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Evaluation of the Accuracy of an Intraoral Scanner: An Update on the Omnicam

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Abstract

Computerized optical impression making is one of the most exciting topics in dentistry today. Therefore, it is very important to know how accurate these devices are.

Purpose: *To investigate the influence of a software update of an intraoral scanner.*

Materials and Methods: *Accuracy was tested in terms of trueness and precision. An acrylic model was scanned with an industrial scanner. The dataset was used a reference for the evaluation of the CEREC AC Omnicam datasets and statistical analyses were implemented.*

Results: *trueness and precision values were significantly smaller utilizing the software version 4.4 as opposed to the earlier version (4.3) used in the previous study.*

Conclusion: *Within the limits of the present study, the investigated intraoral scanner meets the highest standards in terms of trueness and precision. The authors strongly recommend to not use software other than the proprietary workflows to export files to the open STL file format.*

Keywords: *computerized optical impression making; digital impression; optical impression; digital dentistry*

Introduction

Computerized optical impression making is one of the most exciting topics in dentistry today. Every year numerous companies launch new and updated scanning devices and/or updated software for their existing products, making it challenging for dentists to keep up with these accelerating technological developments. The most evolved and widespread systems are Sirona's CEREC acquisition units (Dentsply Sirona, Wals bei Salzburg, Austria) initially developed over 30 years ago. However, it was Francois Duret who first invented a dental CAD/CAM apparatus, and described it in his 1973 dental thesis. Furthermore, Dr. Duret managed the development of the first commercial CAD/CAM system, and brought it to the marketplace through Hennson International. 60 of these units were sold in Europe, the USA, and Japan between 1987 and 1992 [1-13].

The present study specifically focuses on the accuracy of a software update (software version 4.4) of the CEREC AC Omnicam. This report is a follow-up report to the previous Professional Product Review (PPR) study published in 2015, which evaluated the accuracy of six different intraoral scanning devices including the Omnicam [14].

In the previous study, the authors utilized Dentsply Sirona's 4.3 software and reported: "Sirona's new 4.4 software utilizes a bio-statistical procedure to calculate the entire jaw, and we will be reevaluating the Omnicam utilizing the updated software when available" [14].

Materials and Methods

To investigate the accuracy of the latest technology in computerized optical impression making, the CEREC AC Omnicam (Software version 4.4; Dentsply Sirona, Wals bei Salzburg, Austria) was evaluated in terms of trueness and precision. As in the previous study [14], an acrylic (self-curing denture acrylic, Lang Dental Manufacturing Co., Inc., Wheeling, IL) replica of a typodont dental model (Nissin Dental Product, Kyoto, Japan) was fabricated. Typodont teeth (Simple Root Tooth Model, Permanent Tooth [A5A-200], Nissin Dental Product, Kyoto, Japan) were embedded into the fabricated acrylic model, and the maxillary right first molar was prepared for an all-ceramic crown. The model with the tooth preparation was scanned with an industrial grade, highly accurate reference scanner (ATOS Blue Light Triple Scan III, 8 megapixel with a 100 mm lens set, GOM mbh, Braunschweig, Germany), in order to create a digital reference dataset. Additionally, this same acrylic model, with the embedded typodont teeth, was scanned on three separate occasions by a single, trained, experienced dentist (S.P.) utilizing the Omnicam. The present Omnicam datasets were exported/converted to the STL file format by Sirona's

engineers and loaded into a three-dimensional (3D) evaluation software (Geomagic Control 2014, Morrisville, NC). After loading the datasets, the crown preparation was digitally isolated, and all areas not relevant to the present study were removed. The datasets were evaluated in terms of trueness and precision. For the trueness measurements, the digital datasets obtained from the scanner were superimposed (best-fit algorithm of the software) to the reference dataset, and 3D comparisons were performed (n=3). For the precision measurements, each dataset from the scanner was superimposed onto the other two obtained datasets (1 to 2, 1 to 3, 2 to 3), and evaluated for 3D deviations.

Statistical analyses

For descriptive analyses, means, medians and standard deviations (SDs) were computed. Furthermore, boxplots are used for a graphical presentation of the data (Figure 1).
All calculations were performed with Microsoft Excel (Microsoft Excel for mac 2011, Version 14.6.7, Microsoft Cooperation, Redmond, WA).

Remarks

In the present study, the datasets were exported/converted to the STL file format by Sirona's engineers as opposed to the previous study, where the datasets were exported/converted using CrossManager 2013 (Datakit, Lyon, France). Further, Dentsply Sirona uses an extrapolation algorithm in their software to close potential holes in the surface scans. This is an essential step before processing the files for a crown design; however, in the present study these holes were not extrapolated to avoid any negative effect on the evaluations. The scans were performed very thoroughly to avoid any holes on the surfaces to be evaluated and double-checked for correctness by Dentsply Sirona's engineers. Nevertheless, datasets without extrapolated holes are not available to the end user. This needs to be taken into account when interpreting the results of the present study.

CEREC AC Omnicam

Dentsply Sirona's CAD/CAM technology has the longest track record of any of the existing digital impression systems in today's marketplace. The CEREC system has been in existence, in one form or another, for over 30 years. Dentsply Sirona's most recent system, the CEREC AC with Omnicam, was released in the summer of 2012. With the CEREC predecessors (RedCam, BlueCam), imaging was done via stitching together individual images creating a monochromatic yellow stone-like digital model. However, the Omnicam captures images, without the use of powder, via digitally streaming to create a full color digital model.

Results - Evaluation of the Accuracy

In total, three datasets were evaluated for trueness and precision values. The trueness measurements (± standard deviation) between the reference dataset and the updated Omnicam datasets revealed deviations of 15.3 ± 5.0 µm. Precision values were identified to be 9.3 ± 6.2 µm (Figure 1). The visual evaluation of the color-coded images revealed a homogeneous pattern. Highest deviations were identified in areas with a lot of information such as at the preparation margin (dark blue; Figure 2).

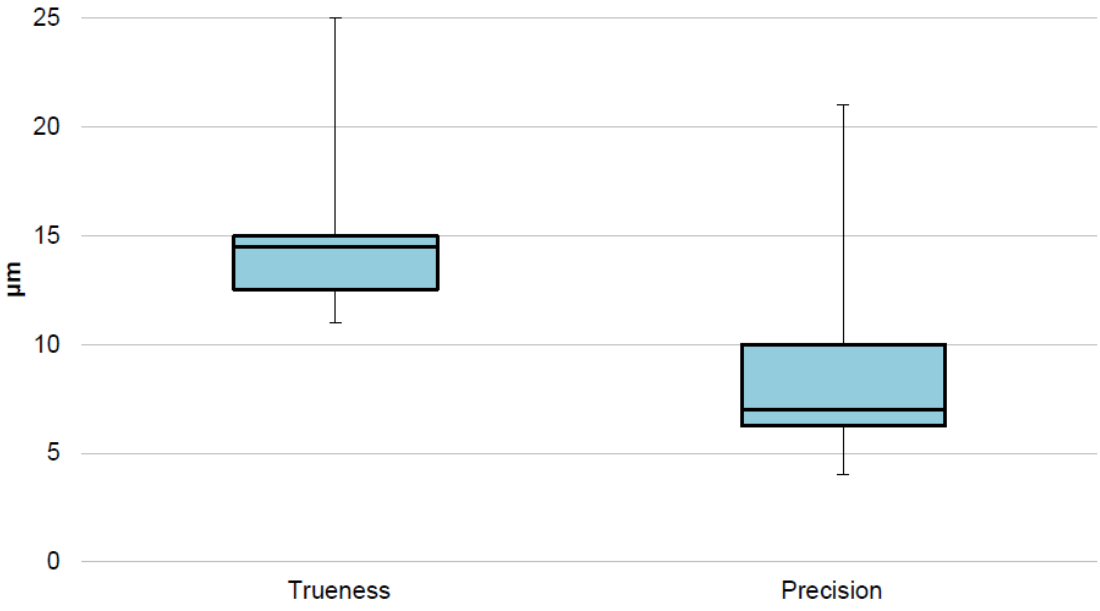

Figure 1. Trueness and precision values of the 3D comparisons.

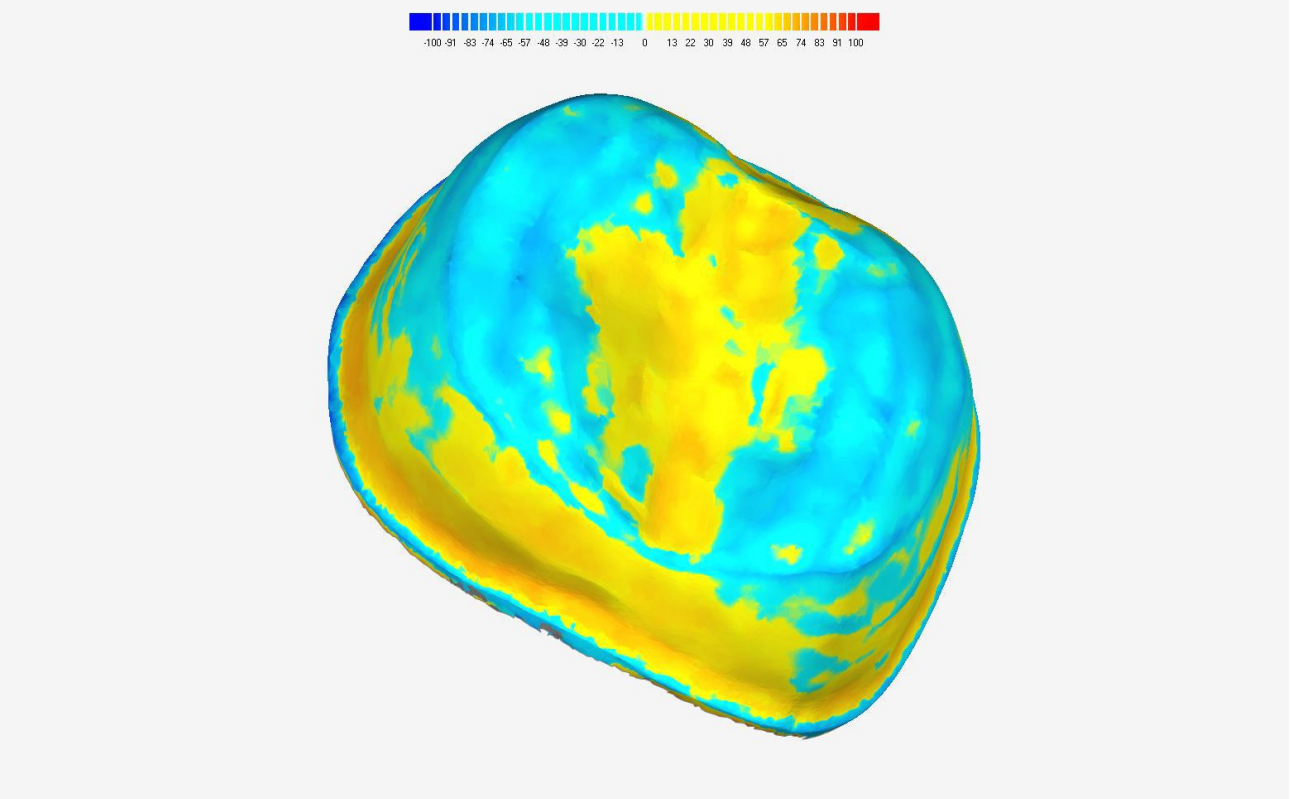

Figure 2. Exemplary color-coded superimposition of an Omnicam test dataset to the reference dataset.

Discussion

Accuracy values for the Omnicam (software version 4.4) were identified via the obtained datasets of the single tooth preparation. One investigator, experienced in making optical impressions, performed all of the scans to minimize the risk of any inter-operator influence. The CEREC Omnicam is a powder-free, true color video-based scanning system utilizing active triangulation while emitting light of different wavelengths to measure surfaces while hovering the scanning wand over the teeth [15]. As opposed to other systems, the chairside CEREC workflow, with the software 4.4, was still a closed system at the time the study was conducted, which means that the exporting of open STL files directly from the acquisition computer was not possible. Therefore, and to perform the 3D comparisons, it was necessary to convert the obtained datasets from the Sirona specific format to the open format. Sirona's engineers performed this procedure. However, with the software update (CEREC SW 4.5) a direct STL export with the corresponding license is offered [16].

Comparing the results of the present study with the previous one (trueness 45.2 ± 17.1 µm; precision 16.2 ± 4.0 µm), reveals a difference of 30 µm for the trueness value, whereas the precision values remain comparable.

To give a possible explanation for the significant difference in trueness found between the two studies, it is necessary to outline the differences between the two studies. In the present study, as in the previous study, the reference model, the reference dataset, the ambient conditions and the methods of evaluation were all the same. However, the software version utilized for the present study was updated from version 4.3 to version 4.4 and the scans were all performed under the supervision of Dentsply Sirona's engineers. Moreover, the datasets were processed and exported to the STL format by these same engineers, and potential holes in the datasets were not extrapolated. The influence of the missing extrapolation of holes, however, can be neglected since thorough double-checking for completeness of the surface scans was guaranteed. The two major factors having positively altered the results were potentially the data exporting process, and the updated software version. By utilizing Dentsply Sirona's exporting system, it was ensured that the files were distortion free when decoded to the STL format. Furthermore, it appears that the updated 4.4 software improved the quality of the 3D surface measurements.

Overall, the current body of literature on computerized optical impression making is still limited. Recent publications focus on full-arch impressions [17-21] or evaluate the fit of the final restoration based on optical impressions [22-24]. Studies focusing on single tooth scans have reported trueness values of 19.2 µm and 27.9 µm, and precision values of 10.8 µm [25,26], as compared to the present study, which determined trueness values as accurate as 15 µm and precision values as accurate as 9 µm. The results of the present study indicate significant progress regarding the accuracy of the Omnicam scanner, which is

possibly related to software developments and improvements, whereas the precision remains as accurate as it was in the previous investigation. Nevertheless, there is always the potential impact of the study design (reference models, reference scanners, and scanning strategies) on the outcomes.

Finally, the results of the present study were based on an in-vitro study design with a sample size of three and a single tooth preparation. Clinical aspects such as blood, saliva, and patient movements may alter the results in an in-vivo setting. Further, the reported results do not provide any information on the quality of a CAD/CAM restorations ultimately fabricated using the optical scans.

Conclusions

Within the limits of the present study, the investigated intraoral scanner, the Omnicam with the CEREC software 4.4 meets the highest standards in terms of trueness and precision in the field of computerized optical impression making. The authors strongly recommend to not use software other than the proprietary workflows to export files to the open STL file format.

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