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Influence of Operator Experience on Clinically Achieved Convergence Angle of Tooth Preparations for Metal-Ceramic Crowns

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ABSTRACT

Objective: To compare clinically achieved convergence angle values of teeth prepared by operators having different experience levels and relate them with recommended values.

Study Design: Cross-sectional analytical study.

Place and Duration of Study: Department of Prosthodontics, Islamic International Dental Hospital, Islamabad Pakistan, from Dec 2018 to May 2019.

Methodology: A total of 100 crown dies of molars prepared by House Officers (Group-I) and Postgraduate Residents (Group-II) of the Prosthodontics department were collected retrospectively. Auto CAD 2007 software was used for the measurement of convergence angle. One sample t-test was applied to compare the mean convergence angle values with theoretical values. In addition, independent samples t-test was applied to compare convergence angle values among Clinician Groups with different experience levels.

Results: Significant difference (p <0.001) was found between the tooth preparations performed by both study Groups. Greater convergence angles were achieved by operators having lesser experience, i.e., Group-I (House Officers) in contrast to Group-II (Post-graduate Residents). The convergence angle achieved by both study groups was far greater than the recommended values (4-14 degrees).

Conclusion: Significant discrepancy exists between the recommended guidelines and the clinically achieved convergence angle values recorded in this study. The recommended values were rarely achieved. Operator experience seems to be an important determinant for achieving better convergence angle values.

Keywords: Convergence angle, Crown preparation, Taper.

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INTRODUCTION

The three cardinal principles of crown preparation, namely retention form, resistance form and tooth structure conservation, are all commonly influenced by a single clinical factor, i.e. total convergence angle.[1] This is perhaps one of the most important clinical tooth preparation parameters that dictate the overall success of the tooth preparation for a full coverage crown with optimal retention and resistance forms according to accepted principles.[2] An adequate convergence angle is also necessary to eliminate unwanted undercuts and properly seat the crown/casting on the prepared tooth. Excessive convergence angle leads to loss of healthy tooth structure and consequent poor retention and resistance forms.[3]

In order to calculate the convergence angle of a prepared tooth, various methods have been employed, including several devices such as 3-D laser scanners, goniometric microscopes, photocopy machines, dental periscopes, photographic mirrors, diamond rotary cutting instruments and overhead projectors. Unfortunately, their widespread acceptability has been questioned in literature.[3,4] This issue has been addressed by a novel technological approach utilizing the Auto-CAD software to measure the convergence angles with superior accuracy and more reliable results. With considerable implications, the utilization of this software has been advocated as an excellent educational tool for clinical assessment.[5]

It has been widely accepted that the ideal theoretical value of 4-6 degrees convergence is difficult to achieve practically.[6] Therefore, some authors deem a range of 4-14 degrees acceptable.[3,7] Even after this relaxation in the convergence angle range, Strain *et al*. [8] reported that dental students did not achieve these convergence angle values in their systematic review. The reviewed review featured 2,306 preparations from twelve articles from eleven countries published between 1978 and 2014. However, the students produced convergence angle values ranging from 10-20 degrees, which has been recommended in research for

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almost two decades.[9] Local literature also reveals considerable disparity among clinically accomplished crown preparations and the recommended values, with a mean reported convergence angle of 22.72 degrees.[7]

Limited literature with conflicting results has been observed regarding the influence of operator experience on the clinically achieved convergence angle. Where Ghafoor *et al*.[7] reported an insignificant association of operator experience with convergence angle, Ali *et al*.[10] concluded that prosthodontists were more capable of producing a lower convergence angle than students and general clinicians. Therefore, this study aimed to measure and compare the convergence angle of tooth preparations accomplished by inexperienced clinicians (house officers) and experienced clinicians (postgraduate residents of Prosthodontics). The difference between the theoretical and practically achieved values was also determined. This information is hoped to reflect upon the influence of operator experience over the process of tooth preparation. In addition to providing an insight into the importance of knowledge and experience in the field of Prosthodontics, the gathered data is thought to aid in considerable improvement in academics leading to better teeth preparations with an increased serviceable life of prostheses. Furthermore, it is hoped that young dentists can be positively influenced towards postgraduation.

METHODOLOGY

This cross-sectional analytical study was conducted in the Prosthodontics department of Islamic International Dental Hospital, Islamabad Pakistan, from December 2018 to May 2019. Before initiation of the study, approval was obtained from the Ethical Review Committee of the hospital.

Inclusion Criteria: Data were collected using consecutive sampling techniques. The dies of molar crown preparations of the maxillary or mandibular arch, half done by House Officers (which constituted Group-1 for inexperienced clinicians) and half done by Postgraduate Residents (which constitu-ted Group-2 for experienced clinicians).

Exclusion Criteria: Sample size was calculated by WHO calculator with confidence level=95%, margin of error=5%, population size=75. The calculated sample size was 63, but 100 preparations were included in this study. After the delivery/cementation of crowns, individual dies were cut from stone casts with the help of a die saw (Dental Lab Plaster Saw of width 95mm) from the mesial and distal sides. All dies were initially assessed to ensure the presence of an appreciable convergence angle between buccal and lingual axial walls. All dies were numbered on their basal portions to identify them for the subsequent analysis. It was ensured that the dies were perpendicular to the bench top before being analysed.

Die analysis was done with the help of a digital camera (Sony Cyber-Shot DSC-WX1 manufactured by Japan) available in the department. The camera was fixed on a tripod stand, and oriented perpendicular to the long axis of each die at a constant distance of 10cm from the camera lens. A black piece of cloth was suspended in the background to ensure good contrast for the photographs. Standardized lighting conditions were created for taking the photographs. After recording the images, they were shifted into a computer and loaded into the AutoCAD 2007 software for measuring the convergence angle of each die between opposing buccal and lingual axial walls. Each image was measured three times in the software, and then the average convergence angle was obtained for each die.

All computer measurements were made by a single well-trained investigator (or the principal investigator). Statistical Package for Social Sciences (SPSS) version 23.0 was used for the data analysis. Descriptive statistics were calculated, and independent samples t-test was applied for comparison amongst both Groups of clinicians. The p-value of ≤0.05 was considered significant.

RESULTS

The sample of 100 dies included an equal number of crown preparations done by relatively inexperienced House Officers (Group-1) and relatively experienced Postgraduate Residents (Group-2). The mean convergence angle (MCA) of both groups was 24.77±11.02 cumulatively (Table-I).

Table-I: Descriptive Statistics (n=100)

Groups	Mean	Minimum	Maximum
Group-1	30.70±11.66°	3.5°	59.0°
Group-2	18.84±6.14°	7.0°	31.0°
Total	24.77±11.02°	3.5°	59.0°

In order to compare the difference in the convergence angle between both groups, independent samples t-test was used, which returned a highly significant association (p <0.001) of operator experience with convergence angle achieved) (Table II).

Table-II: Comparison of Difference in the Convergence Angle between both Groups (n=100)

Variables	Study Groups (Mean±SD)		*p*-value
	Group-1 (n=50)	Group-2 (n=50)	
Mean Convergence Angle	30.70±11.66°	18.84±6.14°	<0.001

DISCUSSION

The mean convergence angle (MCA) calculated in the present study was 24.77±11.02 degrees, depicting the frequently over-tapered tooth preparations performed by house officers and postgraduate residents working in the clinical department of a private tertiary care dental hospital. This is greater than the ideal theoretical value of 4-6 degrees convergence,6, [11] the acceptable range of 4-14 degrees,[3,7] and even the extremely relaxed convergence angle range of 10-20 degrees recommended by Goodacre *et al*.[9] two decades ago. Nonetheless, the results correspond closely to other cohort studies investigating the convergence angle of tooth preparations. The MCA in the present study was slightly lesser than only a few studies, including the ones by Hinnara *et al*.[11] (26.3 degrees) and Al-Omari *et al*.[12] (25.3 degrees). In contrast, the MCA value of the present study was considerably greater than most other studies on the subject, including the ones by Ghafoor *et al*.[7] (22.72 degrees), Rafeek *et al*.[13] (21.9 degrees), Noonan *et al*.[14] (19.7 degrees) and Aleisa *et al*.[3] (18.4 degrees).

The disparity entailing the higher obtained convergence angle values in the current study can be explained by three reasons: Inclusion criteria of molar preparations only, unsupervised clinical environment, and preparation on natural teeth instead of typodonts. First, it has been well-established in the existing literature that the clinically achieved convergence angles of posterior teeth, especially the molars, were signi-ficantly greater than anterior teeth.[7,15-17] This may be explained by the difficult access for molar preparation as they are farther back in the oral cavity.[18] Due to limited access and visibility in the posterior quadrant of the mouth, it was generally difficult to achieve recommended convergence angles intra-orally com-pared to experimental conditions or typodonts.[2,7] Mr. Weed,[19] reported that dental students, who achieved a convergence angle value of 12.7 degrees on typodonts, could not show the same expertise during clinical preparations where the MCA values leapt substantially to 22.8 degrees. Similarly, Noonan *et al*.[14] also found greater values of convergence angles in normal clinical conditions than in testing conditions.

It is commonly accepted that undergraduates often over-taper the preparations due to their lack of working experience.[15] However, conflicting reports are cited in the literature regarding this factor. Therefore, it was deemed important to study the role of operator experience on the value of convergence angle achieved on tooth preparations. Although the MCA achieved clinically in the present study was greater than the recommended values, still, the postgraduate residents performed better than the house officers, which can be attributed to their greater working experience in the field of Fixed Prosthodontics. The difference in MCA for both study groups was in agreement with Ali *et al*.[10] who concluded that prosthodontists achieved a lower convergence angle in tooth preparation when compared with students and even general practitioners. Makker *et al*.[20] also reported the best tooth preparation with the least convergence angle values for prosthodontists, followed by other specialists and, lastly, by general practitioners who achieved the highest convergence angles. Different clinical expertise and limited time set for each patient in general practice were the most viable reasons behind these findings. Similar trends were reported by Hinnara *et al*.[11] The specialists and students achieved somewhat similar convergence angle values, while general practitioners performed poorly with the highest angle values. This was explained by the fact that general practitioners were not following the theoretical guidelines more closely due to their continuous effort to reduce patient chair time.

In contrast, students performed better due to the continuous availability of supervisors. These researches highlight the importance of theoretical knowledge and experience, particularly in Prosthodontics. At the same time, the same is not true regarding the general clinical experience.

In contrast, multiple studies report an insignificant correlation between clinically achieved convergence angle values and operator experience. Such literature advocates that general dental practitioners' and specialists' average convergence angle values fall within a similar range. Where Patel *et al*.[18] found no statistical significance between the convergence angles of general dental practitioners (≥ 20 years experience) and final year dental students, Ghafoor *et al*.[7] reported a quite high value of 22.7 degrees from specialists in

operative dentistry. These findings suggest that clinical skills may be acquired in the undergraduate training phase, and operator experience may not be as vital as in contrasting literature. Hence imparting high-quality education at the undergraduate level must be emphasized. In addition to conventional pre-clinical teaching methods, including lectures, interactive television, multimedia live distant learning and pre-record videos, Robinson *et al*.[21] found that undergraduate students taught with real-time video magnification by the surgical microscope produced substantially lower mean convergence angles than the rest of the candidates. This emphasizes the need for instructors to introduce and rely on modern equipment to enhance the quality of education, especially at the undergraduate level when most operative skills are learnt. Feeling the need to bridge the gap between contemporary digital trends and old teaching methods, Tiu *et al*.[22] developed a seemingly promising software that might be an effective educational tool for dental students in prosthodontics. Similarly, Mays *et al*.[23] practically applied CAD/CAM to measure the taper and occlusal convergence of crown preparations and reported digital assessment to be more precise than visual grading by faculty.

In relation to the present study, it was found that most of the patients were provided with suboptimal restorations over highly convergent preparations. It has been recommended that auxiliary retention methods may be incorporated whenever ideal preparation cannot be achieved.[24] Therefore, auxiliary retention enhancing strategies should be considered, especially by inexperienced clinicians, to improve clinical outcomes and longevity of the final restoration. Another approach can be the novel preparation technique with good results introduced by Rosella *et al*.[25] to address the difficulty in achieving optimal preparations by beginners. The new approach is a valuable alternative in tooth preparation, particularly for novices, after incorporating it as an additional component in the traditional learning curve.

Limitations of the current study include cross-sectional design and lack of randomization during the data collection procedure. Long-term clinical studies should be planned to fully assess the influence of convergence angle on the longevity of full coverage fixed restorations/crowns.

CONCLUSION

Within the limitations of the present study, it can be concluded that mean convergence angle values achieved clinically are more than the recommended values. In the sample of people studied, both the experienced and inexperienced groups achieved MCA values that were far from ideal. However, the experienced lot performed better as compared to the inexperienced lot.

Conflict of Intrest: None.

Author's Contribution

Following authors have made substantial contributions to the manuscript as under:

AN: Data analysis, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

WI & SA: Conception, study design, drafting the manuscript, approval of the final version to be published.

SA & AG: Data acquisition, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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