ORIGINAL ARTICLE

IS CAD-CAM TECHNOLOGY A VALUABLE TOOL FOR PROSTHODONTICS RESIDENTS IN TOOTH PREPARATION ASSESSMENT?

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ABSTRACT

Objective. The purpose of this study was to determine the prevalence of abutment geometry errors that can occur during the tooth preparation stage and to determine if they could have been visualized and corrected with the aid of intra-oral scanning and digital model analysis.

Material and methods. Resin molars and premolars from a typodont were prepared by prosthodontics residents for all ceramic crowns. The prepared abutments were digitized with an intra-oral scanner and the resulting 3D models were analyzed in terms of occlusal and axial clearance, finish line width and also homogeneity and occlusal convergence angle.

Results. More than half of the operators failed to meet the minimum occlusal clearance requirements of at least 1.5 mm. Regarding the interproximal clearance, 70% of the prepared abutments presented more than 1 mm wide shoulders, only 26.6% of the samples meeting the initial required specifications. Finish line width was met only in 16.6% of the samples, meanwhile the finish line homogeneity as well as undercuts were present in 47% of the examined abutments. The ideal occlusal convergence angles criteria were met in 36% of the preparations while 37% of the samples exceeded this interval.

Conclusions. Evaluation of the tooth preparation errors are often overlooked only using the clinical examination.Digital impression can allow an immediate evaluation of the tooth preparation geometry, and therefore can help clinicians to improve preparation skills.

Key words: digital impression, CAD/CAM technology, abutment geometry

INTRODUCTION

Fixed partial dentures are one of the most common dental treatments found in the dental office, with the main purpose of restoring both the esthetics and function of damaged teeth. As a result, aspects such as resistance to occlusal forces, biological integration with the surrounding tissues and adequate shape to promote functional mastication are of the outmost importance [1]. An important factor that needs to be taken into consideration when talking about long lasting restorations is the marginal adaptation, which can only be achieved with a correctly shaped finish line. Failure in achieving a proper geometry of the shoulder leads to secondary caries, leakage, and de-cementation of the restoration [2-4]. This aspect is even more crucial when talking about ceramic crowns, since they require a proper reduction of the tooth structures, to ensure an adequate thickness of the material, for both functional, resistance and esthetic reasons.

Apart from the thickness and the class of material used for the restoration, the geometry of the preparation must ensure the absence of sharp angles, with smooth transition of edges, and also very well-defined finish lines, which may be prepared as a chamfer or a round shoulder [5-7]. The depth of the finish line may vary within 0.5-1.5 mm, however, it is always conditioned by the clinical factors such as the vitality of the abutment and the degree of discoloration that needs to be masked by the future restoration [8,9].

Preserving tooth structure as much as possible is also critical in dentistry. However, when talking about full coverage crowns, there are a number of desiderates that need to be achieved, sometimes even at the cost of reducing considerably the hard tooth structures [10]. Among these tooth preparation requirements, surface smoothness, sufficient occlusal clearance translated as correct abutment height and abutment convergence angle, need to be assessed thoroughly before taking the final impression [11,12].

When taking a conventional impression, the final examination of the abutment can only be made after pouring the cast, which usually is not completed in the same visit. As a result, if any abutment adjustments are required, the whole process needs to be repeated, and for an unexperienced clinician, with the possibility of further errors of the final cast [4].

With the introduction of the digital impression and CAD/CAM technology (computer aided design/ computer aided manufacturing), the evaluation of the preparation can be done in the same appointment, immediately after preparation. All of the characteristics can be assessed in vivo and corrected through the digital workflow provided by the intra-oral scanning (IOS) system. Following the design requirements for the preparation of all ceramic crowns, with proper reduction and equigingival or supragingival margins, will

also enhance the quality of the scan and allow a clearer identification of the finish line [12,13].

Ideally, the occlusal convergence angle of a preparation should be around 50. However, in clinical practice, achieving almost parallel walls of the abutment is challenging and more often than not, the convergence angle is close to 200 or more [14-16].

The purpose of this study was to determine the prevalence of abutment geometry errors that were missed by the prosthodontics residents during the preparation stage and to determine if they could have been visualized and corrected during the digital impression.

MATERIALS AND METHODS

A total of 60 abutments were prepared by 30 prosthodontic residents, and examined in this study. The preparations were made on resin molars and premolars mounted in a typodont (Frasaco) which was fixed on a manikin. The operators were instructed to apply the general design rules for all ceramic crowns, meaning an axial reduction of 1 mm, occlusal reduction of 1.5 mm and the placement of a supragingival chamfer finish line, with a width of 0.7-1 mm. After completing the preparations, the operators were asked to assess the geometry of the abutment, and once they considered it to be ready for the final impression, the abutments were collected for the digital inspection.

Each resin abutment was scanned using the intraoral scanner (PlanScan, Planmeca) and introduced in the digital workflow of the Romexis software (Fig.1), as an STL file (standard tessellation format). Additionally, the antagonist teeth as well as the maximum intercuspation position were scanned, to allow the evaluation of occlusal clearance.

Next, the following parameters were investigated utilizing the tools provided by the Romexis software(Plan CAD Easy, Planmeca).

Occlusal and proximal reduction

The occlusal clearance was evaluated in millimeters, using a calibrated grid, analyzing multiple 'slices' of both the abutment and the opposing teeth and the lowest value was recorded. The same steps were followed for the axial reduction, only the lowest reduction being recorded for both proximal walls (Fig.2).

Occlusal convergence angle

For each preparation, the occlusal convergence was measured from two perspectives, a mesio-distal slice, and a buccal-lingual slice.This was achieved by overlapping a preformed grid that displayed an angle of 60 and 100. The abutment angles were defined as '<60', '60-100', and '>100' (Fig. 3).

Width and homogeneity of the finish line

Marginal preparation was evaluated and measured as the distance between the most outer line and the most inner line of the chamfer. Also, the evenness of the finish line was determined, being recorded as 'present' or 'absent'. This was done using the same calibrated grid provided by the Romexis software, using horizontal slices of the digital model (Fig.4).

Negative angles

The presence of undercuts was visually assessed by rotating the digital models 3600, and recorded as 'present' or 'absent', (Fig.5).

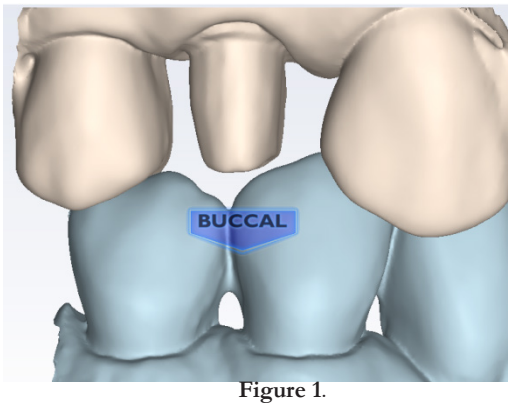

Figure 1.

3D model of the abutment, occlusion and antagonists.

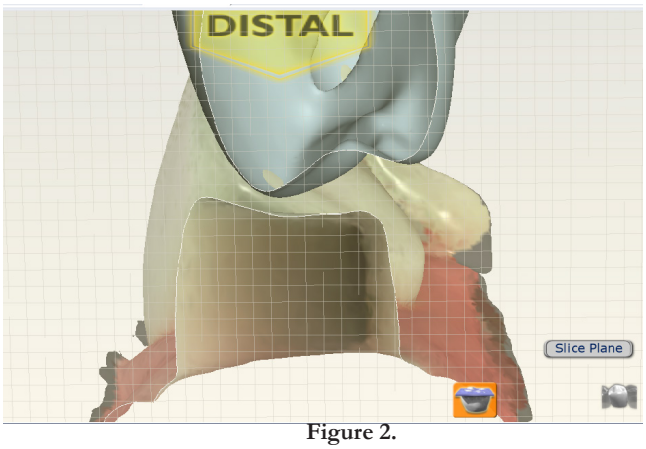

Figure 2.

Occlusal clearance-calibrated grid

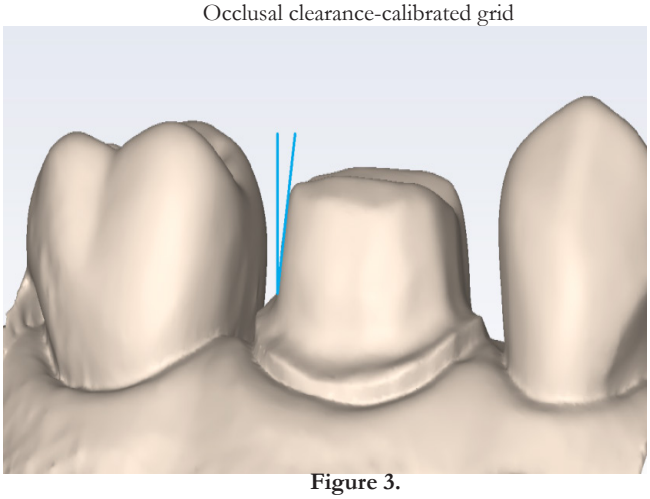

Figure 3.

Occlusal convergence angle

RESULTS

The results of this study are presented in Table 1.

More than half of the operators failed to meet the minimum occlusal clearance requirements of at least 1.5 mm (63.3%). Regarding the interproximal clearance, 70% of the prepared abutments presented more than 1 mm

wide shoulders, only 26.6% of the samples meeting the initial required specifications (Fig. 6).

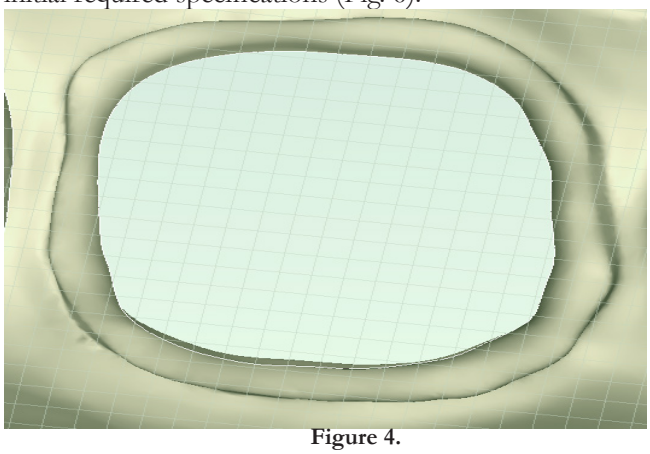

Figure 4.

Shoulder width-calibrated grid

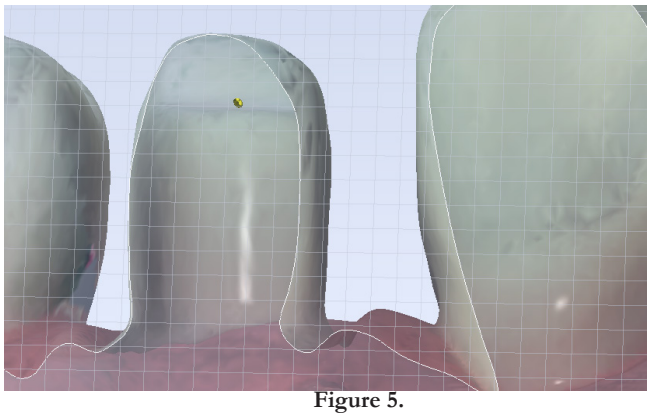

Figure 5.

Undercut assessment.

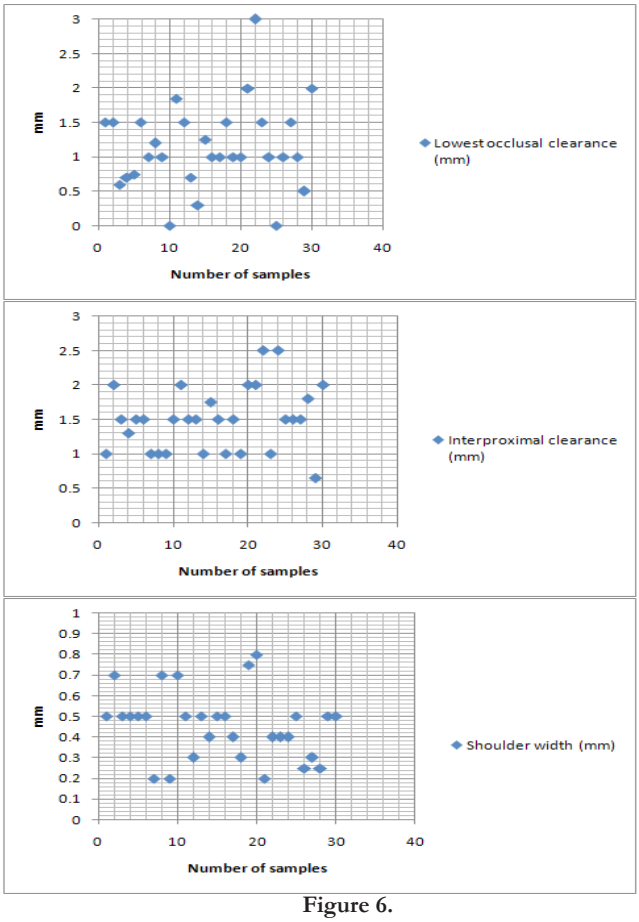

Figure 6.

Occlusal and interproximal clearance and shoulder width values dispersion

Operator	Lowest occlusal clearance (mm)	Interproximal clearance (mm)	Shoulder width (mm)	Undercuts	Finish line homogeneity	Occlusal convergence angle (degrees)
1	1.5	1	0.5	YES	NO	<6
2	1.5	2	0.7	NO	YES	<6
3	0.6	1.5	0.5	NO	YES	6--10
4	0.7	1.3	0.5	YES	YES	<6
5	0.75	1.5	0.5	YES	NO	>10
6	1.5	1.5	0.5	NO	NO	>10
7	1	1	0.2	NO	NO	6--10
8	1.2	1	0.7	NO	YES	6--10
9	1	1	0.2	NO	YES	>10
10	0	1.5	0.7	YES	NO	6--10
11	1.85	2	0.5	NO	YES	6--10
12	1.5	1.5	0.3	YES	YES	<6
13	0.7	1.5	0.5	NO	NO	>10
14	0.3	1	0.4	YES	NO	6--10
15	1.25	1.75	0.5	YES	YES	6--10
16	1	1.5	0.5	YES	NO	6--10
17	1	1	0.4	NO	YES	6--10
18	1.5	1.5	0.3	YES	YES	<6
19	1	1	0.75	NO	NO	>10
20	1	2	0.8	YES	NO	<6
21	2	2	0.2	NO	YES	>10
22	3	2.5	0.4	NO	YES	>10
23	1.5	1	0.4	NO	NO	<6
24	1	2.5	0.4	NO	YES	>10
25	0	1.5	0.5	YES	NO	>10
26	1	1.5	0.25	NO	YES	6--10
27	1.5	1.5	0.3	NO	NO	<6
28	1	1.8	0.25	YES	YES	6--10
29	0.5	0.65	0.5	YES	YES	>10
30	2	2	0.5	YES	NO	>10

Table 1.

Recorded values of the analyzed criteria for the prepared abutments.

Finish line width was met only in 16.6% of the samples (Fig. 6), meanwhile the finish line homogeneity as well as undercuts were present in 47% of the examined abutments. The ideal occlusal convergence angles criteria were met in 36% of the preparations while 37% of the samples exceeded this interval.

DISCUSSIONS

CAD/CAM technologies try to implement a more standardized approach for the prosthodontic treatments, allowing for a real time evaluation of the geometry of the preparation. The possibility of visualizing the 3D model of the preparation, from a 3600 point of view, enhances the clinical assessment of the abutment, allowing for immediate corrections. In case of corrections, the digital impression procedure is not repeated from the beginning (as the conventional impression), only the modified part of the abutment being scanned again, thus reducing the clinical time of the procedure [17-19].

The current study evaluated the quality of abutment preparation for an all ceramic crown, performed by 30 prosthodontic residents with the aim of assessing the prevalence of errors that may affect the final restorations. Even though the results were gathered from first year residents coming from different universities, the results were homogenous. The assessment of the preparations

was made by analyzing some key preparation criteria, such as occlusal and proximal clearance, shoulder geometry, as well as the presence of undercuts. The occlusal clearance was evaluated at the lowest value identified on the occlusal surface, since only one point with insufficient material thickness can lead to cracks. The same idea was applied to the proximal reduction, without analyzing each surface independently, but as a whole.

The finish line was assessed regarding the width and continuity. Usually, the ideal width ranges from 0.5-1 mm. The value of 0.5 mm tends to be used for minimally invasive restorations in the anterior arch, such as veneers, where the occlusal forces are lower. In the posterior arch, a minimum width of 0.7 mm for the shoulder can be accepted, since the working space is more limited, thus allowing for a better visual control. However, 84% of the samples in this study did not meet the ideal criteria, meaning that the values of 0.5 mm obtained by some operators were randomly achieved.

Al-Omari et al. evaluated finish line preparation in both molars and premolars and came to the conclusion that optimal widths vary between 0.71-0.83 mm [21,22]. The homogeneity of the finish line was assessed independently of the width of the shoulder, and taken into consideration even if the shoulder width criteria was not met. In 47% of the cases, the shoulder was discontinuous. However, this study did not investigate the most prevalent axial surfaces with shoulder discontinuity, which can be usually found on the mesio-lingual and disto-lingual angle. Even in cases in which the shoulder continuity is not ideal, it is still considered that a finish line provides more positive aspects when compared to the featheredge, especially in the case of all ceramic restorations [7].

The convergence angle of a preparation dictates the retention and the long-term survival of the restoration. The higher the value of this parameter, the more tooth structure is lost, which may lead to pulpal damage and greatly decrease of the overall abutment strength. The general accepted occlusal convergence angles may vary between 60-100, going up to 220 [22]. In the present study, 36% of the operators met the ideal convergence range. However, the measurements did not analyze the actual value of the convergence, but the interval in which they were present. As a result, for example, samples with 120 might have been placed in the same category with samples of 300 of occlusal convergence, which in a clinical scenario has considerable consequences.

The undercuts were present in almost half of the preparations. Usually the increase in occlusal convergence angles should lead to the elimination of undercuts, however, in the present study, they were distributed in all of the analyzed convergences.

The results of this study showed that the prevalence of preparation errors that were not noticed by the operators was significantly high. These could have been observed and corrected during the digital impression technique, due to the instant feedback that these technologies can provide. Another thing that needs to be taken into consideration regarding the results of this study is the fact that no clinical factors influenced the operators during the preparation stage.

Presence of blood, saliva, patient movements and the limited access for the instruments, all of these can have a major impact on the preparation of an ideal abutment.

CONCLUSIONS

Within the limitation of this study, the following conclusions can be drawn:

1. Preparation errors are often overlooked only using the clinical examination
2. Digital impression allows an immediate evaluation of the preparation geometry, which can be an objective and valuable tools for prosthodontic residents preparation skills.

There are no conflicts of interest regarding this article.

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