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Analysis of the retention properties of teeth prepared for metalceramic crowns and bridges

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Abstract
This article focuses on the retentive properties of teeth prepared for metalceramic crowns and bridges. A total of 268 teeth prepared for metalceramic restorations were studied, as well as three- and two-dimensional images of 3D-scanned plaster models.
Results of the study: The minimal preparation cone was 4,5° and the maximum was 51,5°. In general, satisfactory tooth preparation was found in 31 out of 268 teeth or 11,56% of the total number of columns examined. The remaining 237 teeth (88,44%) were characterized by unsatisfactory preparation parameters.
Conclusion: In general, acceptable tooth preparation was found in 31 teeth out of 268, which is 11,56% of the total number of examined samples. The remaining 237 teeth (88,44%) were characterized by unsatisfactory preparation parameters.

Keywords: Total convergence angle, metalceramic, fixed prosthodontics

Introduction
Ensuring a low preparation convergence angle is an important condition for the long-term functioning of fixed dentures, including those made of metalceramic. It is known that with the increase of the angle of total occlusal convergense (convergence of the lateral walls) of the teeth, the retention properties of the prepared teeth decrease, and the risk of de-cementation increases. Even with adhesive cementation, the quality of the final result is often determined not so much by the type of cement as by the shape or roughness of the prepared teeth surface [1]. At the same time, it is extremely difficult to obtain a convergence angle of 6-7° in practice without the formation of sub-insides. Thus, in various studies, both conventional and more recent, it was found that the total convergence angle of prepared teeth often exceeded the above parameters and ranged from 1 to 50° [2-10].
Based on this, many scientists consider it necessary to prepare teeth for the manufacture of metalceramic fixed dental prostheses with a greater convergence angle and justify it in the range of 10° to 20° [11-14]. At the same time, there is almost no data in the scientific literature on which teeth, depending on the location, margin projection, and type of structure - crown or bridge - are characterized by the highest rates of lateral wall convergence during preparation. Therefore we set out to investigate in detail the retention properties of the teeth for metalceramic crowns and bridges.

Materials and Methods
During the experiment, 268 teeth (164 in the upper jaw and 104 in the lower jaw), 97 incisors (78 in the upper jaw and 19 in the lower jaw), 31 canines (19 in the upper jaw and 12 in the lower jaw), 75 premolars (38 in the upper jaw and 37 in the lower jaw) and 65 molars (29 in the upper jaw and 36 in the lower jaw) were investigated. All the studied teeth were prepared for complete metalceramic crowns and bridges.
During the experiment, three-dimensional images of scanned plaster models of teeth (cast from class IV plaster according to polyvinyl siloxane impressions) of different patients with dentition defects from the dental laboratory database were studied. These models were scanned by a non-contact optical scanner of the CAD/CAM system to obtain a virtual model and then modeled as a fixed metalceramic structure. After that, the total convergence angle of the preparation in the mesiodistal and buccolingual projections was analyzed in 3D. The measured values were recorded in tables.

Results and Discussion

The acceptable limits of the tooth preparation convergence angle were considered to be a value not exceeding 12° for all types of teeth [13], except for molars. For the latter, a convergence angle not exceeding 20° was considered acceptable [12]. The minimum acceptable ratio of the height of the teeth to its width was considered to be 4 to 10 [11]. If the convergence angle value of the preparation was within the specified norm, and the ratio of the teeth height to its width was not less than 4 to 10, then such preparation was considered satisfactory. In all other cases, the preparation of teeth for metalceramic structures was considered unsatisfactory. According to the results of the study, the minimal preparation convergence angle was 4,5°, and the maximum was 51,5°. In general, acceptable tooth preparation was found in 31 teeth out of 268, which is 11,56% of the total number of examined samples. The remaining 237 teeth (88,44%) were characterized by unsatisfactory preparation parameters (Figures 1, 2).

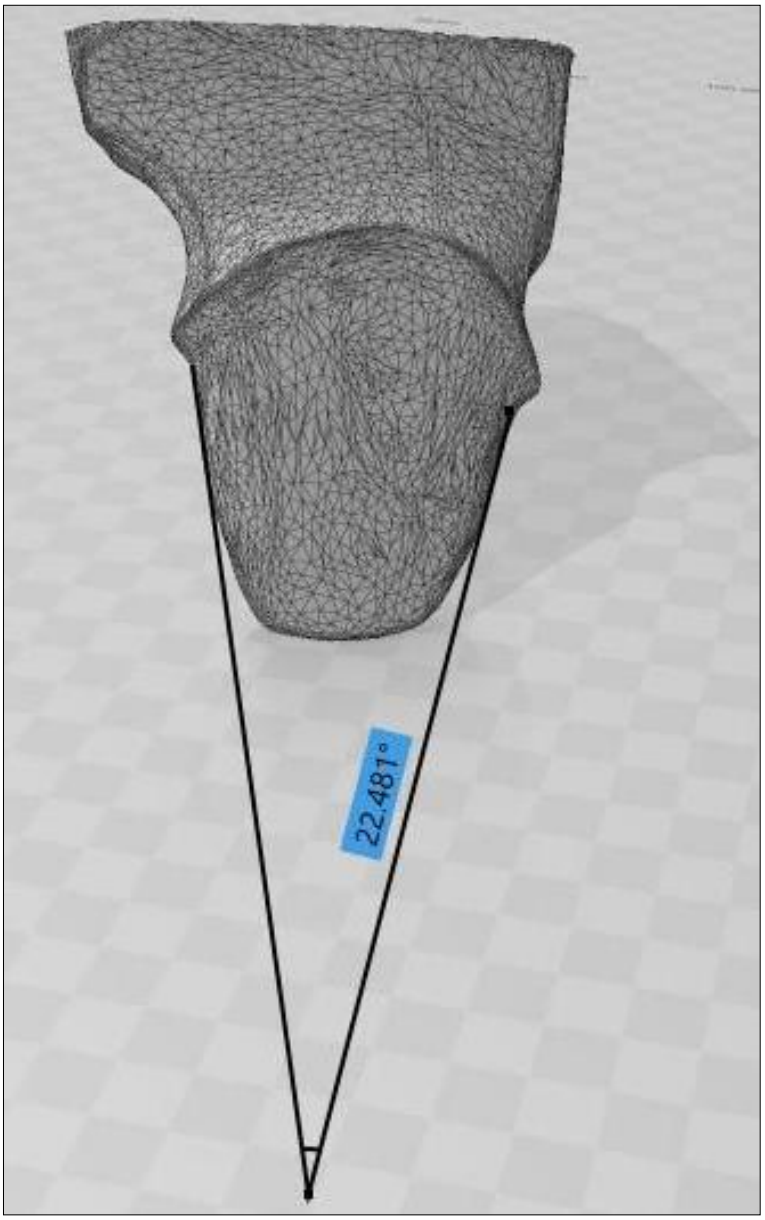

Fig 1: Screenshot with excessive preparation convergence angle in the mesiodistal projection of left upper second incisor

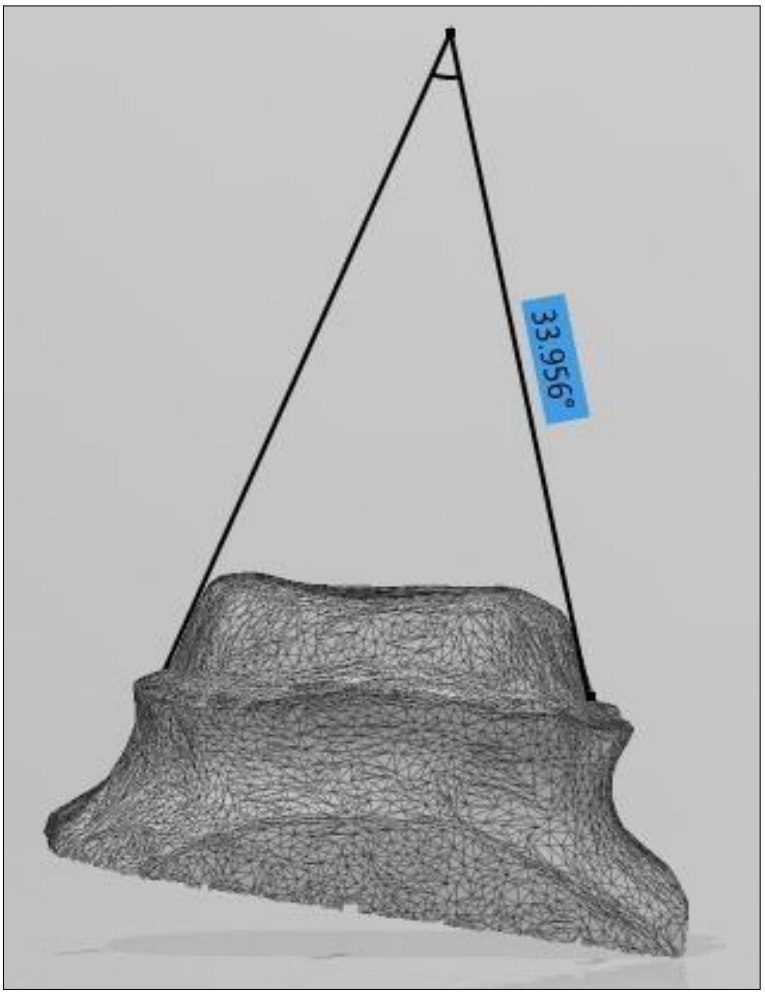

Fig 2: Screenshot with excessive preparation convergence angle in the buccolingual projection of right lower second molar

The results of the convergence angle measurement of each tooth in the mesiodistal and buccolingual projections are presented in Tables 1 and 2.

Table 1: Results of measuring the convergence angle of teeth in the mesiodistal projection

Tooth	Total occlusal convergence and quantity of samples examined in the mesiodistal projection.	Total occlusal convergence of single crowns and quantity of samples examined in the mesiodistal projection	Total occlusal convergence of the dental bridge supports and their quantity of samples examined in the mesiodistal projection
Central incisor	19,80±0,63 (47)	19,00±0,45 (42)	26,48±0,21 (5)
Lateral incisor	19,23±0,62 (50)	18,90±0,43 (45)	22,16±0,16 (5)
Canine	20,05±0,56 (31)	19,39±0,50 (21)	21,46±0,15 (10)
Anterior teeth	19,63±0,60 (128)	19,03±0,45 (108)	22,89± 0,18 (20)
First premolar	16,87±0,50 (33)	18,24±0,44 (23)	12,74±0,23 (10)
Second premolar	19,11±0,55 (42)	22,10±0,34 (15)	17,45±0,24 (27)
First molar	22,13±0,40 (17)	23,24±0,34 (9)	20,88±0,12 (8)
Second molar	20,94±0,41 (31)	20,60±0,25 (11)	21,55±0,23 (20)
Third molar	27,90±0,20 (17)	30,60±0,11 (3)	27,32±0,14 (14)
Posterior teeth	20,42±0,25 (140)	20,96±0,25 (61)	19,99±0,25 (79)
Total:	19,55±0,35 (268)	19,72±0,35 (169)	20,57±0,30 (99)

Table 2: Results of measuring the convergence angle of teeth in the buccolingual projection

Tooth	Total occlusal convergence and quantity of samples examined in buccolingual projection	Total occlusal convergence of single crowns quantity of samples examined in buccolingual projection	Total occlusal convergence of the dental bridge supports and their quantity of samples examined in the buccolingual projection
First premolar	22,63±0,80 (33)	23,50±0,40 (23)	20,69±0,22 (10)
Second premolar	21,35±0,62 (42)	20,32±0,22 (15)	21,96±0,23 (27)
First molar	23,30±0,34 (17)	23,28±0,21 (9)	22,28±0,11 (8)
Second molar	28,44±0,50 (31)	27,05±0,20 (11)	29,27±0,10 (20)
Third molar	30,47±0,42 (16)	33,46±0,11 (3)	29,83±0,13 (14)
Total:	24,57±0,45 (140)	23,21±0,34 (61)	25,06±0,18 (79)

According to the results of the study, the total occlusal convergense of the preparation of the posterior teeth for metalceramic structures in the mesiodistal projection (20,42±0,25) exceeded the similar indicators of the total occlusal convergense of the preparation of teeth in the anterior area (19,63±0,60). This difference would be even more noticeable if it were not for the total occlusal convergense of the preparation of premolars, the total occlusal convergense angle of which in this projection approximately corresponded to the results of the total occlusal convergense of the anterior teeth. Moreover, for the first premolar, the indicators of total occlusal convergense in the mesiodistal projection (16,87±0.50) were the best of all the studied teeth. At the same time, the total occlusal convergense of the preparation of the posterior teeth in the buccolingual direction (24,57±0.45) significantly exceeded the similar indicators of total occlusal convergense in the mesiodistal projection (20642±0625). The highest indicators of preparation convergence angle in both projections were characterized by molars, especially wisdom teeth. The average value of the preparation convergence angle of the supporting crowns of bridges, in both projections, exceeded the average values of the preparation convergence angle for single crowns (in the mesiodistal projection – 20,57±0,30 vs. 19,72±0,35, in the buccolingual projection – 25,06±0,18 vs. 23,21±0,34), although this pattern was not observed for all types of teeth.

The results of the total occlusal convergense of the tooth preparation depending on the location on a particular jaw are presented in Table 3.

Table 3: Results of the convergence angle of the tooth preparation depending on the location of the jaw

	Total occlusal convergence of the anterior teeth and quantity of samples examined in the mesiodistal projection	Total occlusal convergence of the posterior teeth and quantity of samples examined in the mesiodistal projection	Total occlusal convergence of the all teeth and quantity of samples examined in the mesiodistal projection	Total occlusal convergence of the posterior teeth and quantity of samples examined in buccolingual projection
Maxilla	20,23±0,67 (97)	19,05±0,44 (67)	19,74±0,55 (164)	24,49±0,34 (67)
Mandible	16,63±0,31 (31)	22,17±0,42 (73)	20,51±0,47 (104)	24,73±0,35 (73)
Total	19,35±0,62 (128)	20,67±0,43 (140)	19,55±0,54 (268)	24,65±0,35 (140)

As can be seen from the results presented in Table 3, the preparation convergence angle of the anterior teeth in the lower jaw in the mesiodistal projection (16,63±0,31) indicated significantly lower preparation convergence angle indices in the lateral areas (22,17±0,42). At the same time, in the upper jaw, on the contrary, the indicators of the total convergence angle of teeth in the anterior region (20,23±0,67) exceeded the similar indicators of the total convergence angle teeth in the lateral regions (19,05±0,44).

In general, the teeth of the upper jaw were prepared with lower convergence angle indices in the mesiodistal projection (19,74±0,55) than in the lower jaw (20,51±0,47). Our measurements here are in line with the studies of Smith B.G.N., and Howe L.C. [12], who emphasize that it is most difficult to achieve low convergence angle values when preparing mandibular molars, as well as with the data of Goodacre C.J. *et al* [8], who states that mandibular teeth are generally prepared with a higher convergence angle than maxillary teeth. It should also be noted that the average value of the lateral teeth convergence angle in the buccolingual direction was significantly higher (24,65±0,35) than in the mesiodistal direction (20,67±0,43), both in the upper and lower jaws. The results of the ratio of the height of the teeth of the prepared molars to its width are shown in Table 4.

Table 4: Results of the ratio of the height of the teeth of prepared molars to its width

Tooth	Quantity	A sufficient ratio (≥0.4)	Insufficient ratio (<0.4)
First premolar	33	33 (100,0%)	-
Second premolar	42	42 (100,0%	-
First molar	17	11 (64,7%)	6 (35,3%)
Second molar	31	22 (71,0%)	9 (29,0%)
Third molar	17	9 (52,9%)	8 (47,1%)
Total:	65	42 (64,6%)	23 (35,4%)

As can be seen from the results presented in Table 4, 35,4% of all studied teeth were characterised by an insufficient ratio of the teeth height to its width (Fig. 3).

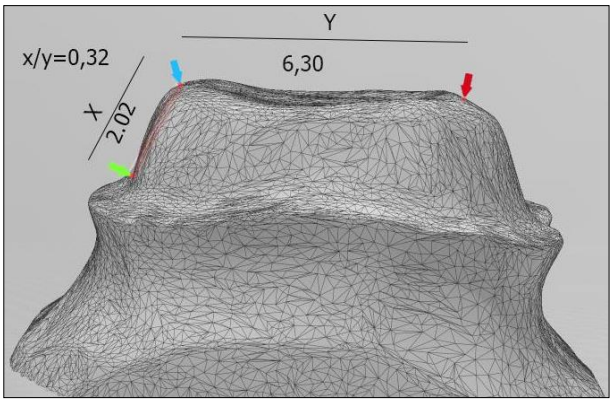

Fig 3: Screenshot of right upper second molar teeth with insufficient teeth height to width ratio

All premolars were characterized by a sufficient teeth height-to-width ratio. At the same time, a significant number of molars were prepared with a teeth height-to-width ratio (in the buccolingual direction) of less than 0,4. The percentage of teeth with an insufficient ratio increased from the first to the third molar. In the latter, almost half of the teeth (47,1%) were characterized by an insufficient ratio of the teeth height to its width.

Conclusions

1. The overwhelming majority of the studied teeth (88,44%) were characterized by unsatisfactory qualities concerning the retentive properties of the preparation teeth.
2. The total occlusal convergense of preparation of the posterior teeth in the mesiodistal projection (20,42±0,25) exceeded the similar indicators of the total occlusal convergense of prepared teeth in the anterior area (19,63±0,60).
3. The total occlusal convergense of the preparation of the posterior teeth in the buccolingual direction (24,57±0,45)

significantly exceeded the similar indicators of total occlusal convergense in the mesiodistal projection (20,42±0,25).
4. The teeth of the upper jaw in the mesiodistal projection were prepared with lower convergence angle indices (19,74±0,55) than in the lower jaw (20,51±0,47).
5. About 35,4% of all studied teeth were characterized by an insufficient ratio of the teeth height to its width.
6. The most obviously unsatisfactory total occlusal convergense and the insufficient ratio of the height of the teeth to its width were characterized by molars, especially wisdom teeth (47,1%).

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