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ORIGINAL RESEARCH

The Effect of Student Experience and Tooth Location on Finish Line Width and Angle of Full Metal Crown Preparations in Preclinical Setting

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Purpose: To determine the effect of experience and tooth location on the finish line width and angle of crown preparations performed by undergraduate students.

Methods: Eighty full metal crown preparations on typodont teeth were divided into four groups: Group 1: 20 preparations performed on mandibular first molar in the first semester. Group 2: 20 preparations performed on mandibular first molar in the second semester. Group 3: 20 preparations performed on mandibular second molar in the first semester. Group 4: 20 preparations performed on mandibular second molar in the second semester. All prepared teeth were scanned, and the finish line width and angles were measured at 8 different locations. Paired *t*-test in the SPSS software was used to compare and determine the effect of experience and tooth location on the students' performance.

Results: There was a statistically significant difference in the mandibular first molar finish line width between the first and second semesters for the same student in the distal, distolingual, and mesiobuccal areas of the tooth. There was a statistically significant increase in finish line width between first and second molars in the distobuccal, distal, distolingual, lingual, and mesial side of the tooth. Regarding the finish line angle, there was a statistically significant difference between the first and second semesters on the distal side of the tooth. There was a statistically significant increase in finish line angle between first and second molars in the distobuccal side of the tooth.

Conclusion: As students gain more experience in different types of tooth preparations, they tend to produce a wider finish line than that recommended for full metal crown preparation. The tooth location in the mouth influences the width and angle of the finish line hence the more inaccessible areas on the tooth have a wider finish line.

Keywords: fixed prosthodontics, dental education, undergraduate, finish line design, full cast restoration

Introduction

Crown preparation is a scientific art that must be carefully executed to achieve successful restoration. The quality of tooth preparation is influenced by different factors, such as the amount of occlusal reduction, total occlusal convergence, finish line configuration, and the amount of axial reduction.[1] Several previous studies have investigated occlusal reduction,[2–4] total occlusal convergence,[2–16] the presence of undercuts,[12] and finish line width of metal-ceramic and all-ceramic crowns.[2,8,13,14] However, none have concentrated on the finish line width and angle of full metal crown preparation.

The width of the finish line is an important feature of crown preparation because it determines the marginal integrity and durability of full-coverage restorations. Each dental material has its requirements and configurations for the type and width of the finish line. A full metal crown is indicated when there is limited inter-arch space, and a short clinical crown requires the least amount of tooth reduction. The recommended width of the finish line for the full metal crown is 0.3–0.5 mm chamfer finish line with TOC range between 10 and 20 degrees and 1 mm occlusal reduction.[1] Boftino et al found that the chamfer finish line had the best full metal crown cervical adaptation compared to the shoulder finish line, regardless of the cement type used.[17] Increasing the width of the finish line compromises the remaining tooth structure,

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whereas decreasing the width of the finish line compromises the minimum thickness of the metal at the margin or can result in an over-contoured crown.[18]

The finish line angle depends on the configuration of the bur used for the preparation. Using a flat-end bur produced a sharp 90° internal line angle. Shillingburg suggested that eliminating a sharp internal line angle decreases the stress concentration inside the crown.[19] Ardakani et al compared the fracture resistance between 90° and 135° shoulder finish line zirconia copings and concluded that the 135° finish line had a significantly lower fracture value.[20] Chamfer finish line with a rounded internal angle has a better distribution of the occlusal force.[21] The chamfer finish line prepared with a round-end diamond bur produced a desirable angle of 135°-150°. This angle, along with the width of the finish line, can be used to compare the tooth preparation quality between different tooth sites, tooth locations, and preparation experiences of dental practitioners.

This study aimed to measure the finish line width and angle of full metal crown preparations performed by preclinical undergraduate 4th-year students at King Abdulaziz University to compare the first and second semester preparations to determine if there is any improvement with more experience. In addition, we compared the finish line width and angle between the first and second mandibular molars to determine whether the tooth's location influenced student performance.

The first null hypothesis was that there would be no difference between the finish line width and angle at various tooth locations between the first and second semesters. The second null hypothesis was that there would be no difference in the finish line width and angle at various tooth locations between tooth preparations on the first and second mandibular molars.

Materials and Methods

Eighty randomly selected mandibular first and second molar full metal crown preparations on typodont teeth (KaVo Dental, Biberach/Riß, Germany) were included in the study. The teeth were prepared by undergraduate 4th-year students at King Abdulaziz University for a mid-year and final competency examination. For objective evaluation by the students, a putty index was used during the exam to evaluate their occlusal, axial and finish line width. The burs were distributed by the school for all the students at the beginning of the exam to ensure all the students were using the required bur size and dimension during the teeth preparation. The teeth were divided into four groups: Group 1: twenty preparations performed for the mid-year exam on mandibular first molar in the first semester. Group 2: twenty preparations performed for the final exam on mandibular first molar in the second semester. Group 3: twenty preparations performed for the mid-year exam on mandibular second molar in the first semester. Group 4: twenty preparations performed for the final exam on mandibular second molar in the second semester. All prepared teeth were scanned using a desktop scanner (KaVo Arctica; Smartoptics Sensortechnik GmbH), and stereolithography (STL) files were generated for each preparation. All the preparations were performed with supragingival finish line so there were no problems during the scan. The STL files were imported into a software program (AUTODESK FUSION 360; Kilsyth, Victoria, Australia) to analyze the preparation (Figure 1). Finish line width and angle were measured at 8 different locations (mesiobuccal, mid-buccal, distobuccal, distal, distolingual, lingual, mesiolingual, mesial) (Figures 2 and 3). The angle was measured by the software by placing 3 points on the outer surface of the finish line, the beginning of the axial wall and the deepest area of the finish line curvature, as shown in the Figure 2.

The finish line width and angle produced by each student in the first semester at various tooth locations were compared with the same student preparation in the second semester using a paired *t*-test in the SPSS software (version 25.0; IBM SPSS Inc., Chicago, IL, USA) to determine the experience effect. In addition, the finish line width and angle of the mandibular first molar were compared to the preparation of the mandibular second molars using the paired *t*-test in SPSS software for each location to determine the effect of tooth position on student performance.

Results

Forty prepared mandibular first molars (20 in the first semester and 20 in the second semester) and 40 mandibular second molar teeth (20 in the first semester and 20 in the second semester) were analyzed for finish line width and angle to evaluate the effect of experience and tooth location on the student's performance. To evaluate the effect of experience, the comparison

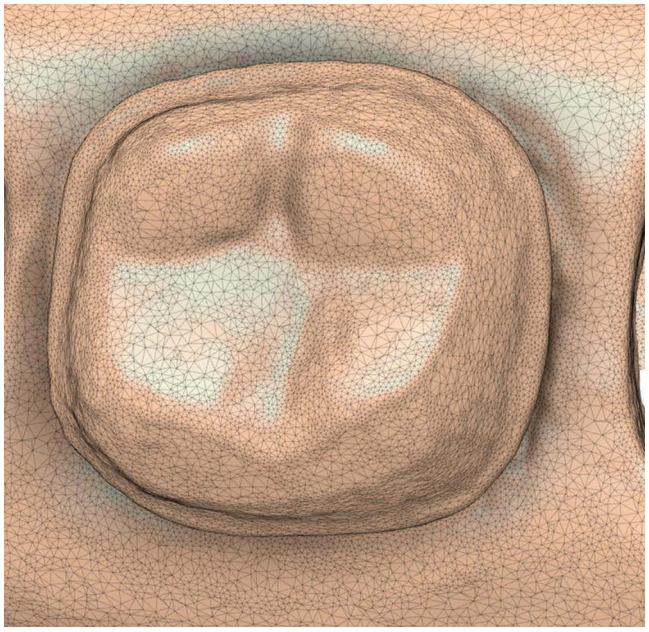

Figure 1 Sample of the scanned prepared tooth.

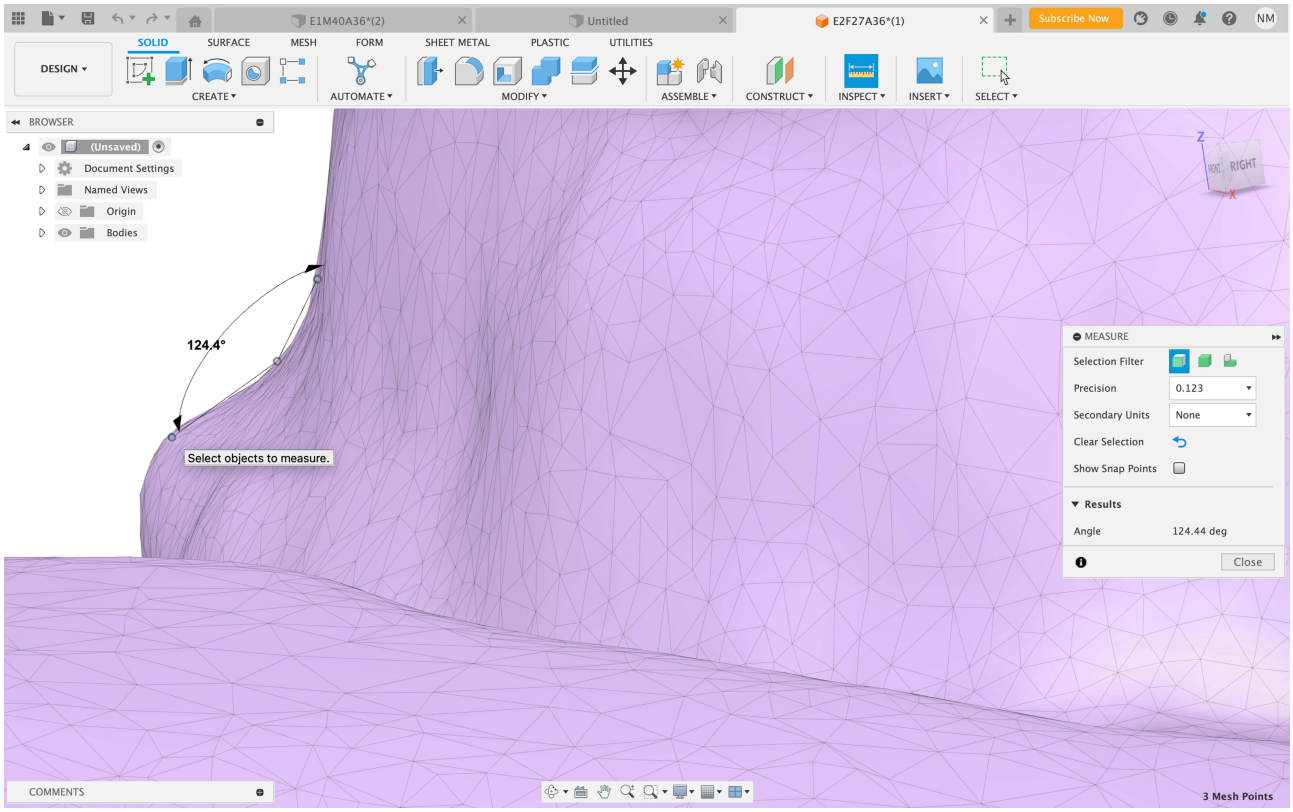

Figure 2 Sample of the finish line angle measurement in the software.

was between the preparation in the first semester and in the second semester for the same student. The effect of tooth position was evaluated by comparing the first molar with the second molar preparations of different students.

The finish line width for the mandibular first molar ranged between 0.51 ± 0.14 mm and 0.73 ± 0.16 mm. In the first semester, the maximum finish line width was 0.61 ± 0.16 mm in the mesiolingual side of the tooth while the maximum in

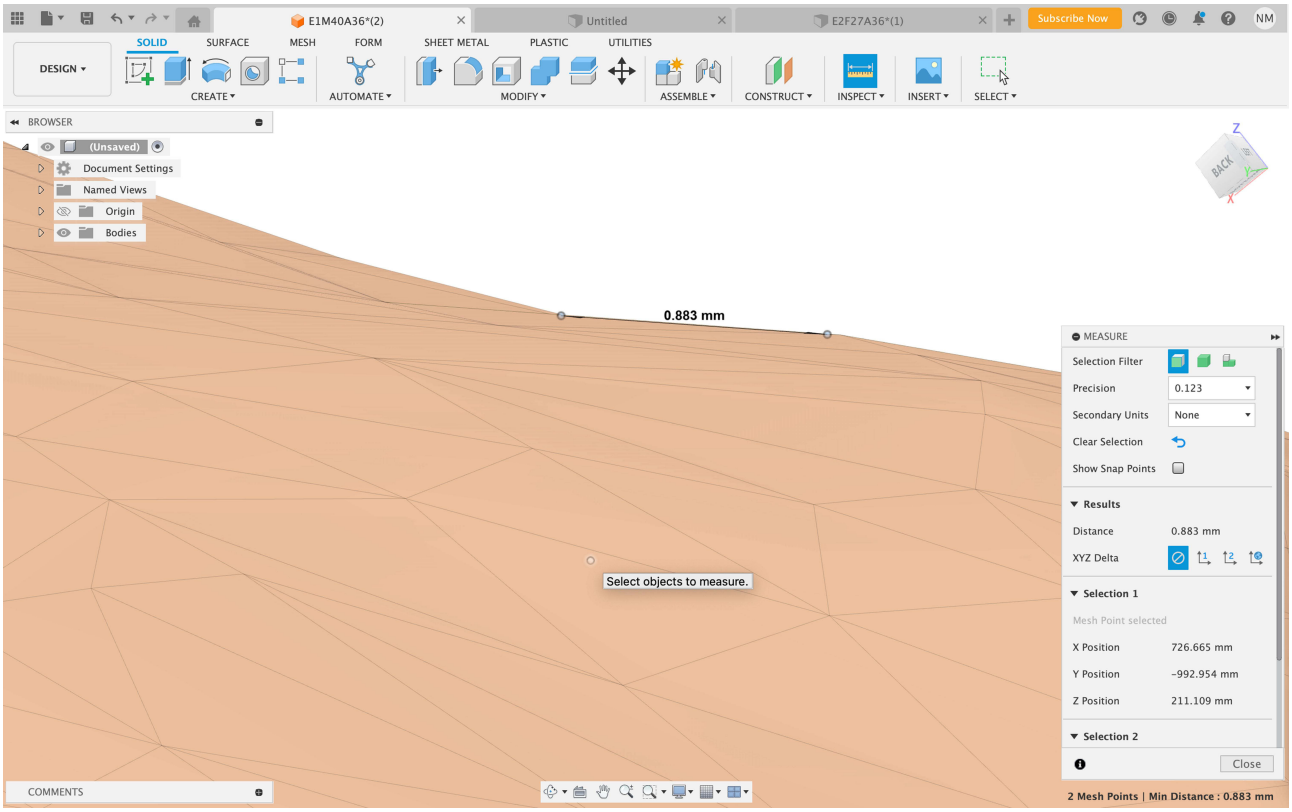

Figure 3 Sample of the finish line width measurement in the software.

the second semester was 0.73 ± 0.16 mm in the mesiobuccal side of the teeth. There was a statistically significant difference in the mandibular first molar finish line width between the first and second semesters in the distal, distolingual, and mesiobuccal areas of the tooth (P= 0.010,0.028 and 0.005, respectively) (Table 1).

Table 1 Statistical Analysis of Finish Line Width at Different Tooth Locations by Semester

Tooth	Location	First Semester Finish Line Width Mean (SD)	Second Semester Finish Line Width Mean (SD)	*P*-value	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Mandibular First Molar	B	0.56 (0.09)	0.53 (0.15)	0.515	−0.067	0.133
	DB	0.61 (0.14)	0.65 (0.16)	0.564	−0.156	0.085
	D	0.53 (0.13)	0.71 (0.20)	0.010*	−0.327	−0.046
	DL	0.57 (0.16)	0.72 (0.21)	0.028*	−0.285	−0.017
	L	0.54 (0.13)	0.57 (0.16)	0.568	−0.133	0.073
	ML	0.61 (0.16)	0.65 (0.21)	0.606	−0.175	0.103
	M	0.51 (0.14)	0.57 (0.12)	0.417	−0.197	0.082
	MB	0.58 (0.17)	0.73 (0.16)	0.005*	−0.260	−0.047
	All locations	0.56 (0.14)	0.64 (0.17)			

(*Continued*)

Table 1 (Continued).

Tooth	Location	First Semester Finish Line Width Mean (SD)	Second Semester Finish Line Width Mean (SD)	*P*-value	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Mandibular Second Molar	B	0.63 (0.19)	0.57 (0.19)	0.221	−0.038	0.163
	DB	0.74 (0.19)	0.71 (0.25)	0.590	−0.088	0.153
	D	0.70 (0.25)	0.76 (0.28)	0.366	−0.204	0.076
	DL	0.79 (0.27)	0.76 (0.21)	0.702	−0.108	0.160
	L	0.68 (0.23)	0.60 (0.12)	0.130	−0.024	0.182
	ML	0.70 (0.22)	0.65 (0.28)	0.480	−0.089	0.188
	M	0.64 (0.29)	0.76 (0.28)	0.096	−0.258	0.021
	MB	0.68 (0.18)	0.67 (0.16)	0.910	−0.100	0.112
	All locations	0.70 (0.23)	0.69 (0.22)			

Note: *Statistically significant at $P < 0.05$.
Abbreviations: SD, standard deviation; B, buccal; DB, distobuccal; D, distal; DL, distolingual; L, lingual; ML, mesiolingual; M, mesial; MB, mesiobuccal.

Regarding the mandibular second molar, the finish line width ranged between 0.57 ± 0.19 mm and 0.79 ± 0.27 mm. The maximum finish line width in the first semester was 0.79 ± 0.27 mm in the distolingual area, while in the second semester, the maximum width was 0.76 ± 0.28 mm in the distal side of the tooth. There was no statistically significant difference between semesters in finish line width (Table 1).

Comparing the finish line width between first and second molars of different students showed that the maximum in the first molar was 0.66 ± 0.18 mm in the mesiobuccal area while the maximum in the second molar was 0.77 ± 0.23 mm in distolingual area of the tooth. There were statistically significant differences in the distobuccal, distal, distolingual, lingual, and mesial side of the tooth (P = 0.028, 0.033, 0.007, 0.019 and 0.002 respectively) (Table 2).

Table 2 Statistical Analysis of Finish Line Width at Different Locations by Tooth Position

Tooth Location	Mandibular First Molar Finish Line Width Mean (SD)	Mandibular Second Molar Finish Line Width Mean (SD)	*P*-value	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
B	0.54 (0.12)	0.60 (0.19)	0.102	−0.130	0.012
DB	0.63 (0.15)	0.73 (0.22)	0.028*	−0.181	−0.011
D	0.61 (0.19)	0.73 (0.26)	0.033*	−0.207	−0.009
DL	0.64 (0.20)	0.77 (0.23)	0.007*	−0.226	−0.036
L	0.55 (0.14)	0.64 (0.18)	0.019*	−0.160	−0.015
ML	0.63 (0.18)	0.68 (0.25)	0.308	−0.148	0.047
M	0.54 (0.14)	0.70 (0.29)	0.002*	−0.257	−0.060
MB	0.66 (0.18)	0.68 (0.19)	0.621.	−0.094	0.056
All locations	0.6 (0.16)	0.69 (0.23)			

Note: *Statistically significant at $P < 0.05$.
Abbreviations: SD, standard deviation; B, buccal; DB, distobuccal; D, distal; DL, distolingual; L, lingual; ML, mesiolingual; M, mesial; MB, mesiobuccal.

The finish line angle for the mandibular first molar tooth preparation ranged between 148.05° ± 15.32° and 155.61° ± 13.40°, with a mean of 152.59° ± 14.46°. In the first semester, the maximum finish line angle was 156.42° ± 14.88° in the buccal side of the tooth, while the maximum in the second semester was 156.19° ± 12.70° in the lingual side of the teeth. There was a statistically significant difference in the finish line angle between the first and second semesters for the same student on the distal side of the tooth (P = 0.005) (Table 3).

Regarding the mandibular second molar, the maximum finish line angle in the first semester was 155.47° ± 18.43° on the mesial side, while in the second semester, the maximum angle was 154.03° ± 16.21° on the lingual side of the tooth. There was no statistically significant difference in the finish line angle between semesters (Table 3).

Comparing the finish line angle between the first and second molars of tooth preparation for different students showed that the maximum in the first molar was 155.61° ± 13.4° in the distobuccal area while the maximum in the second molar was 153.31° ± 16.98° mm in mesial area of the tooth. There was a statistically significant difference between the first and second molars' finish line angles in the distobuccal side of the tooth (P = 0.003) (Table 4).

Discussion

This study compared 4th year students' full metal crown preparations based on finish line at different tooth locations, tooth positions, and practice experience. The first null hypothesis of this study was that there would be no difference in

Table 3 Statistical Analysis of Finish Line Angle at Different Tooth Locations by Semester

Tooth	Location	First Semester Finish Line Angle Mean (SD)	Second Semester Finish Line Angle Mean (SD)	*P*-value	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Mandibular First Molar	B	156.42 (14.88)	152.85 (14.52)	0.471	−6.249	13.386
	DB	155.74 (12.70)	155.49 (14.39)	0.957	−8.942	9.437
	D	154.84 (12.16)	141.26 (15.39)	0.005*	4.230	22.931
	DL	154.78 (15.24)	152.95 (11.56)	0.715	−8.153	11.824
	L	153.26 (14.85)	156.19 (12.70)	0.508	−11.700	5.844
	ML	151.14 (12.87)	149.70 (17.59)	0.768	−8.264	11.146
	M	150.82 (14.73)	148.14 (16.22)	0.604	−7.577	12.951
	MB	152.82 (14.69)	155.00 (16.86)	0.659	−11.966	7.608
	All locations	153.73 (14.02)	151.45 (14.90)			
Mandibular Second Molar	B	150.56 (14.72)	151.46 (17.98)	0.856	−10.716	8.918
	DB	145.61 (12.85)	145.52 (17.83)	0.984	−9.095	9.284
	D	144.77 (15.56)	145.52 (15.87)	0.872	−10.110	8.592
	DL	148.41 (15.48)	148.91 (20.02)	0.922	−10.480	9.497
	L	152.13 (11.45)	154.03 (16.21)	0.667	−10.677	6.867
	ML	151.64 (13.19)	146.52 (17.34)	0.296	−4.578	14.831
	M	155.47 (18.43)	151.14 (15.57)	0.403	−5.932	14.596
	MB	154.31 (13.12)	151.09 (17.13)	0.514	−6.565	13.009
	All locations	150.36 (14.35)	149.27 (17.24)			

Note: *Statistically significant at *P* <0.05.
Abbreviations: SD, standard deviation; B, buccal; DB, distobuccal; D, distal; DL, distolingual; L, lingual; ML, mesiolingual; M, mesial; MB, mesiobuccal.

Table 4 Statistical Analysis of Finish Line Angle at Different Locations by Tooth Position

Tooth Location	Mandibular First Molar Finish Line Angle Mean (SD)	Mandibular Second Molar Finish Line Angle Mean (SD)	*P*-value	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
B	154.63 (14.62)	151.01 (16.22)	0.302	−3.317	10.567
DB	155.61 (13.40)	145.56 (15.34)	0.003*	3.551	16.547
D	148.05 (15.32)	145.14 (15.57)	0.384	−3.705	9.519
DL	153.86 (13.38)	148.66 (17.66)	0.146	−1.859	12.267
L	154.72 (13.72)	153.08 (13.89)	0.599	−4.557	7.848
ML	150.42 (15.23)	149.08 (15.43)	0.699	−5.524	8.201
M	149.48 (15.35)	153.31 (16.98)	0.297	−11.084	3.432
MB	153.91 (15.65)	152.70 (15.15)	0.727	−5.705	8.136

Note: *Statistically significant at $P < 0.05$.
Abbreviations: SD, standard deviation; B, buccal; DB, distobuccal; D, distal; DL, distolingual; L, lingual; ML, mesiolingual; M, mesial; MB, mesiobuccal.

the finish line width and angle at various tooth locations between the first and second semesters. This null hypothesis was rejected because there was a statistically significant difference in the mandibular first molar finish line width between the first and second semesters for the same student in the distal, distolingual, and mesiobuccal areas of the tooth. This difference at all sites indicated an increase in the width of the finish line from an almost ideal width (0.5 mm) to a wider finish line (0.7 mm) during the second semester. The assumption was that students should engage in more idealistic preparation while gaining more experience, but the results showed the opposite. This can be explained by the fact that the students in the first semester performed four full metal and three porcelain-fused-to-metal crown preparations with a lingual metal collar as requirement before entering the mid-year exam to perform the full metal crown preparation by the end of the first semester. Therefore, the students were used to performing the chamfer finish line with 0.5 width. In the second semester, the students performed anterior and posterior all-ceramic crown preparations with a shoulder finish line as well as three-unit fixed dental prosthesis preparation, which made them more accustomed to performing a wider finish line at the final exam of full metal crown preparation.

Comparison of the finish line angle between the first and second semesters showed a statistically significant decrease only in the finish line angle at the distal site of the tooth. This showed that there is improvement between the first and second semesters by preparing a lower finish line angle distally with more conservation of tooth structure and more ideal total occlusal convergence.

The average finish line widths for all sites in the first and second semesters (0.56 mm [0.14], 0.64 mm [0.17] respectively) were clinically acceptable and close to the recommended finish line width (0.3–0.5) for full metal crown preparation.[1] Most of the other studies that evaluated the finish line width of student preparations cannot be compared with the results of this study because they used metal ceramic or all-ceramic crown preparations with a shoulder finish line and not full metal crown preparations with a chamfer finish line.[2,8,13,14] The reason could be that these types of preparations are more commonly used nowadays in clinical situations for full-coverage crowns, and it is much easier to measure and evaluate the width of the shoulder finish line than that of the chamfer finish line. Poon et al retrospectively evaluated the preparation of stone dies for occlusal reduction, convergence angle, and axial reduction of complete gold crowns without investigating the finish line width and angle.[15] Therefore, in this study, the full metal crown finish line width and angle preparation were investigated because they are more indicative of the student's skills in preserving the tooth structure than other types of preparations.

The second null hypothesis was that there would be no difference in the finish line width and angle at various tooth locations between tooth preparations on the first and second mandibular molars. This null hypothesis regarding the tooth

position was also rejected since the study showed a statistically significant increase in the finish line width in the mandibular second molar compared to that in the mandibular first molar in five out of eight measured locations. This could be because accessibility of the second molar is more difficult, particularly on the distal side of the tooth. Since the tooth's location in the mouth influences the student's ability to produce the required finish line configuration, it can be suggested that students need more practice in the preparation of second molars, although the average finish line produced was clinically acceptable (0.68 [0.19]).

The comparison of finish line angle between the first and second molar showed a statistically significant difference only in the distobuccal side of the tooth. This difference showed improvement in the finish line angle from 155.61° in the first molar to more idealistic angle of 145.56° in the second molar. While all the other tooth locations showed comparable finish line angle in the first and second molar, the tooth position seems to have less effect on the finish line angle. The literature search of the data bases showed no other studies addressing the tooth position to compare the study results with. With these results, we hope to add a reference to the dental educational community for future studies regarding tooth position.

The teaching method did not influence the students' performance since all students received live demonstration performed by supervisors and video demonstration that runs throughout the session. The supervisor to student ratio was 1:8 and all supervisors were calibrated every year before starting the preclinical sessions. The interrater reliability using the Intra-class Correlation Coefficient (ICC) for all procedures for all raters was 0.929 which is considered excellent reliability.

Unfortunately, the students thought that they had more confidence in their abilities by the end of the year which led to them overpreparing the teeth with wider finish line. After identifying the problem, our role is to educate them to be more conservative and not use their little experience and eyeball for judging the width of the finish line and keep using the putty index to produce the desired finish line width.

Regarding the clinical significance of the study, it firstly gave us an indication about the student performance in preparation of finish line width and angle - whether they were within the recommended width of finish line for full metal crown preparation and they were. Also, the study tested the assumption that as the student gains more experience, they will produce a more ideal finish line. Unfortunately, the results showed that they produced a wider finish line than required as they gained more experience, so a modification and reinforcement and more practice will be introduced in the curriculum to overcome and address this issue. Finally, the study tested the effect of tooth position on the students' performance. The results showed significant differences between the first and 2nd molars which indicates that the selected tooth for the exam must be the same for all students and more practice is needed on the more inaccessible teeth for the students before they are introduced to the clinical sessions to improve their preparations.

One of the limitations of the study is that it was difficult to measure the finish line width and angle exactly in the same point for all the samples as we were limited by the software functions. However, all measurements were done by one author and in the same area of the teeth to reduce variability and the resulted measurements were representative for the samples.

Conclusions

Within the limitations of this preclinical study, it could be concluded that as students gain more experience in different types of tooth preparations, they tend to produce a wider finish line than that recommended for full metal crown preparation. Location of the tooth influences the finish line width and angle.

Also, the tooth's location in the mouth influences the width and angle of the finish line because the more inaccessible areas on the tooth have a wider finish line.

Ethics Approval and Informed Consent

The Research Ethics Committee of the Faculty of Dentistry at King Abdulaziz University reviewed this retrospective study (KAUDH; Ref: 4429209) and waived the requirement for ethical approval.

The need for informed consent was waived due to the retrospective nature of the study, and all participant data were anonymised for analysis within the study.

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Disclosure

The author reports no conflicts of interest in this work.

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