Angle of Convergence of Posterior Crown Preparations Made by Predoctoral Dental Students


Abstract: The aim of this study was to determine angle of convergence (AC) of posterior crown preparations made by predoctoral dental students at the University of Toronto. Ninety-one dies of students’ crown preparations were digitally scanned with an in-Eos-Blue scanner (Sirona). Created images were virtually sliced at three similar locations of mesiodistal and buccolingual planes. Virtual protractor was used to determine AC of each section. Means and SDs were calculated, and data were statistically analyzed with ANOVA and student’s t-test for operator’s gender, experience, and tooth type. There were no significant differences among the groups except for AC of preparations grouped by tooth type (p<0.0001). The greatest mean mesiodistal AC was 26.4° found with mandibular molars, while the smallest was 16° found with maxillary premolars. ANOVA revealed significant difference in mean mesiodistal AC among groups (p<0.01). Also, greatest mean buccolingual AC was 25° found with mandibular molars, while the smallest was 20.8° found with maxillary premolars. ANOVA did not reveal significant difference in mean buccolingual AC among groups (p>0.05). Overall mean AC values were greater than ideal range of 2-5°; however, they were within ranges published for dentists/prosthodontists. Gender and experience had no significant effect on AC, but tooth type significantly affected AC.

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Angle of convergence (AC) of crown preparations is a calculated taper between two opposing walls. It significantly influences crown retention.1-3 The essential factors in crown retention are adequate geometric design of the tooth preparation (e.g., angle of convergence and preparation height), materials being cemented, and film thickness of the luting agent.1 However, the key factor in cemented complete crown retention is parallelism or, in other words, adequate convergence angle.1 The more nearly parallel the opposing walls of a preparation, the greater the retention.1,3 When the effect of preparation taper on retention of cast gold crowns cemented with zinc phosphate cement was studied, researchers found that crowns with a 20° angle of convergence had the highest retention values compared to crowns with 40° and 60°.2

For optimum retention, AC of 2°-5° has been recommended.3 However, it seems that clinically this kind of taper is seldom achieved. In one study, the mean AC of crown preparations made by dental students was 21°.2 In another study, dentists and specialists made crown preparations with a mean AC of 20°.3 Moreover, a clinical study suggested a minimum of 12° to ensure absence of preparation undercut.5 The purpose of our study was to determine AC of posterior cast gold crown preparations made by final-year undergraduate dental students at the University of Toronto. Although the taper achieved by students in dental schools has been investigated,7-10 none of the studies has shown the angle of convergence degree measurements achieved by dental students at the University of Toronto. The outcomes will reflect on the training dental students receive on the preparation of crowns and bridges because it is a common procedure in general dental practice. Therefore, it is essential that dental students become competent in achieving acceptable abutment taper.
Materials and Methods

Ninety-one posterior cast gold crown preparations made by final-year students at the Faculty of Dentistry, University of Toronto as part of a clinical competency examination were included in this study. Preparation distribution among posterior teeth was as follows: maxillary premolars (n=11), maxillary molars (n=22), mandibular premolars (n=14), and mandibular molars (n=44). Of the ninety-one students, twenty-five were identified as foreign-trained dentists (FTD). Fifty-five crowns were prepared by female students, while thirty-six were prepared by males.

Trimmed stone dies of preparations were powder-sprayed and digitally scanned with in-Eos-Blue scanner (Sirona) to create digital images. Created 3-D images were virtually sliced at three locations (buccal, middle, and lingual) of the mesiodistal plane and three locations (mesial, middle, and distal) of the buccolingual plane. A virtual protractor (MB-Ruler) software program was used to measure AC of each section. Measurements were recorded, means and SDs were calculated, and data were statistically analyzed with ANOVA and student’s t-test for operator’s gender, experience, and tooth type.

Results

Means and standard deviations for AC values of preparations made by male, female, FTD, and regular D.D.S. students are shown in Table 1. The mean mesiodistal convergence angle of all prepared teeth by the groups ranged from 22° to 23.2°, while mean buccolingual convergence angel ranged from 23.3° to 25.6°. ANOVA revealed a significant difference among AC means (p<0.0001). Student’s t-test revealed no significant differences among preparations made by female and male students (p>0.14). Also, student’s t-test revealed no significant differences in preparations made by FTD and regular D.D.S. students (p>0.21).

However, when analyzed by tooth type, a statistically significant difference was detected among the groups (p<0.01). The greatest mean mesiodistal AC was 26.4° found with mandibular molars, while the smallest was 16° found with maxillary premolars (Table 2 and Figure 1). Also, the greatest mean buccolingual AC was 25° found with mandibular molars, while the smallest was 20.8° found with maxillary premolars (Table 3 and Figure 2). ANOVA did not reveal a significant difference in mean buccolingual AC among groups (p>0.05).

Discussion

In this study, the mean AC of crown preparations by dental students was higher than the ideal range of 2-5°. However, it fell well within the ranges reported in previously published studies on preparations made by dental students, general practitioners, and prosthodontists. Noonan and Goldfogel reported a mean taper of 19.2° for student-prepared full gold crown preparations. Annerstedt et al. examined 478 full crown preparations performed by dental students and general practitioners in Sweden and found a mean angle of 21° and that the mean values for premolars and molars differed significantly. Sato et al. assessed teeth prepared for crowns by final-year dental students under clinical supervision and found that the average taper was 9.5°. Furthermore, Rafeek et al. compared the convergence angle of teeth prepared for full-veneer crowns by dental students on typodonts in the laboratory and on patients. They found that the mean taper of the laboratory anterior specimens were 26.7° buccolingual and 14.9° mesiodistal, and the laboratory posterior specimens were 18.2° buccolingual and 14.2° mesiodistal. The mean taper of the clinical anteriors were 31.6° buccolingual and 16.8° mesiodistal, and the clinical posteriors were 16.8° buccolingual and 22.4° mesiodistal.
In our study, the anatomic shape of the tooth and its position in the dental arch had an impact on the AC of the preparations. Mandibular molars had the highest AC values, perhaps due to relative difficulty in accessing their distal surfaces with appropriate upright approach of the handpiece. In addition, while patients are seated in the dental chair, the mandible continues to remain mobile while the maxilla is relatively stable. This along with anatomical differences between maxillary and mandibular molars (maxillary molars being generally longer) may have contributed to the higher AC values found with mandibular molars.

There are many techniques for measuring convergence angles of preparations; examples include photocopy machines, tool marker microscope, overhead projectors, goniometric microscopes, CAD/CAM machines, and diamond rotary cutting instruments. In our study, Sirona’s in-Eos-Blue scanner machine was used. Images produced by the in-Eos-Blue scanner machine, an advanced 3D scanner with innovative bluecam technology that utilizes short-wavelength visible blue light for image recording, are considered to be sufficiently accurate. They are typically used for fabrication of CAD-CAM crowns.

### Conclusion

In our study, the overall mean AC values were greater than the ideal range of 2-5°; however, they

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**Figure 1.** Mesiodistal angle of convergence of crown preparations grouped by tooth type

*Note: ANOVA revealed significant difference in mean mesiodistal AC among groups (p<0.01).*

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<th>Table 2. Mean and standard deviation (SD) of angle of convergence for preparations grouped by tooth type in mesiodistal (MD) plane</th>
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<tr>
<td>Convergence Angle MD</td>
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<td>Max. premolar</td>
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<th>Table 3. Mean and standard deviation (SD) of angle of convergence for preparations grouped by tooth type in buccolingual (BL) plane</th>
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<td>Convergence Angle BL</td>
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<td>Max. premolar</td>
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<td>Max. molar</td>
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were within ranges published for dentists/prosthodontists. Gender and experience had no significant effect on AC, but tooth type significantly affected AC with mandibular molars having highest AC and maxillary premolars having lowest values.

Acknowledgments

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REFERENCES