Comparative Evaluation of Effect of Scan Body Exposure on The Accuracy of Digital Implant Impressions: An In Vitro Study.

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Abstract

Statement of Problem: In the CAD Program accurate image matching of scan with the design of scan body is important to replicate the actual implant position. In clinical situations where the scan part of the scan body is partially submerged in gingival tissue, the influence of scan image deficiency on the accuracy of image matching is not clear.

Purpose: This in vitro study aims to compare and evaluate the effects of different submergence of the scan body on the accuracy of digital implant impressions.

Materials and Method: Four groups Groups control ,1,2, and 3 with different scan body exposures (Fully Exposed, 1mm, 2mm, and 3mm less exposed) were digitized with a desktop scanner, saved in STL format and transferred to CAD software, where the design of the scan body was matched to scanned image of each group. Depending on scan body design, a virtual implant was drawn. The design image of the scan body and virtual implant was extracted as a single STL file (Combined image). The image-matching process was performed 5 times for each group (n=5). The accuracy of the geometric position of virtual implant was evaluated by comparing it with standard image. The linear deviations of virtual implants were analyzed 3 dimensionally using imaging software. One-way ANOVA F test followed by Tukey's post hoc test was used to verify the effects of scan body exposure on image matching.

Result: The meanlinear deviation of group 1 (36.6 +/- 8.2 microns) and group 2 (31.4+/-7.14) was statistically not significant than control group (19 +/- 5.87) whereas it was statistically significant for group 3 (56.4+/-15.04)

Conclusion: Submergence of scan body of more than 2mm influenced virtual implant positioning in software program

Keywords: Scan Body, Exposure, Accuracy, Digital, Implant, Impression

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Introduction

Implant-supported Prosthesis is a reliable and effective treatment option for natural missing teeth.[1] In any implant treatment obtaining accurate implant impression is of paramount importance.[2-4.] Incorrect implant position transfer can result in an ill-fitting prosthesis, putting unnecessary strain on the various prosthetic components in the system and ultimately leading to complications. Incorrect implant position transfer can result in an ill-fitting prosthesis, putting unnecessary strain on the various prosthetic components in the system and ultimately leading to complications.[5,6] Impression or transfer copings have traditionally been used in osseointegrated implant impression procedures. At the time of the impression, these are connected to the implant body and captured along with the surrounding teeth and mucosa using impression trays and elastomeric impression materials such as polyvinyl siloxane or polyether.[7] With the advancement of computer-aided design and computer-aided manufacturing (CAD-CAM) technology, it is now possible to eliminate this step and use a completely digital workflow for the fabrication of implant-supported restorations. [8] The digital workflow can be either direct or indirect. [9-11] The indirect workflow begins with a traditional implant impression, which is then digitized in the laboratory using a benchtop extraoral optical scanner and laboratory scan body. In the digital direct implant impression workflow, intraoral scan bodies (ISBs) and an intraoral scanning (IOS) device are used to generate a digital scan directly from the patient's mouth. [11] A scan body is used as a transfer device for acquiring the 3-dimensional (3D) position of implants.The scan data are transferred to a computer-aided designing (CAD) software program where the 3D position of the actual implant is localized by matching the geometric image of the scan body design with the scan data.[12-18] A virtual implant corresponding to the actual implant is then designed in the software program, and the prosthetic component of the implant-supported prosthesis can be produced. Accurate image matching of the scan with the design of the scan body is required to replicate the actual implant position in the software program, resulting in a 3D virtual space that is identical to the actual oral cavity. Image acquisition and matching operations may have an impact on image-matching accuracy.[19] Although the digital scanning technique for implants has been evaluated, the factors influencing accurate scan body image matching have yet to be fully elucidated[20,21,22,23]. As a result, this in vitro study aims to compare and evaluate the effects of different scan body exposure on the accuracy of digital direct implant impressions. The null hypotheses were that the amount of scan body exposure does not affect the accuracy of image superimposition of the scan body in the software program.

Material And Methods

Figure 1 shows the experimental workflow of this study. A dental implant analog (RS5737, Adin dental implant systems, Israel) was inserted into a self-cure acrylic resin (Dental products of India, Mumbai, India) block with the help of a surveyor. The block was fabricated from a customized metal jig. The customized metal die was designed to standardize the placement of implant analog on acrylic blocks, so that they are positioned approximately at the center on the top-facing side of the sample and to ensure a common base for intragroup and intergroup comparison. After the placement of the implant analog in the models the implant analog was covered by a cover screw,1mm, 2mm, and 3mm healing abutment for control group, group 1, group 2, and group 3 respectively. After the placementof the healing abutment (Adin dental implant systems ltd, Israel), a soft resilient material was flown at the same heightas that of the healing abutment for each group. Soft resilient materialsimulates the soft tissue of the model i.e gingiva. Soft resilient material also ensures easy placement and removalof the implant scan body (Bioline Dental, Germany) in the master referencemodel of each group. Once the model is lined by soft resilientmaterial the healing abutment was removed and the scan body was attached to the implant. The scan body consisted of the scan body portion and connection portions. The scan portion of the scan body was made of titanium and was 4.6mm in diameter and 9mm in height. The exposure of the scan body was reduced 3 times in the gradient of 1mm by placing models the implants deeper into the model to model to simulate the clinical submergence of the scan body in the gingival tissues. Thus 4 groups were classified based on the exposure height of the scan body: fully exposed, 1mm, 2mm, and 3mm less exposed **(figure 2**). All conditions were digitized with a desktop scanner (T310, Med it, Vancouver, BC. Canada) and the files were saved in the standard tessellation language format and transferred to CAD software (Exocad Galway Version 3.0, Exocad Gmbh, Germany). The virtual implant and design image of the scan body was extracted as a single STL file (combined image). This process was performed 5 times by the same operator in all groups (n=5 for each of the 4 groups. The CAD software was used to make the standard image. The standard image has precise relation of the scan body and the virtual implant position. To evaluate the accuracy of the geometric position of the virtual implant it was compared with the standard image. The scan body portion of the standard image and combined image were used as the congruent area to match the 3D images. Image matching was performed using an image software program. Discrepancies in the implant analog position were analyzed 3 dimensionally between the combined image and the standard image in the analysis software program. The discrepancies were calculated as linear deviations by using The linear deviations were calculated by measuring the distance between the reference and test images of the implant analog body using manual position registration and embedded best fit matching functionof the cad software. A virtual implant was drawn based on the position of the scan body design (figure 3).

Statistical analysis was performed using Statistical Product and Service Solution (SPSS) version 21 for Windows (SPSSInc, Chicago, IL). The confidence interval was set at 95% and the probability of alpha error (level of significance) was set at 5%. The power of the study was set at 80%. Overall intergroup comparison among four study groups was done using One-way Anova ‘F’ test followed by Tukey’s post hoc test for pairwise intergroup comparison between each group.

Result

The linear deviations of the implants in the different exposure conditions of the scan body are shown in **table 1**. Submergence of scan body resulted in increased deviation values. One Way ANOVA tests the results for mean deviation among four groups for scan body exposure and shows statistically significant differences among the four groups for mean linear deviation. The linear deviation was least among the control group (fully exposed) followed by group 2, and group 1 and maximum linear deviation was observed in group 3. A statistically significant difference ($p<0.05$) was observed between the four groups. On pairwise comparison using Tukey’s Post Hoc Test, there was no statistically significant ($p>0.05$) difference between control group, group 1, and group 2. On pairwise comparison with group 3, there was a statistically significant difference of ($p<0.05$) in all groups compared to group 3.

Discussion

The purpose of this study was to assess the accuracy of scan body image matching when the scannable area is limited by the partial submergence of the scan body in gingival tissues.The results of this study showed that the limited exposure conditions led to deviations in the virtual implant positioning because of the inaccurate image superimposition of the scan body image in the software program. Thus, the null hypothesis that scan body exposure would not affect the accuracy of the image superimposition of the scan body was partially accepted as the submergence of the scan body till 2mm did not affect the accuracy of the digital implant impression. The result of the present study is consistent with previous studies[22,23]which found that submergence of implant scan body of more than 1 mm significantly influenced the virtual implant positioning in the software program and deficiencies in the scanned images of a scan body can decrease the accuracy of the implant positioning in CAD software when the defect is large, thus leading to the incorrect fabrication of implant prostheses. Intraoral optical scanners are of a noncontact type and capture the morphologic information of an object by light reflection. Therefore, when the implant is deeply placed or the mucosa around the implant is thick, the exposure of the scan body is reduced.The results of this study showed that the virtual implant positioning during the digital image registration process could be inaccurate when the scan body was submerged by more than 2mm. The missing part of the scan body image led to inaccuracies when registering the scan body surface with the respective scan body design in the software program. Special attention is required in evaluating whether the scannable area of the scan body is exposed when the scan body is connected to the implant in the oral cavity. To match the 3D images of the point cloud in the dental CAD software program, typically, the best-fit algorithm is used. This algorithm places a target image in relation to a reference image in the position where the sum of root-mean- square error between the images is minimized. The best-fit function is a computed calculation. As shown in the results of this study, different quantities of scan body surface information led to varying accuracy in image matching. Linear deviation in different scan body exposure may be the result of the discrepancy in the amount of image surface between the scanned data and design data. Therefore, a function that designates the portion of the scan body used for image matching with the scanned data should be added to the computer program to increase the accuracy of overall image matching when the scan body is not fully exposed in the oral cavity.

Conclusion

Within the limitations of this study, the following conclusion can be drawn:

Submergence of scan body of more than 2mm caused by the gingival tissue around the implant significantly influenced the virtual implant positioning in the software program

Clinical Significance

In clinical situations where a scan body is partially embedded in the gingival tissue, attention is needed when making a digital direct implant impression because the exposure of the scan body could affect the accuracy of image matching in the software program, as well as the fit of the definitive implant-supported prosthesis.

List Of Abbreviations

CAD: Computer Aided Designing

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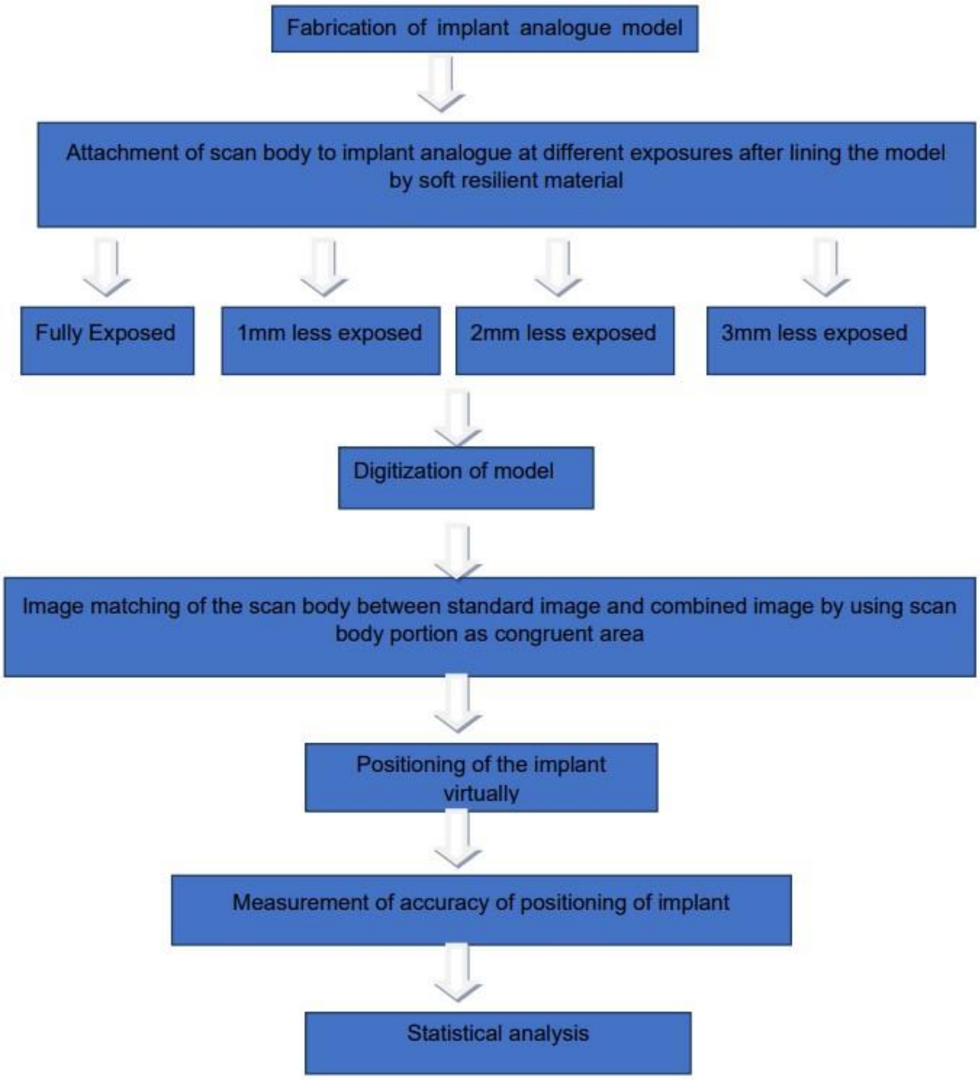

Figure 1: Depicting the experimental workflow of this study

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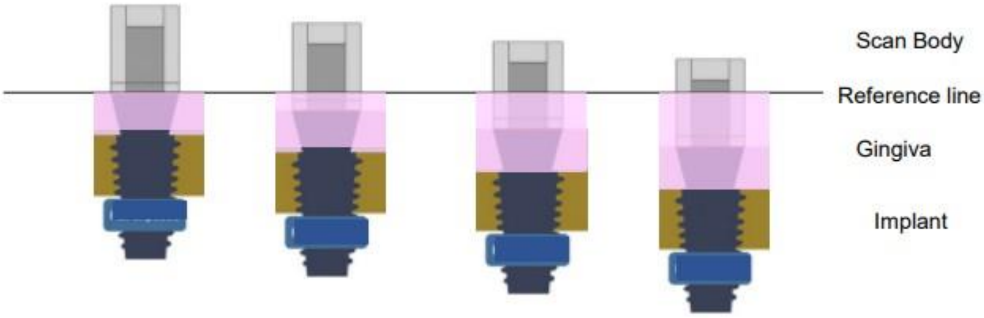

Figure 2: Figure illustrating different Exposure Conditions of Scan Body i.e fully exposed (a), 1mm less exposed (b)2mm less exposed (c) and 3mm less exposed (d) respectively

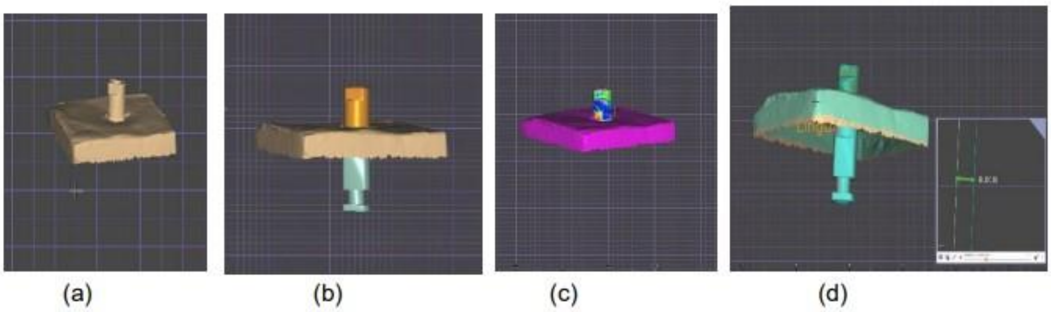

Figure 3 illustrating virtual implant positioning in CAD software (a) scanned data (b) a virtual implant drawn to fabricate standard image in cad software (c) Alignment of the scan body design on the scanned data (d) Combined image.

GROUPS	MEAN +/-SD
CONTROL GROUP (FULLY EXPOSED)	19.0+/-5.87[a]
GROUP 1 (1 MM LESS EXPOSED)	36.6 +/-8.2[a]
GROUP 2(2 MM LESS EXPOSED)	31.4 +/-7.12[a]
GROUP 3(3 MM LESS EXPOSED)	56.4+/-15.04[b]

Significant differences within the same column are represented by different superscript letters

Table 1 depicts Linear discrepancy (mean ± SD; μm) in virtual implant positioning according to the different scan body exposure.