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Effect of scannable area of scan body on accuracy of image matching in digital implant impression

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Purpose: The aim of this study was to investigate the relationship of the exposure of scan body and the positioning accuracy of implant in computer software.

Materials and Methods: An implant was placed in a stone block, and a scan body was attached to the implant. Exposure condition of scannable part of scan body was controlled: Full-exposed, 3 mm-less exposed, and 6 mm-less exposed. At each condition, the block was digitized with a desktop scanner, and a virtual implant was created by matching the scan image and design of scan body in a computer design software. The virtual implant position was located 10 times in the 3 mm- and 6 mm-less exposed conditions. The accuracy of matching process in the less-exposed conditions was evaluated comparing with the full-exposed condition at the abutment level. One sample *t* test and Independent samples *t*-test were used to verify the equivalence and difference between conditions.

Results: Non-equivalence of the implant positioning was found between the Less-exposed conditions and Full-exposed condition ($P < 0.001$). Linear and angular deviations were greater in the 6 mm-less exposed group than in the 3 mm-less exposed group ($P < 0.001$).

Conclusions: The amount of scan body exposure influences the accuracy of implant positioning in software program. **(THE JOURNAL OF KOREAN ACADEMY OF OSSEOINTEGRATION 2018;10(1):1-4)**

Key words: Scan body, Digital impression, Matching, Accuracy, Implant positioning

INTRODUCTION

A conventional silicone impression technique has already been used for many years, but it implies many possible error sources in each step[1,2]. Since computer-aided design/computer-aided manufacturing was introduced in 1980s, the importance of digital impression has highlighted[3]. Now, in the complete digital workflow, the optical intraoral scanner is used for the data acquisition from oral cavity. The scan data is saved in the format of Standard Tessellation Language (STL), and then delivered to computer software program where implant prosthodontic components are designed[4].

Scan body is a tool for transferring the actual position of implants in oral cavity to the computer software[5]. The scan body is attached to the implant inside mouth and scanned using an intraoral scanner. The geometrical feature of scan body provides a fiducial area for locating implants in computer software, relating with soft and hard tissue[6]. Clinically, as gingiva is thicker, the exposure area of scan body is decreased. The purpose of this study is to investigate the relationship of the exposure of scan body and the positioning accuracy of implant in computer software. The null hypothesis was that there is no difference in the accuracy of implant positioning in software with the different conditions of exposure level of scan body.

MATERIALS AND METHODS

Figure 1 represents the overall procedure of this *in vitro* study. A hole was made at the center of stone block, and a dental implant (AnyOne, Megagen, Daegu, Korea; Ø4.0 × 10 mm) was placed. A scan body, composed of 10-mm scan portion, was connected to the implant (Figure 2). The condition exposed

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all scan portion of scan body on the block. Afterwards, the block was digitized using a desktop scanner (IDC S1, Amann Girrbach, Koblah, Austria), and the scan file was transferred to a CAD software program (IDC D1, Amann Girrbach). The implant position was located by matching the scan and design image of scan body in the software (Figure 3). The scan body and drawn implant were extracted from the software (Full-exposed condition) (Figure 4).

To make a comparative group having less scan body exposure, the implant was placed deeper, exposing 7 mm of scan portion of scan body. This block was scanned, and the scan image was transferred to the software as performed before. Using the scan body portion, the implant was drawn, and the scan body-and-implant image was extracted (3 mm-less exposed group). The STL images were obtained 10 times. For make another experimental group, the implant was placed deeper, exposing 4 mm of scan portion of scan body. After scanning and image matching, another 10 scans body-and-implant images

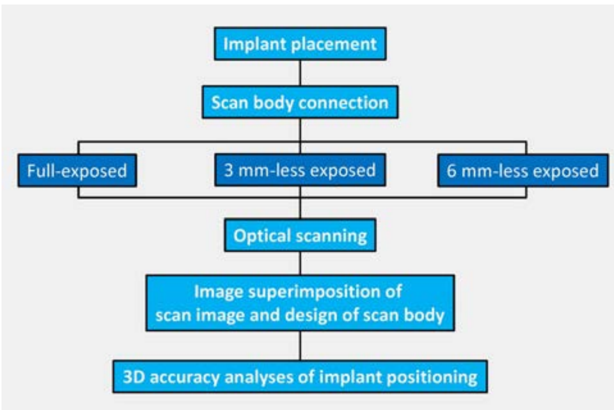

Figure 1. Workflow of this study.

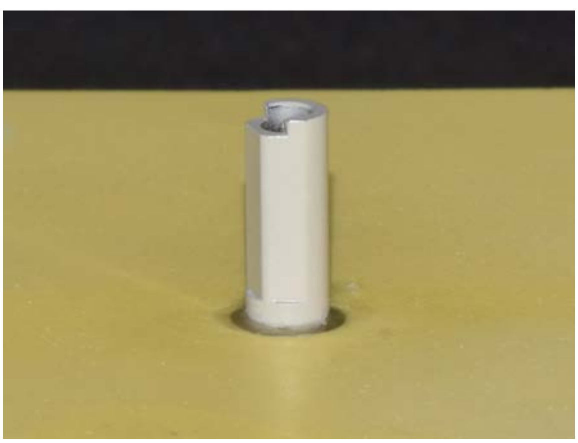

Figure 2. Full-exposed condition of scan body on stone cast.

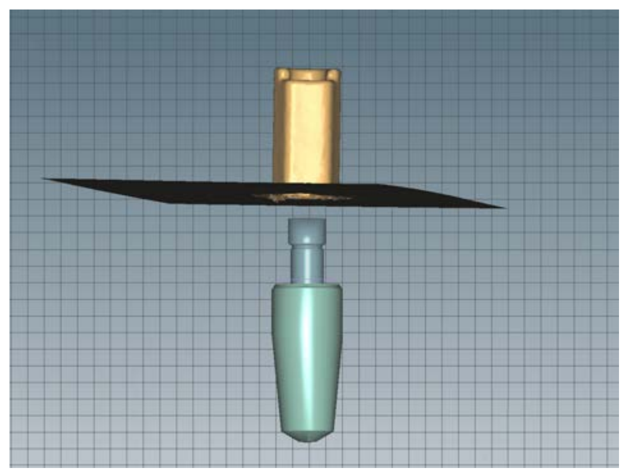

Figure 4. Virtual implant positioning according to matching process of scan body.

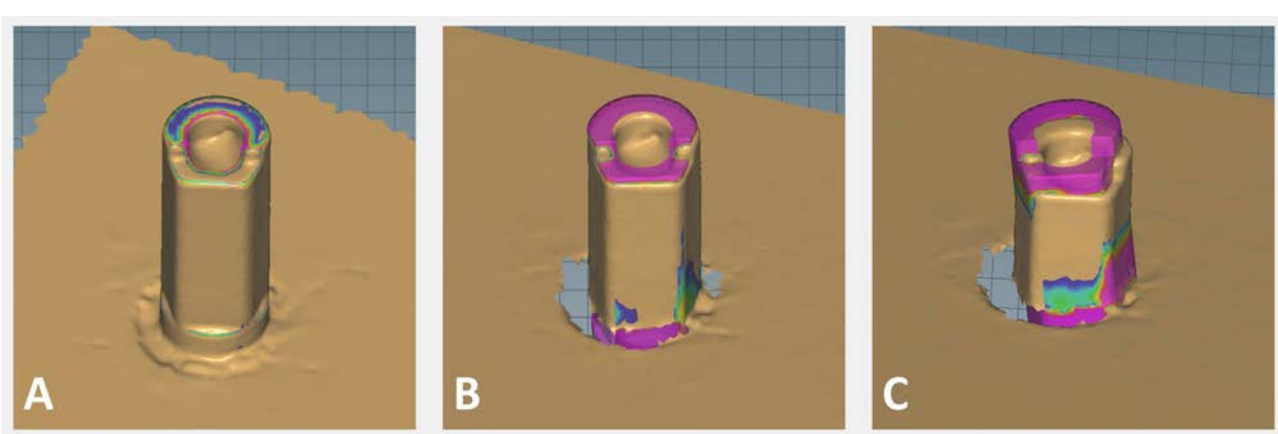

Figure 3. Matching of the scan and the design image of scan body in the software. (A) Full-exposed condition, (B) 3 mm less-exposed condition, (C) 6 mm less-exposed condition.

were obtained (6 mm-less exposed group).

The accuracy of locating implant at the Less-exposed conditions was evaluated at the abutment level (Figure 5). The implant-and-scan body image at Full-exposed condition was superimposed to the implant-and-scan body image at Less-exposed conditions based on the implant portion as the congruent area. After the superimposition of implants, the error of matching process was calculated by comparing the 2 scan body images 3-dimensionally. Linear and Angular deviations were measured using the top and vertical axes of scan bodies of Full-exposed and Less-exposed conditions.

Equivalence of image matching at Less-exposed conditions to the Full-exposed condition was statistically accessed using One sample t test. Mean and 95% confidence interval were calculated. The difference between results of 3 mm- and 6 mm-less exposed groups was compared using the Independent samples t test. The significant level was set 0.05.

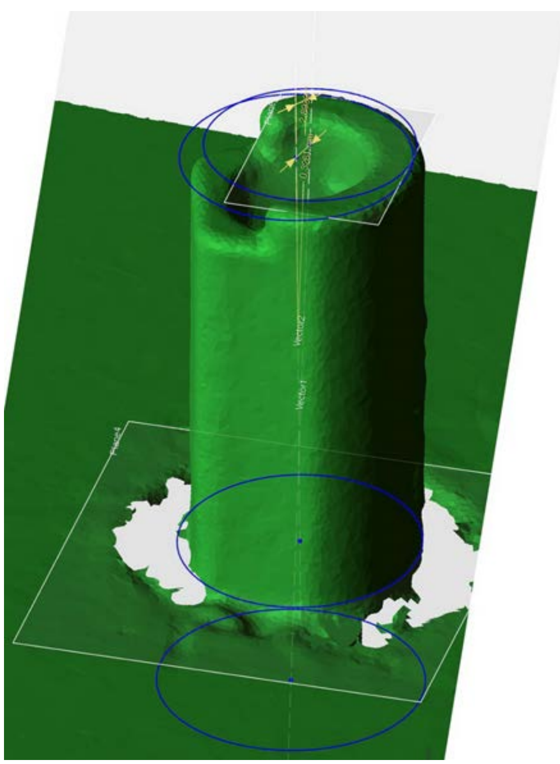

Figure 5. Linear and angular deviation assessment on matching process at abutment level.

RESULTS

The means and 95% Confidence intervals of the linear and angular deviations at Less-exposed conditions were presented in Table 1. The linear and angular deviations were greater in the 6 mm-less exposed group than in the 3 mm-less exposed group. One sample t test showed non-equivalence of the implant positions at Less-exposed conditions to the implant position at Full-exposed condition ($P < 0.001$). Independent samples t test revealed that the discrepancy data were significantly different between 3 mm- and 6 mm-exposed groups ($P < 0.001$).

DISCUSSION

Based on the results of this study, the null hypothesis, there is no difference in the accuracy of implant positioning in software with the different conditions of exposure level of scan body, was rejected. There were significant linear and angular deviations in the matching process of Less-exposed conditions in comparison with that of the Full-exposed condition. When the groups were compared each other, less deviations were shown linearly and angularly in 3 mm-less exposed group than in 6 mm-less exposed groups. Whole results of this study provide the information that inaccurate implant positioning could be occurred in computer software when the scanning process is performed with less exposure of scan body. Thus, it is important to secure the full surface of scan body so that the full area of scan body can be caught digitally by an intraoral scanner. Partial submergence of scan body happens when implants are placed deeply or the gingiva around implant is thick. Clinicians should be precautious if any level of scan body is covered with soft tissue around implants in any condition dur-

Table 1. Mean and 95% confidence interval of deviation at abutment level in different scan body exposal

Scan body exposal	3 mm-less		6 mm-less	
	Mean (CI)	P*	Mean (CI)	P*
Lineal deviation (mm)	0.256 (0.244 ~ 0.269)	< 0.001	0.809 (0.789 ~ 0.828)	< 0.001
Angular deviation (°)	1.482 (1.126 ~ 1.838)	< 0.001	6.360 (5.699 ~ 7.022)	< 0.001

CI: Confidence interval. *Equivalence P value of each deviation result between the Less-exposed and the Full-exposed conditions.

ing capturing oral data and estimate the possible inaccuracy of implant positioning in software.

Related with accuracy, trueness and precision are evaluated[7]. Trueness refers to the closeness of agreement between the arithmetic mean of a large number of test results and the true or accepted reference value. Precision refers to the closeness of agreement between test results[8,9]. In this study, to describe the accuracy of image matching of scan body, the statistical equivalence assessment was used. To control confounding factors, one scan body was used, and the high quality desktop scanner was used. Persson *et al*[10] pointed out that point cloud density of scan image affects the accuracy of image surface reconstruction[11]. In the present study, the number of point cloud per surface area was controlled to eliminate the effect of point cloud.

There are several limitations in this study. First, this study has 1 independent factor. Even though this design is clear to show the influence of the factor, other related factors should be included in the further studies. Second, this is an *in vitro* study. Comprehensive clinical studies are required to confirm the finding of this study to be confirmed.

CONCLUSION

With the limitations of this *in vitro* pilot study, we concluded that the implant positioning in software program using scan body and digital impression was affected by the amount of scan body exposure. When the soft tissue around implant covers the scan body, incomplete digital impression of scan body could lead to the production of erroneous implant prosthodontic components.

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