Clinical Factors Influence the Trueness of Intra-oral Scanning

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ABSTRACT

Aims: The aim of this in vitro study was to evaluate the influence of adjacent teeth in the trueness of digital impressions. Materials and Methods. In this study the first premolar on a typodont mounted in a phantom head was prepared for an all ceramic crown. Three different operators scanned the tooth with an intraoral scanner, with three different clinical scenarios: with no adjacent teeth, with one adjacent tooth and with two adjacent teeth. Resulting scans from each operator were compared with a reference scan using metrology software. Results: The results of this in vitro study showed differences of scanning trueness between each clinical simulated situation. Conclusions: The presence of adjacent teeth can decrease the view of interproximal surfaces and may generate a less precise scan in these regions. The results of this study showed that the trueness of an intraoral digital impression is conditioned by a good visibility of the abutment.

INTRODUCTION

An accurate dental impression is critical for obtaining precisely fitting dental restorations. Intraoral conditions should be reproduced as accurately as possible, as errors may have far greater consequences for the end result of the treatment.[1]

Optical impressions have a number of benefits over conventional impressions. They are not prone to damage or distortions, are not influenced by external factors such as the ambient temperature, no trays or adhesive are required for the impression. Digital impressions remove the risk of cross infection with the dental laboratory, are more time efficient and the clinician can observe in real time the quality of the impression.[2-4]

However, the accuracy of intraoral optical impressions is conditioned by a number of factors. These factors include humidity levels, presence of saliva on the interest area, presence of blood, the number of teeth involved in the scan, the location of the abutments, patient movements, design of the preparations, crown margins and last but not the least the experience of the operator.[5-8]

Marginal fit is a key feature in obtaining long lasting restorations. Recording as precise as possible the area where the future crown will rest on the prepared tooth allows a clear identification of the finishing margin, and leads to an appropriate emergence profile. Usually, a poorly fitting margin is susceptible to secondary caries due to leakage or even pulpal effects.[8-11]

The accuracy of an intraoral scanner can be measured by performing an *in vitro* assessment. These tests usually use a dental model, cast in a type IV dental stone or fabricated from metal, and then, with the aid of a high precision scanner, they are converted into digital models. The next step consists in taking a conventional impression of the reference model, that is later on scanned directly, using the same reference scanner, or indirectly, by scanning the cast resulting from the impression.[12-14]

The accuracy of an impression is determined by two factors: trueness and precision. Trueness can be defined as the difference between a measurement and a reference, while precision shows the difference between repeated measurements. The lower the values of these two variables, the higher the trueness and precision of a measurement.[15-17]

The aim of this study was to evaluate the influence of adjacent teeth over the trueness of intraoral scanning. The null hypothesis is that interproximal areas are more difficult to reach by the light radiation from the scanning tip.

MATERIALS AND METHODS

A typodont right upper first premolar was prepared for an all ceramic crown, with a shoulder margin width of 1 mm and an occlusal reduction of 2 mm. The palatal margin was positioned 1 mm supragingival, the buccal margin was prepared equigingival, while the interproximal margin was placed 0.5 mm below gingival free margin. The prepared premolar, fixed in a typodont, was scanned with a high precision scanner (D 700 Trios, 3 shape), with a dimensional accurcy of 20 µm. Three different clinical situations were simulated:one with no adjacent teeth to the prepared premolar, one with one adjacent tooth, the second premolar, and one with both the canine and the second premolar present on the arch.The resulting STL files were used later on as the reference digital models.

Next, the same procedures were repeated, this time using an intraoral scanner from Planmeca PlanScan *(Figure 1)*.

Figure 1: Scanning the preparation with Plan Scan

Each situation was scanned by three different operators: a prosthodontic specialist, a prosthodontic resident and a dentistry student. Each operator scanned four times all the simulated situations, that led to 36 different scanned images *(Figure 2)*.

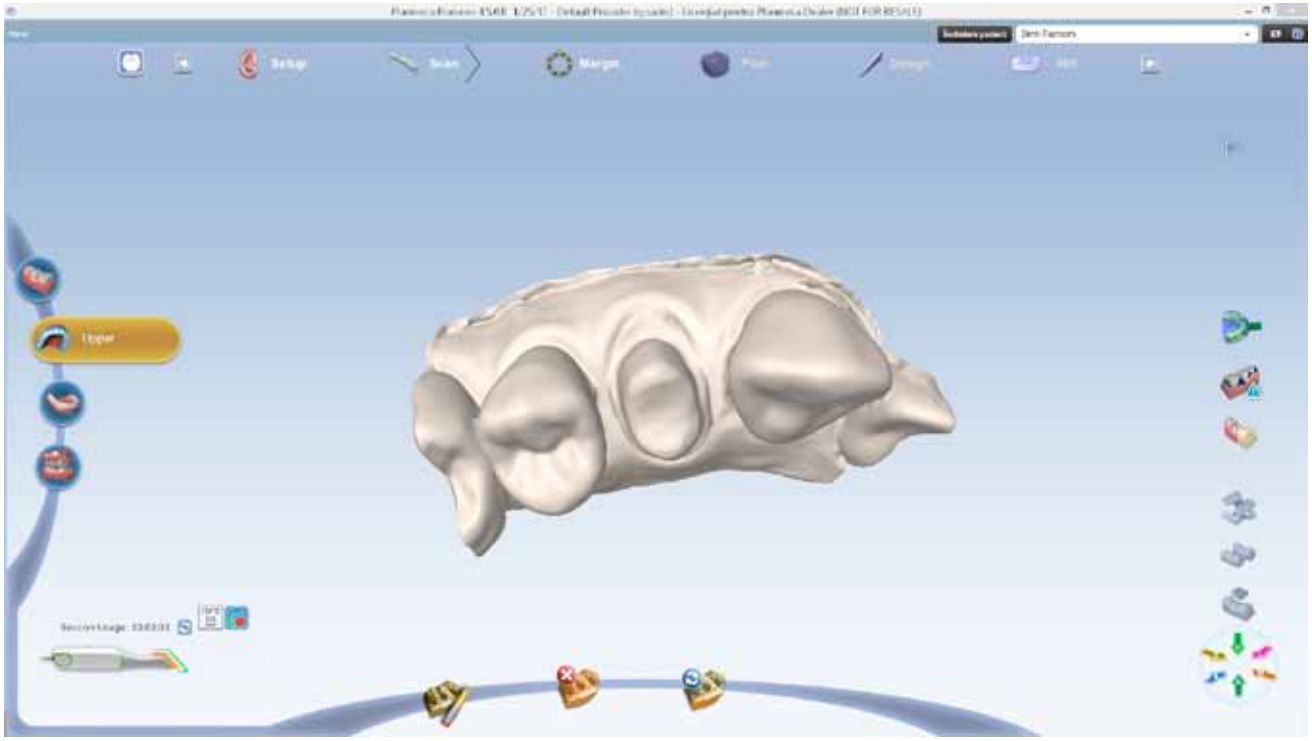

Figure 2: Digital model generated by the software

All data and computations were performed using metrology software, Geomagic Qualify. The 3D models were cropped below the finish line, using the shoulder preparation as a guide for all the analysed 3D models, leaving only the interest area, in order to minimize the deviation values. Each scan from the intraoral scanner was superimposed over it's corresponding scan from the reference scanner, in order to evaluate the trueness values *(Figure 3)*. The overlapping of the preparations was made using a best fit algorithm provided by the software. The result is a color map on the mesh object showing the difference between the mesh object and the modeled solid or surface. The color map updates when you input different values in the Deviation Analysis box.

The effect of confounding factors was assessed for statistical significance ($p < 0.05$) using univariate ANOVA test. For each situation the mean trueness value was calculated and then compared with the mean values from the other 2 groups.

RESULTS

The presence of adjacent teeth influenced the trueness of the scans and was significant for the overall trueness of the scans *(Table 1)*, with a *p* value lower than 0.05. Poorest overall trueness was shown in the situation with two adjacent teeth for all the operators, followed by one tooth adjacent tooth and last with no teeth in relation with the abutment *(Figure 4)*.

The difference in scanning trueness between operators was present, but by small margins, and with no significance, *p* values higher than 0.05 *(Figure 5)*.

DISCUSSIONS

The shape and placement of a preparation's margins is crucial for the quality of a prosthodontic restoration.[18]

We used the scans of a prepared tooth, fixed in a model, to define a precise and constant location of the margin. From this, the three different scenarios, combined with three different operators, aimed to determine the way the adjacent teeth and also each individual (subjective) scanning technique influences the accuracy of digital impressions.

Not all confounding factors were analysed in this study. Due to the fact that this was an *in vitro* study, aspects such as humidity and moisture, patient's movements, adjacent tissues such as cheeks or tongue did not have any influence in the scanning process. In addition, only one location was investigated, in a fairly accessible space. Scanning of the last molars may cause even more difficulties in acquiring a precise scan.

The palatal axial wall played the role of a control surface during the scans. This was due to the fact that it was visible throughout the entire scanning process, and the adjacent teeth did not influence it's visibility. In the absence of external factors, the quality of the palatal surface was consistent.

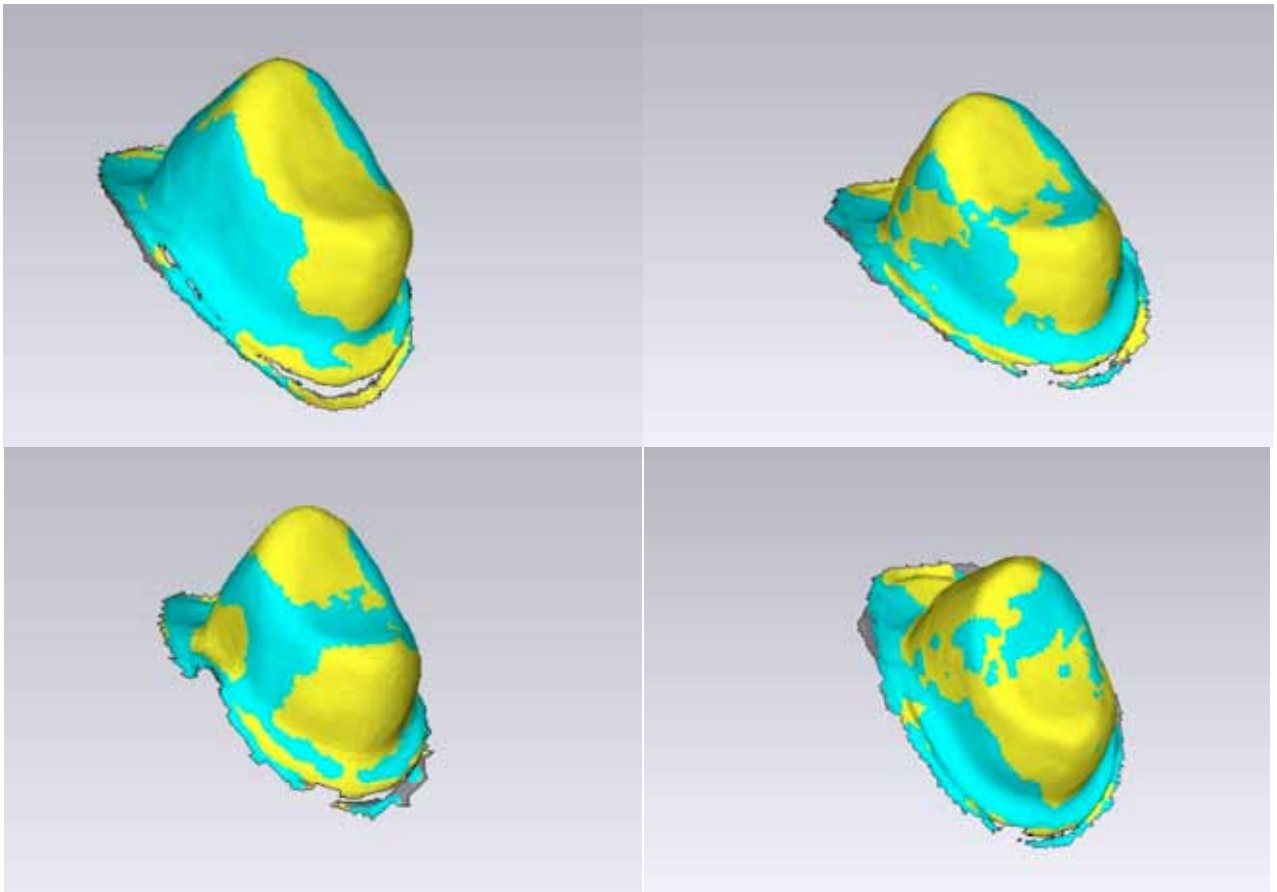

Figure 3: Visual representation of deviation values

Table 1. Mean(SD) trueness scan values for all the operators

	0 adjacent teeth	1 adjacent tooth	2 adjacent teeth
Prosthodontics specialist	4.00±0.18 µm	5.08±0.26 µm	5.88±0.87 µm
Prosthodontics resident	4.28±0.33 µm	5.03±0.22 µm	5.83±0.35 µm
Dentistry student	4.40±0.37 µm	4.88±0.36 µm	5.48±0.44 µm

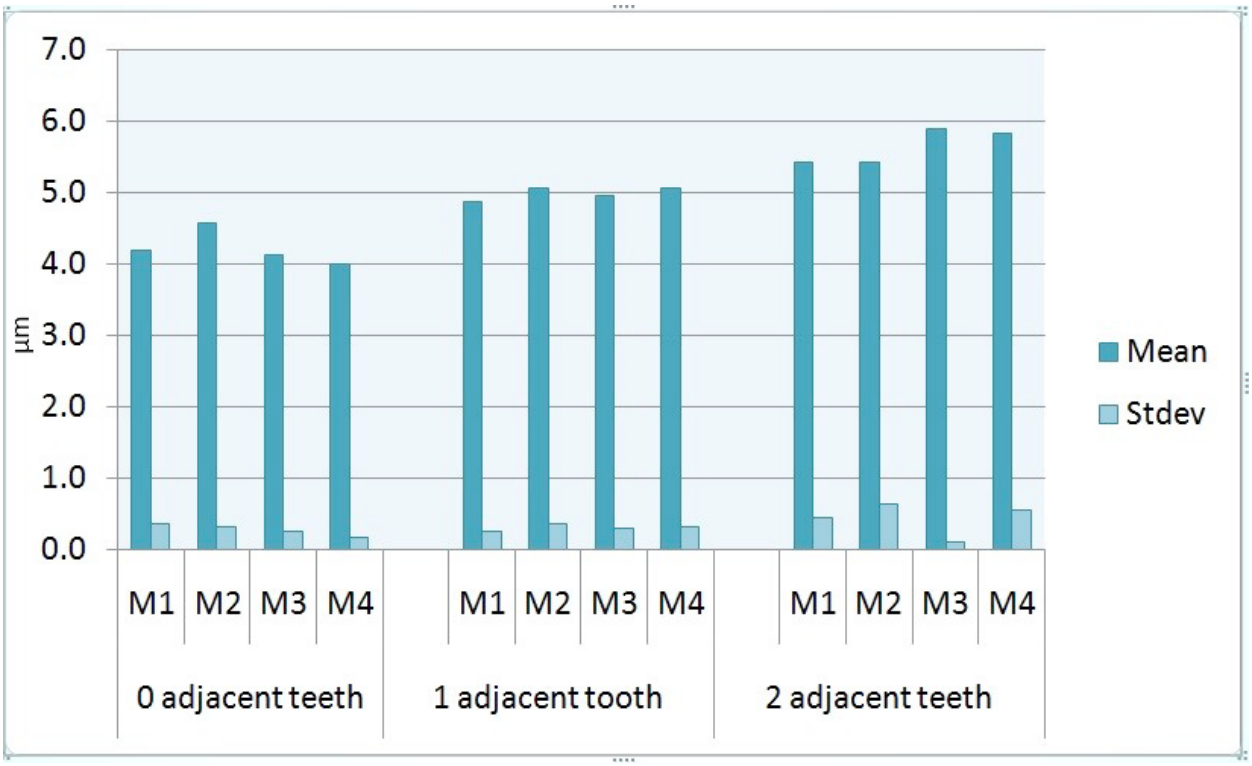

Figure 4: Graphical representation of mean(SD) trueness values between each simuated scenario

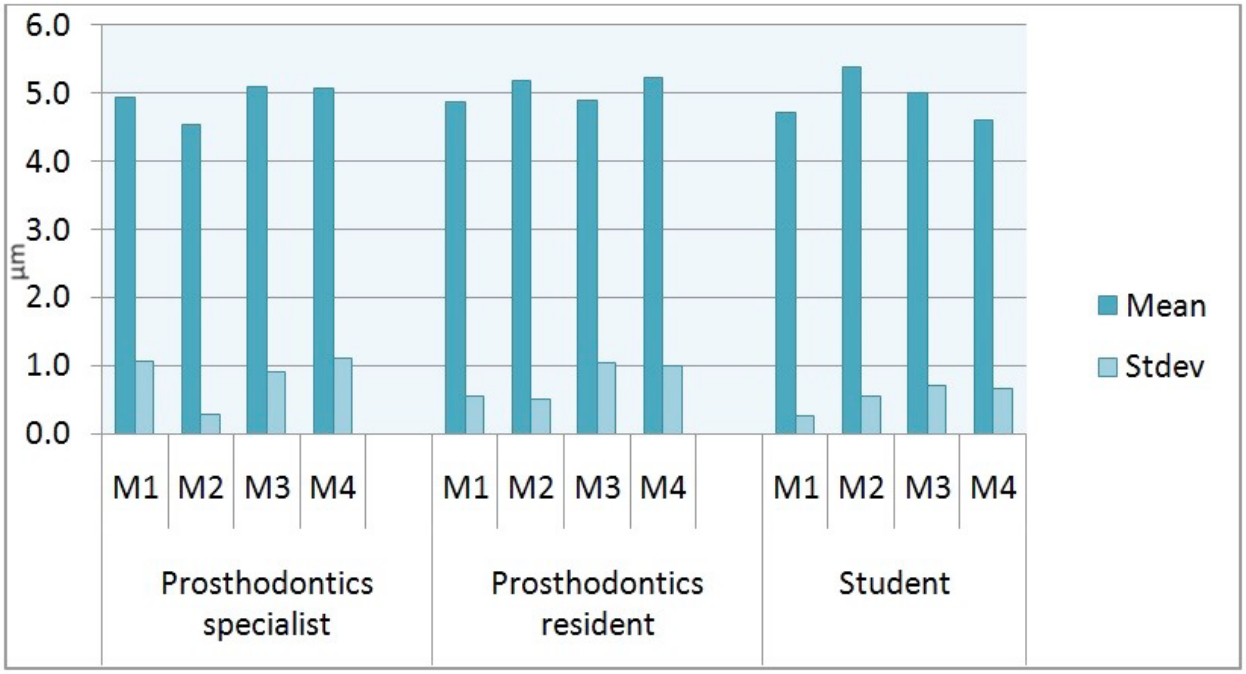

Figure 5: Graphical representation (comparison) of the mean(SD) trueness values between op

The buccal surface was also easy to reach with the scanning tip, and showed no significant difference compared to the palatal side.

The presumed important confounding factor for the accuracy of the scan, the presence of adjacent teeth, influenced the accuracy of the scans. Scanning accuracy was similar for all the situations, but the "no adjacent teeth" case showed the best overall trueness. However, the differences in trueness in all the situations were significant.

Another study showed similar results regarding the influence of adjacent teeth in the overall accuracy of the scan, the situation with a lone prepared tooth having the best trueness.[8]

This study sheds some light on the implications of two confounding factors, represented by adjacent structures of a prepared tooth as well as the operators experience technique of scanning. All these factors may influence the accuracy of digital impressions and their impact is not well documented so far.

A number of studies show that intraoral scanners can reliably record the margins of a preparation, and can generate acceptable crowns. However, most of them do not take into consideration all the factors that influence the accuracy of digital impressions, and as a result have limited relevance in clinical practice.[18-20]

Mean surface deviation should be interpreted with caution since it will always be artificially low based on the mathematics of the alignment algorithm. Larger, potentially clinically relevant, deviations will be masked out by the overwhelming number of well fitted points. Therefore, the significance of our results is in showing a measurable decrease in scan trueness in the presence of adjacent teeth. The absolute mean deviation values reported here will not equate with, for example, the size of a marginal gap.

CONCLUSIONS

Within the limitation of this study it can be concluded that the accuracy of an intraoral digital impression is conditioned by a good visibility of the abutment. The presence of adjacent teeth can decrease the view of interproximal margins, generating a less precise scan in these regions. The results of this study should be regarded as a work in progress, and should be interpreted with care. More studies are required to evaluate the clinical impact of these factors.

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