Original Article

The Convergence Angle of Full-coverage Crown Preparations Made by Dental Students

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Abstract:

Objective: A clinically feasible convergence angle in full-coverage crown preparations, meeting the requirements for proper retention and resistance forms, has always been a matter of interest for laboratory and clinical researches. This study aims to evaluate the angle in teeth prepared by both under- and post-graduate students at Tehran University of Medical Sciences, Faculty of dentistry, Department of Prosthodontics.

Materials and Methods: Samples consisted of 196 prepared teeth for full-coverage crown restoration by third year postgraduate and fifth year undergraduate students in the Department of Prosthodontics. Two images were obtained from each die by a scanner and both bucco-lingual and mesio-distal convergence angles were measured, by two different assessors, via Auto CAD 14 software. The data were analyzed using analysis of variance.

Results: There were statistically significant differences between the teeth prepared by under- and post-graduate students in mesio-distal convergence angles of all maxillary teeth, except for canines. Significant differences were found between bucco-lingual convergence angles of the maxillary canines and molars.

Conclusion: The recently recommended convergence angles are more clinically feasible compared to the classic 4 to 10 degrees that was previously suggested for all teeth. It also seems that clinical experience does not necessarily lead to a decrease in convergence angles during preparation.

Key Words: Tooth Preparation, Prosthodontic; Professional Competence

INTRODUCTION

The appropriate convergence angle for adequate retention and resistance of cast crowns has always been a matter of research and discussion. Parallel opposing walls enhance retention and resistance; however, preparing them in the oral cavity with no undercuts is not an easy task to fulfill. Also, some degrees of convergence seem to be necessary in order to compensate the possible inaccuracies of the fabrication process and permit more favorable seating of restorations [1].

Nevertheless, the proposed values of axial inclination of preparations are believed to vary dramatically. A range of 4 to 10 degrees of convergence is recommended as optimal [2-3]. While these angles are considered ideal for optimal retention, they are difficult to achieve clinically. Several techniques have so far been described for evaluating convergence angles of preparations. Devices such as photocopy machines [4], overhead projectors [5], goniomet-

ric microscopes [6], 3-D laser scanners [7] and diamond rotary cutting instruments [8] have been used to measure the convergence angle of working dies.

Ohm and Silness [9] examined stone dies prepared by dental students and reported mean tapers of 19.2 degrees mesio-distally (M-D) and 23.0 degrees bucco-lingually (B-L) on vital teeth. In nonvital teeth, mean M-D and B-L tapers were found to be 12.8 degrees and 22.5 degrees, respectively. Noonan and Goldfogel [4] described an overall mean taper of 19.2 degrees surveying 909 student-prepared full gold crown preparations. On proficiency evaluations, preparation tapers were decreased by 20%. Eames et al [10] found a mean convergence angle of 20 degrees on 50 dies randomly selected in a commercial laboratory.

Shillingburg et al [1] recommended convergence angles of 10, 14, 19, and 22 degrees for anterior teeth, premolars, maxillary, and mandibular molars, respectively. Kent et al [11] studied the taper of 418 dies prepared by Shillingburg during a period of 12 years. Convergence angles of 15.8 degrees between mesial and distal walls and 13.4 degrees between facial and lingual walls with an overall mean of 14.3 degrees were observed.

Nordlander et al [5], compared dies prepared by eight residents (88 dies), with those of two prosthodontists (120 dies) and found no statistically significant difference in axial wall convergence.

This study measured the convergence angles of full veneer crown preparations, made by both under- and post-graduate students under supervision of an instructor in a dental school clinic.

MATERIALS AND METHODS

The angle of convergence was measured on 196 full crown dies that were selected randomly from preparations made by third year postgraduate (84 dies) and fifth year undergraduate students (112 dies) at the Department
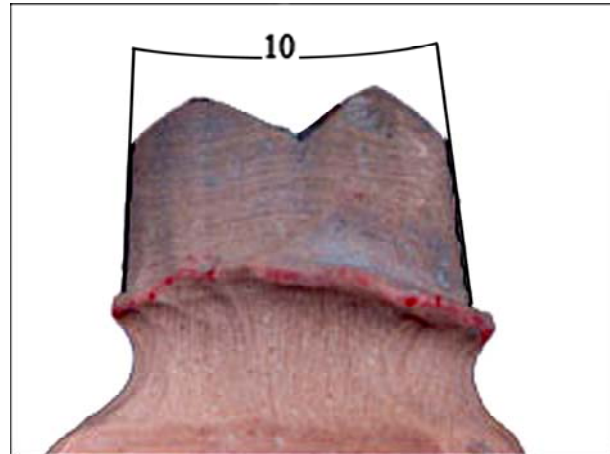

Fig 1. Measuring convergence angles of dies by Auto Cad 14

of Prosthodontics, Faculty of Dentistry, Tehran University of Medical Sciences. No special instructions were given to either the instructor or the student. Dies were classified into maxillary and mandibular groups and were further divided into anterior, premolar, and molar categories. Anterior mandibular dies were excluded from the study because of their insufficient number.

Two images were obtained from each of the 196 dies using a scanner (EPSON STYLUS CX 3700, Indonesia): one with the die placed B-L, and one M-D. By means of Auto CAD 14 (Autodesk Inc, San Rafael, CA), lines were drawn parallel to either the traced axial walls in the gingival one third of the buccal and lingual surfaces, or all proximal surfaces. These lines were then extended until they met to form an angle above the image (Fig 1). Convergence angles were measured using the software tools. Measurement reliability was evaluated by having two investigators draw the reference lines and measure the resulting convergence angles. Variations were in the range of 1 degree. The data were analyzed for differences in means among examiners and different tooth positions using analysis of variance techniques.
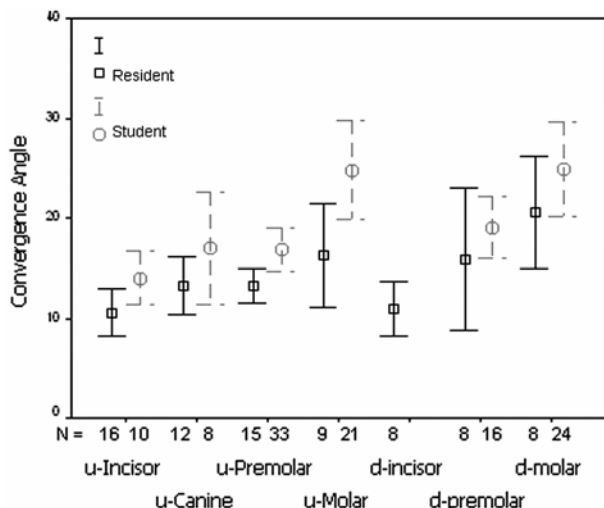
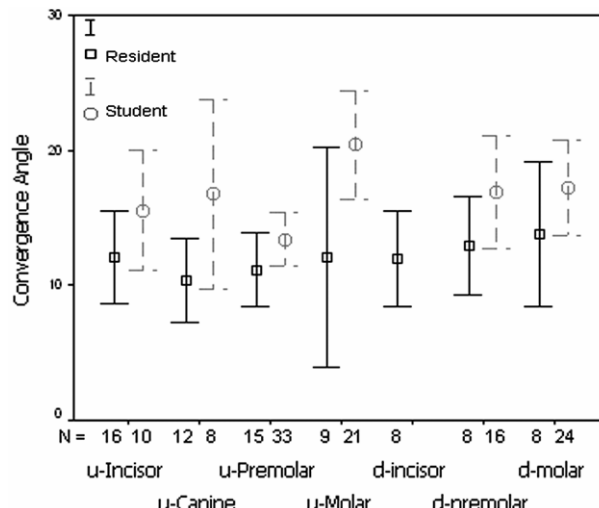**Fig 2.** Mesio-distal convergence angles of clinical preparations.

Fig 3. Bucco-lingual convergence angles of clinical preparations.

RESULTS

Mean convergence angles of post- and under-graduate students are shown in Table 1. There were statistically significant differences between the two groups in M-D convergence angles of upper incisors (P=0.05) premolars (P=0.005) and molars (P=0.04), but not canines (Fig 2).

Moreover, significant differences were found between B-L convergence angles of the maxillary canines (P=0.04) and molars (P=0.034). However, in the mandibular arch, there were no significant differences among the teeth prepared by post- and under-graduate students (Fig 3).

DISCUSSION

According to the results obtained in the current investigation, the convergence angles that were recently proposed by Shillingburg et al [1] were far more clinically feasible compared to the ideal range of 4 -10 degrees reported in former studies [4,5]. Although statistical analysis showed significant differences between some of the measured angles and the recommended values, the angles were in the suggested range in many other aspects.

Comparing the convergence angles of the present study with those proposed by Shillingburg et al, significant differences were observed in both M-D and B-L angles of the maxillary incisors and the M-D angles of the upper premolars and molars. Regarding incisors, it seems that anatomic factors, such as short cingula,

Table 1. Means (standard deviations) for bucco-lingual (B-L) and mesio-distal (M-D) convergence angles of dies.

Tooth		Residents		Students		Total	
		Maxilla	Mandible	Maxilla	Mandible	Maxilla	Mandible
Incisor	M-D	10.53(4.46)	10.91(3.27)	13.96(3.63)	—	11.85(4.42)	10.91(3.27)
	B-L	12.06(6.43)	11.92(4.22)	15.53(6.18)	—	13.39(6.44)	11.92(4.22)
Canine	M-D	13.19(4.52)	15.25(5.00)	16.90(4.52)	—	14.67(5.66)	15.25(5.00)
	B-L	10.32(4.84)	18.97(6.91)	16.72(4.84)	—	12.88(7.05)	18.97(6.91)
Premolar	M-D	13.22(3.11)	15.83(8.48)	17.27(6.46)	18.95(5.81)	16.00(5.91)	17.91(6.79)
	B-L	11.10(4.93)	12.87(4.35)	13.35(5.58)	16.89(7.93)	12.65(5.44)	15.55(7.11)
Molar	M-D	16.22(6.73)	20.50(6.73)	24.71(10.97)	24.81(11.18)	21.81(10.55)	23.74(10.32)
	B-L	12.05(10.60)	13.73(6.44)	20.39(8.88)	17.20(8.37)	17.62(9.97)	16.34(7.98)

are the main reasons for over tapering in the B-L aspect. However, in the M-D aspect, visual errors play a great role and may lead to underestimation of the existing taper of the preparation, ultimately causing over reduction. Limited access might be a major factor in the M-D aspect of premolars and molars. Interestingly, in the mandibular arch, significant differences were only found in the B-L angles of premolars (P=0.022) and molars (P=0.014). It seems that both post- and under-graduate students had less difficulty in tooth preparation in the lower jaw.

Comparison was also performed between dies prepared by undergraduate and postgraduate students. Surprisingly, there were no significant differences in the mandible; however, the M-D angle of the maxillary incisors demonstrated a significant variation, probably due to the mentioned reasons. The difference was again seen in the M-D angle of premolars and molars, as well as the B-L angle of molars. This finding emphasizes the role of the operator's skills in handling preparations in the upper jaw, where gaining a convenient and suitable position seems to be an important factor.

A comparison between the results of a study evaluating the convergence angle in preparations performed by general dentists in Tehran [12], and that of the undergraduate group in the present study, depicts notable differences in all parts, except the M-D angle of the maxillary molars and the B-L angle of the mandibular premolars. Surprisingly, full crown dies prepared by undergraduate students had smaller convergence angles than the ones completed by general dentists. This comparison revealed better performance of the students under supervision, surpassing their limited experience. Therefore it seems that principles of preparation must be frequently reminded for general dentists.

Nordlander et al [5] studied convergence angles in dies prepared by postgraduate students. A comparison between their findings and that of the postgraduate group in the current investigation, manifests considerable differences in all the measured angles, except for the B-L angle of the maxillary molars (P=0.88) and the M-D angle of the mandibular premolars (P=0.806). In general the convergence angles obtained in our study were smaller than those reported by Nordlander et al [5].

CONCLUSION

The convergence angles recently recommended by Shillingburg et al are clinically more feasible compared to the classic 4 to 10 degrees previously suggested for all teeth. It also seems that operators have more difficulties preparing maxillary teeth due to the fact that acquiring the proposed criteria in the upper jaw is more challenging. Limited access, visual errors, and anatomic variations are some of the obstacles against ideal preparation.

The findings of the present study indicate that clinical experience does not necessarily lead to a decrease in convergence angles of preparations.

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