Intraoral Scanning Systems: Need for Maintenance

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Purpose: This study aimed to analyze a possible gain in accuracy in intraoral scanning systems by manufacturer calibration. ***Materials and Methods:*** A master model was scanned tenfold with a Lava Chairside Oral Scanner (3m ESPE) and a CEREC Bluecam suspected to be decalibrated. Thereafter the scanners were calibrated and the model was scanned again. An iTero system served as comparison. All scans were compared to the master scan, and the mean deviation (entire arch, single tooth) was calculated. ***Results:*** After calibration, there was a significant gain in accuracy for both systems. ***Conclusions:*** Intraoral digital scanners may be sensitive to hardware decalibration invisible to the user and therefore need maintenance. *Int J Prosthodont 2017;30:27–29. doi: 10.11607/ijp.4976*

Quite a few publications are available regarding the accuracy of intraoral scanning systems. The results reported for the accuracy of the systems are somewhat inconclusive, as some articles report contradictory results for comparable experimental settings and identical systems.[1,2] This is especially true for data regarding the accuracy of the entire jaw.[1,3] However, to the knowledge of the present authors no investigation so far has questioned the reliability of the scanning devices. The investigation reported here is based on the observation that the present authors were not able to reproduce the results obtained[4] with identical scanners in a comparable setup after 18 months (CEREC Bluecam; Lava Chairside Oral Scanner, 3M ESPE). Therefore, it was the aim of this study to analyze a possible gain in accuracy achievable by calibration of the system by the respective manufacturer.

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Materials and Methods

A laser-sintered cobalt-chromium master model (Bego) based on a Frasaco model of a maxilla was fabricated. A second molar, a second premolar, and a central incisor were separately machine milled with a cone angle of 4 degrees and a shoulder margin and inserted into the model (Fig 1). The final master model was digitized using a Nikon LC 15DX laser scanner (Nikon Metrology) with an accuracy of ± 3.5 µm, and saved in STL format as a reference data set (Focus Inspection V.9.3, Nikon Metrology).

All scans (n = 10 per device) were performed after the prescribed calibration according to the manufacturer's guidelines with a CEREC Bluecam (SN: 08736), a Lave Chairside Oral Scanner (SN: B091005), and an iTero scanner (SN: E0110Jan24h13). The latter device was included as a control as we did not see a difference in the results for this scanner after 18 months, in a repetition of Seelbach et al.[4] After the first series (old) was obtained with the Bluecam and Lava systems, the manufacturers were asked to inspect and, if necessary, calibrate the system. Thereafter an additional scan series (n = 10) with both calibrated systems was carried out (new). All scans were exported to STL format and compared to the master scan (GOM Inspect 7.5) (Fig 2). Subsets of the entire scan representing the prepared teeth were analyzed separately. The mean deviation (positive and negative) was calculated for the superimposed areas. The data were tested for normal distribution (Kolmogorov-Smirnov). Analysis of variance was used to check for significant differences among all groups. In case of significant differences, Dunnett C test was applied (SPSS 19, IBM).

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Fig 1 Laser-sintered cobalt-chromium master model *(right)* based on a Frasaco model *(left)*.

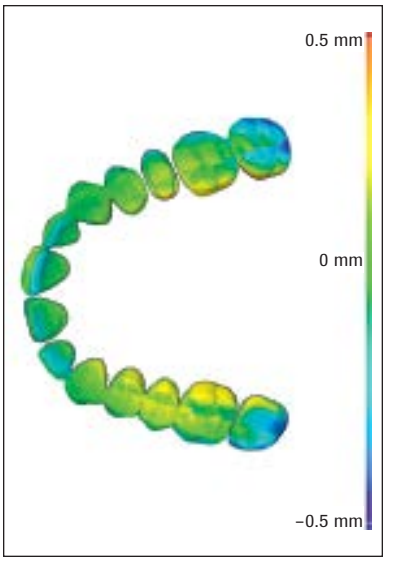


Fig 2 Example of a color-coded presentation of the comparison to the master scan.

Table 1 Mean ± SD Positive and Negative Deviation Between the Scan Models of the Test Series and the Reference Model

	Mean deviation (µm)	Whole jaw	Second molar	Central incisor	Second premolar
iTero (n = 10)	Positive	24.4 ± 6.9	12.3 ± 1.7	14.1 ± 1.2	12.3 ± 0.8
	Negative	−24.4 ± 5.5	−8.9 ± 0.9	−9.9 ± 0.7	−12.8 ± 1.0
Lava new (n = 10)	Positive	39.7 ± 10.7	17.3 ± 2.4	17.2 ± 3.4	15.6 ± 1.9
	Negative	−30.0 ± 7.3	−9.3 ± 0.9	−13.6 ± 2.3	−11.3 ± 1.8
Lava old (n = 10)	Positive	91.9 ± 34.8	25.2 ± 3.5	18.1 ± 2.9	20.9 ± 2.2
	Negative	−69.8 ± 19.6	−14.2 ± 3.7	−19.0 ± 4.4	−17.3 ± 3.8
CEREC new (n = 10)	Positive	16.4 ± 3.0	11.2 ± 2.4	10.9 ± 2.1	13.0 ± 1.2
	Negative	−16.6 ± 4.3	−10.0 ± 1.6	−10.5 ± 1.9	−11.8 ± 2.1
CEREC old (n = 10)	Positive	98.5 ± 28.2	12.2 ± 2.4	17.9 ± 4.8	17.1 ± 4.6
	Negative	−118.2 ± 35.2	−18.0 ± 4.3	−17.5 ± 13.2	−20.0 ± 7.9

Results

After inspection and calibration there was a significant gain in accuracy for both systems (Bluecam and Lava) for the single preparations as well as for the entire arch. There were no significant differences among all systems after calibration, including the iTero. The positive and negative deviations observed were comparable (Table 1).

Discussion

Results clearly indicate that at least some intraoral scanning systems are prone to decalibration and thus a loss of accuracy that the user cannot directly recognize. From a technical viewpoint, all these systems are high-precision, sensitive optical instruments. Any shock applied to them (eg, concussions and vibrations while moving the system around or even dropping of the camera) may be expected to foster decalibration. The problem is that—at least in the cases reported—this decalibration was not discernible, the system software did not offer any hint in this regard, and the systems worked without visible problem. The inaccuracy would not necessarily have led to clinically unacceptable results or completely nonfitting restorations in either decalibrated system, so it is likely no clinician would have noticed. The fact that the present authors could not reproduce the results obtained with identical systems 18 months earlier in a laboratory setup[4] led to the discovery of the problem. To the authors' knowledge, this is the first study addressing this issue.

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After calibration, all systems showed results comparable to previous studies pointing toward a high scanning accuracy.[3–5]

Aside from decalibration, the specifics of the different scanner types (eg, scan path, powdering) are known to affect the results and have to be considered.

Conclusions

The results of this study clearly indicate that although intraoral digital scanners may show a high accuracy, some systems seem to be sensitive to hardware decalibration that is invisible to the user. Therefore, manufacturers should consider establishing control procedures or offering regular hardware maintenance for their systems.

Acknowledgments

The authors reported no conflicts of interest related to this study.

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Literature Abstract

Tooth Loss in Molars With and Without Furcation Involvement: A Systematic Review and Meta-analysis

This systematic review article performed a meta-analysis on the risk of tooth loss in molars with furcation involvement (FI) based on initial clinical diagnosis. The systematic search of the literature was conducted in various databases (Ovid MEDLINE, Embase, LILACS, and Cochrane Library) for longitudinal studies with at least 3 years of follow-up based on measures of FI and data on tooth loss. Out of 1,207 titles initially searched, 21 studies were included in the review. The relative risk (RR) of tooth loss during maintenance therapy (third molars excluded) attributable to FI was 1.46 (95% CI = 0.99–2.15, $P = .06$) for studies up to 10 years and almost doubles to 2.21 (95% CI = 1.79–2.74, $P < .0001$) for studies with a follow-up of 10 to 15 years and triples to 4.46 (95% CI = 2.62–7.62, $P < .0001$) for longer follow-ups (15–53 years). Furthermore, a gradual increase in the risk of tooth loss was observed for molars, with increasing severity of FI (RR of 3.13 [95% CI = 2.30–4.24, $P < .0001$] when comparing degree III to degree I). In summary, this systematic review provides further evidence that the risk of tooth loss is significantly associated with the degree of FI and length of follow-up periods. Nevertheless, most molars, even with grade III FI, respond well to periodontal therapy (30% of molars were lost in follow-ups of 5–15 years), suggesting that every effort should be made to maintain these teeth when possible. The strengths of this systematic review are a relatively high sample size and the small heterogeneity for most of the meta-analyses. Limitations are the residual heterogeneity for studies with >15 years of follow-up and the possible presence of publication bias.

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