International Journal of Dentistry Research

Research Article

ISSN: 2581-3218
IJDR 2024; 9(2): 46-48
Received: 25-04-2024
Accepted: 27-07-2024

www.dentistryscience.com
doi: 10.31254/dentistry.2024.9204

Analysis of Resistance Form of Molar Crown Preparations for Full-Coverage Porcelain Fused to Metal Crowns: A Prospective Study at The University of Ghana Dental School

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Abstract

Background: A good molar crown preparation with adequate resistance form for a porcelain fused to metal (PFM) crown should have a minimum height of 4mm, a maximum width of 10mm and a height-to-width ratio of at least 0.4. Aims and Objectives: To determine whether the molar crown preparations for full-coverage PFM crowns made by Resident dentists at the University of Ghana Dental School (UGDS) meet the recommended requirements for resistance form. Study design: This is a cross-sectional study to analyse the resistance form of molar crown preparation of patients scheduled for full-coverage PFM crown. Materials and Methods: This was a prospective study to analyse the height, width, and height-to-width ratio (some of the intrinsic factors of resistance form) of 77 molar crown preparations. The height, width, and height-to-width ratio of each molar die were determined using the Exocad software. A descriptive summary of the various heights, widths and height-to-width ratio were summarized as means and their standard deviations. Chi-square test was used to compare the acceptability levels of the variables with their respective recommended clinically acceptable values. Results: The mean height and mean width of all the molar dies were 3.3±0.8mm and 10.1±1.1mm respectively. The mean height-to-width ratio of all the molar dies was 0.3±0.1. Only 19.5% of the dies were able to achieve the recommended height, and 18.2% of the molar dies had a minimum height-to-width ratio of 0.4 which is required for molar crown preparation. Conclusion: The findings of this study did not meet most of the recommended clinically acceptable values of the resistance form of molar crown preparations. The authors recommend organising in-service training or continuous professional development for clinicians who lack the skills in crown preparation in order to perfect their skills to create acceptable prepared crowns with adequate resistance form and to conduct a longitudinal clinical study to assess the crown preparations and the longevity of their fabricated crowns.

Keywords: Resistance form, Height, Width, Molar tooth, Porcelain fused to metal crown.

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INTRODUCTION

Coronal tooth tissue cannot regenerate as found with other tissues once it erupts into the oral cavity.[1] Hence if enamel or dentin is lost due to trauma, caries, or wear, dental restorative materials are used to restore them to reestablish form, function and aesthetics. A porcelain fused to metal crown is a fixed extracoronal prosthesis that restores missing or damaged coronal tooth tissue by veneering part or all of the clinical crown while protecting the remaining tooth structure.

Full-coverage PFM crowns are a form of oral rehabilitation device that helps to maintain function, aesthetics, and speech and to improve the quality of life of patients. However, this prosthesis can dislodge which may reduce its average lifespan of 5-15years [2] and rather affect the quality of life the prosthesis has to offer. To avoid or reduce this mishap, there are recommended guidelines as to how to prepare the abutment tooth to receive this restoration. To prevent dislodgements of these restorations, it is recommended that the crown preparation should have a resistance and retention form. [1,3]

The fundamental success of a full-coverage crown depends on the ability of the dentist to adequately prepare the tooth to receive this restoration. [4, 5] Deficient tooth preparation for full-coverage PFM crown leads to mechanical, [6] aesthetic, [7] and biological failures.[8]

Retention form is that which prevents the displacement of the crown along the path of its insertion, while resistance form also prevents the displacement of the crown by forces directed on the restoration in the apical and oblique directions. To achieve resistance form for molar crown preparation, it is recommended that the prepared molar crown should have a minimum height of 4mm [9], a maximum width of 10mm and a height-to-width ratio of at least 0.4 [9] among other factors, to provide adequate resistance form for a full-coverage PFM crown.

This study seeks to assess some of the intrinsic factors that affect the resistance form of molar crown preparation for full-coverage PFM crowns.

METHODOLOGY

Ethical approval was sought from the institutional review Board of the Korle-Bu Teaching Hospital (KBTH-STC/IRB/000187/2021). Also, written informed consent was sought from all the participants of this study. This was a prospective study on seventy-seven (77) molar crown preparations made by Residents of the Restorative Department at the University of Ghana Dental School (UGDS) clinic, from December 2021 to July 2022.

After molar crown preparation by the Resident at UGDS clinic, Perfil condensation silicon impression material was used to make an impression of the prepared molar crown. The impression was poured with Pyrax gypsum type IV die stone (Dental Plaster manufacturers & OEM manufacturers, India). A die of the prepared crown is made and the apical 2mm from the margin is ditched to make the margin more prominent and distinct. Two vertical points 1mm apart were marked on the mid-buccal, mid-lingual, mid-distal and mid-mesial. Also, two vertical points were marked on the junction of buccal and mesial, buccal and distal, lingual and mesial and lingual and distal. The dies were scanned using a 3D Cyber-Scan Art plus scanner (Pi Manufacturing Co. Ltd, Hungary) and the images were digitalised on a computer. The buccal, lingual, mesial and distal heights were measured from the margin through the two vertical points to the coronal point on their respective sides using the Exocad DentalDB 3.0 Galway 7754 software (Exocad GmbH, Germany) as shown in figure 1. The average of the buccal height, lingual height, mesial height and distal height of a die was computed to represent the overall height of the die.

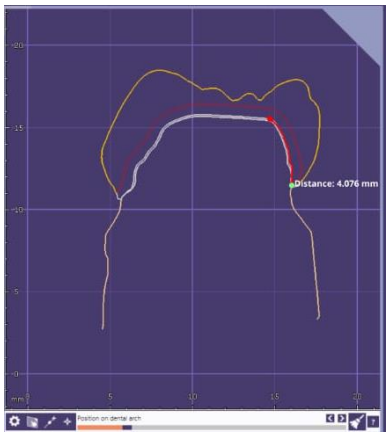

Fig. 1: Measurement of height using Exocad software

The buccolingual and mesiodistal widths were measured using the Exocad DentalDB 3.0 Galway 7754 software (Exocad GmbH, Germany) as shown in figure 2. The average of the buccolingual width and the mesiodistal width of a die was computed to represent the overall width of the die.

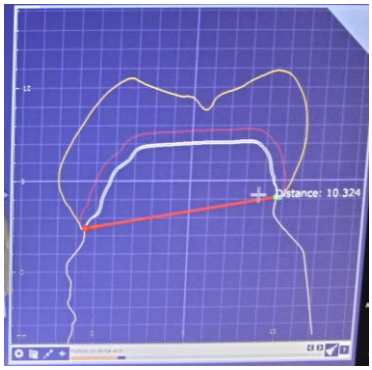

Fig. 2: Measurement of width using Exocad software

The average height of each die was divided by the average width of the same die to give the height-to-width ratio of the die. This method was used to calculate the height-to-width ratio of all the dies.

Statistical Analysis

A descriptive summary of the various heights and widths were summarized as means and their standard deviations. These summaries were presented as tables. To compare the levels of acceptability of the measurements in proportions, the chi-square test was used. A significant level was set at $p< 0.05$.

RESULTS

There was a total of 77 dies of molar crown preparations. Thirty-seven (37) maxillary molar dies and forty (40) mandibular molar dies. Of these, fifty (50) were first molars with twenty-seven (27) being second molars. Also, 74 of these dies were made from endodontically treated teeth while the remaining 3 were made from vital teeth.

The mean height of the buccal, lingual, mesial, distal and the overall height of all the maxillary and mandibular molar dies are shown in Table 1. There was a significant difference in the mean buccal, lingual, mesial, distal and overall height between the maxillary and mandibular molar dies.

Table 1: Mean height (mm) of all the maxillary and mandibular molar dies

Variable	Maxillary (mm)	Mandibular (mm)	P value
Buccal height	4.2 ± 1.8	3.7 ± 0.9	0.031*
Lingual height	3.8 ± 1.3	3.4 ± 1.0	0.034*
Mesial height	3.1 ± 1.4	2.5 ± 0.6	<0.001*
Distal height	3.0 ± 0.9	2.6 ± 0.8	0.004*
Overall height	3.5 ± 1.0	3.1 ± 0.6	0.003*

*significant difference

Table 2 shows the proportion of acceptability and unacceptability of the height of the molar dies measured. There were significant differences in the level of acceptability among the buccal, lingual, mesial, distal and overall heights ($p<0.001$) with the buccal and lingual heights having the highest level of acceptability while the mesial height had the lowest level of acceptability.

Table 2: Comparison of the acceptability and unacceptability levels of all the heights

Variable	Acceptability (%)	Unacceptability (%)	P value
Buccal height	32(41.6)	45(58.4)	<0.001*
Lingual height	20(26.0)	57(74.0)	<0.001*
Mesial height	8(10.4)	69(89.6)	<0.001*
Distal height	10(13.0)	67(87.0)	<0.001*
Overall height	15(19.5)	62(80.5)	<0.001*

*significant difference

Table 3: Mean width of maxillary and mandibular molar dies

Variable	Maxillary (mm)	Mandibular (mm)	P value
Buccolingual width	10.8 ±1.3	9.9 ±1.5	<0.001*
Mesiodistal width	9.4 ± 1.1	10.1 ± 1.1	<0.001*
Overall width	10.1 ± 1.0	10.0 ± 1.2	0.575

*significant difference

Table 4: Comparison of the acceptability and unacceptability levels of all the width

Variable	Acceptable (%)	Unacceptable (%)	P value
Buccolingual	38 (49.4)	39 (50.6)	0.268
Mesiodistal	48 (62.3)	29 (37.7)	
Overall width	43 (55.8)	34 (44.2)	

Table 5: Comparison of the level of acceptability and unacceptability of the height-to-width ratio

Variable	Acceptability (%)	Unacceptability (%)	P value
Height-to-width ratio	14 (18.2)	63 (81.8)	<0.001*

*significant difference

The mean buccolingual, mesiodistal and overall width of all the maxillary and mandibular molar dies are shown in Table 3. There was a significant difference in the buccolingual width between the maxillary and mandibular molar dies (p<0.001). Also, there was a significant difference in the mesiodistal width between the maxillary and mandibular molar dies (p<0.001) as shown in Table 3.

Table 4 shows the proportions of acceptability and unacceptability of the buccolingual, mesiodistal and overall width of the molar dies measured as compared to the recommended value. It also shows the comparison of the level of acceptability between the buccolingual, mesiolingual and overall width of the molar dies.

The height-to-width ratio was 0.4 ± 0.1 and 0.3 ± 0.1 for all the maxillary and mandibular molar dies respectively.

Table 5 shows the proportions of acceptability and unacceptability of the height-to-width ratio of the molar dies. It also shows the comparison of the level of acceptability and unacceptability of the height-to-width ratio. The level of acceptability of the height-to-width ratio was significantly low (p<0.001).

DISCUSSION

There were almost equal numbers of mandibular molar dies compared to maxillary molar dies because they had similar pathology requiring PFM crown restoration. The majority of the study dies were first molars which may be because they are the first permanent molars to erupt into the oral cavity which makes them vulnerable to dental caries and its sequela of which root canal treatment and PFM crown is needed to restore the tooth. This compares favourably with some studies [10-12] where most endodontically treated teeth were mandibular first molar. However, this was inconsistent with a study by Al-Negrish [13], who reported that most endodontically treated teeth were maxillary central incisors because they are the teeth most frequently traumatized by accident.

The mean of the overall height recorded for all the molar dies in this present study did not meet the recommended requirement of 4mm or more for molar crowns. This may be due to the over-reduction of the occlusal surface to provide adequate occlusal clearance for the PFM crown. Also, because most of the molar dies were endodontically treated and the access cavity was restored with restorative material which is not as hard as enamel. The mean buccal height of all the molar dies was the only section that met the requirement of at least 4mm. This may be due to the easy accessibility and visibility of the buccal aspect of the molar crown.

This current study found that 80.5% of the study dies did not achieve the recommended 4mm or more height required for molar crown preparation to have adequate resistance form. This may result in the debonding of the PFM crowns that will be fabricated on these molar crown preparations if they are not cemented with adhesive cement.

Based on this study, it is recommended that Dentists at UGDS make use of depth grooves to help in occlusal reduction that follows the anatomic configuration of the molar crown and thus minimize or prevent over-reduction of the crown height while ensuring adequate occlusal clearance.

The mean overall width of the molar dies recorded was 10.1±1.1mm which is very close to the recommended 10mm width for molar dies. Hence it can be said that the Residents at UGDS were able to prepare molar crowns to meet the recommended width of molar dies for PFM crowns. More than half (55.8%) of the molar dies in this current study met the recommended maximum width of 10mm for a prepared molar crown to achieve adequate resistance form. This means that in terms of the width most of the molar crown preparations done by Residents at UGDS have adequate resistance form to help retain the PFM crown fabricated on them.

The mean overall height-to-width ratio recorded for this study was below the recommended acceptable value. This is because the mean overall height of the molar dies was less than the recommended acceptable value, although the mean overall width met the recommended value.

From this present study, only 14(18.2%) of the study dies achieved the recommended height-to-width ratio of 0.4 or more. This means that majority of the study dies (81.8%) did not meet this requirement and hence did not have adequate resistance form in terms of the height-to-width ratio. This may result in the debonding of the PFM crowns (if not cemented with adhesive cement) fabricated on these molar crown preparations when oblique forces act on the crown during function.

The mean height-to-width ratio of the maxillary molar dies for this current study was within the recommended range. However, the mandibular molar dies did not meet the acceptable height-to-width ratio to provide adequate resistance form.

CONCLUSION

The findings of this current study showed that it was a challenge to achieve all the recommended clinically acceptable values of the intrinsic factors of resistance form in terms of the height, width, and height-to-width ratio for a molar crown preparation for full-coverage PFM crown made by Residents at UGDS.

Based on the findings of this study the authors recommend that in-service training or continuous professional development be organised for clinicians who lack the skills in crown preparation to perfect their skills to create acceptable crown preparations with adequate resistance form and to conduct a longitudinal clinical study to assess the crown preparations and the longevity of their fabricated crowns.

Authors' contribution

Stephen Ekow **Ankoh** was involved in the conceptualisation, data curation, formal analysis, funding acquisition, methodology, project administration, resources, validation, writing (original draft) and writing (review and editing). Patrick Caldicock **Ampofo** was involved in methodology, project administration, supervision, validation, writing (original draft) and writing (review and editing). Sandra Ama **Hewlett** was involved in methodology, formal analysis, project administration, supervision, validation, writing (original draft) and writing (review and editing). Ebenezer Anno **Nyako** was involved in conceptualisation, supervision, and writing (review and editing). Tom Akuetteh **Ndanu** was involved in the data curation, formal analysis, validation, visualisation, supervision and writing (review and editing). Akua Boakyewaa **Konadu** was involved in supervision and writing (review and editing). Ruby Yayra **Goka** was involved in the formal analysis, resources and writing (review and editing). Nana Frimpomaa **Adu-Ampomah** was involved in the formal analysis, resources and writing (review and editing). Gladia **Toledo Mayari Yabang** was involved in writing (original draft) and writing (review and editing). Neil Quartey **Papafio** was involved in supervision and writing (review and editing).

Acknowledgement

Our appreciation goes to Mrs. Sheila Bannerman, Mr. Nafe Abdul Sanofi, Mr. Freddy Francky Tchoussam, and all the Residents and Patients who assisted in diverse ways to make this study a reality.

Conflicts of Interest

The author reports no conflicts of interest.

Funding

None declared.

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HOW TO CITE THIS ARTICLE-
Ankoh SE, Ampofo PC, Hewlett SA, Nyako EA, Ndanu TA, Konadu AB, Goka RY, Adu-Ampomah NF, Yabang GTM, Papafio NQ. Analysis of Resistance Form of Molar Crown Preparations for Full-Coverage Porcelain Fused to Metal Crowns: A Prospective Study at The University of Ghana Dental School. Int J Dent Res 2024; 9(2):46-48. doi: 10.31254/dentistry.2024.9204