The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
20(3): S.I (3), 190-195, 2025 www.thebioscan.com

An In Vitro Study to Compare and Evaluate the Preparation Details of Three Different Tooth Preparation Techniques for Metal Ceramic Crown

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DOI: 10.63001/tbs.2025.v20.i03.S.I(3).pp190-195

Received on:
28-05-2025
Accepted on:
29-06-2025
Published on:
02-08-2025

ABSTRACT

Introduction: Tooth preparation for metal ceramic crowns must allow for an adequate thickness of metal and porcelain to overcome the limitations of each material as well as preserve the integrity of the pulp.

Excessive reduction can cause sensitivity and pulpal exposure which may necessitate a root canal treatment. In anterior teeth, a minimal incisal reduction of 2 mm is recommended to prevent an excessively long crown or a blunt incisal table. Hence, a successful porcelain fused to metal restoration is mainly dependent on an adequate tooth preparation. Under preparation may result in inappropriate labial and palatal contours, leading to poor esthetics. Over preparation can compromise tooth vitality.

The use of indices or suitable depth gauge burs are the two recognized methods of accurate tooth preparation; however, no study to date has investigates the effect of these two guides vis a vis free hand preparation.

Methodology:

Forty five maxillary left central incisor typodont teeth used in the study were allocated to 3 equal groups as **Group A** (n=15) : Teeth prepared with free hand approach, **Group B**(n=15)**:** Teeth prepared using silicon putty index as guide, **Group C**(n=15) : Teeth prepared with the use of depth gauge burs. Silicon putty replica index made were used for evaluation. The index was sectioned axially along the midline of the prepared tooth and an optical microscope was used for evaluation of the dimensions.

Result:

This study found that under preparation of the labial aspect of teeth occurred when a freehand approach was adopted for the preparation of teeth to receive metal ceramic crowns ,Labial and incisal reduction was found to be accurate and consistent when teeth were prepared with the aid of depth gauge burs and silicone indices .

Conclusion: Whenever the clinical situation permits considerable importance should be given to the use of putty index and depth gauge burs.

INTRODUCTION

In many dental practices, Metal ceramic is one of the most widely used fixed restoration. The restoration consists of a complete coverage cast metal crown (or substructure) which is veneered with a layer of fused porcelain to mimic the appearance of a natural tooth.[1] It is universally accepted that "finish line configuration" and "position in relation to the gingival tissues" can influence the longevity and esthetics of the final restoration.[2,3,4]

Therefore, Tooth preparation for metal ceramic crowns must allow for an adequate thickness of metal and porcelain to overcome the limitations of each material as well as preserve the integrity of the pulp. The minimum thickness of porcelain and metal required for metal ceramic crowns, dependent on the alloy used, is 0.7 and 0.5mm, respectively; it is accepted that a labial reduction of 1.5 mm is required to achieve this. [2,3,4]

Excessive reduction led to pulpal exposure and subsequent loss of vitality, which can lead to early failure of the restored unit. Similarly in anterior teeth, a minimal incisal reduction of 2 mm is recommended to prevent an excessively long crown or a blunt

incisal table. Hence, it can be said that successful technical reproduction of anatomic contours and profiles in metal ceramic crowns is mainly dependent on an adequate tooth preparation. Under reduction may results in inappropriate labial and palatal contours, leading to compromised esthetics.[5] It can also lead to overbulking of the crown at the gingival margin to allow for adequate material strength, which results in a poor emergence profile. Several studies have considered an improper emergence profile as a significant etiologic factor in the marginal inflammation associated with crowns.[6]

A failed crown has been described as one that was unserviceable, thus requiring repair or replacement.[7] Inadequate tooth preparation can lead to esthetic failures.[8] Biological failures such as caries, periodontal disease, and endodontic or periapical pathology may also result from inappropriate tooth preparation.[9] Thus, inadequate quality of tooth preparation seems to be a common thread contributing to metal ceramic crown failure.

Marginal configuration and geometry of metal ceramic crowns have always been under review. Several designs have been advocated to optimize esthetics and minimize marginal openings. The shoulder margin provides the required aesthetics and marginal stability necessary during porcelain firing, and it is the most suitable for a labial finishing line for anterior crowns.[2,3] A chamfer finish provides the least stress and marginal opening for a metal-only finish and is therefore indicated for the lingual/palatal aspect where esthetics are not a primary concern, allowing for the preservation of tooth structure.[2] In vitro studies evaluating preparations for metal ceramic crowns have been reported.[10] All studies have reported a tendency for clinicians to underprepare teeth when a freehand approach was used. This tendency occurred in spite of the better access and visibility afforded by an in vitro experimental setup. The use of indexes or suitable depth gauge burs are the two recognized methods of improving the accuracy of preparation features; however, no study to date has investigated the effect these have on an operator's ability to appropriately and consistently prepare teeth for metal ceramic crowns.

Aim :

The purpose of this study was to investigate the effect that an index and a depth gauge bur have on an operator's ability to appropriately and consistently prepare teeth for metal ceramic crowns.

Objectives :

- To measure the mean depth of labial ,incisal and palatal preparation by free hand technique (group A).
- To measure the mean depth of labial ,incisal and palatal preparation by putty indices (group B).
- To measure the mean depth of labial ,incisal and palatal preparation by depth gauze burs (group C).
- To compare the mean value of group A,B,C.

The null hypothesis was that the "use of an index or depth gauge bur have no effect on a practitioner's ability to appropriately and consistently prepare teeth for metal ceramic crowns."

Methodology :

A. Grouping of the samples:-

Forty five maxillary left central incisor typodont teeth used in the study were allocated to 3 equal groups as

Group A (n=15) : Teeth prepared with free hand approach

Group B(n=15)**:** Teeth prepared using silicon putty index as guide

Group C(n=15) : Teeth prepared with the use of depth gauge burs

Teeth were mounted in the Nissin- standard working model one at a time, before starting preparation sectional index that could be reconstructed over the original tooth was produced using an addition cured silicone impression material.

B. **Tooth preparations**:-

Teeth were prepared for metal ceramic crown requiring shoulder finish line on the labial aspect for metal ceramic finish and chamfer finish line palatally for metal finish using standard burs (shofu inc, kyoto, japan).

Following were the methods of preparation for one tooth in each group. Other teeth in the same group were prepared essentially in similar way.

Group A Teeth preparation (Free Hand approach):-

In this group teeth were prepared with free hand approach without using any extra guide for preparation (figure1). The preparation was divided into five major steps:

- guiding grooves,
- incisal reduction,
- labial reduction in the area to be veneered with porcelain,
- axial reduction of the proximal and lingual surfaces, and
- final finishing of all prepared surfaces

Guiding grooves:-

Three depth grooves approximately 1.3 mm deep were placed, one in the center of the facial surface and one each in the approximate locations of the mesiofacial and distofacial line angles , in two different planes: the cervical portion paralleled the long axis of the tooth, the incisal portion followed the normal facial contour. Three depth grooves (about 1.8 mm deep) were placed in the incisal edge of tooth.

Incisal reduction:-

Guiding grooves placed on the incisal edge of central incisor were united to provide at least 2mm of incisal clearance after finishing.

Labial reduction:-

Guiding grooves placed on the labial surface of central incisor were united in both cervical and incisal plane to achieve at least 1.3mm of clearance on the labial surface before finishing. Shoulder was essentially created simultaneously during the procedure. Margin was placed at the level of crest of gingiva.

Axial reduction of proximal and lingual surface:-

Proximoaxial and linguoaxial surfaces were prepared with diamond bur held parallel to the intended path of withdrawl of the restoration. Smooth chamfer of about 0.5mm width was developed and extended labially into the proximal to blend with the interproximal shoulder placed earlier.

Finishing:

All the line angles were rounded to produce a preparation with satin finish free from obvious diamond scratch marks .

Group B Teeth preparation (Use of putty index as a guide):-

Before starting tooth preparation for Group B one more silicon putty index was prepared including one tooth on either side of the tooth being prepared. This index was sectioned vertically and horizontally using scalpel. This sectioned index was used as a guide during tooth preparation procedure to check and recheck at each step whether the required amount of tooth preparation was achieved or not. The step by step procedure was essentially the same mentioned under group A procedure.

Group C Teeth preparation (use of depth gauge burs):-

For teeth allocated in Group C preparation steps and procedure was same as mentioned with Group A preparation except that the labial and incisal reduction were done with depth gauge burs (1.5mm). Palatal reduction in this group was completed using free hand approach.

Preparation of test specimen:-

After the tooth preparation for each group was completed, silicon putty index made prior to tooth preparation was reconstructed and a light body addition cured silicone, of contrasting colour, was injected into the index to occupy the space created by tooth preparation (figure 2). The index was then sectioned axially along the midline of the prepared tooth with a scalpel and the left-hand side mounted on a microscope slide(figure 3).

Measurement of specimen:-

An optical microscope, with a resolution of ± 0.02 mm, attached to a personal computer was used to capture an image of the sectioned relined index (figure 4). The magnification used for the measurement was 4 X.

- Images captured by optical microscope were subsequently analyzed by an image analysis software (Image J). Contrasting color of light bodied silicon in the image helped in the measurement of preparation depths.
- Preparation depths in millimeters for each tooth were measured at 5 sites namely the labial- cervical , mid-labial, incisal, mid- palatal and palatal- cervical aspects on two occasions. These results were averaged to give a mean labial, incisal and palatal reduction for each preparation.

RESULT:

Measurement were done on images of sectioned relined putty index captured from optical microscope with image analysis

software (figure 3) . Preparation depths in millimeters for each tooth were measured at 5 sites namely the labial- cervical, mid-labial, incisal, mid- palatal and palatal-cervical aspects on 2 occasions. These results were averaged to give a mean labial, incisal and palatal reduction for each preparation.

Statistical analysis was performed using analysis of Variance(ANOVA) and then Tukey honestly significantly different (HSD) test for comparisons among groups at the 0.05 level of significance.

The comparative preparation depths of labial, incisal and palatal reduction for Group A, Group B and Group C is shown in following Tables (TABLE I, TABLE II, TABLE III,TABLE IV, TABLE V).

This study found that under preparation of the labial aspect of teeth occurred when a freehand approach was adopted for the preparation of teeth to receive metal ceramic crowns (TABLE I,II).

Labial and incisal reduction was found to be accurate and consistent when teeth were prepared with the aid of depth gauge burs and silicone indices (TABLE III).

Results of this study shows over reduction of palatal surfaces of teeth when prepared with depth gauge burs and with the use of putty index as guide compared with freehand approach which shows nearly ideal palatal reduction (TABLE IV,V).

Discussion:

Metal-ceramic restorations have represented the "gold standard" for years in Prosthetic dentistry, owing to their mechanical properties and to somewhat satisfactory esthetic results, along with a clinically acceptable quality of their marginal and internal adaptation.[11]

Metal-ceramic restoration is composed of metal casting or coping, which fits over the prepared tooth and ceramic is fused to the coping. The metal coping in a metal-ceramic restoration is covered with three layers of porcelain namely, Opaque porcelain, dentin or body porcelain, enamel or incisal porcelain.

According to Rosenstiel[1], principles of tooth preparation may be divided into three broad categories:

1. Biologic considerations, which affect the health of the oral tissues
2. Mechanical considerations, which affect the integrity and durability of the restoration
3. Esthetic considerations, which affect the appearance of the patient

Successful tooth preparation and subsequent restoration depend on simultaneous consideration of all these factors. Often improvement in one area will adversely affects another, For example, in the fabrication of a metal-ceramic crown , sufficient thickness of porcelain is necessary for a life like appearance. However, if too much tooth structure is removed to accommodate a greater thickness of porcelain for esthetic reasons, the pulpal tissue may be damaged (biologic consideration) and the tooth gets unduly weakened (mechanical consideration).Hence for a successful restoration an amalgamation of all three factors is necessary.

In the present study three different tooth preparation techniques for metal ceramic crowns namely Free Hand Approach (Group-A), Use of silicon putty index as a guide (Group-B) and use of Depth gauge burs(Group-C) were evaluated and compared for labial , incisal and palatal preparations. This study found that under preparation of the labial aspect of teeth occurred when teeth were prepared with freehand **Aminian and Brunton** and **N. H. F. Wilson**[12] which stated that when teeth were prepared using freehand approach under preparation is common on labial aspect. If there is to be sufficient bulk of porcelain for appearance and metal for strength, adequate reduction of the labial surface is essential. The exact amount of reduction will depend to some extent , on the physical properties of the alloy used for the substructure as well as on the manufacturer and the shade of the porcelain. A minimum reduction of 1.5 mm is typically required for optimal appearance. Shade problems are frequently encountered in maxillary incisor crowns at the incisal and cervical thirds of the restoration, direct light reflection from the opaque layer can make the restoration appear very noticeable.[1]

The labial aspect of the preparation, particularly in the cervical region, requires careful consideration during tooth preparation to prevent under preparation. This will affect the emergence profile of the restoration and cause technical difficulties when the restoration is produced, possibly with insufficient porcelain or metal or an over bulbous crown. **Clayton F. Parkinson**[14] in his study concluded that the creation of artificial crown contours that are greater than natural tooth convexities must be considered a parameter promoting the endemic plaque niches. Under reduced finish lines may also predispose the restoration to technical failure arising from metal flexure and subsequent porcelain fracture or cement loss.

As far as incisal preparation is considered, under preparation of the incisal surfaces was observed when a freehand approach was adopted for the preparation of teeth to receive metal ceramic crowns. **Aminian and Brunton** [15] **in their study concluded that** "over reduction of incisal surfaces of teeth occurred when teeth were prepared with freehand approach to receive metal-ceramic crowns". This can be attributed to the fact that Brunton et al conducted their study on typodont teeth mounted in individual plaster block without any adjacent teeth for visual comparisons whereas this study was carried out on typodont teeth mounted on working model with adjacent and opposing teeth present for visual comparisons even during the freehand approach.

The incisal edge of a metal-ceramic restoration has no metal backing and can be made with a translucency similar to that of natural tooth structure. An incisal reduction of 2 mm is recommended for good esthetics.

Labial and incisal reduction was found to be accurate and consistent when teeth were prepared with the aid of depth gauge burs and silicone indices; consequently, the null hypothesis was rejected. It is therefore suggested that the use of either of these two aids during tooth preparation will reduce the potential for esthetic, biologic, and technical failure of teeth prepared for metal ceramic crowns compared with freehand preparation techniques.

Results of this study show over reduction of palatal surfaces of teeth when prepared with depth gauge burs and with the use of putty index as guide compared with freehand approach which shows nearly ideal palatal reduction. This finding is in favor of the studies done by **Aminian and Brunton** [12]according to which over reduction of palatal surfaces of teeth occured when teeth were prepared with depth gauge burs .

Tooth surfaces prepared with a freehand approach in this study (all surfaces of Group A teeth and palatal surfaces of Group C teeth prepared labially using a depth gauge bur) relied solely on visual acuity to assess the amount of tissue removal.

Comparing the prepared tooth with an adjacent unprepared tooth may assist this visual decision making. Visual perception is also necessary for directly assessing preparation depths when indexes are used. When replacing the index over the prepared tooth, the depth of preparation must be evaluated and adjusted accordingly. The potential limitations of visual assessment of preparations may account for the underprepared labial aspects of the preparations performed with a freehand approach. A freehand approach was used for the preparation of the palatal aspect of teeth in Group A, and an accurate reduction was achieved. Further research is necessary to investigate why freehand preparation of palatal surfaces appears to be more accurate than freehand reduction of the labial surface.

Group B teeth prepared with the use of a silicone index displayed accurate labial and incisal depth of preparation, although the palatal reduction tended to be somewhat excessive. Similarly, the palatal surface was over prepared to a statistically significant level when a depth gauge bur was used. Further research is necessary to investigate a possible pattern of palatal over preparation when indexes and depth gauge burs are used to aid in assessing tooth removal.

In comparing the depth of preparation at the labial cervical and mid labial aspects, it is possible to evaluate each technique in terms of maintaining the 2 or 3 anatomic planes of the labial

profile. This is an important consideration, because failure to reproduce the anatomic planes of the natural tooth during tooth preparation will create further technical limitations in terms of providing the best esthetic result, as well as needlessly sacrifice further tooth tissue and cause loss of retention and resistance form. Anatomic preparation of the labial aspect of the tooth may be more readily achieved with the use of indexes or depth gauge burs, but further research is needed to establish this.

CONCLUSION

From the results it can be concluded,

- tooth preparation for metal ceramic crown with free hand approach is not reliable because of the tendency to under prepare tooth on labial and incisal surface.
- Tooth preparation on palatal aspect done by putty index and dept gauge bur led to an overpreparation of the tooth, free hand approach showed better results.
- Whenever the clinical situation permits considerable importance should be given to the use of putty index and depth gauge burs.

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TABLES :

TABLE I
Multiple comparisons among groups for labial-cervical preparation

(I) Groups	(J) Groups	Mean Difference (I-J)	p value
Group A	Group B	-.2362000*	0.001*
Group A	Group C	-.1838667*	0.002*
Group B	Group C	.0523333	0.565

Post Hoc Tukey test; * indicates significant at p≤0.05

Difference in mean values of group A and group B (0.2362) and group A and group C (0.1838) are significant (p<0.05). However, difference in mean values of group B and group C (0.0523) is not significant (p=0.565)

TABLE II
Multiple comparisons among groups for mid-labial preparation

(I) Groups	(J) Groups	Mean Difference (I-J)	p value
Group A	Group B	-.2350667*	0.001*
Group A	Group C	-.1789333*	0.008*
Group B	Group C	.0561333	0.582

Post Hoc Tukey test; * indicates significant at p≤0.05

Difference in mean values of group A and group B (0.2351) and group A and group C (0.1789) are significant (p<0.05). However, difference in mean values of group B and group C (0.0561) is not significant (p=0.582)

Table III
Multiple comparisons among groups for incisal preparation

(I) Groups	(J) Groups	Mean Difference (I-J)	p value
Group A	Group B	-.2325333*	0.020*
Group A	Group C	-.2248667*	0.025*
Group B	Group C	.0076667	0.995

Post Hoc Tukey test; * indicates significant at p≤0.05

Difference in mean values of group A and group B (0.2325) and group A and group C (0.2248) are significant (p<0.05). However, difference in mean values of group B and group C (0.0076) is not significant (p=0.995)

Table IV
Multiple comparisons among groups for mid-palatal preparation

(I) Groups	(J) Groups	Mean Difference (I-J)	p value
Group A	Group B	-.1780000*	0.001*
Group A	Group C	-.1323533*	0.011*
Group B	Group C	.0456467	0.549

Post Hoc Tukey test; * indicates significant at p≤0.05

Difference in mean values of group A and group B (0.1780) and group A and group C (0.1323) are significant (p<0.05). However, difference in mean values of group B and group C (0.0456) is not significant (p=0.549)

TABLE V
Multiple comparisons among groups for palatal-cervical preparation

(I) Groups	(J) Groups	Mean Difference (I-J)	p value
Group A	Group B	-.1442667*	0.033*
Group A	Group C	-.0838000	0.296
Group B	Group C	.0604667	0.525

Post Hoc Tukey test; * indicates significant at p≤0.05

Difference in mean values of group A and group B (0.1442) are significant (p<0.033). However, difference in mean values of group A and group C (0.0838) and difference in mean values of group B and group C (0.0456) are notsignificant (p>0.05).