mesio-distal dimensions of each specimen was measured at the cemento-enamel junction by using a thickness gauge. The baseline mass for each tooth was measured

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with the help of a digital analyzer (accurate up to 0.0001gm) and recorded at the beginning of the study. (Fig-2) All teeth were blotted for 10 minutes on absorbent paper towel prior to weighing.⁶ The teeth were then mounted on a mounting jig prepared with impression compound prior to preparation. The specimen teeth were then prepared for receiving Porcelain laminate veneer, Conventional metal ceramic and All-ceramic restoration according to pre-determined standardized preparation design. The pre-determined standardized preparation designs followed in this study were as following using proper armamentarium (Fig-3 and Fig-4) – ^{6,7}

Porcelain-laminate veneer -	-Long Chamfer finish line with 0.5-mm labial reduction extending interproximally. -2-mm incisal reduction with 1-mm incisal overlap, with chamfer finish line.
Conventional Metal-ceramic crown -	-Buccal shoulder with level margin and lingual chamfer margin. -1.5-mm labial reduction extending interproximally through contact point. -0.8-mm reduction palatally / lingually and 2-mm incisal reduction was maintained.
All ceramic crown -	- Shoulder finish margin. - 1.2-mm labial reduction, 0.8-mm lingual reduction and 2.0 mm incisal reduction.

Two addition silicon putty indexes were made of each tooth and sectioned bucco-lingually and mesio-distally and used as reference guide throughout the reduction procedure to standardize and estimate the amount of tooth reduction (Fig-5 and Fig-6). This was achieved by measuring the distance between the tooth and the fitting surface of the reduction index.⁸ (Fig-7)

After preparation each specimen tooth was kept in 4% formalin-saline solution and then blotted in absorbent paper towel for 10 minutes. The teeth were then weighed in a digital analyzer.

The weight was calculated as follows – ⁹

$$\text{Weight of the reduced tooth structure} = (\text{weight of the tooth before preparation} - \text{weight of the tooth after preparation}) / \text{weight of the tooth before preparation.}$$

$$\text{Percentage of tooth structure reduction} = \frac{\text{Above formula}}{100}.$$

For statistical analysis, descriptive statistics were used to analyze the percentage of tooth mass reduction. Student’s t-test was used to compare the mean tooth reduction among the different types of preparation, and a p value <0.05 was considered statistically significant.

Results

On calculation of final weight difference between laminate veneer & all ceramic, laminate veneer & metal ceramic and all ceramic & metal ceramic using unpaired t test, it was noticed that there is no statistically significant difference in mean final weight between Laminate Veneer & All Ceramic, and All Ceramic & Metal Ceramic. (P value >0.05). While, there was statistically significant difference in mean final weight between laminate veneer & metal ceramic. (p value <0.05). (Table-1)

The loss of weight between laminate veneer and all ceramic, laminate veneer and metal ceramic and all ceramic and metal ceramic by using unpaired t test, no statistically significant difference was seen in mean loss of weight between all ceramic & metal ceramic. (p value >0.05). Whereas, there was statistically significant difference in mean loss

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of weight between laminate veneer & all ceramic and laminate veneer & metal ceramic. (p value <0.05). In laminate veneer there was significantly less loss of weight as compared to the other types of preparations. (Table -2)

The mean weight loss for porcelain laminate veneer was (0.11 ± 0.03) gm, for all ceramic crown preparation is (0.26 ± 0.09) gm, for metal ceramic it is (0.30 ± 0.10) gm. There was no statistically significant difference in mean weight loss between all ceramic and metal ceramic but there was statistically significant difference in mean loss in weight between laminate veneer and metal ceramic, in laminate veneer there was statistically significant difference in mean loss of weight as compared to other types of preparation. (Graph – 1)

The percentage of loss of tooth structure between laminate veneer and all ceramic, laminate veneer and metal ceramic, all ceramic and metal ceramic were statistically significant. (p value <0.05). In laminate veneer percentage of weight loss is minimum followed by all ceramic & metal ceramic. (Table – 3)

The percentage of loss of tooth structure between laminate veneer and all ceramic, laminate veneer and metal ceramic, all ceramic and metal ceramic were statistically significant. In laminate veneer preparation percentage of weight loss was minimum followed by all ceramic and metal ceramic. The mean percentage of weight loss obtained for laminate veneer as (11.87 ± 0.78), for all ceramic (25.77 ± 1.93) and for metal ceramic (32.66 ± 0.88). (Graph – 2)

Table 1 - Mean, standard deviation, p value for laminate veneer, all ceramic and metal ceramic preparation with respect to final weight.

	RESTORATION			p Value		
	Laminate Veneer	All Ceramic	Metal Ceramic	Laminate Veneer & All Ceramic	Laminate Veneer & Metal Ceramic	All Ceramic & Metal Ceramic
	Mean ± SD	Mean ± SD	Mean ± SD			
Final Weight (GM)	0.85 ± 0.23	0.76 ± 0.3	0.62 ± 0.21	0.303	0.002	0.093

Table 2 - Mean, standard deviation, p value for laminate veneer, all ceramic and metal ceramic preparation with respect to loss of weight.

	RESTORATION			p Value		
	Laminate Veneer	All Ceramic	Metal Ceramic	Laminate Veneer & All Ceramic	Laminate Veneer & Metal Ceramic	All Ceramic & Metal Ceramic
	Mean ± SD	Mean ± SD	Mean ± SD			
LOSS (GM)	0.11 ± 0.03	0.26 ± 0.09	0.3 ± 0.1	<0.001	<0.001	0.158

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On comparison of incisor group of teeth with canine group after tooth preparation for all selected types of restorations, the mean loss in weight was significantly higher for canine group as compared to incisor group. (p value <0.05). (Table 4)

The percentage of loss of tooth structure for incisor and canine group for all selected types of restorations were not significantly difference. (p value >0.05). (Table 5)

The incisor group of teeth when compared with canine group after tooth preparation for all selected types of restorations, the mean loss of weight for incisor group is (0.19 ± 0.09) gm and for the canine group it was (0.29 ± 0.13) gm, which was statistically significant. So, it can be said that in canine group loss of tooth structure is more when compared to incisor group. The percentage of loss

of tooth structure for incisor and canine group for all selected types of restorations was (24.1 ± 8.84) and (23.18 ± 8.79) respectively, there was no significant difference in mean percentage of weight loss across canine and incisor group.

Discussion

The importance of quantification of tooth structure removal cannot be over emphasized. There is very limited number of studies that quantified the tooth structure loss with respect to different preparation designs. Different methods have been described to measure the amount of tooth structure removal associated with different preparation designs. [9,10] Given the accuracy, ease and simplicity gravimetric analysis was employed to measure the tooth structure removal.

Table 3 -Mean, standard deviation, p value for laminate veneer, all ceramic and metal ceramic preparation with respect to percentage of loss of weight

	TREATMENT			p Value		
	Laminate Veneer	All Ceramic	Metal ceramic	Laminate Veneer & All Ceramic	Laminate Veneer & Metal Ceramic	All Ceramic & Metal Ceramic
	Mean ± SD	Mean ± SD	Mean ± SD			
Percentage of Loss	11.87 ± 0.78	25.77 ± 1.93	32.66 ± 0.88	<0.001	<0.001	<0.001

Table 4 - Mean, standard deviation, p value comparing between incisor and canine group for loss of weight of specimen teeth prepared for all three types of restoration.

	INCISOR	CANINE	p Value	Significance
	Mean ± SD	Mean ± SD		
LOSS (GM)	0.19 ± 0.09	0.29 ± 0.13	0.001	Significant

Table 5 - Mean, standard deviation, p value comparing between incisor and canine group with respect to percentage of loss for all three types of preparation

	Incisor	Canine	p Value	Significance
	Mean ± SD	Mean ± SD		
Percentage of Loss	24.1 ± 8.84	23.18 ± 8.79	0.703	Not Significant

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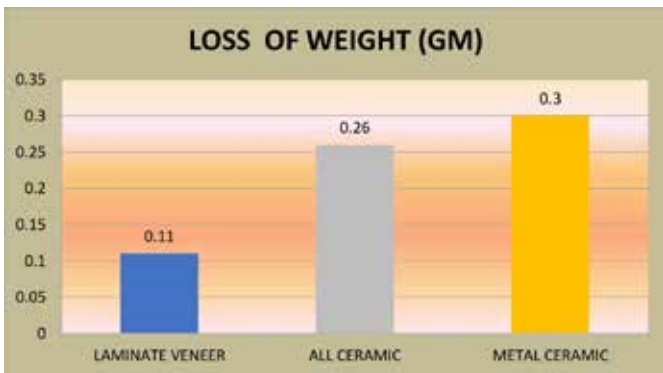
Commonly practiced treatment options for anterior tooth restoration are porcelain laminate veneer, all ceramic full veneer crown and conventional metal ceramic crown.^{10,11} So, in this study, all three forementioned preparations were chosen. Sixty anterior teeth were chosen as sample and underwent preparation for porcelain laminate veneer, all ceramic full veneer crown and metal ceramic crown.

For anatomical crown, Edelhoff and Sorensone had quantified and compared the tooth weight only of acrylic resin typodont teeth with different preparation designs. The authors had reported that different preparations designs resulted in

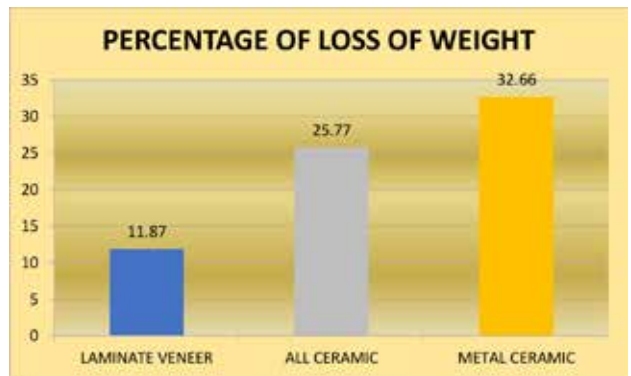
significant differences in the amount of tooth removed.^{5,10-13}

Based on the findings of Hussain Sela .K F , McDonald Aibhe and Moles David R a baseline could be established for comparison in the current study. They found the marginal mean percentage of tooth structure loss at the end of preparation for porcelain laminate veneer to be 80.7% and for metal ceramic preparation it was 61.30%, which were similar to the findings of our study.⁸

The results in case of loss of tooth structure in the canine group being more compared to incisor group loss was in contradiction to Hussain Sela K F , McDonald Aibhe and Moles DR's study where



Graph 1 - The comparison of mean loss of weight of specimen teeth prepared for laminate veneer, metal ceramic & all ceramic restoration



Graph 2- The comparison of percentage of loss of laminate veneer, metal ceramic & all ceramic preparation



Fig 1 - The selected teeth were stored in 4% formalin saline solution



Fig 2 - Digital weight analyzer (accurate up to 0.0001gm)



Fig 3 - Guide

PROSTHETIC AND IMPLANT DENTISTRY

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they found that incisor group of tooth preparation demanded more tooth structure removal than that of canine group.⁸ This phenomenon could be explained by the use of heterogenous morphology of collected sample of tooth. There might have also been a racial variation in tooth morphology particularly in anterior teeth.

It should be noted that in this ideal preparation design only specific requirement of the material were considered as a factor for tooth structure removal beyond that, other criteria might control the preparation design in the patient’s mouth.

By conducting this experiment on similarly sized single rooted natural teeth and reduction by a single operator, it was attempted to minimize both the amount of morphological and operator variability encountered and subsequently it ensured that the results obtain were as accurate as possible with regards to change in mass. Further investigations are needed to confirm the relative contribution of the loss of tooth structure with respect to different preparation design.

Limitations –

In this study only two preparation designs i.e. partial and complete coverage were used for the tooth morphology. Many more designs could have been incorporated. The sample size of the tooth studied were not equal and newer methods for

quantifying removed tooth structure could have been used.

Future prospects –

The sample size can be increased to achieve more definite results. The number of designs of tooth preparation can be increased to incorporate more variability. In this study manual techniques were used, with the advent of technology, digitilisation of the entire process can be done using digital scans, computer added designing and computer aided milling.

Conclusion

Within the limitations of this in vitro study the following conclusions can be drawn –

1. Porcelain laminate veneer restoration demands $11.87 \pm 0.78\%$ removal of tooth structure by weight.
2. All – ceramic restoration demands $25.77 \pm 1.93\%$ removal of tooth structure by weight.
3. Conventional metal ceramic restoration demands $32.66 \pm 0.88\%$ removal of tooth structure by weight.

Though the metal ceramic restorative procedure is most widely practiced across the world it de-



Fig 4 – Armamentarium

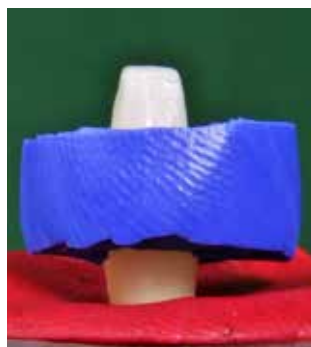


Fig 5 - Addition silicon putty index of tooth sectioned bucco-lingually



Fig 6 - Addition silicon putty index of tooth sectioned mesio-distally



Fig 7 - Thickness gauge

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mands highest amount of tooth structure removal. So, when clinical condition permits, considering this restorative procedure, the clinician may think over the other modalities of treatment once more. Minimally invasive veneer preparation offers a tremendous advantage over all ceramic crown and conventional metal ceramic crown preparation.

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