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**Comparison of CEREC Primescan image
quality with disposable and reusable mirror
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Comparison of CEREC Primescan image quality with disposable and reusable mirror sleeves

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ABSTRACT

Background. The purpose of this study was to evaluate image accuracy (trueness) of the Primescan using a reusable steel mirror sleeve with large scanning window and a disposable mirror sleeve with small scanning window to determine if there are any significant accuracy differences between different types of sleeves. **Methods.** A plastic typodont with a Biomet 3i implant and Encode Healing Abutment was used as a reference model. A digital scan image of a typodont was obtained using a high-resolution lab scanner as a data reference. A single operator scanned the typodont using a Primescan with three different types of mirror sleeves: disposable plastic sleeves, pre-sterilized stainless-steel sleeves, and stainless-steel sleeves with 50 cycles of dry-heat sterilization (COX RAPIDHEAT sterilizer). Ten scans were obtained using each type of mirror sleeve. All scan data was exported in the highest quality standard tessellation language (STL) file format. All STL files were imported to CloudCompare 3D mesh comparison software to evaluate any deviation from the reference scan. Using the mean deviation values obtained from each group of 10 scans, a one-way ANOVA test was performed using IBM SPSS Statistics software to assess the statistical difference among the groups.

Results. The steel sleeves without dry heat sterilization had the best overall trueness ($19.9 \pm 1.5 \mu\text{m}$) followed by the disposable plastic sleeves ($21.8 \pm 2.7 \mu\text{m}$), and then the steel sleeves after 50 cycles of dry heat sterilizations ($22 \pm 2.1 \mu\text{m}$). The deviations within all three

groups ranged between 0.2 to 2.1 μm . The one-way ANOVA test resulted in $p=0.069$ (>0.05), indicating that there was no statistically significant deviation difference among the three groups.

Conclusion. This study shows that a disposable mirror sleeve and a reusable mirror sleeve with and without dry-heat sterilization generate similar and reliable accuracy in implant restoration regarding the trueness, however, further research is needed to confirm this result in various clinical setting.

Practical Implications. Within the limitation of this study, use of a disposable mirror sleeve in Primescan may be a viable alternative to a reusable steel mirror sleeve in terms of accuracy.

Key Words. CAD/CAM, intraoral scanning, accuracy, trueness, CEREC, Primescan

INTRODUCTION

Intraoral scanners (IOS) are digital dentistry devices that allow clinician to acquire an optical digital impression without conventional trays and impression materials. Over the years, there has been rapid advancements in IOS technology with increased demand for more accurate methods to capture intraoral structure. CEREC Primescan manufactured by Sirona is the most advanced intraoral scanning device used by Army Dental Treatment Facilities (DTF). For infection control purposes, the Primescan camera has an intraoral mirror sleeve that is detachable from the camera. The reusable stainless-steel sleeve, which is the most widely

used in Army DTFs, must be sterilized between patients. The Army's protocol for the sterilization of a reusable mirror sleeve per manufacturer's instructions is dry heat sterilization.^{1,2} As an alternative to reusable sleeves, Sirona launched a disposable plastic mirror sleeve, which provides complete prevention from cross-contamination between patients, without the need for sterilization (Fig. 1). Sirona claims that both types of sleeves have the same scan performance despite different structural design; the reusable steel sleeves have bigger sapphire coated windows (23mm X 21mm) while the disposable sleeves have a smaller plastic window (19mm X 19mm).

Accuracy in detecting intraoral structures is the most important feature of IOS technology. According to the International Organization for Standardization, accuracy is the sum of trueness and precision.³ Trueness is defined as "the closeness of agreement between a measured quantity value and true quantity value".³ Precision is defined as "the closeness of agreement between measured quantity values acquired by repeatable measurements on the same objects".³ Hence, the Ideal IOS should possess both high trueness and high precision, providing reliable results without generating notable deviation when scanning the same object.

Several studies have evaluated the accuracy of different intraoral scanners in different clinical situations.⁴⁻⁶ Mangano et al (2019) assessed the accuracy of 5 different intraoral scanners on the impression of single and multiple implants.³ In that study, the author superimposed different scan images on each other with a 3D compare analysis software to quantify deviations for comparing the trueness and precision of different intraoral scanners. Mangano et al also utilized a high-resolution desktop scanner to get a reference scan for calculating the trueness value.⁴ In the study conducted by Fueki et al (2018), the larger intraoral scanning head

showed better trueness and precision than the smaller intraoral head.⁵ There was a study conducted by Dantes et al (2021), in which the author assessed the effect of multiple dry-heat sterilization cycles on CEREC Primescan reusable steel sleeves.⁶ Dantes et al found some minor image deviations caused by dry heat sterilization.⁶ To the author's knowledge, there have been no existing studies that have compared the accuracy of images produced with the different types of sleeves on Primescan.

The purpose of this in vitro study was to compare the trueness of Primescan images taken with reusable steel mirror sleeves (with and without dry heat sterilization) and a disposable plastic sleeve. The aim of this study is to quantify the image deviation of Primescan with different types of sleeves by comparing the scans from Primescan to a reference scan from a high-resolution lab scanner. The primary null hypothesis of this study was that there would be no significant image accuracy difference between a reusable steel mirror sleeve with large scanning window and a disposable mirror sleeve with small scanning window. A secondary null hypothesis was that there would be no significant image accuracy difference between the pre-sterilized reusable steel sleeve and the reusable steel sleeve with multiple cycles of dry-heat sterilization.



Figure 1. A reusable steel mirror sleeve (left) and a disposable plastic mirror sleeve (right)

MATERIALS AND METHODS

Testing model, reference dataset, and digital impression of model

A plastic typodont with a Biomet 3i T3 4.1mmx10mm implant (Zimmer Biomet, Warsaw, IN) and BellaTek Encode Healing Abutment 4.1 (D) x 5.0 (P) x 4.0 (H) mm (Zimmer Biomet, Warsaw, IN) was used as a reference model in the study (Fig. 2). The Encode healing abutment was served as the known quantifiable landmark. The digital scan image for the typodont was obtained using a high-resolution lab scanner, Ineos X5 (Dentsply Sirona, York, PA). The accuracy of the Ineos X5 was verified at $2.1 \pm 2.8 \mu\text{m}$ according to DIN EN ISO 12836.⁷ The scan from Ineos X5 was converted into the STL file format for a reference scan data. A single operator scanned the typodont using a CEREC AC Primescan with three different types of the mirror sleeve: disposable plastic sleeves, pre-sterilized stainless-steel sleeves, and stainless-steel sleeves with 50th cycles of dry-heat sterilization. The dry-heat sterilization for the stainless-steel sleeves was processed by COX RAPIDHEAT sterilizer (CPAC Equipment, INC, Leicester, NY). The steel sleeves were placed in Self-Seal Nylon Pouches and sealed. The pouches were then placed in Cox Rapid Heat Sterilizer at 375-degree F (195 degrees C) for 12 minutes according to the manufacturer's pre-programmed cycle III.⁸ 15 minutes were allotted for cooling after each cycle. The sleeves were then re-subjected to the same sterilization protocol until 50 total sterilizations. 10 scans were obtained from each type of the mirror sleeve. All scan data were exported as the highest quality standard tessellation language (STL) file format and assigned to their corresponding group.



Figure 2. The plastic typodont with a Biomet 3i T3 4.1mmx10mm implant and BellaTek Encode Healing Abutment 4.1 (D) x 5.0 (P) x 4.0 (H) mm

Deviation Analysis

All STL files were imported to CloudCompare (EDF R&D, Paris, France) for deviation analysis.⁹ The scan models were cut and trimmed through CloudCompare to make them uniform. For the evaluation of trueness, each scan from three different types of Primescan mirror sleeve was aligned to the reference scan from the lab scanner by manual point-based alignment. Then, the scans were further aligned and calibrated using the fine alignment algorithm (Fig. 3). Using C2M function (Cloud to Mesh distance) within the software, the deviation value for the superimposition of each scan were determined.⁹

Statistical Analysis

IBM SPSS Statistics software (IBM, Armonk, NY) was used to perform a one-way ANOVA test using the mean deviations values obtained from 10 scans from each of the three groups. A p value of < 0.05 is considered statistically significant. Post hoc test would be used only if ANOVA test identify significant differences between three groups

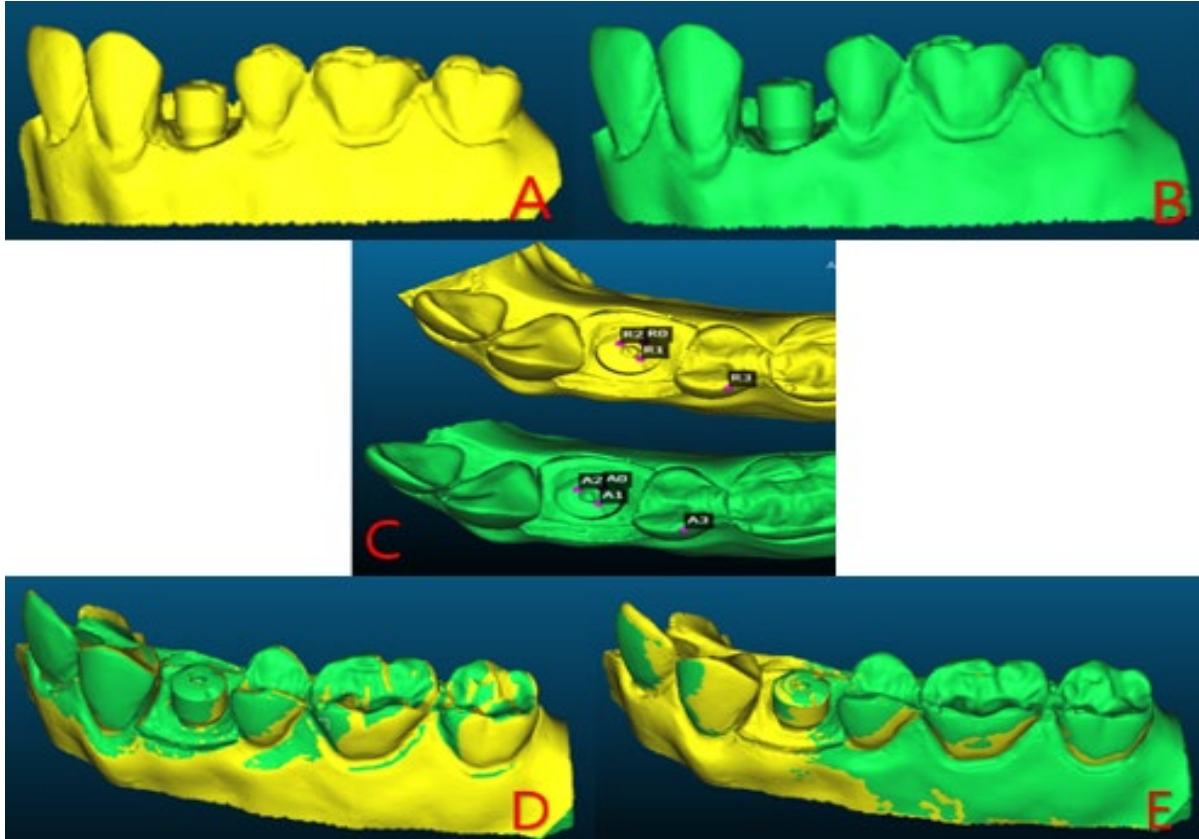


Figure 3. Reference Scan from a lab scanner (A), Scans from Primescan (B), four points picked from each scan for manual points alignment (C), manual points-based alignment (D), and fine algorithm alignment (E)

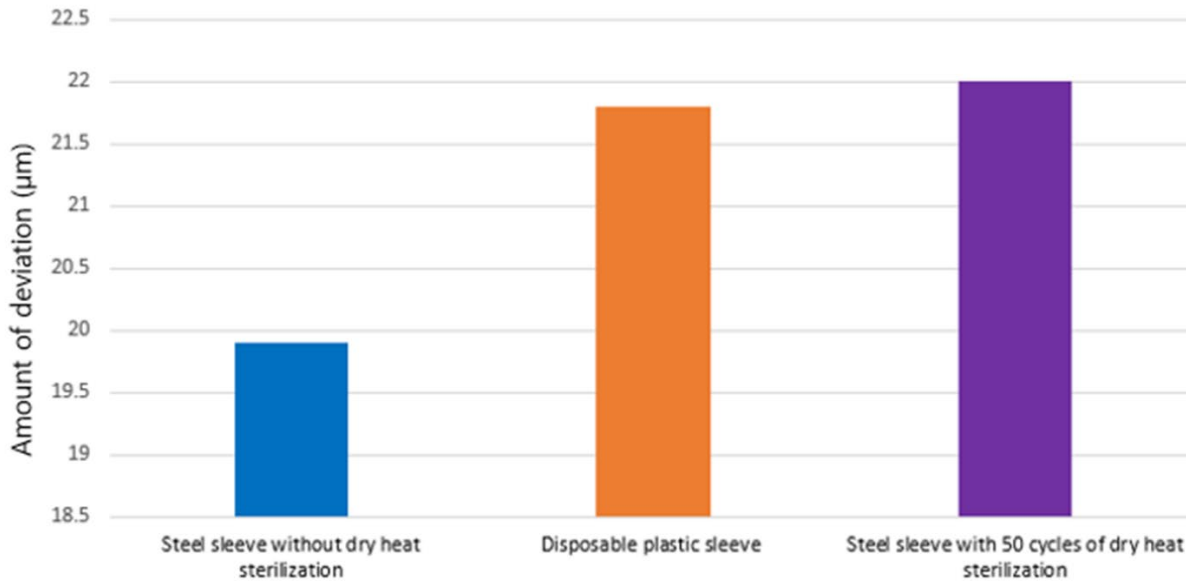


Figure 4. The mean deviation value (trueness) of each three different sleeve is measured in micrometer ($0.001\text{mm} = 1\ \mu\text{m}$)

RESULTS

The mean deviation value (trueness) of each group is shown in Fig. 4. Steel sleeve without dry heat sterilization had the best overall trueness ($19.9 \pm 1.5 \mu\text{m}$) followed by the disposable plastic sleeve ($21.8 \pm 2.7 \mu\text{m}$), and steel sleeve with 50 cycles of dry heat sterilization ($22 \pm 2.1 \mu\text{m}$). The deviations within all three groups ranged between 0.2 to $2.1 \mu\text{m}$. The one-way ANOVA test resulted in $p=0.069$ (>0.05), indicating that there was no statistically significant deviation among the three groups.

DISCUSSION

The results of this study lead to accepting the primary null hypothesis as there were no significant image accuracy differences between the reusable steel mirror sleeve with large scanning head and the disposable mirror sleeve with small scanning head regarding the trueness. The secondary null hypothesis was also accepted in that there was no significant image trueness difference between the pre-sterilized reusable steel sleeves and the reusable steel sleeve with multiple cycles of dry heat sterilization. This is consistent with results obtained by Dantes et al (2021).⁶ The deviations within three groups ranged between 0.2 to $2.1 \mu\text{m}$ which are far lower than the clinically acceptable deviation range of $120 \mu\text{m}$ for single crown and $50\text{-}90 \mu\text{m}$ for implant supported restorations.^{10,11}

The evaluation of trueness in this study was based on 3D compare analysis using known linear measurements of the encode healing abutment, the reference scan data from the lab scanner, manual points-based alignment, and fine-fit alignment using 3D reverse engineering software. To get precise reference scan data, we used Ineos X5 (lab scanner) which was accredited as a high accuracy reference scanner by several studies.^{7,9} This lab scanner is known

to be more accurate than the intraoral scanner, as they use a structured laser without inhibiting factors such as lens wetting, reflections from scanned surfaces, and movement of soft tissues.⁹

In the present study, the accuracy of the intraoral scanner (Primescan) was evaluated by changing the size of the scanning head by using different types of mirror sleeves: a reusable steel sleeve with bigger scanning window ($23\text{mm} \times 21\text{mm}$) and a disposable plastic sleeve with smaller window ($19\text{mm} \times 19\text{mm}$). We found that the use of a steel sleeve with a bigger scanning head had slightly lower deviations than did the disposable plastic sleeve with a smaller scanning head, but those deviations differences between the two sleeves were not statistically significant. The increased deviations on the small scanning window could be caused either by hand fixation or the number of scanned images. Since this pen type of IOS is held by hand, it is susceptible to error caused by camera shaking from unstable hand fixation.⁵ Fueki et al (2018) found that the small scanning head requires greater number of scanned images than a large scanning head, so camera shaking error could have been responsible for the increased deviations.⁵

There were, however, several limitations in this study. First, this study used only CEREC Primescan, and, different degrees of accuracy among different scanners could be encountered. Second, a single operator performed all scans. Calibration and analysis of agreement between multiple operators on the digital impression would be a worthwhile improvement to this protocol to cement the universality of the results. Third, only 50 cycles of dry heat sterilization were applied on the steel sleeve. More research is needed to assess the life span of the steel sleeves by incorporating extensive cycles of dry heat sterilization, so cost analysis between a disposable and a reusable sleeve would be conducted.

CONCLUSION

Within the limitation of this in vitro study, this project likely confirms that the CEREC Primescan generates equal amounts of accuracy independent of the type of sleeve used (a reusable steel sleeve versus a disposable sleeve). Based on this finding, disposable sleeves may be a feasible replacement for reusable steel sleeves, especially in a clinic without dry heat sterilizer support.

None of the authors reported any disclosures or conflict of interests.

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