

Convergence Angle Values of Metal-Ceramic Crowns Achieved by Dental Students at Qassim University, Saudi Arabia

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ABSTRACT

Aim: To measure the convergence angle (CA) of tooth preparation for single metal-ceramic crown carried out by fourth and fifth-year undergraduate dental students and to compare angles with the recommended CA.

Design: Observational study

Place and duration of study: Qassim University, College of dentistry, from January to June 2020

Methodology: A total of 45 preparations, made by 23 male and 22 female students, were randomly selected for evaluation of the buccolingual and mesiodistal convergence angles. Each tooth was scanned using Sirona Cerec 2 scanner to produce 3-dimensional digital object. A digital analysis software program 'image j' was used to calculate the convergence angles for each abutment tooth. One sample t-test was used to compare the mean convergence angle values and two-sided t tests were performed to compare the buccolingual and mesiodistal angles between the genders.

Results: The mean mesiodistal convergence angle was 18.22 ± 7.99 degrees, and the mean buccolingual convergence angle was 16.55 ± 8.51 degrees. The mean buccolingual convergence angle in preparations by male students was 16.16 ± 10.19 degrees, compared with 16.96 ± 6.52 degrees by female students, whereas, the mean mesiodistal convergence angle prepared by male students was 19.03 ± 8.08 degrees, compared to 17.37 ± 7.98 degrees by female students. No statistical difference was observed between the genders. The overall mean reported convergence angle value was 17.38 which was significantly greater ($p < 0.000$) than the recommended values.

Conclusion: There was a considerable difference between the CA values recorded in this study and the recommended guidelines. The recommended CA ($<12^\circ$) was difficult to achieve clinically by the students.

Key words: convergence angle, tooth preparations, dental education, metal-ceramic crowns, dental students, pre-clinical training.

INTRODUCTION

Metal-ceramic crown restorations are commonly used to compensate for an extensive tooth loss. Adequate retention and stability are particularly important pre-requisites for the success of fixed prosthodontics restorations. These requirements can be achieved by following recommended guidelines and preparing certain geometrical design on the tooth¹.

The retention of the prepared tooth restoration depends on several important factors including the height of the prepared tooth, the convergence angle of the preparation, surface texture, the use of bonding, the adaptation of retainers to the abutment and the type of cement that has been used.^{1,2} The retention and resistance form of the cast crown restorations can be increased by having two parallel opposing axial walls in prepared tooth. However, preparing parallel axial walls inside the patient mouth and under the clinical conditions without the risk of having an undercut cannot be always possible due to several reasons including the differences in vision, accessibility, and hand-eye coordination.³ Therefore, teeth are prepared with slight convergence angle to avoid the possibility of having an undercut, to compensate for any possible defects during the fabrication process and to allow better seating during cementation

Convergence angles (CA) are usually measured degrees and defined in dental literature as the taper of a crown or the angle that is formed between the two opposing axial walls of the prepared tooth for fixed dental

prostheses⁴. The guidelines in textbooks of fixed prosthodontics recommend an ideal range of 4-6 degree for preparing CA and 4-14 degree as an acceptable range.^{1,2} However, these recommended values were found to be difficult to achieve under the clinical condition⁵. Therefore, recommended CA value must be at least 12 degree to be observed clinically as divergence from the parallel wall⁶. A study by Mack⁷, also suggested a minimal taper of 12° to avoid the possibility of creating an undercut. In another study, Goodacre et al recommended the total CA between 10° and 20° .⁸ While several other researchers have recommended total CA of 10° and 16° based on laboratory studies^{9,10}. Although the opinions of dentists might differ considerably regarding the optimal CA, there is inadequate data concerning the degree to which recommended values are to be used in dental practice^{11,12,13}

On the other hand, there are several devices and techniques used to measure the convergence angle of tooth preparation such as photocopy machines⁹, diamond rotary cutting instruments¹², goniometric microscopes¹⁴ and 3-D laser scanners.¹⁵ However, some of these devices are not widely accepted and used. A new technological method is using the Auto-CAD software to measure the convergence angle, which is reliable and with a high degree of accuracy¹⁶.

Since, preparation of metal-ceramic crowns is a common procedure in general dental practice, it is therefore imperative to develop best possible skills and expertise during training period.¹⁷ It is also required to

examine the impacts of teaching not only as an element of curriculum development and quality audit, but also to examine the competency of graduates.^{18,19} Such an assessment can show whether the students are at par with their peers. The aim of the present study was to record the average convergence angle achieved by dental students at the Qassim college of dentistry, and to compare these achieved values with recommended optimal values of CA. To compare the convergence angles of tooth preparations produced by male and female students was another objective of this study. Based on acquired data it could be evaluated whether the teaching methods for preparing metal-ceramic crowns during the laboratory sessions need an improvement.

The first null hypothesis was that convergence angles produced by dental students would not significantly differ from the recommended convergence angle values.

The second null hypothesis was that convergence angles produced by male and female students would not significantly differ.

METHODOLOGY

After receiving ethics committee approval (F2018-3009), this study was conducted on fourth and fifth-year undergraduate dental students at Qassim University, Saudi Arabia. This is an observational study in which data regarding the tooth preparation characteristics were collected from dental students who had completed their course of fixed prosthodontics preclinical training experience.

A total of 60 students, 30 (15 male and 15 female students) each from fourth and fifth year were randomly selected using randomization function of Excel 2013; Microsoft Corp to produce the serial number of selected students. Students who had not completed their course of fixed prosthodontics preclinical training experience were not included in the study. Next, Students were divided into two groups (male and female) of 30 students each, having 15 male and 15 female students of both levels. Both male and female groups in the skill labs of their own campuses were instructed to prepare fresco typodont teeth placed inside phantom head for metal ceramic crowns on first mandibular molars (#36). Students were given maximum of 40 minutes to submit their prepared tooth under standardized clinical examination conditions for evaluation. To match the examination conditions between the two groups, proctors were instructed regarding uniform

guidelines and instructors or evaluators were not allowed during the preparation.

Out of 60 preparations, a total of 45 prepared teeth for ceramic –metal preparations of 23 males and 22 females were randomly selected from fourth year and fifth year dental students. To measure the CA, the preparations were scanned and digitalized using Sirona Cerec 2 scanners to produce 3-dimensional rendering. The measurements of CA for each tooth were accomplished using software program “image J” (Figure 1). Using the “angle “ feature provided in the software, we were able to draw two lines extending coronally and representing the axial walls on the right and left contour of each tooth from the B-L and M-D aspects. The angle that was formed by the intersection of the two lines was subsequently calculated (Figure 2). Afterwards, data were analysed using descriptive and t-test with a statistical software package (SPSS v22.0, SPSS Corp., Chicago, IL, USA). One sample t-test was applied to compare the difference in mean clinically practiced convergence angle values with its recommended values, also two-sided t tests were performed separately to identify the differences in BL and MD convergence angles from preparations made by male and female students (p<=.05)

RESULTS

Preparations from 45 students (22 females and 23 males) were collected and analyzed. The results of statistics of convergence angles for the teeth are shown in the Table I. The result of our study showed that only 40 percent of both M-D and B-L CA were within the recommendations (<12°). The mean of the BL-CA of all preparations was 16.55±8.51 and the mean of MD-CA was 18.22±7.99. The mean of BL-CA achieved by male students was 16.16 ±10.19, while the mean of BL CA for the teeth that was prepared by female students was 16.96 ± 6.52. The mean of the MD –CA was 19.03 ±8.08 in preparations that were made by the male students and 17.37±7.78 in preparations that were made by female students. The smallest convergence angle recorded was 5.8 while largest convergence angle recorded was 40.28. Approximately 2.2 % of students were able to prepare with convergence angle less than 6 and 4.4% of the students made the preparation with MD convergence less than 6 degrees (Table II). The results from the T-test comparisons of the convergence angle preparations that were made by male and female students showed no significant difference between the genders for both BL and MD convergence angle.

Table I: Difference between hypothesized and convergence angles achieved by the students

Variable	Hypothesized CA mean	CA achieved by the students (mean + SD)	P value
Convergence angle (CA)	12	17.38 ±8.42	0.000

Table II: A summary of convergence angles from preparations made by students in examination setting.

Gender	C A	Mean	SD	Median	Minimum	Maximum
Female	BL	16.96	6.5209	14.52	6.7	31.96
	MD	17.37	7.9850	15.36	7.4	36.62
Male	BL	16.16	10.19	14.44	5.97	40.28
	MD	19.03	8.08	19.21	5.8	32.74
Combined	BL	16.55	8.51	14.47	5.97	40.28
	MD	18.22	7.99	16.82	5.8	36.62

-BL: buccolingual, MD: mesiodistal.

- All measurements are in degrees.

Table III: Distribution of students who achieved convergence angle less than 6,12,14, 16 and above 16:

Gender	CA	No of students	No.(%) of student with CA <6	No.(%) of student with CA <12	No.(%) of student with CA <14	No.(%) of student with CA <16	No.(%) of student with CA =>6
Female	BL	23	1 (4.3)	9 (39.1)	1(4.3)	2 (8.7)	10(43.5)
	MD	23	2 (8.7)	2 (8.7)	1 (4.3)	4 (17.4)	14 (60.9)
Male	BL	22	0	3 (13.6)	5(22.7)	4(18.2)	10(45.5)
	MD	22	0	4 (18.2)	4(18.2)	4(18.2)	10(45.5)
Combined	BL	45	1 (2.2)	12 (26.7)	6 (13.3)	6 (13.3)	20 (44.4)
	MD	45	2 (4.4)	6 (13.3)	5 (11.1)	6(13.3)	26 (57.8)

CA, convergence angle; BL, buccolingual; MD, mesiodistal.

Fig. 1: Measurement of the mesiodistal and buccolingual CA using the "angle" tool in ImageJ software.



DISCUSSION

The overall acceptability of crown preparations is directly influenced by numerous factors, one of which is the convergence angle^{20,21}. Recommendations for the convergence angle of cast restorations have been suggested in the literature. However, these recommendations are merely theoretical and have proven difficult to achieve under clinical conditions^{6,8,10}.

The results of our study led to the rejection of the first hypothesis that there is no significant difference between the convergent angles achieved by the students and the ideal values recommended in fixed prosthodontics and dental literature which is close to the results reported by Nordlander et al.¹¹ Moreover, the results of the present study showed no significant difference between the CA values achieved by male and female students. Therefore, the second proposed hypothesis was verified.

A study by Annerstedt et al²² which included general dentists and students reported a mean convergence angle of 21 degrees, which is greater than the mean convergence angles obtained by the participants in the current study. Another study by Al-Omari, reported a mean mesiodistal and buccolingual CA of 22.4 and 25.3 degrees achieved by final year dental students using microscope.²³ On the contrary, the students in our study produced a lower mean of mesiodistal and buccolingual convergence angles than the participants in the study by Al- Omari.

Moreover, previous studies reported mean CA of 19.2° mesiodistally (M-D) and 23° buccolingually (B-L) for vital teeth and 12.8° (M-D) and 22.5° (B-L) for non-vital teeth, that were achieved by dental students were greater than suggested values in textbooks.²⁴ In addition, a study by Noonan and Goldfogel reported a mean CA of 19° for normal clinic conditions and 15.7° for examination conditions⁹.

Another study reported only 12.7 percent of final year students who were taught to maintain CA of 4-10° during tooth preparation were able to achieve these optimal values whereas the average CA achieved by the students was 19° (Patel et al, 2005).²⁵ Furthermore, an average CA value of 21° achieved by general dental practitioners and 19.4° by dental students were reported in the study by Annerstedt et al.²² Study by Sato et al also reported that only 12.7% of teeth prepared by final-year dental students fell within the ideal range of 2 to 5 degrees, and the average taper was 9.5 degrees (19.0 degrees convergence angle).²⁰ In our study, the average convergence angle is approximately 17.39 degrees, which is close to the average reported angle of 19 degrees achieved by dental students in these studies.

Weed et al also reported a mean CA of 21.57 in crown preparations made by dental students.²⁶ Another study by Mack et al reported a mean CA of 16.43 degrees of crown preparations gathered from five different dental schools.⁷ The results of our study show a great similarity to the previously reported values.

In the present study, 2.2 % of student made preparation with BL convergence angles less than 6 degrees and 4.4% of students achieved similar MD angles. Angles less than 14 degrees are considered acceptable and 13.3%of students achieved BL convergence angle below this threshold. Similarly, 11.1% of students achieved MD angles less than 14 degrees. The percentage of students achieving convergence angle within the acceptable limits is comparable with that of other studies done on dental students in different preclinical settings.

The convergence angle has been calculated in literature using different methods as summarized in Table III, including microscopy, digital laser scanning and other techniques. In study by Patel et al, each tooth die was trimmed and sectioned in the MD and BL planes and then they were displayed on an overhead projector and the

angle was calculated using the silhouette. Another method of measuring the CA was by depending on the student's ability to estimate the ideal convergence angle, which resulted in measurements that were less accurate and with large convergence angles.²¹ studies by Ghafoor et al and Güth et al reported mean CA achieved by residents and specialists and measured using computer-aided design (CAD) software(AutoCAD; Autodesk Inc).¹⁶ However, the mean convergence angle was greater than the recommended guidelines and the values produced by the students in our study.

In the current study, Sirona (Cerec 2) software was used to scan each tooth in order to produce 3D renderings and the convergence angles were measured using "image j" software program and based on that method we found that 40 percent of the participants were within the recommended range for a CA ($<12^\circ$), as recommended by textbooks on prosthodontics.

In the light of findings of our study, there are some limitations that needs to be stated:

First, all of students made the preparations under examination conditions, which differ greatly from the clinical settings. Secondly, the time that was given to perform the preparations (40 mins) might not be available for dentists in high-volume practices. Third, this study was performed on phantom head mannequins. Thus, several variables such patient cooperation, accessibility, and soft tissue were not present. All the mentioned limitations could impact the ability of the students to achieve similar results and convergence angle in clinical conditions.

In this study, other properties and parameters of tooth preparations and their relation to student's control or other aspects were not described. Any further study should consider reporting other properties of tooth preparation and other related problems for the same selected group of students' tooth preparations.

CONCLUSION

Based on the mentioned limitations of this study, the conclusion can be drawn that there was a considerable difference between the CA recorded in this study and the ideal recommended values in fixed prosthodontics textbooks and the dental literature. This disparity might be due to examination conditions under which study was performed and can be considered as confounding factor. The results of our study show that there is great need for improvement in the skills lab teaching methods for crown preparation using advanced preparation methods like real time video magnification. Also, greater emphasis should be placed on the teaching of proper patient-operator positioning and the usage of silicone indices.

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Statement of conflict of interest The authors have no conflict of interest to declare.

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