TIME AND ACCURACY OF THE CEREC OMNICAM USING TWO DIFFERENT SOFTWARE PROGRAMS

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ABSTRACT

Statement of problem. The impact of "guided scanning" on the accuracy of full arch digital impressions is unknown.

Purpose. The purpose of this *in vitro* study was to evaluate the effect of guided scanning on scan time, trueness and precision of digital impressions created by three providers using the CEREC Omnicam.

Materials and Methods. A total of 60 (20/provider) digital impressions of a standard resin model were made by 3 different providers using the CEREC Omni-cam. 10 scans each were completed using the CEREC Ortho module and 10 scans each were completed using the CEREC SW 4.4.4 software. Time required to complete each full arch scan was recorded. Trueness was calculated by overlaying the digital models against a reference scan created using the standard model and a laboratory white light scanner. Intra-operator precision was calculated by overlaying each of digital models against each other, using each model as a reference. Non-parametric Mann Whitney U tests were used to determine significance between groups.

Results. Scan times for the two programs were significantly different in each provider, with the Ortho module requiring a longer time to scan. In terms of trueness, no intra-provider difference was seen between the two programs. Pooled data indicated the Ortho software had significantly higher trueness than SW. Precision results showed a significant intra-provider difference in two providers with the Ortho software showing higher precision than SW. With data pooled the Ortho software demonstrated significantly higher precision.

Conclusions. The CEREC Ortho software demonstrated higher overall trueness and precision, with slightly higher time needed to complete an impression.

Clinical Implications. The field of dentistry continues to push towards a fully digital workflow. Determining the impact of guided scanning strategies on scan accuracy will help direct future software development.

Introduction

The creation of an indirect dental restoration has always required three main steps. The first is data acquisition from the patient. Traditionally this would consist of capturing a final impression of the tooth to be restored. The second required step is the design of the restoration. In classic fixed prosthodontics, this would be the wax-up of either a full contour restoration for casting or pressing, or a coping for future layering of a veneering ceramic. The final step is the actual manufacturing of the restoration. Traditionally, this would be the casting/pressing of the wax up or coping, possibly followed by the stacking of veneering porcelain in the case of a layered restorations.

Due to advances in digital dentistry and the introduction of computer-aided design (CAD) and computer-aided manufacturing(CAM) each of these three steps can now be completed digitally. The use of CAD/CAM technology in the field of dentistry has shaped the profession since its introduction nearly 30 years ago[1]. In the beginning this technology was developed for use in single unit or quadrant applications. The comparison of digital vs analog methods for single unit restoration fabrication has been well researched. Multiple studies have shown that digital impression and a digital workflow can produce single-unit restorations with the same, or better fit, than conventionally fabricated crowns.[2,3,4,5]

As the overall use of digital impressions grew, so too has the push to utilize this technology for full arch applications. In 2011, Ender and Mehl were the first to evaluate the accuracy of intra-oral scanners vs conventional impressions in a full arch application.[6] Their study used a master cast which was impressed digitally with the CEREC Blue-cam and Lava COS and then conventionally with polyether. The results also showed no difference in trueness, but higher precision with the digital impression technique than the conventional impressions.[6] In a follow-on study, Ender and Mehl again evaluated accuracy of full arch digital impressions compared to conventional techniques, and found that conventional impressions, specifically made with polyvinylsiloxane (PVS), showed significantly higher trueness and precision than did direct full arch digital impressions.[7]

In addition to evaluating the accuracy of digital vs conventional impressions, research has also been conducted that investigates the accuracy of different intra-oral scanners on the market.[2, 5, 6, 7, 8, 9, 10, 11] Several studies have shown statistically significant differences in accuracy and precision based on the brand of intra-oral scanner used. [7, 11] Müller *et al.* have also demonstrated that the scan strategy, or order in which a model/patient is scanned, has an impact in the trueness and precision of the digital model.[12] Scan strategies vary based on the manufacturer's recommendations and it has been suggested that providers follow these recommendations to achieve the highest accuracy. [12]

The CEREC AC or acquisition unit is a mobile trolley complete with intra-oral scanner, CAD software and CAM software.[13] The AC unit may be equipped with either the CEREC Blue-cam or the CEREC Omni-cam, both of which depend on active triangulation to acquire their images[13]. The Blue-cam captures and stiches single images, whereas the Omni-cam utilizes a video sequence capture mode.[13] Multiple software packages are available for installation on the CEREC AC unit such as CEREC SW 4.4.4, CEREC Ortho and CEREC inLab.[13] The CEREC SW software is designed for single, multiple and implant restorations. In 2015 Dentsply Sirona released the CEREC Ortho software, which is designed for full arch scanning.[13] This software offers guided scanning which takes away the control of scan strategy from the provider, and requires the user to follow on-screen prompts, which is intended to increase repeatability (precision).

The aim of the current study was to assess the impact of guided scanning on the time needed to scan and accuracy (trueness and precision) of full arch digital impressions completed by multiple providers using the CEREC Omnicam and two different software programs, CEREC SW 4.4.4 and CEREC Ortho. The null hypothesis was that there would be no difference in the time or accuracy of the scans completed with the CEREC Ortho software vs the CEREC SW 4.4.4 software.

Materials and Methods

The study was approved by the Walter Reed National Military Medical Center Department of Research Programs. An STL file of a full arch maxilla was created by the United States Air Force Dental Laboratory, Lackland Air Force Base. Five spherical fiducial markers werer placed at the sites of teeth 2, 6, 11, 15 and mid-palatally. The STL was then printed out of a photopolymer resin (E-Dentsone 3SP° Peach by Envisiontec, Inc). The printed model was scanned three times using a laboratory based white light scanner (Freedom HD by Degree of Freedom), which has an accuracy and precision of 10µm according to the manufacturer. The three STLs were compared using best fit analysis in a 3D modeling software (Materialise 3 Matic®). One STL of the two that most closely matched each other was chosen as the standardized digital refence file.

A single CEREC Omnicam was calibrated according to the manufacturer's recommendations. The manufacturer's recommendations for the full arch scanning stragety was reviewed by three providers as outlined in the CEREC AC operators manual [14]. The standardized printed model was secured to a dental chair head rest. Three providers completed 20 full arch scans of the reference model 10 scans completed using CEREC Ortho and 10 scans completed using CEREC SW 4.4.4. Scans were completed in a randomized order. Time required for each scan was recorded. The STL files from each scan were then exported from the CEREC AC unit.

Each STL file was compared against the reference file using best fit analysis in a 3D modeling software (Materialise 3 Matic®). The unsigned mean global error was recorded. Intra-operator precision was measured by comparing each of the 10 Ortho scans to each other and each of the 10 SW scans to each other using best fit analysis in the 3D modeling software. Each scan served as the reference scan in one comparison.

Mean trueness and precision for each provider using the two software programs was calculated. Data from all three providers was pooled based on scan software for further analysis. Non-parametric Mann Whitney U tests were used to determine significance between groups (Alpha =0.05)

Results

Pooled scan time data for all providers showed significantly faster scanning times with SW software; Ortho=168.37 seconds, SW=116.78 seconds ($p<0.001$). When data was separated by provider, each provider demonstrated significantly faster scanning times with the SW software vs the Ortho software. Provider 1: Ortho=160.43 seconds , SW=118.41 seconds ($p=0.035$). Provider 2: Ortho=212.54 seconds, SW=130.92 seconds ($p<0.001$). Provider 3: Ortho=132.14 seconds, SW=101.03 seconds ($p=0.009$). (Figure 1).

A significant difference is scan trueness was observed between the Ortho and SW software programs when data was pooled between all providers, with the Ortho software showing less error. Mean error for Ortho=27.19µm, SW=31.93µm ($p=0.029$). When data was separated by provider, no significant differences between the two software programs were observed. Provider 1: Ortho=26.99μm, SW=34.77μm (p=0.436). Provider 2: Ortho=29.94μm, SW=32.40μm (p=0.29). Provider 3: Ortho=24.64μm, SW=28.61μm (p=0.105). (Figure2)

Pooled precision data for all providers showed that the Ortho software produced greater precision than the SW software. Mean precision for Ortho=20.55μm, SW=28.72μm (p=<0.001). When data was separated by provider, significantly greater precision was seen using the Ortho software in two of the three providers. Provider 1: Ortho=20.35μm, SW=35.06μm (p=0.003). Provider 2: Ortho=20.95μm, SW=29.07μm (p<0.001). Provider 3: Ortho=20.36μm, 22.03μm (p=0.091). (Figure 3).

Discussion

When considering material/equipment options for full arch impressions accuracy (trueness and precision) and chair time needed are two important attributes. The current study demonstrated that time needed to scan was significantly longer using the Ortho software vs the SW software. In terms of accuracy, the Ortho software demonstrated higher trueness and precision than the SW software. This data support the rejection of the null hypothesis that there would be no difference in accuracy or scan time between the two software programs.

When pooled across the three providers the mean difference in time needed to scan between the Ortho software and the SW software was 51.58 seconds. The increased time needed with the Ortho software can be attributed to the program's need to validate the scan data after each "guided" segment of scanning. This verification step is not needed when using the SW software. While the time difference was statistically significant, it is questionable as to whether or not an increase in scan time of 1 minute per arch is clinically significant. When comparing scan times to the time needed for polymerization of conventional elastomeric materials, digital impressions with either software still offer the clinician a savings of chair time.

Pooled trueness data demonstrated mean global errors of 27.19µm for the Ortho software and 31.93µm for the SW software ($p=0.029$). While pooled precision mean errors were 20.55µm for Ortho, and 28.72µm for SW ($p<0.001$). The overall levels of trueness and precision for the SW software is similar to that previously reported by Ender and colleagues.[7] Müller *et al.* clearly demonstrated the effect of scan strategy on full arch digital impressions. [14] Although each provider in this study reviewed the recommended strategy for the SW software, utilizing the strategy is still up to the provider and the software will progress regardless of whether or not the strategy is precisely followed. Conversely, in the Ortho software the provider must follow the guided strategy or the software will not progress to the next step. The increased accuracy (trueness and precision) seen with the Ortho software could be attributed to the guided scanning strategy.

Interestingly the difference seen in accuracy between the two software programs was not the same in each provider. In terms of trueness, the difference between the two software programs was not significant in any of the three providers. Precision data showed a significant difference between Ortho and SW in only two of the three providers (providers 1 and 2). The lack of a significant difference in each of the providers could be due to the experience level of the providers. All three providers had been through training with the CEREC AC unit and both software modules. However, provider 3 had the most clinical experience using the CEREC omnicam, which could explain the lack of significant difference in either category (trueness or precision) for this provider.

Within the limitations of this study the CEREC Ortho software produced full arch digital scans with increased trueness and precision, but increased scan times when compared to the SW software. Intra-provider comparison showed differences amongst providers, but is limited due to the limited number of providers included in the study. In order to better assess intra-provider differences and the possibility of a learning effect future studies should include a higher number of providers and providers with varying levels of experience.

Conclusion

Based on the findings of this *in vitro* study the CEREC omicam produced scans with greater accuracy (trueness and precision) when using the Ortho software. Using the Ortho software increased scan time by approximately 50 seconds per arch.

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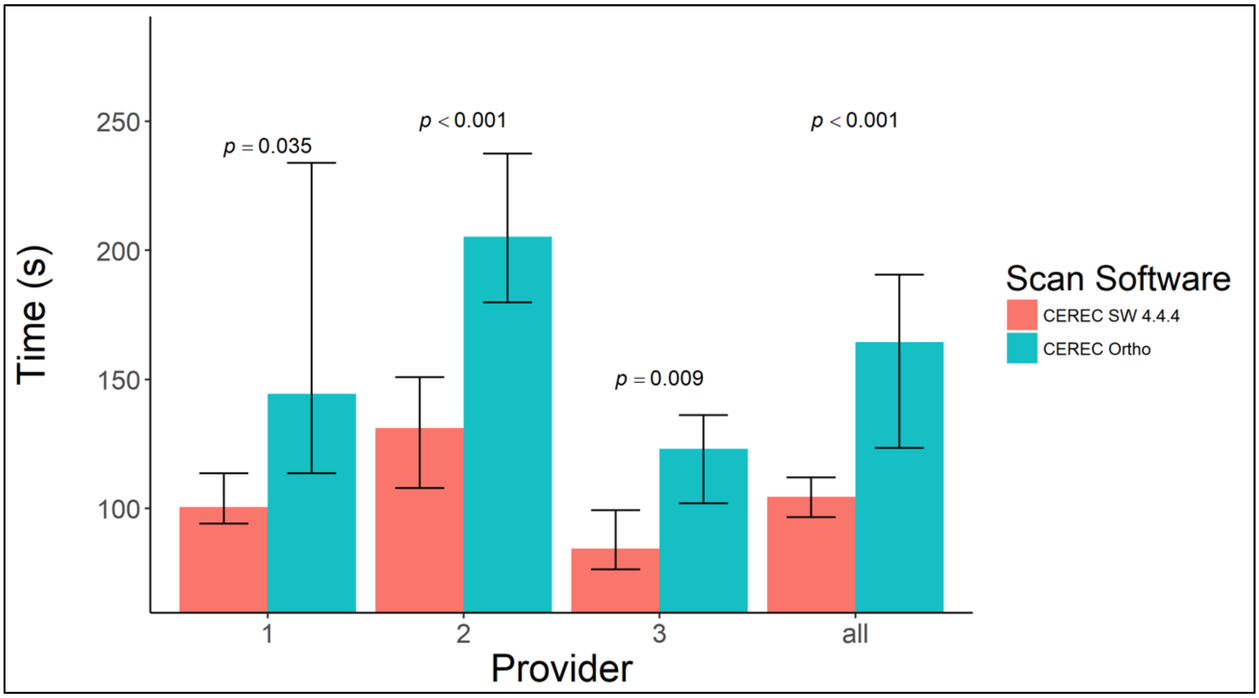

Figure 1. Average scan times (seconds) for each provider and pooled providers divided by software program. Error bars show 95% confidence interval.

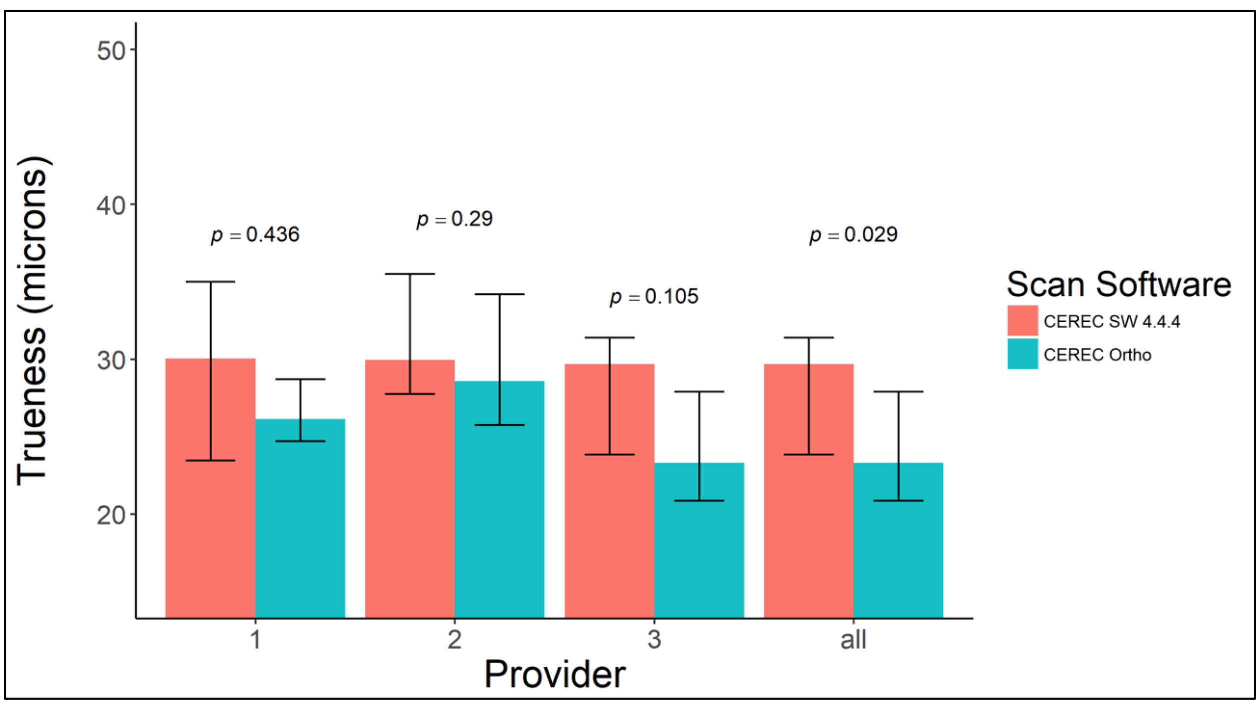

Figure 2. Average mean error (trueness) for each provider and pooled providers divided by software program. Error bars show 95% confidence interval.

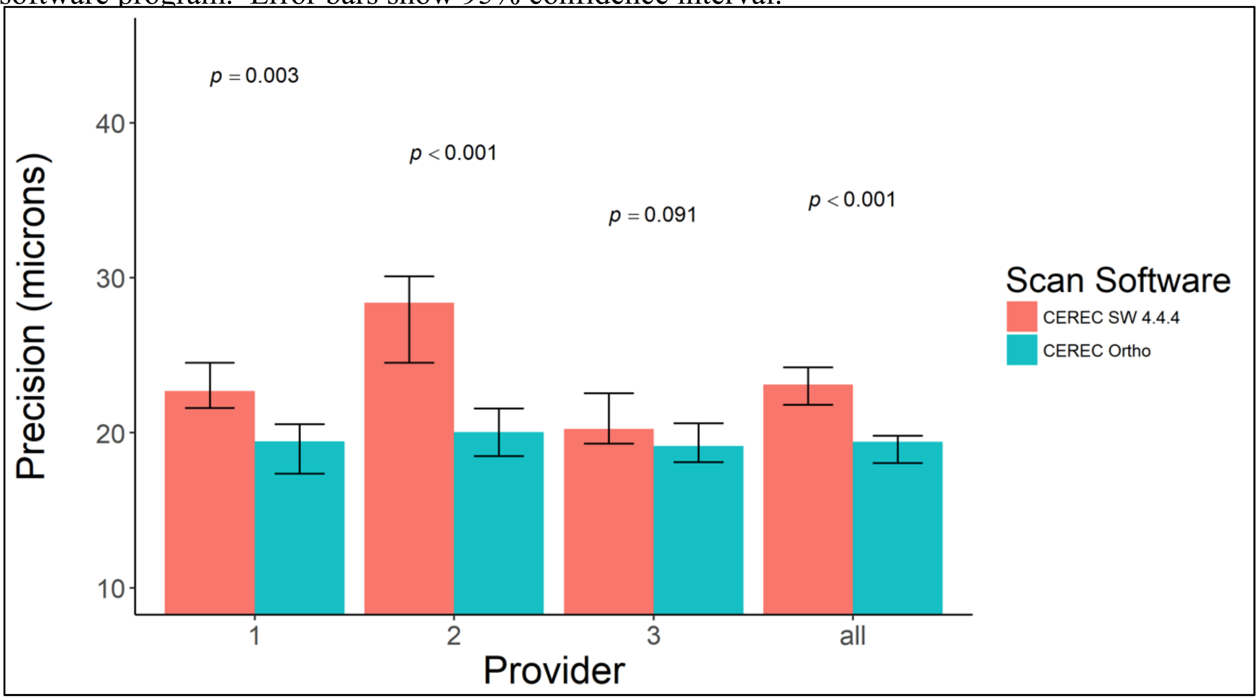

Figure 3. Average precision for each provider and pooled providers divided by software program. Error bars show 95% confidence interval.