

Trueness of Intraoral Scanners Considering Operator Experience and Three Different Implant Scenarios: A Preliminary Report

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Purpose: To evaluate the trueness of two intraoral scanners in different clinical situations and considering operator experience. **Materials and Methods:** Two intraoral scanner systems were used to perform a total of 120 digital impressions of three master casts reproducing three scenarios (single implant, two implants, and four implants [full-arch]). Two operators, one experienced and one unexperienced, were selected. **Results:** No differences were found between the two operators. A statistically significant correlation was found with regard to the scanning system used and the clinical scenario analyzed. **Conclusions:** Within the limits of this preliminary report, operator experience seems not able to significantly influence the trueness of a digital impression; however, imprecision increased in the full-arch cases for both operators. The two-implant scenario presented similar trueness values for both scanner systems. *Int J Prosthodont 2020 (4 pages). doi: 10.11607/ijp.6224*

A precise impression is critical for fabricating dental restorations with adequate fit.^{1,2} The introduction of digital impressions and scanning systems in dentistry in the mid-1980s created the expectation of eliminating errors that result from conventional impression techniques such as expansion, shrinkage, and distortion. Additionally, intraoral scanners (IOS) have been shown to be preferred by the patient in several clinical studies.³⁻⁵ Conversely, the disadvantages of using digital impressions are the difficulty in detecting deep margin lines in prepared teeth and/or in the case of bleeding; the learning curve; and the purchasing and managing costs.⁵ Moreover, as reported in a recent systematic review, the literature so far does not support the use of an IOS in long-span restorations.⁵ Implant impressions, especially in edentulous patients, are the most challenging situation for an IOS due to the reduced number of reference points.

The aim of the present study was therefore to evaluate the trueness of two IOS systems considering operator experience and different clinical scenarios.

MATERIALS AND METHODS

Three master casts reproducing three different clinical situations made with an improved type IV die stone (GC Fujirock EP, GC America) were fabricated (Fig 1), and scan bodies were screwed (Sweden & Martina) on implant analogs.

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Fig 1 The three models used in the research.

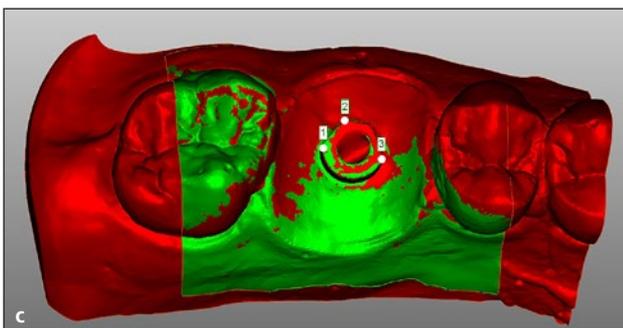
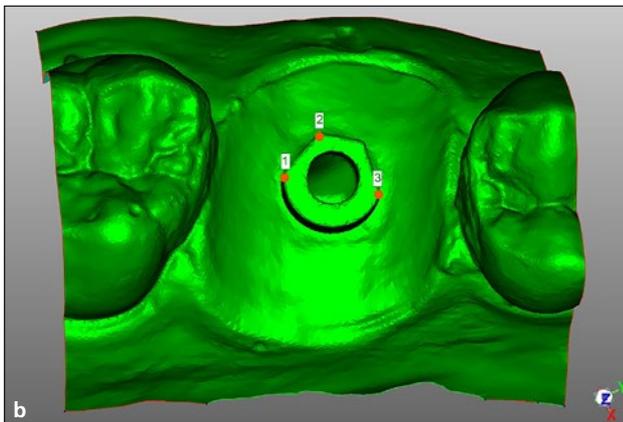
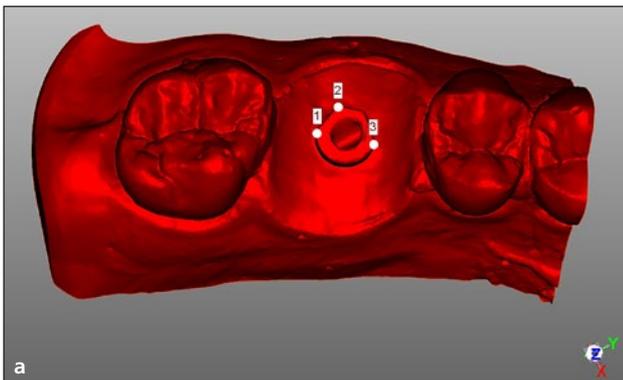


Fig 2 The three-point registration process at the edges of the implant scan bodies, as equidistant as possible.

Three scenarios were investigated: (1) single implant; (2) two implants with two pontic elements; and (3) four implants (full-arch).

Two IOS systems (system 1: CS 3600, Carestream Dental; system 2: TRIOS 3, 3Shape) were each used by two operators, who each performed 10 scans of each of the 3 scenarios with each system for a total of 120 scans. The two included operators were an operator experienced with IOS (more than 2 years of experience with digital impression systems)⁶ and an inexperienced operator who had never used an IOS before.

Scans were taken at 10-minute intervals in order to allow the operator to rest and the device to cool down. A zig-zag scanning technique was followed in all cases and for each IOS, where, starting from the first quadrant (superior right), the tip of the scanner went over the full arc while zig-zagging from vestibular to palatal and back.⁷

To test trueness, the three models were scanned three times each with a reference scanner (ScanRider, V-GER) with a standard resolution of 25 to 50 μm , an average error (accuracy) of 5 to 10 μm , and a precision (standard deviation [SD]) of 15 to 30 μm .⁸ All generated datasets were imported into powerful reverse-engineering software (Geomagic Studio 2012) and superimposed onto each other in order to select one reference dataset for each model.⁹

The digital impressions were therefore imported into the same reverse-engineering software and superimposed onto the reference dataset. The superimposition consisted of two different procedures. First, the three-point registration function was used, in which three reference points were identified on the surface of the implant scan bodies. This function allowed a first, rough alignment of the two three-dimensional (3D) surface models to be compared (Fig 2). After this process, the best-fit algorithm was applied for the final superimposition and registration of discrepancies. With this second phase of alignment, after defining the reference dataset

Fig 3 Evaluation of mean deviation between the reference dataset and a digital impression.

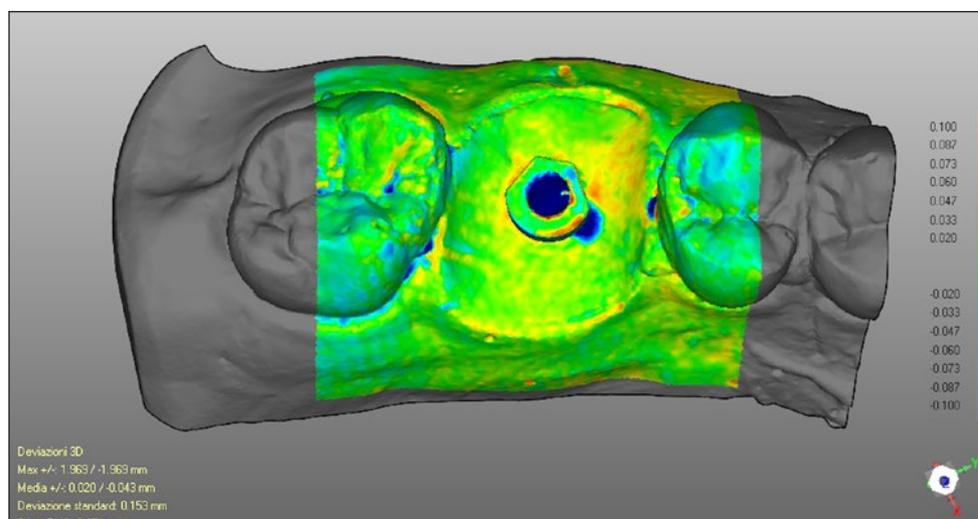


Table 1 Mean (Standard Deviation) Trueness (μm)

Operator	Single implant		Two implants		Full-arch	
	System 1	System 2	System 1	System 2	System 1	System 2
Experienced	26.1 (12.1)	19.1 (12.9)	34.8 (19.2)	30.2 (5.7)	78 (22.8)	127.5 (14)
Unexperienced	22.9 (3.8)	13.6 (3.2)	28.1 (5.2)	34.9 (6.4)	66.8 (17.2)	129.9 (15.5)

as well as the parameters for registration (a minimum of 100 iterations were requested in all cases, with the sample size set to 50,000), the corresponding polygons of the selected models were automatically superimposed. A robust iterative closest point (RICP) algorithm was used for this final registration, and the distances between the reference dataset and the superimposed models were minimized using a point-to-plane method.¹⁰ Congruence between specific corresponding structures was calculated. With this method, the mean and SD of the distances between the two superimposed models was calculated by the software (Fig 3).

For an optimal 3D visualization of the results, the distances between corresponding areas of reference and all superimposed models were color-coded using the 3D deviation function.

Mean values and SDs were calculated. Statistical analyses were performed with SPSS (IBM). Statistical significances for IOS system, operator skill, and clinical scenario were assessed with two-tailed Pearson correlation coefficient (level of significance was set to .05).

RESULTS

The results are reported in Table 1. No statistically significant differences were found between the two operators, but there were statistically significant correlations with regard to the scanning system and the clinical

scenario analyzed (Pearson two-tailed test, $P < .05$). Imprecision increased in longer-span cases.

Single-implant and two-implant scans both differed significantly from full-arch scans, but there was no significance between single- and two-implant scans (two-way analysis of variance [ANOVA]).

System 2 showed better performance compared to system 1 in scenarios with one and two implants, while system 1 showed better results in the full-arch scenario. The difference between the two IOS systems was statistically significant in single-implant and full-arch scenarios (Sidak multiple comparisons test) (Fig 4).

DISCUSSION

The results of this preliminary report suggest that in cases of digital impressions of single implants or two implants with two pontic elements, both an experienced and an inexperienced operator could obtain satisfactory results.⁵ However, when a fully edentulous arch scenario was faced, both operators presented similar significantly lower trueness compared to the reference scan.

The use of only two digital scanners and operators are limitations of the present work; however the two IOS presenting the best results in the available literature were selected.^{8,11} The in vitro design is an additional shortcoming, as some clinical difficulties (saliva, tongue presence, etc) may affect the results. The conditions of the study were designed to adhere to optimal

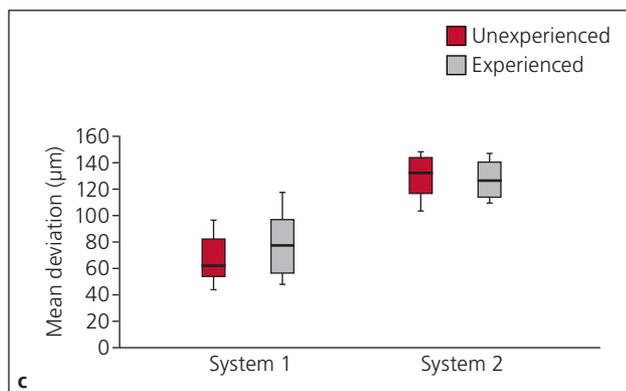
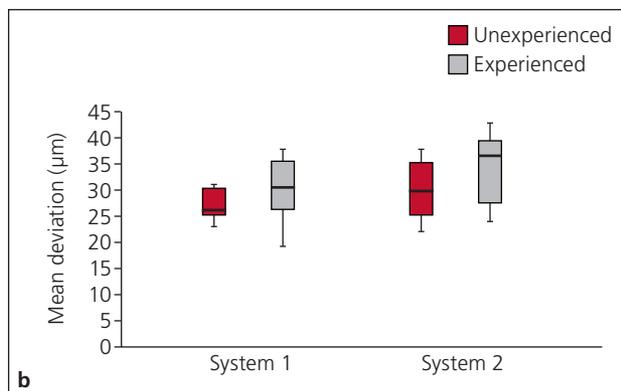
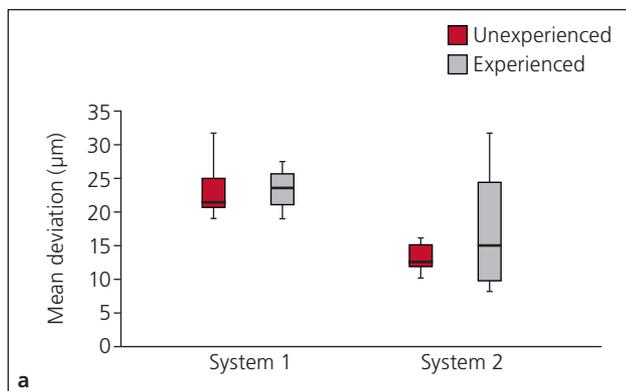


Fig 4 Mean deviation values for scenario, scanner system, and operator experience. (a) Single implant. (b) Two implants. (c) Full-arch.

impression conditions to avoid the shortcomings of an in vivo design, such as the introduction of extra steps in the fabrication of the reference model. In addition, the in vitro design allowed numerous digital impression repetitions. In vivo studies involving more operators are needed to validate these results.

CONCLUSIONS

Within the limitations of this preliminary report, it appears that operator experience does not significantly influence the trueness of a digital impression among different clinical scenarios. The full-arch impression presented the worst values for trueness, even for the system that performed better (system 1), whereas the two-implant scenario presented similar trueness values for both IOS systems.

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