

ORIGINAL RESEARCH



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In vitro study about the abutment axial wall's convergence.Diana Cerghizan¹, Adriana Crăciun¹, Aurița Albu¹, Monica Baloș¹, Kinga Mária Jánosi¹¹George Emil Palade University of Medicine, Pharmacy, Science, and Technology of Targu-Mures, Romania**Abstract**

Introduction: The total convergence of the axial walls is the angle made between the opposing axial walls of an abutment. The lower the taper value, the better the retention of the crowns is. Obtaining a proper convergence of the axial wall is a challenge for dental practitioners due to limited access and low visibility, but it also greatly depends on the clinician's practical skills.

This study aims to compare the total convergence of axial walls obtained after tooth preparation done by different experience practitioners in various positions of the patient and different working time (different days of the week, various parts of the day).

Materials and methods: To perform this study, 40 acrylate model teeth have been prepared by two last year dental students and two prosthetists. All of them performed two teeth preparations per day in every working day of a week. All the prepared teeth have been photographed, and digitally measured.

Results: The extremely statistically significant difference was found in the two beginners' case, the values of the second beginner being much higher, as in the two experienced operators, where the values are higher for the second prosthetist.

Conclusion: The total convergence of the axial wall did not depend on the operators' experience or education level.

Keywords: convergence, taper, tooth preparation

Introduction

Optimal prosthetic oral rehabilitation is the result of complex and consistent clinical treatment steps. The abutment preparation is vital in order to achieve proper prosthetic reconstruction from an aesthetic and functional point of view.

In fixed prosthodontics, the therapeutic success depends on retention and durability of the prosthetic reconstruction, which is an intensely researched topic in literature [1].

Jorgensen and Rosenstiel defined the total convergence of the axial walls as the angle made between the opposing axial walls of an abutment [2, 3].

The total convergence is a popular study topic in prosthodontics [4, 5, 6, 7]. The recommended value, by many studies, is by 4 – 14 degrees [8, 9]. Shillimburg and al., as well as Rosenstiel, defined the ideal value as 6 degrees [10, 11]. To obtain this value is a challenge for dental practitioners due to limited access and low visibility, but it also greatly depends on the clinician's practical skills [12, 13]. The lower the taper value, the better the retention of the crowns is [3, 4, 14, 15].

Clinical research performed on teeth prepared by students, dentists, and prosthetists has shown a mean convergence value of 10–24°, much higher than theoretically established [6, 15, 16, 17, 18, 19, 20].

This study aims to compare the total convergence of axial walls obtained after tooth preparation done by different experience practitioners in various positions of the patient and different working time (different days of the week, various parts of the day).

Materials and methods

To perform this study, 40 acrylate model teeth (second molar) were used, mounted on intact dental arches, assembled in a simulator unit used for practical teaching.

The teeth preparation was done by two last year dental students and two Fixed Prosthodontics Department (George Emil Palade University of Medicine, Pharmacy, Science, and Technology of Târgu-Mureș, Faculty of Dental Medicine) prosthetists. All of them performed two teeth preparation per day in every working day of a week.

For tooth preparation, a round-end diamond size 016 with a standard 3° taper has

been used, maintained as much as possible parallel with the tooth's long axis to achieve an ideal taper. In ideal conditions, using this diamond, a total convergence by 6° and 0,5 mm wide can be achieved to obtain a deep chamfer finish line.

Each tooth was prepared with a new diamond. In the end, each operator prepared two acrylic teeth every day, during five days, with the same finishing area.

The prepared teeth were repositioned on the same simulator model; adjacent teeth have been removed. A proper position for picture was chosen by a survey; pictures have been

taken with a Canon D5300 camera mounted on a tripod.

The survey's table, on which the models were positioned, was tilted until it was found an appropriate position of the prepared tooth so that it could be photographed with the Macro lens perpendicularly positioned on the vestibular surface.

A ruler has been placed parallel with the table of the survey, at the cervical area of the prepared tooth, close to the finish line to calibrate the digital measurements, with the Image-Pro Insight software (figure 1).

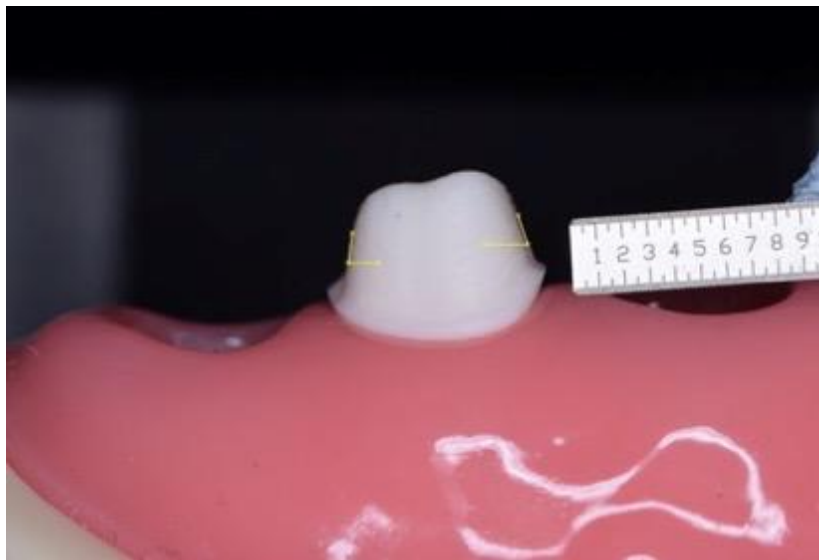


Figure 2. Graphic representation of axial walls taper measurements for all operators

For the evaluation of the measurements, an ideal convergence established by Shillingburg or Rosenstiel of 6° [10, 11] was established as a reference value, respectively, a clinically accepted convergence of 22° .

The inclination of the axial walls of 3° and 11° , respectively, have been taken into account for measurements.

For each tooth, three measurements were performed, calculating their average.

The statistical analysis was performed by using GraphPad Prism 8 for macOS version 8.4.3. software. The statistical significance was set at $p < 0,05$. The mean (M), median (Me) and standard deviation (SD) were calculated.

The used test: Wilcoxon Signed Rank and Mann-Whitney test (non-Gaussian distribution).

Null hypothesis: Experienced practitioners with a higher level of education are able to obtain a value of axial wall taper closer to the ideal (6°) and clinically accepted (22°) than beginners.

Results

The results of the descriptive statistic obtained by the four practitioners are shown in table 1 and figure 2.

Table 1. Descriptive statistics

	S1d	S1m	T1d	T1m	T2d	T2m	S2d	S2m
Number of values	10	10	10	10	10	10	10	10
Minimum	-5,290	3,945	0,000	3,342	-4,399	6,357	0,000	10,13
Median	1,614	6,376	5,335	13,21	8,294	18,14	2,633	15,41
Maximum	5,711	12,80	12,68	19,65	18,44	26,57	15,59	21,32
Range	11,00	8,859	12,68	16,31	22,83	20,21	15,59	11,19
Mean	1,220	6,882	6,044	12,62	7,564	18,10	4,464	15,55
Std. Deviation	2,945	2,665	4,428	5,607	5,969	6,078	4,906	4,011
Std. Error of Mean	0,9312	0,8426	1,400	1,773	1,887	1,922	1,551	1,268
Lower 95% CI of mean	-0,887	4,976	2,877	8,611	3,294	13,75	0,9541	12,68
Upper 95% CI of mean	3,326	8,788	9,211	16,63	11,83	22,44	7,974	18,42

Note: S1d – first student distal wall; S1m – first student mesial wall; S2d – second student distal wall; S2m – second student mesial wall; T1d – first prosthetist distal wall; T1m – first prosthetist mesial wall; T2d – second prosthetist distal wall; T2m – second prosthetist - mesial wall

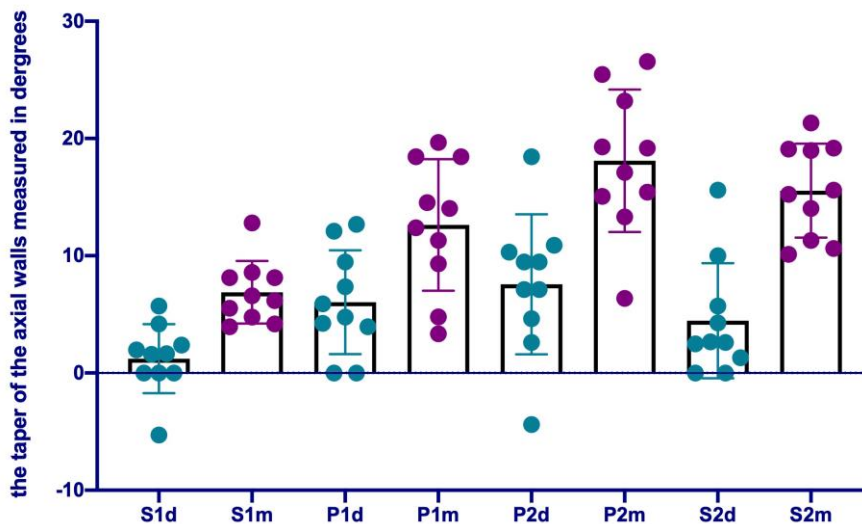


Figure 2. Graphic representation of axial walls taper measurements for all operators

For comparing the four study participants' recorded values with the standard (3°) and clinically accepted (11°) values, the Wilcoxon

Signed-Rank test was used. The results are presented in tables 2 and 3.

Table 2 Wilcoxon Signed-Rank test results - participants' recorded values vs. standard (3°)

	S1d	S1m	T1d	T1m	T2d	T2m	S2d	S2d
Theoretical median	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Actual median	1,614	6,376	5,335	13,21	8,294	18,14	2,633	2,633
Number of values	10	10	10	10	10	10	10	10
Sum of signed ranks (W)	-37,00	55,00	33,00	55,00	37,00	55,00	3,000	3,000
Sum of positive ranks	9,000	55,00	44,00	55,00	46,00	55,00	29,00	29,00
Sum of negative ranks	-46,00	0,000	-11,00	0,000	-9,000	0,000	-26,00	-26,00
P value (two tailed)	0,0645	0,0020	0,1016	0,0020	0,0645	0,0020	0,8984	0,8984
P value summary	ns	**	ns	**	ns	**	ns	ns

Note: S1d – first student distal wall; S1m – first student mesial wall; S2d – second student distal wall; S2m – second student mesial wall; T1d – first prosthetist distal wall; T1m – first prosthetist mesial wall; T2d – second prosthetist distal wall; T2m – second prosthetist mesial wall; ns -not significant; ** - very significant $p \leq 0,01$

Table 3 Wilcoxon Signed-Rank test results - participants' recorded values vs. clinically accepted (11°)

	S1d	S1m	T1d	T1m	T2d	T2m	S2d	S2d
Theoretical median	11,00	11,00	11,00	11,00	11,00	11,00	11,00	11,00
Actual median	1,614	6,376	5,335	13,21	8,294	18,14	2,633	15,41
Number of values	10	10	10	10	10	10	10	10
Sum of signed ranks (W)	-55,00	-53,00	-47,00	19,00	-39,00	47,00	-51,00	45,00
Sum of positive ranks	0,000	1,000	4,000	37,00	8,000	51,00	2,000	50,00
Sum of negative ranks	-55,00	-54,00	-51,00	-18,00	-47,00	-4,000	-53,00	-5,000
P value (two tailed)	0,002	0,0039	0,0137	0,3613	0,0449	0,0137	0,0059	0,0195
P value summary	**	**	*	ns	*	*	**	*

Note: S1d – first student distal wall; S1m – first student mesial wall; S2d – second student distal wall; S2m – second student mesial wall; T1d – first prosthetist distal wall; T1m – first prosthetist mesial wall; T2d – second prosthetist distal wall; T2m – second prosthetist mesial wall; ns -not significant; * - significant $p \leq 0,05$; ** - very significant $p \leq 0,01$

Statistically significant differences were found between the prosthetists and the first student (Mann-Whitney test) when the distal axial wall's taper was considered. In the case of

the values recorded on the mesial axial wall, there were statistically significant differences except those between the prosthetists and the second student (Mann-Whitney test) (table 4).

Table 4 Mann-Whitney test results

	S1d vs T1d	S1d vs S2d	S1d vs T2d	T1d vs T2d	T1d vs S2d	T2d vs S2d	S1m vs T1m	S1m vs S2m	S1m vs T2m	T1m vs T2m	T1m vs S2m	T2m vs S2m
P value	0,017 7	0,106 2	0,002 6	0,516 0	0,340 1	0,109 1	0,021 8	<0,000 1	0,000 2	0,049 9	0,239 1	0,255 6
P value summary	*	ns	**	ns	ns	ns	*	****	***	*	ns	ns
Mann-Whitney U	19	28,50	12	41	37	28,50	20	3	5	24	34	34,50
Difference: Actual	3,721	1,019	6,680	2,959	- 2,702	- 5,661	6,833	9,037	11,77	4,933	2,204	- 2,729
Difference: Hodges-Lehmann	4,292	2,088	7,101	2,236	- 2,094	- 4,522	6,081	8,831	11,09	5,199	2,363	- 3,387

Note: S1d – first student distal wall; S1m – first student mesial wall; S2d – second student distal wall; S2m – second student mesial wall; T1d – first prosthetist distal wall; T1m – first prosthetist mesial wall; T2d – second prosthetist distal wall; T2m – second prosthetist mesial wall; ns -not significant; * - significant $p \leq 0,05$; ** - very significant $p \leq 0,01$; *** - extremely significant $p \leq 0,001$; **** - extremely significant $p \leq 0,0001$

Discussion

The total convergence of an abutment will affect the retention and stability of a prosthetic reconstruction [21, 22]. According to the literature, the ideal and clinically acceptable value of it is between 4-6°, respectively 4-14°, but unfortunately, the clinical application thereof is challenging [18,19]. In a study conducted by Mack, the result showed that the minimum axial walls convergence in order to prevent undercuts must be 12° [13]. Goodacre et al. recommend values between 10-20°, while other in-vitro studies suggested 10-16° total axial wall convergence [6].

Based on the data obtained in this study, an unusual taper of the axial walls was found. Surprisingly, the values recorded were higher for mesial walls, except for the values obtained by the first student. This may be explained by the more inaccessible and less visible area, a level at which more attention is likely to be paid to the tooth preparation. The mean values obtained on the mesial walls were within the clinically acceptable range of 10-25°.

Results obtained by the students in researches conducted by Tiu and al. showed a mean value of the mesio-distal convergence angle of 31,49° [22]; a similar study conducted by Mack reveals lower values, 16,34° [13]. Years ago, Nordlander [23] and Eames [24] already demonstrated a mean value of 20° obtained by experienced practitioners. More recent results were reported in a study conducted by Winkelmeier et al. where the mean total occlusal convergence was 17,9 degrees [25].

In the present study, the mesio-distal convergence angle in most cases, except the mean value of the mesial wall taper registered by the second prosthetist and the first student, is lower than a clinically acceptable convergence angle of 22°. In a study conducted in 2018 by Fahad Abdulla et al. in which the experimented dentists performed teeth preparation, the conclusion was that the mesio-distal convergence angle exceeded the clinically acceptable convergence angle between 10° and 22° [26].

The extremely statistically significant difference was found in the two beginners' case, the values of the second beginner being much higher, as in the case of the two

experienced operators, where the values are higher for the second prosthetist.

These data are similar with data from the literature that achieving ideal convergence in the mouth is impossible and does not depend on the work experience or education level of the operator [27, 28, 17].

The values obtained in the study are considerably higher than the ideal values, as demonstrated by Safa et al. in research where students, prosthetists, and dentists do teeth preparation [28].

The limitation of the present study is the difference between hard dental and acrylic teeth structure being an in vitro study. The lack of standardization of the landmarks used to perform the measurements does not allow an accurate assessment of the total occlusal convergence. For an accurate assessment of the abutment axial wall's convergence, clinical trials are needed.

Conclusion

Within the limitation of this study, the total convergence of the axial wall did not depend on the operators' experience or education level. With increased attention and maximum dedication, the distal walls of the teeth, less accessible, can be appropriately prepared. Using diamond with ideal taper for tooth preparation, an ideal preparation of the abutment will not result.

Conflict of interest: None declared

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