Axial wall convergence of full veneer crown preparations

Documented for dental students and general practitioners

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The convergence angle in 478 full crown preparations was assessed. Of these preparations, 351 had been performed by general practitioners and 127 by dental students. Groups of preparations performed on incisors, premolars, and molars were compared, as were preparations performed by dentists and students. Two different convergence angles were measured for each tooth, buccolingually and mesiodistally. The results showed a mean angle of 21°. The mean values for premolars and molars differed significantly. When a comparison was made of preparations performed by students, a significant difference was found between premolars and molars. The same comparison for general practitioners showed a significant difference both for incisors compared with molars and for premolars compared with molars. A wide range was found for the convergence of the axial walls, especially for the preparations performed by general practitioners. □ *Convergence angle; crowns; dental abutments*

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Between the axial opposite surfaces of teeth prepared for artificial crowns an angle is formed which is usually called the convergence angle. In previous studies the optimal magnitude of this angle has been discussed (1–3). Textbooks of crown and bridge prosthodontics often recommend a convergence angle of approximately 5° (4–6) as the ideal, but with a range of 4–14° as acceptable. These recommendations, however, are theoretical and have proved to be difficult to achieve in clinical practice. Furthermore, divergence from parallel might have to be as much as 12° to be observed clinically as converging surfaces (7).

Several clinical studies have been performed in attempts to establish the optimal convergence angle possible to achieve in clinical practice and at the same time acceptable for long-term retention and prognosis. Ohm & Silness (7) showed that long-term retention was obtained for vital teeth when the mean convergence angle varied between 19° and 27° and for endodontically treated teeth between 12° and 37° Furthermore, Leempoel et al. (8) found a convergence angle between 15° and 30°, slightly higher for molars. In another report measurements on teeth prepared by dental students in their last year of clinical training showed a mean convergence angle of 19° (9).

Not only the convergence angle is important for proper crown retention and resistance to dislodgement. Other factors, such as the length and diameter of the preparation, will also be decisive for the retention of a crown (10–12). An angle of approximately 15° and even around 20° has been advocated provided that the retentive surfaces of the axial walls are long enough (13). Söderbäck recommends a convergence angle of 13° for a 7-mm-high preparation (14). In the same study angles of convergence larger than 24° were reported to be close to non-self-retaining—that is, without luting cement.

The aim of this study was to compare the angle of convergence between full crown preparations performed by general practitioners and dental students. A secondary aim was to assess differences between convergence angles for incisors, premolars, and molars and whether they were within the range of recommended angles.

Materials and methods

The study is based on measurements of convergence angle for full coverage preparations, performed by students and general practitioners. From clinical files at the Department of Prosthetic Dentistry, Faculty of Odontology, Göteborg University, 127 stone dies of preparations performed by dental students in 1992–1994 were randomly selected. In addition, 351 preparations performed by dentists and earlier scanned with the Procera CAD/CAM technique were likewise selected. These preparations had been filed on hard disc at Procera Nobelpharma AB, Göteborg. The criteria for selection were that the preparations should be single crowns or abutments in fixed partial dentures with a maximum of three units. None of the participants,

students or dentists, were aware that the selected preparations would in the future be subjected to an examination. To achieve a comparable registration and measuring technique, the stone dies from the Students' Clinic were also scanned in accordance with a standard procedure, used for the manufacturing line of full crowns by the Procera technique.

In the next step the computer converted the 3-D image into two cross-sections. The 0–180° (buccolingual view) and 90–270° (mesiodistal view) cross-sections were selected for measuring the angles of convergence of each preparation, and a transcription on paper was made.

The angle of convergence was measured by two of the authors. Complementary lines were drawn directly on the transcriptions, along the axial walls from the mesiodistal and buccolingual surface of the retention cylinder (Fig. 1), and the angles were measured with a protractor. The abutments were divided into the three categories incisors/canines, premolars, and molars (Table 1).

The accuracy of the measurements was assessed by pairwise reading of 30 randomly selected preparations. An interindividual difference of less than ±1° was recorded. Student's unpaired *t* test was used to evaluate possible differences between categories of teeth, different views, and different preparations performed by dental students and dentists.

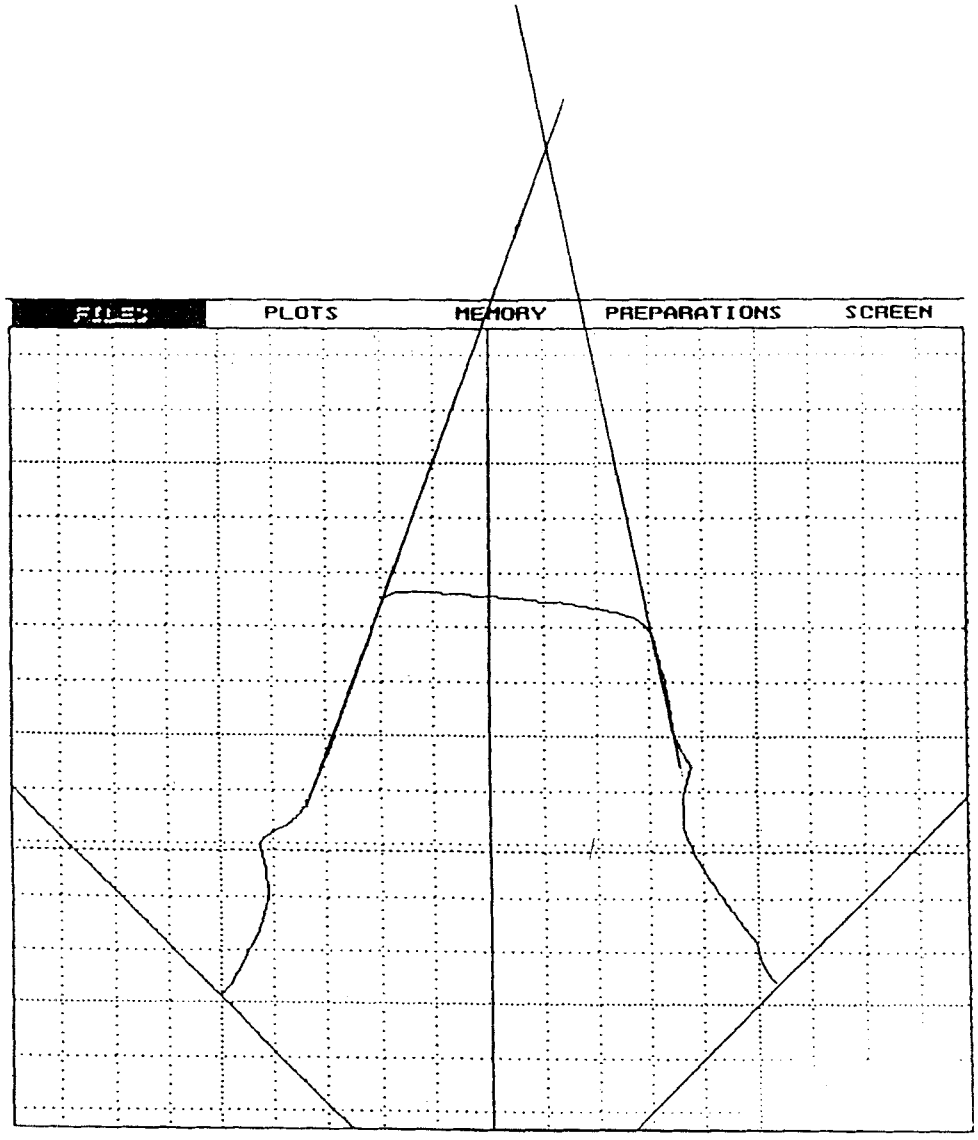

Fig. 1. Complementary lines used for measurement forming the angles from mesiodistal and buccolingual axial walls.

Table 1. Distribution of examined teeth with regard to tooth categories

Teeth	Student		Dentist	
	n	%	*n*	%
Incisors/canines	34	27	101	29
Premolars	73	57	97	28
Molars	20	16	153	43
Total	127	100	351	100

Table 3. Significant levels for differences between incisors, premolars, and molars prepared by students and dentists

	Dental students		Dentists	
	P		*P*	
Incisors–premolars	0.2161	NS	0.1287	NS
Incisors–molars	0.3361	NS	<0.0001	***
Premolars–molars	0.0226	*	<0.0001	***

Results

In the examined preparations the convergence angle averaged 21.4° and was significantly less for dental students (19.4°) than for general practitioners (22.1°) (Table 2). A great range was recorded for preparations performed by both dental students and dentists. When molars were compared, a significantly ($P < 0.05$) smaller convergence was found for preparations performed by the students (Table 2), whereas no such difference was found for the other categories of teeth.

Significant differences were also found between premolars and molars (Table 3). Incisors and premolars had about the same angle of convergence, and for those preparations performed by dentists it was significantly smaller than for the molars (Fig. 2). In the upper jaw significantly ($P < 0.05$) less tapered preparations had been performed in the mesiodistal view than in the buccolingual. This was a consistent finding for both dental students and dentists.

Of the total number of measured axial walls 28% showed a convergence angle within the recommended range of 4–14° (5). Twelve per cent of the prepared teeth were within this range of convergence angle in both the buccolingual and the mesiodistal aspect.

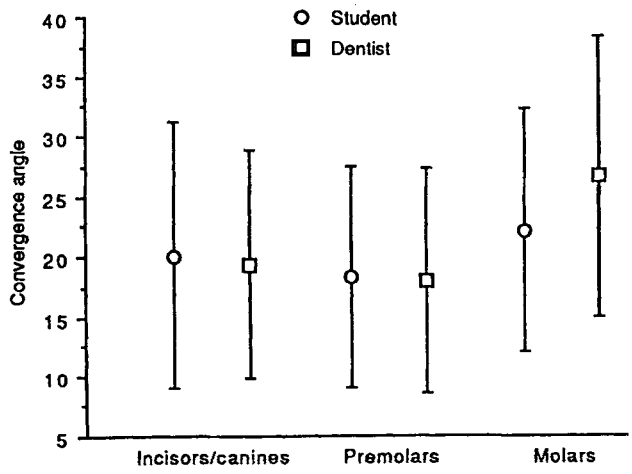

Fig. 2. Categorized convergence angle, mean and standard deviation, for 478 full crown preparations.

Discussion

In this study a mean convergence angle of 22° for the preparations performed by general practitioners was found. The corresponding value for dental students was 19°. These values are higher than usually recommended in textbooks but in agreement with other studies investigating convergence angles achieved in clinical practice, both for students and dentists.

Studies by Jørgensen (1) and Kaufmann et al. (11) have shown the relationship between increased convergence angle and decreased retentive force. Increasing the convergence angle from 5° to 10° reduces the retentive force by as much as 40–50%. The explanation for the fact that crowns in a clinical situation will function despite convergence angles much greater than recommended might be that intraoral forces and loads interact in a manner that is far more complex than can be reproduced in a laboratory test.

In a recent study Parker et al. (12) recommended guidelines for preparation taper based on mathematical calculation. The taper required to provide resistance

Table 2. Range, mean angle ($\bar{x}$), mean differences ($\bar{d}$), and significant levels for differences between preparations

Teeth	Dental students		Dentists		Dental students–Dentists		
	Range	$\bar{x}$	Range	$\bar{x}$	$\bar{d}$	*P* value	
Incisors	2 to 50	20	0–50	19.4	0.707	0.6108	NS
Premolars	−2 to 49	18.3	0–56	17.9	0.356	0.7272	NS
Molars	5 to 51	22.2	1–70	26.6	−4.438	0.0223	*
Total	−2 to 51	19.4	0–70	22.1	−2.742	0.0006	***

form for an individual preparation was calculated by using a preparation height to base ratio. The calculated recommended values were 29–33° for incisors and canines, 10° for premolars, and 8° for molars, which are outside the range for most values registered for premolars and molars in the present study (Fig. 2).

The retention and stability of artificial crowns depend on the magnitude of the convergence angle of the axial walls. In addition, there will be a mechanical locking when a cement, especially phosphate cement, is used to fill the crevices and other irregularities in the casting and dentin surface. A wide angle will result not only in reduction of retention and stability but also in reduced axial discrepancy. In contrast, a small angle will improve the retention and stability but increase the axial discrepancy and make it more difficult to seat the crown.

Several factors may have influenced the results in this study. It has not been possible to assess any differences between vital teeth and those with artificial posts and cores, which have proved to be of importance (7). Furthermore, the correct convergence angle may not have been measured owing to a retention cylinder difficult to define. The interindividual differences for each measurement were small and not significant, however.

This study has analyzed the differences in convergence angles for 478 preparations made by general practitioners and dental students. A wide range, −2° to 70°, of this angle was registered. The difference in convergence angle between groups of teeth may have several explanations. One of them could be the better accessibility for some groups than for others. In addition to this, saliva, the tongue, and surrounding tissues will interfere differently during preparation.

Furthermore, the anatomic shape of the tooth may be decisive. An incisor with its long and slender shape, may be easier to prepare with a small convergence angle than a short, chubby lower molar. The findings also reflect possible differences in preparation technique between students and dentists. Students have a fresh concept of how the optimal preparation is supposed to be performed and are constantly being checked and corrected by their teachers. Dentists, on the other hand, with more extensive clinical experience, might have another view of the magnitude of mechanical retention and stability needed. Twenty-eight per cent of the axial walls had an angle of convergence of more than 4° and less than 14°. This emphasizes the difference between what is theoretically possible and learned at dental schools and the outcome in clinical practice. Nevertheless, only long-term clinical studies will make it possible to assess fully the influence of the convergence angle on crown and bridge longevity.

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