


Original article

Evaluation of Convergence Angles in Posterior Crown Preparations by Dental Students at Zawia University

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ABSTRACT

Background and objectives: Achieving optimal axial taper and occlusal convergence in crown preparations is a crucial concern among dental students. Proper preparation design is essential for the long-term success of full-coverage restorations. This study aimed to evaluate the convergence angles and axial taper achieved by dental students in their crown preparations. **Methods.** A total of 80 posterior tooth preparations (40 mandibular first molars and 40 mandibular second molars) created by second-year dental students on a dental simulator were analyzed. The total occlusal convergence (TOC), bucco-lingual (BL) and mesio-distal (MD) convergence angles, as well as the degree of taper on the axial walls, were measured using the B&B dental software (Guide system, B&B, Italy). Statistical analysis was performed using SPSS version 27. **Results.** The overall mean of the total convergence angle was 21.88°, with a BL convergence angle mean value of 23.11° (standard deviation of 13.3°) and an MD convergence angle mean value of 20.66° (standard deviation of 11.0°). The results showed a statistically significant difference between the mesial axial taper and the distal axial taper (p -value < 0.001). However, no significant differences were observed between the buccal axial taper and lingual axial taper (p -value > 0.05), or between the BL convergence angle and MD convergence angle (p -value > 0.05). **Conclusion.** The study revealed variations in the convergence angles of full metal crown preparations created by dental students. The recommended convergence angle was difficult for these students to achieve.

Keywords: Crown Preparations, Axial Taper, Occlusal Convergence, Dental Students.**Citation:** Esmeda F, Omar K, Eljaballi A, Hwisa S. Evaluation of Convergence Angles in Posterior Crown Preparations by Dental Students at Zawia University: West of Libya. Khalij-Libya J Dent Med Res. 2024;8(2):155–161.<https://doi.org/10.47705/kjdmr.248202>**Received:** 01/05/24; **accepted:** 26/06/24; **published:** 02/07/24Copyright © Khalij-Libya Journal (KJDMR) 2024. Open Access. Some rights reserved. This work is available under the CC BY-NC-SA 3.0 IGO license <https://creativecommons.org/licenses/by-nc-sa/3.0/igo>

الخلفية والأهداف: يعد تحقيق التقارب المحوري الأمثل والتقارب الإطباق في تحضيرات التاج مصدر قلق بالغ الأهمية بين طلاب طب الأسنان. يعد تصميم التحضير المناسب ضروريًا لتحقيق النجاح الطويل الأمد لترميمات التغطية الكاملة. تهدف هذه الدراسة إلى تقييم زوايا التقارب والتقارب المحوري التي حققها طلاب طب الأسنان في تحضيرات تيجانهم. **الطرق.** تم تحليل إجمالي 80 تحضيرًا للأسنان الخلفية (40 ضرسًا أوليًا في الفك السفلي و40 ضرسًا ثانيًا في الفك السفلي) تم إنشاؤها بواسطة طلاب طب الأسنان في السنة الثانية على جهاز محاكاة الأسنان. تم قياس التقارب الإطباق الكلي (TOC) وزوايا التقارب الشدقي لللساني (BL) والمتوسطي البعيد (MD)، بالإضافة إلى درجة التقارب على الجدران المحورية، باستخدام برنامج B&B (لطب الأسنان) نظام Guide، B&B، إيطاليا. (تم إجراء التحليل الإحصائي باستخدام برنامج SPSS الإصدار 27. **النتائج.** كان المتوسط العام لزوايا التقارب الكلية 21.88 درجة، مع متوسط قيمة زاوية تقارب BL 23.11 درجة (انحراف معياري 13.3 درجة) ومتوسط قيمة زاوية تقارب MD 20.66 درجة (انحراف معياري 11.0 درجة). أظهرت النتائج وجود فرق كبير إحصائيًا بين التضيق المحوري الأوسط والتضيق المحوري البعيد (القيمة الاحتمالية > 0.001). ومع ذلك، لم تُلاحظ أي فروق كبيرة بين التضيق المحوري الخدي والتضيق المحوري اللساني (القيمة الاحتمالية < 0.05)، أو بين زاوية تقارب BL وزاوية تقارب MD (القيمة الاحتمالية < 0.05). **الاستنتاج.** كشفت الدراسة عن اختلافات في زوايا التقارب لتحضيرات التيجان المعدنية الكاملة التي ابتكرها طلاب طب الأسنان. كان من الصعب على هؤلاء الطلاب تحقيق زاوية التقارب الموصى بها.

INTRODUCTION

Complete crown preparation is a fundamental step for other variations of crown preparations. Full coverage restorations are often recommended for the restoration of extensively damaged and endodontically treated teeth. The ability of dental students to create optimum preparations with recommended total occlusal convergences (TOC) is the primary focus for restoration success, as visibility, accessibility, tooth anatomy, and practitioner experience are important factors to achieve two opposing axial walls with maximum retention.

Theoretically, greater retention and more conservation of tooth structure can be obtained by parallelism of the axial walls [1]. However, the achievement of parallel walls (4° - 6°) without incorporating undercuts is difficult during tooth preparation.

The retention and resistance are one of the five important principles of tooth preparations, which depend on several factors such as the convergence angle, height, and surface area of the preparation [2]. Moreover, the clinically acceptable taper is estimated to be between (10°) and (20°) [3]. Additionally, full coverage cast preparations are recommended to have (10°) to (20°) of TOC with a minimal height of 4 mm for molars and 3 mm for other teeth [4].

Further investigations by Saleh YS et al. [5] compared clinically practiced convergence angle values of tooth preparations with recommended values, and the effect of tooth position on convergence angle. They found a considerable disparity between the convergence angle values and the recommended guidelines. Measured convergence angle values were greater for posterior teeth compared to anterior teeth [5].

The convergence angle significantly influences crown retention. Therefore, it is important to determine the ability of dental students to competently achieve acceptable abutment taper. Thus, desirable tooth preparation is considered one of the most challenging tasks within preclinical training, resulting in a large

number of aspects that have to be taken into consideration by preparation novices.

The present study aimed to determine the mean convergence angle and axial taper for full metal crown preparations performed by second-year dental students at Zawia University using a dental simulator.

METHODS

This descriptive study investigated the preparation of mandibular first and second molars for full cast crowns restorations. The procedures were performed by second-year dental students using a dental simulator in the fixed prosthodontics department at the faculty of dentistry, Zawia University. The study was conducted from January 2023 to May 2023.

These preparations were conducted under preclinical conditions. Impressions were taken for 80 randomly selected preparations, which were then poured with Type IV dental stone (Moldarock Royal, Moldastone, Kulzer, Germany) to produce master cast models.

The cast models were scanned using a 3D model scanner (Ceramill Map300, AmannGirrbach, Austria). Evaluation of the TOC, bucco-lingual (BL), and mesio-distal (MD) convergence angles of each abutment tooth was conducted using B&B dental software (Guide system, B&B, Italy). Serial numeric coding was used for die identification purposes. The scanning procedures were performed according to the instructions provided by a dental laboratory technician at Alzendah dental laboratories in Tripoli, Libya. As the following procedures:

Step 1

The standardized reference axes were the midlines on each surface, as determined by the software. These midlines determined a plane slice through the image perpendicular to an occlusal grid reference (Fig. 1).



Fig. 1. Scanned image of lower first molar showing mid-bucco-lingual plane

Step 2

The TOC, bucco-lingual, and MD angles were calculated by measuring the angles formed by drawing straight lines along the axial inclination of the opposing axial surfaces (Fig. 2, 3).



Fig 2: Total convergence angle bucco-lingually =11.6 of mandibular molar. buccal inclination in relation to horizontal plane =96.09. Lingual inclination in relation to horizontal plane =92.04

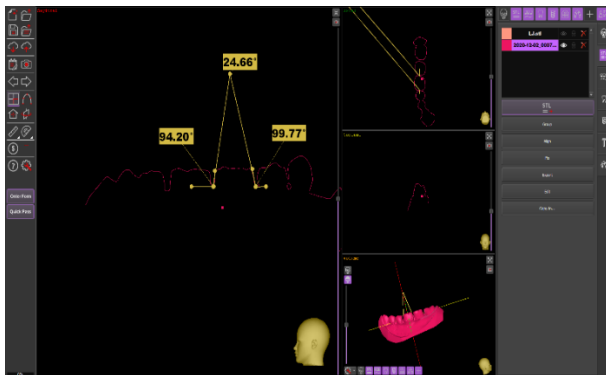


Fig 3. Total convergence angle mesiodistally =24.66 of mandibular first molar. mesial inclination in relation to horizontal plane =99.77. Distal inclination in relation to horizontal plane =94.20

Step 3

Individual axial taper, in contrast, was calculated by measuring the angle of axial inclination of each side in relation to the horizontal plane, followed by subtracting it from 90°, which represented the angle between the axial inclination and the vertical plane. The axial wall tapers for each preparation (mesially, distally, buccally, and lingually) were measured, and the TOC (MD and BL) were illustrated in Tables 1.

Tables 1. The axial wall tapers for each preparation.

N	Number Tooth	Mesial Axial taper	Distal Axial taper	Buccal Axial taper	Lingual Axial taper	BL Convergence angle	MD Convergence angle
1.	6	99.77°	94.20°	102.02	104.73°	31.69°	24.66°
2.	7	96.09°	92.04°	98.88°	98.11°	18.08°	11.61°
3.	6	95.23°	90.00°	101.6°	97.61°	19.59°	12.49°
4.	7	90.53°	88.37°	108.0°	82.24°	9.31°	16.11°
5.	6	91.19°	109.4°	94.68°	121.34°	36.67°	18.36°
6.	7	111.4°	92.17°	102.0°	102.87°	22.80°	24.46°
7.	6	86.08°	92.74°	96.58°	96.83°	12.11°	4.65°
8.	7	90.01°	80.49°	88.24°	91.55°	7.71°	2.92°
9.	6	93.48°	104.0°	101.7°	96.24°	18.44°	18.64°
10.	7	108.50	100.4°	99.20°	101.92°	22.95°	27.00°
11.	6	90.11°	75.94°	104.65	79.74°	10.34°	4.25°
12.	7	122.55	105.7°	106.1°	107.79°	36.84°	42.62°
13.	6	99.15°	91.82°	105.80°	108.77°	37.34°	13.71°
14.	7	96.08°	114.87	105.3°	111.79°	38.16°	29.63°
15.	6	98.14°	93.64°	98.04°	100.98°	18.37°	14.83°
16.	7	96.69°	106.68	103.4°	110.87°	24.45°	35.53°
17.	6	103.03	87.65°	110.2°	99.42°	35.05°	13.53°
18.	7	97.13°	95.01°	91.04°	90.81°	07.05°	14.29°
19.	6	89.82°	92.30°	102.9°	86.29°	12.77°	06.45°

N	Number Tooth	Mesial Axial taper	Distal Axial taper	Buccal Axial taper	Lingual Axial taper	BL Convergence angle	MD Convergence angle
20.	7	93.46°	95.85°	96.95°	98.78°	19.92°	12.61°
21.	6	86.76°	81.66°	88.60°	100.36°	13.26°	0.35°
22.	7	96.87°	83.81°	105.97°	94.36°	17.97°	8.91°
23.	6	96.99°	85.30°	111.4°	98.87°	30.27°	10.65°
24.	7	120.6°	98.98°	112.9°	100.76°	34.04°	41.53°
25.	6	92.23°	86.98°	115.5°	90.76°	27.04°	7.11°
26.	7	102.8°	94.03°	98.61°	108.25°	24.81°	21.74°
27.	6	86.51°	86.36°	97.83°	95.70°	18.62°	0.43°
28.	7	94.84°	100.5°	101.5°	103.47°	25.91°	17.35°
29.	6	96.33°	106.88	92.02°	96.33°	12.39°	21.67°
30.	7	91.37°	110.60	103.3°	95.44°	19.45°	27.85°
31.	6	85.76°	90.69°	94.93°	104.19°	18.16°	3.86°
32.	7	83.46°	104.76	103.6°	101.56°	24.84°	10.83°
33.	6	97.49°	93.08°	111.98	106.90°	40.30°	11.79°
34.	7	103.1°	97.13°	107.23	101.70°	29.56°	23.49°
35.	6	103.49	91.87°	103.01	99.64°	26.98°	21.03°
36.	7	106.1°	106.4°	104.59	102.94°	28.70°	34.68°
37.	6	108.36	101.58	94.81°	105.32°	21.29°	31.58°
38.	7	93.66°	96.86°	97.69°	104.47°	20.42°	12.01°
39.	6	110.3°	103.72	100.48	109.28°	29.07°	32.55°
40.	7	121.43	88.60°	107.59	111.45°	37.44°	36.05°
41.	6	107.89°	91.95°	99.05°	98.17°	20.96°	21.14°
42.	7	106.54	108.5°	110.3°	99.64°	32.69°	37.29°
43.	6	105.37	93.27°	87.92°	94.54°	4.20°	20.15°
44.	7	84.34°	98.34°	94.18°	83.50°	1.71°	5.53°
45.	6	104.06	92.86°	96.06°	102.05°	18.85°	19.47°
46.		103.86	103.3°	103.0°	98.03°	22.93°	24.20°

N	Number Tooth	Mesial Axial taper	Distal Axial taper	Buccal Axial taper	Lingual Axial taper	BL Convergence angle	MD Convergence angle
	7						
47.	6	99.14°	97.89°	101.4°	90.13°	12.71°	19.19°
48.	7	93.65°	96.20°	99.04°	101.33°	24.16°	8.85°
49.	6	96.99°	90.48°	93.75°	105.31°	21.06°	7.72°
50.	7	98.45°	98.02°	87.35°	99.55°	14.91°	20.92°
51.	6	106.98	98.93°	102.3°	115.91°	38.18°	25.38°
52.	7	98.25°	107.13	86.81°	98.08°	11.99°	25.86°
53.	6	109.24	106.80	108.6°	104.05°	33.17°	35.52°
54.	7	103.45°	102.28°	106.60°	91.67°	20.58°	26.44°
55.	6	95.04°	97.58°	100.89°	92.63°	15.31°	15.06°
56.	7	95.12°	89.93°	86.79°	91.38°	3.57°	8.66°
57.	6	103.85°	92.32°	91.26°	96.50°	13.07°	19.97°
58.	7	106.86°	85.72°	112.14°	87.58°	22.67°	16.19°
59.	6	98.93°	108.87°	108.02°	115.43°	43.32°	28.82°
60.	7	124.64°	105.25°	111.92°	113.85°	47.50°	53.55°
61.	6	106.17°	89.32°	99.56°	104.77°	25.18°	18.23°
62.	7	102.10°	110.97°	91.98°	93.88°	7.92°	30.86°
63.	6	80.89°	89.35°	108.83°	94.65°	20.08°	/
64.	7	109.92°	95.63°	100.75°	98.92°	21.58°	26.37°
65.	6	114.66°	101.18°	102.44°	106.56°	29.64°	37.92°
66.	7	102.62°	96.14°	100.29°	100.00°	20.54°	19.37°
67.	6	103.21°	103.02°	94.29°	103.07°	19.31°	26.28°
68.	7	95.98°	98.27°	91.54°	97.32°	11.05°	16.04°
69.	6	100.73°	99.37°	105.21°	95.04°	21.44°	20.00°
70.	7	94.20°	94.53°	100.01°	96.65°	17.21°	10.40°
71.	6	105.03°	84.65°	99.47°	102.12°	24.56°	10.87°
72.	7	99.17°	101.78°	101.67°	96.33°	20.16°	22.00°

N	Number Tooth	Mesial Axial taper	Distal Axial taper	Buccal Axial taper	Lingual Axial taper	BL Convergence angle	MD Convergence angle
73	6	104.50°	103.02°	95.06°	94.96°	14.40°	30.74°
74	7	100.46°	92.30°	95.94°	99.79°	17.43°	16.54°
75	6	108.51°	94.88°	103.51°	103.12°	28.15°	24.15°
76	7	105.59°	98.73°	91.56°	106.99°	20.83°	25.49°
77	6	109.17°	96.52°	92.96°	101.22°	17.99°	26.78°
78	7	116.95°	107.65°	110.17°	107.86°	33.83°	41.94°
79	6	121.3°	100.67°	44.13°	113.94°	104.04°	38.67°
80	7	104.9°	98.34°	91.09°	94.77°	9.83°	25.75°

Statistical analysis

The statistical analysis was conducted using Statistical Package for the Social Sciences (SPSS V27). Descriptive procedures, including mean, and standard deviation (SD), were employed. Furthermore, statistical tests such as independent samples t-test. A significance level of $P < 0.05$ was considered statistically significant, while a significance level of $P < 0.001$ was considered highly significant.

RESULTS

A total of 80 crown (40 mandibular first molars and 40 mandibular second molars) preparations were performed by dental students. The overall mean of the total convergence angle was (21.88°), and the total axial taper mean was (99.32°) (Table 2)

The mesial axial taper had a mean value of (100.70°) with a standard deviation of (9.3°), while the distal axial taper had a mean value of (96.69°) with a standard deviation of (7.8°). The buccal axial taper had a mean value of (99.74°) with a standard deviation of (9.4°), and the lingual axial taper had a mean value of (100.15°) with a standard deviation of (7.7°). The BL convergence angle had a mean value of (23.11°) with a standard deviation of (13.3°), while the

MD convergence angle had a mean value of (20.66°) with a standard deviation of (11.0°).

Table 2: Mean values for convergence angle and axial taper angle on all crown preparations.

Angle	N	Mean	SD
Mesial Axial taper	80	100.70°	9.3°
distal Axial taper	80	96.69°	7.8°
Buccal Axial taper	80	99.74°	9.4°
Lingual Axial taper	80	100.15°	7.7°
BL Convergence angle	80	23.11°	13.3°
MD Convergence angle	80	20.66°	11.0°

Based on the results presented in Table 3, the results suggested that there was a statistically significant difference between the mesial axial taper and the distal axial taper. However, no significant differences were observed between the buccal axial taper and lingual axial taper, or between the BL convergence angle and the MD convergence angle, based on the provided p-values.

Table 3: Mean comparison between convergence angles and taper values

Angle	N	Mean	SD	P-value
Mesial Axial taper	80	100.70	9.3	< 0.001**
Distal Axial taper	80	96.69	7.8	
Buccal Axial taper	80	99.74	9.4	0.773
Lingual Axial taper	80	100.15	7.7	
BL Convergence angle	80	23.11	13.3	0.081
MD Convergence angle	80	20.66	11.0	

DISCUSSION

Several clinical studies have been performed in an attempt to establish optimal convergence angles for clinical practice in order to achieve acceptable results. The achievement of appropriate convergence angles that provide adequate retention and resistance for full metal crowns has been a subject of research among dental students.

In the present study, the mean convergence angle of (80) crown preparations were (21.88°), which is higher than the recommended value of less than (12°) for cast crowns. The students faced difficulties in achieving

the ideal convergence angle. Although the mean convergence angle was significantly higher than the recommended value, it was comparable to the results found in previous studies by Rafeek RN et al. [6]. This can be explained by the fact that less experienced second-year dental students created the preparations. Additionally, the preparations were performed in a laboratory setting on artificial teeth, rather than on actual dental hard tissues. According to a study by Ohm E. and Silness J. [7], the mean convergence angles for metal-ceramic crown preparations on vital teeth varied between approximately (19°) and (27°). In root-filled teeth, the mean convergence angles ranged from (12°) to (37°) [7].

Multiple studies have found that the clinically established mean convergence angle among dental students and general practitioners typically ranges between (12°) and (26°). Furthermore, these studies have indicated a wide variation in convergence angles observed among general practitioners [8].

In the current study, the mean convergence angle (CA) for MD axial wall preparations was (20.66°), which was less than the mean CA of (23.11°) for the BL axial wall preparations. This finding is in agreement with the study by Aleisa K, [9] where the mean CA for MD axial wall preparations (16.66°) was less than the mean CA for the BL axial wall preparations (20.45°). on posterior tooth preparations.

Additionally, the current findings align with the study by Ayad MF et al. [10], which reported the greatest convergence value (19.8°) ± (10.0°) for bucco-lingual, and the smallest convergence value (14.1°) ± (3.8°) for MD prepared by dental students.

In contrast, the study performed by Amine M et al. [11] which measured the highest convergence value for MD (14.74°) ± (5.63°) and the lowest convergence value for BL (12.23°) ± (6.85°) for cast crown preparations on a simulator. However, this study found no statistically significant difference between the BL and MD convergence angles. The discrepancy between these findings suggests that the relationship between tooth surface accessibility and convergence angle may vary depending on the specific study

conditions and the dental simulator used. Further research is needed to fully understand the factors influencing the differences in convergence angles for MD and BL tooth preparations performed by dental students.

This study found that the mesial and distal axial taper were (100.7°) and (96.6°), respectively, which exceeded the recommended guidelines in the literature. This suggests that the degree of axial taper was influenced by the tooth surface. The mesial taper was significantly higher than the distal taper, which may explain the difficulty of the preparations on molar region especially distally. This could be attributed to the angling of the handpiece and the limited visibility of the distal surface, as it is not in the direct line of sight, compared to the mesial surface, which might lead to limitation of the preparations on distal surface with less taper.

Interestingly, this finding is in contrast to the expectations, as the mesial surface is generally considered easier to prepare. This is opposite to the results reported by Abdulla F et al. [12]. The current study was conducted in a dental simulation setting, which may have contributed to these unexpected findings.

The study found that the BL taper angles emphasized the impact of tooth surface anatomy on the degree of axial taper among dental students. Specifically, the lingual taper was greater than the buccal taper. The suggested reason for this difference is the variations in tooth surface anatomy. The attempt to eliminate the very prominent undercuts associated with the lingual surface of mandibular molars might have led to an increase in the lingual convergence angle. However, the study did not find any statistically significant differences between the buccal and lingual axial taper. Given these findings, the study recommends that more research should be conducted to further evaluate TOC among dental students from different college programs. Investigating the CA variations across various educational institutions could provide valuable insights into factors that influence the

preparatory skills and clinical decision-making of future dental practitioners.

CONCLUSION

This study measured the TOC of full metal crown preparations performed by dental students in a laboratory setting. The findings indicated that the TOC achieved by the students exceeded the recommended CA of less than (12 O).

The study found that the recommended CA was difficult for the dental students at Zawia University Faculty of Dentistry to consistently achieve. This suggests that further training and practice are needed for these students to develop the necessary skills to prepare teeth within the ideal CA range.

Additionally, the time period allotted for students to practice and refine their tooth preparation techniques is an important factor that deserves consideration. Adequate time for repetition and feedback is crucial for students to improve their ability to meet the recommended CA targets.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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