iTero™ Compendium

Research publications

iTero™

Last update on 04.02.2025
MKT-0003041 Rev C

Research publications

List of Research publications evaluating the iTero™ scanner

- Digital vs. conventional implant prosthetic workflows: a cost/time analysis
- Patient-centered outcomes comparing digital and conventional implant impression procedures
- Time-Efficiency Analysis Comparing Digital and Conventional workflows for Implant Crowns
- Accuracy of full-arch digital impressions: an in vitro and in vivo comparison
- A new method to measure the accuracy of intraoral scanners along the complete dental arch: A pilot study
- Randomized controlled clinical trial of digital and conventional workflows for the fabrication of zirconia-ceramic fixed partial dentures.
- Trueness of 12 intraoral scanners in the full-arch implant impression: a comparative in vitro study
- Diagnostic validity of early proximal caries detection using near-infrared imaging technology on 3D range data of posterior teeth
- In Vitro Comparison of Three Intraoral Scanners for Implant—Supported Dental Prostheses
- Intraoral scanning reduces procedure time and improves patient comfort in fixed prosthodontics and implant dentistry: a systematic review
- Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries
- Accuracy of the Intraoral Scanner for Detection of Tooth Wear
- Clinical validation of near-infrared imaging for early detection of proximal caries in primary molars
- Differences in maxillomandibular relationship recorded at centric relation when using a conventional method, four intraoral scanners, and a jaw tracking system: A clinical study
- Trueness and precision of complete arch dentate digital models produced by intraoral and desktop scanners: an ex-vivo study
- Comparison of treatment time for single implant crowns between digital and conventional workflows for posterior implant restorations: A randomized controlled trial
- Accuracy, Time, and Comfort of Different Intraoral Scanners: An In Vivo Comparison Study
- Full arch accuracy of intraoral scanners with different acquisition technologies: An in vitro study

List of Research publications evaluating the iTero™ scanner

Below is a list of external articles evaluating the iTero™ scanner, the following pages focus on the 17 articles highlighted below.

	Publication	Topic	Author	Reference	Conclusion
1	Digital vs. conventional implant prosthetic workflows: a cost/time analysis.	Efficiency	Tim Joda, Urs Brägger	Clin. Oral Impl. Res. 26, 2015, 1430–1435 doi: 10.1111/clr.12476	The digital workflow was more efficient than the well-established conventional pathway.
2	Patient-centered outcomes comparing digital and conventional implant impression procedures: a randomized crossover trial.	Efficiency	Tim Joda, Urs Brägger	Clin. Oral Impl. Res., 00, 2015, 1–5. doi: 10.1111/clr.12600.	The digital technique emerges as the most preferred one according to patientcentered outcomes and was more time-effective compared to conventional impressions.
3	Time-Efficiency Analysis Comparing Digital and Conventional Workflows for Implant Crowns: A Prospective Clinical Crossover Trial.	Efficiency	Tim Joda, Urs Brägger	The International journal of oral & maxillofacial implants. 30. 1047-1053. DOI :10.11607/jomi.3963.	The digital workflow seems to be more time-efficient than the established conventional production pathway for fixed implant-supported crowns. Both clinical chair time and laboratory manufacturing steps could be effectively shortened with the digital process.
4	Accuracy of full-arch digital impressions: an in vitro and in vivo comparison.	Full-arch, accuracy	Keul C, et al.	Clin Oral Investig. 2019 May 27.	Within the limitations of this study, the iTero™ scan seems to be a valid alternative to conventional impressions for full arches
5	A new method to measure the accuracy of intraoral scanners along the complete dental arch: A pilot study.	Full-arch, accuracy	Iturrate M, et al.	J Adv Prosthodont. 2019 Dec;11(6): 331- 340.	iTero Element™ was more accurate than the 3shape Trios 3 scanner and 3M True Definition. Importantly, the proposed methodology is considered reliable for analyzing accuracy in any dental arch length and valid for assessing both trueness and precision in an in vivo study.
6	Randomized controlled clinical trial of digital and conventional workflows for the fabrication of zirconia-ceramic fixed partial dentures. Part III: Marginal and internal fit.	Marginal fit	Benic GI, et al.	J Prosthet Dent. 2019 Mar;121(3): 426-431.	In terms of frameworks presented similar or better fit than the conventionally fabricated metal frameworks. In the occlusal regions, the conventionally fabricated metal frameworks achieved a more favorable fit than the CAD-CAM zirconia frameworks.
7	Trueness of 12 intraoral scanners in the full-arch implant impression: a comparative in vitro study	Full-arch, accuracy	Francesco Guido et al.	BMC Oral Health. 2020; 20 (1): 263.	Different levels of trueness were found among the Intraoral scanners evaluated in this study. Further studies are needed to confirm these results.
8	Diagnostic validity of early proximal caries detection using near-infrared imaging technology on 3D range data of posterior teeth	NIRI, caries diagnostics	Friederike Litzenburge, et al.	Clin Oral Investig . 2022 Jan;26(1): 543-553.	The iTero Element 5D imaging system scanner achieved diagnostic results comparable to those of BWR. NIRR with and without the trilateral information can detect initial defects in the enamel with higher sensitivity than BWR
9	In Vitro Comparison of Three Intraoral Scanners for Implant—Supported Dental Prostheses	Full-arch, accuracy	Costa V, et al.	Dent J (Basel). 2022 Jun 15;10(6):112.	iTero™ intraoral scanner was found to be the most accurate (26.00 µm), followed by the Medit scanner (35.90 µm) and Planmeca PlanScan scanner (57.30 µm)
10	Intraoral scanning reduces procedure time and improves patient comfort in fixed prosthodontics and implant dentistry: a systematic review	Efficiency, patient comfort	Siqueira R, et al.	Clin Oral Investig. 2021 Dec;25(12): 6517-6531.	Intraoral scanner is faster than conventional impressions, independent of the size of the scanned area
11	Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries: A multicenter prospective clinical study conducted in private practices	NIRI, caries diagnostics	Metzger Z, et al.	J Dent. 2022 Jan;116:103861.	NILR had higher sensitivity than BWR in the detection of early enamel lesions and comparable sensitivity to BWR in detecting lesions that involved the DEJ
12	Accuracy of the Intraoral Scanner for Detection of Tooth Wear	Patient monitoring	Somsak Mitrirattanakul et al.	Int Dent J. 2022 Aug 2:S0020-6539(22)00116-2.	Findings suggest that an intraoral scanner is a reliable tool for detecting tooth wear in a clinical setting. Its high accuracy supports its suitability as a screening instrument for tooth wear during routine dental examinations, potentially enhancing the early diagnosis and management of dental erosion.

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	Publication	Topic	Author	Reference	Conclusion
13	Clinical validation of near-infrared imaging for early detection of proximal caries in primary molars	Caries detection in primary teeth	Jingwei Cao et al.	Journal of Dentistry. 2023 Aug.	iTero™ NIRI technology (Near Infra-Red Imaging) offers a non-invasive, radiation-free, and potentially more sensitive alternative to visual inspection for early caries detection.
14	Differences in maxillomandibular relationship recorded at centric relation when using a conventional method, four intraoral scanners, and a jaw tracking system: A clinical study	Jaw relation registration	Marta Revilla-León et al.	The Journal of Prosthetic Dentistry. 2023 Jan.	The study concluded that the iTero scanner exhibited superior accuracy in bite registration for CR, with a deviation of only 0.14 ±0.09 mm, showcasing comparable trueness to the Modjaw and TRIOS4, and significantly outperforming the i700 and Primescan. This underlines iTero's potential as a reliable tool for precise CR recording in dental practices, offering an effective alternative to traditional methods and other intraoral scanners.
15	Trueness and precision of complete arch dentate digital models produced by intraoral and desktop scanners: an ex-vivo study.	Palatal scanning accuracy.	Janos Vag et al.	Journal of Dentistry 2023 Oct 26:139:104764.	All investigated IOSs, and indirect digitization could be used for complete arch scanning in mandibular and maxillary dentate arches. However, direct optical digitization is preferable for the palate due to the low accuracy of physical impression techniques for soft tissues.
16	Comparison of treatment time for single implant crowns between digital and conventional workflows for posterior implant restorations: A randomized controlled trial.	Efficiency	Worapat Jarangkul et al.	Int J Oral Maxillofac Implants 2023 Nov 1;0(0).	According to this study, digital workflows for single-implant crowns using iTero intraoral scanners are 39.2% faster than conventional workflows
17	Accuracy, Time, and Comfort of Different Intraoral Scanners: An In Vivo Comparison Study	Patient experience, Accuracy	Lione, R., De Razza, F. C., Gazzani, F., Lugli, L., Cozza, P., & Pavoni, C. (2024).	Applied Sciences, 14(17), 7731.	Within the context of this study, the iTero Lumina scanner demonstrated superior patient comfort, reduced scanning time, and enhanced visualization compared to iTero Element 5D, while demonstrating clinically acceptable accuracy in capturing full-arch digital impressions.
18	Full arch accuracy of intraoral scanners with different acquisition technologies: An in vitro study	Full arch accuracy	Ingo Baresel, Jen Baresel	German Society for Digital Oral Impression (DGDOA), Germany	The iTero Lumina™ scanner, equipped with Multi Direct Capture (MDC) technology, demonstrated superior full-arch accuracy to other 4 intraoral scanners included in this study, demonstrating elevated trueness and precision under ADA/ANSI Standard 132 guidelines for long-distance accuracy. Its innovative MDC technology decouples the field of view (FOV) from the wand size, allowing a larger FOV without increasing wand dimensions. A wider field of view of the iTero Lumina™ reduces the number of images needed to capture extended distances, thereby minimizing the stitching process and subsequent misalignment errors.
19	The effect different substrates have on the trueness and precision of eight different intraoral scanners.	Substrates	Dutton E, et al.	J Esthet Restor Dent. 2019 Sep 30.	Substrate type affects the trueness and precision of a scan. Active Triangulation scanners are more sensitive to substrate differences than their parallel confocal counterparts. Some scanners scan certain substrates better, but in general the new generation of scanners outperforms the old, across all substrates.
20	Comparison of two intraoral scanners based on three-dimensional surface analysis.	Accuracy	Lee KM, et al.	Prog Orthod. 2018 Feb 12;19(1):6.	Although there were some deviations in visible inspection, there was no statistical significance between the two intraoral scanners.
21	Intraoral digital scans-Part 1: Influence of ambient scanning light conditions on the accuracy (trueness and precision) of different intraoral scanners.	Light conditions	Revilla-León M, et al.	J Prosthet Dent. 2019 Dec 18.	Ambient lighting conditions influenced the accuracy (trueness and precision) of the Intraoral scanners tested. The recommended lighting conditions depend on the Intraoral scanner selected. For iTero Element™ scanner, chair and room light conditions resulted in better accuracy mean values. For CEREC Omnicam scanner, zero light resulted in better accuracy, and for 3shape Trios 3 scanner, room light resulted in better accuracy.
22	Trueness of digital intraoral impression in reproducing multiple implant position.	Implants, trueness	Kim RJ, et al.	PLoS One. 2019 Nov 19;14(11):e0222070.	Within the limitations of the present study, all the Intraoral scanners exhibited increasing deviation with an increasing distance from the start position of scanning. The direction and magnitude of deviation differed among jaw regions and Intraoral scanners. All the Intraoral scanners were similar for unilateral arch scanning, while i500 scanner, and Trios 3 scanner outperformed the other Intraoral scanners for partially edentulous scanning. The accuracy of Intraoral scanners requires additional improvement.

List of Research publications evaluating the iTero™ scanner

	Publication	Topic	Author	Reference	Conclusion
23	Trueness and precision of 5 intraoral scanners for scanning edentulous and dentate complete-arch mandibular casts: A comparative in vitro study.	Edentulous, precision, trueness	Braian M, et al.	J Prosthet Dent. 2019 Aug;122(2): 129- 136.e2.	Significant differences were found in scanning edentulous and dentate scans for short arches and complete arches. Trueness for complete-arch scans were <193 µm for edentulous scans and <150 µm for dentate scans. Trueness for short-arch scans were <103 µm for edentulous scans and <56 µm for dentate scans.
24	Trueness and Precision of Three-Dimensional Digitizing Intraoral Devices.	Edentulous, precision, trueness	Mutwalli H, et al	Int J Dent. 2018 Nov 26;2018:5189761.	Within the limitations of this in vitro study, the results suggest significant differences between Intraoral scanner devices when scanning fully edentulous arch with multiple implants. ,e main observation was the low precision for all intraoral scanners, suggesting that the intraoral scanning devices are unreliable for scanning fully edentulous arch with multiple implants. Two scanners, however, 3shape Trios 3 mono scanner and iTero Element scanner showed fair trueness.
25	Local accuracy of actual intraoral scanning systems for single-tooth preparations in vitro.	Single tooth, accuracy	Zimmermann M, et al.	J Am Dent Assoc. 2020 Feb;151(2): 127- 135.	Intraoral scanner systems use different behaviors in terms of local accuracy. Preparation MA shows higher deviations than preparation SU for all test groups. Trueness and precision values for both MA and SU of single-unit preparations are equal or close to CO impressions for several Intraoral scanner systems
26	Investigation of the Accuracy of Four Intraoral Scanners in Mandibular Full-Arch Digital Implant Impression: A Comparative In Vitro Study	Full-arch, accuracy	Adolfo Di Fiore, et al.	Int J Environ Res Public Health. 2022 Apr 13;19(8):4719	1. The 3D position analysis showed that all Intraoral scanners, including the iTero Element scanner, were able to execute digital impressions for a full arch, according to the clinically desirable value of the position errors reported in the literature (150 µm). 2. The 3D distance analysis showed that the CEREC Primescan scanner, iTero™ scanner presented regression close and almost parallel to the x-axis, which meant that the systematic errors sources were negligible.
27	Effect of pulp chamber depth on the accuracy of endocrown scans made with different intraoral scanners versus an industrial scanner: An in vitro study	Endocrowns, accuracy	Bahar Gurpinar, et al.	J Prosthet Dent. 2022 Mar;127(3):430-437.	1. iTero™ scanner is the second most accurate scanner for endocrowns after the CEREC Primescan scanner. 2. Increasing the pulpal chamber extension depth of endocrown preparations can reduce scanning accuracy.
28	Comparison of the acquisition accuracy and digitizing noise of 9 intraoral and extraoral scanners: An objective method	Digitizing noise	Lucien Dupagne, et al.	J Prosthet Dent. 2021 Mar 26:S0022-3913(21)00076-7.	Primescan scanner, iTero Element™ 5D imaging system, CS3600 scanner, and 3Shape Trios 3 scanner showed minimally significant differences. Conclusions Significant differences were found among the intraoral scanners for small-scale scans. The objective methodology of using a gauge block provided coherent and repeatable results.
29	Comparison of conventional, photogrammetry, and intraoral scanning accuracy of complete-arch implant impression procedures evaluated with a coordinate measuring machine	Full-arch, accuracy	Marta Revilla-León, et al.	J Prosthet Dent. 2021 Mar;125(3):470-478.	The 2 Intraoral scanners - iTero Element scanner and 3Shape Trios 3 scanner, tested provided a reliable digitizing procedure as no significant differences were found between the linear discrepancy compared with the conventional impression technique.
30	Accuracy of Digital Impressions Obtained Using Six Intraoral Scanners in Partially Edentulous Dentitions and the Effect of Scanning Sequence	Partially edentulous, accuracy	Burcu Diker, et al.	Int J Prosthodont. 2021 Jan-Feb;34(1):101-108.	The accuracy of partially edentulous models was affected by the scanning sequence when using Virtuo vivo scanner, Emerald scanner, Primescan scanner, and iTero™ scanner. the effect of scanning sequence on the accuracy of digital impressions. Based on the results of the present study, scanner and scanning sequence have an important role in the success of digital scanning. it could be considered that deviation on the digital impression may affect the accuracy of RPD frameworks and, consequently, the success of the dentures in the digital workflow.
31	Effect of scan pattern on complete-arch scans with 4 digital scanners	Full-arch, accuracy	Jason Latham, et al.	J Prosthet Dent. 2020 Jan;123(1):85-95.	1. Scan pattern affected the trueness, precision, and speed of digital scanners, and differences were found when different scanners were compared by using the same scan pattern. 2. The iTero Element™ scanner, Planmeca PlanScan scanner, and 3Shape Trios 3 scanner were close to equivalent regarding trueness and precision.
32	Full-arch accuracy of five intraoral scanners: In vivo analysis of trueness and precision	Full-arch, accuracy	Miran Kwon, et al.	Korean J Orthod. 2021 Mar 25;51(2):95-104.	Regarding trueness, Omnicam scanner showed greater dimensional errors followed by i500 scanner, CS3600 scanner, iTero™ scanner, and 3Shape Trios 3 scanner. CS3600 scanner showed greater errors followed by Omnicam scanner, i500 scanner, iTero™ scanner, and 3Shape Trios 3 scanner in the linear distance from the canine to the molar in the same quadrant. Thus, the dimensional accuracy of intraoral scan data may differ significantly according to the type of scanner, with the amount of error in terms of trueness being clinically significant.

Article summary of:

“Digital vs. conventional implant prosthetic workflows: a cost/time analysis”

iTero™

Objectives:

Prospective cohort trial to perform a cost/time analysis for implant-supported single-unit reconstructions in the digital workflow compared to the conventional pathway.

Materials and methods:

- 20 patients
- Rehabilitation with 2 x 20 implant crowns
- Crossover study design
- Test: customized titanium abutments plus CAD/CAM-zirconia-suprastructures
- Control: standardized titanium abutments plus PFM-crowns
- Starting with prosthetic treatment, analysis was estimated for clinical and laboratory work steps including measure of costs in Swiss Francs (CHF), productivity rates and cost minimization for first-line therapy.
- Statistical calculations with Wilcoxon signed-rank test

Article:

CLINICAL ORAL IMPLANTS RESEARCH

Tim Joda
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Digital vs. conventional implant prosthetic workflows: a cost/time analysis

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Date:
Accepted 3 August 2014

To cite this article:
Joda T, Brägger U. Digital vs. conventional implant prosthetic workflows: a cost/time analysis.
Clin. Oral Impl. Res. 26, 2015, 1430–1435
doi: 10.1111/clr.12476

Key words: conventional, cost minimization analysis (CMA), costs, dental crown, dental implant, digital, economics, productivity rate, workflow

Abstract

Objectives: The aim of this prospective cohort trial was to perform a cost/time analysis for implant-supported single-unit reconstructions in the digital workflow compared to the conventional pathway.

Materials and Methods: A total of 20 patients were included for rehabilitation with 2 × 20 implant crowns in a crossover study design and treated consecutively each with customized titanium abutments plus CAD/CAM-zirconia-suprastructures (test: digital) and with standardized titanium abutments plus PFM-crowns (control conventional). Starting with prosthetic treatment, analysis was estimated for clinical and laboratory work steps including measure of costs in Swiss Francs (CHF), productivity rates and cost minimization for first-line therapy. Statistical calculations were performed with *Wilcoxon signed-rank test*.

Results: Both protocols worked successfully for all test and control reconstructions. Direct treatment costs were significantly lower for the digital workflow 1815.35 CHF compared to the conventional pathway 2119.65 CHF ($P = 0.0004$). For subprocess evaluation, total laboratory costs were calculated as 941.95 CHF for the test group and 1245.65 CHF for the control group, respectively ($P = 0.003$). The clinical dental productivity rate amounted to 29.64 CHF / min (digital) and 24.37 CHF / min (conventional) ($P = 0.002$). Overall, cost minimization analysis exhibited an 18% cost reduction within the digital process.

Conclusion: The digital workflow was more efficient than the established conventional pathway for implant-supported crowns in this investigation.

Introduction

As the introduction of dental implants, the evidence for the validity of this treatment concept has been increased [Branemark et al. 1977; Albrektsson et al. 1986]. Surgical and prosthetic protocols improved over time, resulting in predictable treatment outcomes with well-documented high long-term survival rates of the implants [Buser et al. 2012; Degidi et al. 2012] as well as the prosthetic suprastructures [Jung et al. 2012, Pjetursson et al. 2012].

The implementation of digital processing can be regarded as the technological key development for the next generation of implant treatment protocols, including 3D cone beam computed tomography (CBCT), planning software, intraoral scanning (IOS), and computer-assisted-design and computer-assisted-manufacturing (CAD/CAM) [Hamerle et al. 2009]. In general, it is assumed that computer-aided technologies (CAx) open the opportunity to streamline workflows in implant rehabilitation concepts (Patel 2010, Schoenbaum 2012). Moreover, the digitization trend has been presented to potentially reduce treatment costs (Fasbinder 2010, van Noort 2012).

However, studies evaluating cost analyses and economic parameters are still rare in the dental literature. Important as challenging at the same time, the development of economic analyses integrating diverse treatment protocols constitutes a complex mission (Eaddy et al. 2012). Differences between service delivery systems, such as a university environment or a private practice setting, and the variability of treatment approaches combined with patient-based factors have to be taken into account. Moreover, international properties with dissimilar health care systems, purchasing power, cultural, generational, and gender differences markedly

1430

Authors:
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Article summary of:

“Digital vs. conventional implant prosthetic workflows: a cost/time analysis”

Results:

Overall, cost minimization analysis exhibited an 18% cost reduction within the digital process.

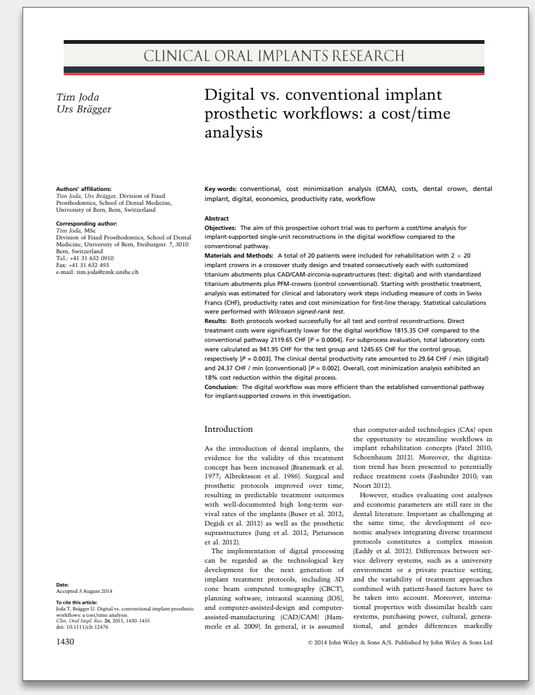
Both protocols worked successfully for all test and control reconstructions.

	Digital Workflow	Conventional Workflow	Statistic
Direct treatment costs	1815.35 CHF	2119.65 CHF	Significant [P = 0.0004]
Total laboratory costs	941.95 CHF	1245.65 CHF	Significant [P = 0.0003]
The clinical dental productivity rate	29.64 CHF / min	24.37 CHF / min	[P = 0.0002]

Conclusion:

The digital workflow was more efficient than the well-established conventional pathway.

Article:



CLINICAL ORAL IMPLANTS RESEARCH

Tim Joda
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Digital vs. conventional implant prosthetic workflows: a cost/time analysis

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Article summary of:

“Patient-centered outcomes comparing digital and conventional implant impression procedures: a randomized crossover trial”

iTero™

Objectives:

The aim of this randomized controlled trial was to compare patient-centered outcomes during digital and conventional implant impressions.

Materials and methods:

Intraoral scanning (IOS) [test] as well as classical polyether impressions [control] were both performed on

- 20 patients
- single-tooth replacement with implant-supported crowns
- Crossover study design
- Test: Patients’ perception and satisfaction on the level of convenience-related factors were assessed with visual analogue scale (VAS) questionnaires.

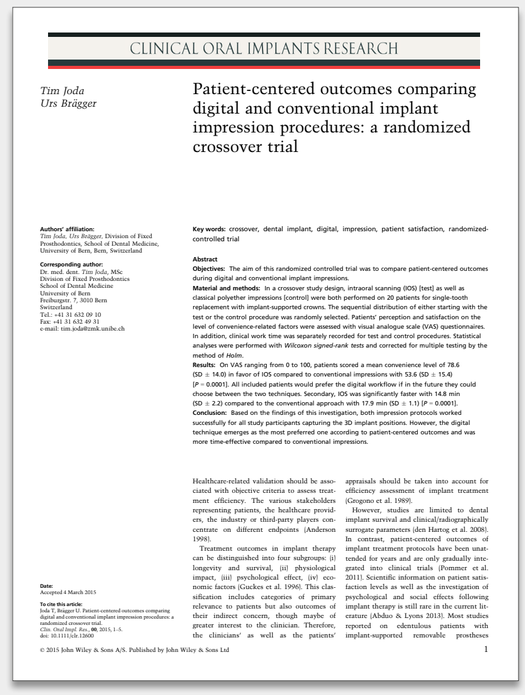
In addition, clinical work time was separately recorded for test and control procedures.

- Statistical analyses with Wilcoxon signed-rank tests and corrected for multiple testing by the method of Holm.

Results:

On VAS (visual analogue scale) ranging from 0 to 100, patients scored a mean convenience level of 78.6 (SD ± 14.0) in favor of Intraoral scanner compared to conventional impressions with 53.6(SD ± 15.4) [P = 0.0001]. All included patients would prefer the digital workflow if in the future they could choose between the two techniques. Secondary, Intraoral scanner was significantly faster with 14.8 min (SD ± 2.2) compared to the conventional approach with 17.9 min (SD ± 1.1) [P = 0.0001].

Article:



CLINICAL ORAL IMPLANTS RESEARCH

Tim Joda
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Patient-centered outcomes comparing digital and conventional implant impression procedures: a randomized crossover trial

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Key words: crossover, dental implant, digital, impression, patient satisfaction, randomized-controlled trial

Abstract

Objectives: The aim of this randomized controlled trial was to compare patient-centered outcomes during digital and conventional implant impressions.

Material and methods: In a crossover study design, intraoral scanning (IOS) [test] as well as classical polyether impressions [control] were both performed on 20 patients for single-tooth replacement with implant-supported crowns. The sequential distribution of either starting with the test or the control procedure was randomly selected. Patients' perception and satisfaction on the level of convenience-related factors were assessed with visual analogue scale (VAS) questionnaires. In addition, clinical work time was separately recorded for test and control procedures. Statistical analyses were performed with *Wilcoxon* signed-rank tests and corrected for multiple testing by the method of *Holm*.

Results: On VAS ranging from 0 to 100, patients scored a mean convenience level of 78.6 (SD ± 14.0) in favor of IOS compared to conventional impressions with 53.6 (SD ± 15.4) [*P* = 0.0001]. All included patients would prefer the digital workflow if in the future they could choose between the two techniques. Secondary, IOS was significantly faster with 14.8 min (SD ± 2.2) compared to the conventional approach with 17.9 min (SD ± 1.1) [*P* = 0.0001].

Conclusion: Based on the findings of this investigation, both impression protocols worked successfully for all study participants capturing the 3D implant positions. However, the digital technique emerges as the most preferred one according to patient-centered outcomes and was more time-effective compared to conventional impressions.

Date:
Accepted 4 March 2015

To cite this article:
Joda T, Brägger U. Patient-centered outcomes comparing digital and conventional implant impression procedures: a randomized crossover trial.
Clin. Oral Impl. Res., **00**, 2015, 1–5.
doi: 10.1111/clr.12600

Healthcare-related validation should be associated with objective criteria to assess treatment efficiency. The various stakeholders representing patients, the healthcare providers, the industry or third-party players concentrate on different endpoints (Anderson 1998).

Treatment outcomes in implant therapy can be distinguished into four subgroups: (i) longevity and survival, (ii) physiological impact, (iii) psychological effect, (iv) economic factors (Guyatt et al. 1996). This classification includes categories of primary relevance to patients but also outcomes of their indirect concern, though maybe of greater interest to the clinician. Therefore, the clinicians' as well as the patients' appraisals should be taken into account for efficiency assessment of implant treatment (Cosgrove et al. 1989).

However, studies are limited to dental implant survival and clinical/radiographically surrogate parameters (den Hartog et al. 2008). In contrast, patient-centered outcomes of implant treatment protocols have been unattended for years and are only gradually integrated into clinical trials (Pommer et al. 2011). Scientific information on patient satisfaction levels as well as the investigation of psychological and social effects following implant therapy is still rare in the current literature (Abduo & Lyons 2013). Most studies reported on edentulous patients with implant-supported removable prostheses

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Article summary of:

“Patient-centered outcomes comparing digital and conventional implant impression procedures: a randomized crossover trial”

Questions on patient satisfaction with digital and conventional impression procedures and mean scores of the results.

VAS (visual analogue scale): unsatisfactory 0 – 100 excellent

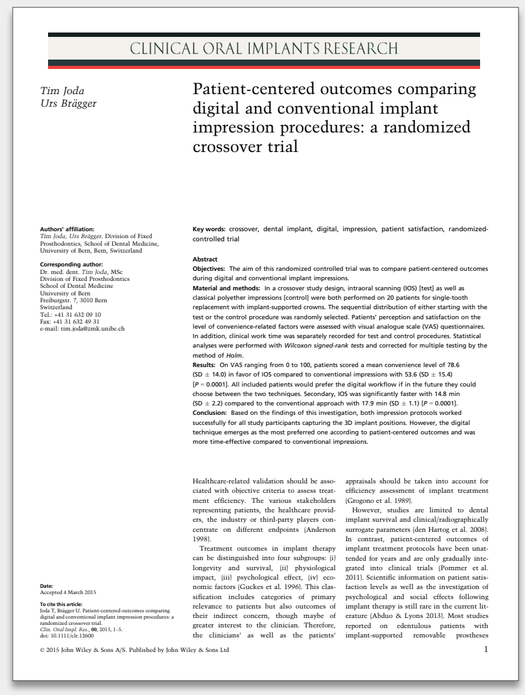
12 Questions (2 x 6)	Digital Impression	Conventional impression
What is your opinion on the treatment time required for the impression procedure?	Mean 79.2; SD ± 12.1 median 83.0; range 50–95	Mean 57.6; SD ± 15.6 median 59.5; range 17–95
How convenient was the impression procedure for you?	Mean 78.6; SD ± 14.0median 84.0; range 35–90	Mean 53.6; SD ± 15.4 median 53.5; range 15–85
Was there a bad oral taste present and/or after the impression procedure?	Mean 10.9; SD ± 9.5 median 6.5; range 0–36	Mean 71.3; SD ± 15.7 median 77.5; range 25–87
Was there a bad oral taste present and/or after the impression procedure?	Mean 10.9; SD ± 9.5 median 6.5; range 0–36	Mean 71.3; SD ± 15.7 median 77.5; range 25–87
Did you experience a nausea sensation during impression procedure?	Mean 12.2; SD ± 11.4 median 7.0; range 0–51	Mean 68.7; SD ± 18.0 median 74.0; range 10–93
Did you experience pain during impression procedure?	Mean 13.9; SD ± 10.3median 13.0; range 0–36	Mean 44.6; SD ± 20.7 median 45.0; range 5–77

Conclusion:

The digital technique emerges as the most preferred one according to patient-centered outcomes and was more time-effective compared to conventional impressions. Within the limitations of this clinical crossover study, the following conclusions can be summarized:

- The digital workflow was significantly accepted as the most preferred and time effective implant impression procedure compared to the conventional technique with regard to the patients’ perception and satisfaction.
- With regard to treatment comfort, the digital impression protocol with Intraoral scanners was more patient-friendly than the conventional approach when it was performed by an experienced team of dentist/dental assistance.
- Both workflows worked clinically successful restoring single-tooth gaps with implant-supported crowns.

Article:



CLINICAL ORAL IMPLANTS RESEARCH

Tim Joda
Urs Brägger

Patient-centered outcomes comparing digital and conventional implant impression procedures: a randomized crossover trial

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Reference:

Clin. Oral Impl. Res., 00, 2015, 1–5. doi: 10.1111/clr.12600

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Article summary of:

“Time-Efficiency Analysis Comparing Digital and Conventional Workflows for Implant Crowns: A Prospective Clinical Crossover Trial”

Objectives:

To compare time-efficiency in the production of implant crowns using a digital workflow versus the conventional pathway.

Materials and methods:

- 20 patients
- single-tooth replacements in posterior sites
- Crossover study design
- Test: Each patient received
  - for those in the test group, using digital workflow: a customized titanium abutment plus a computer-aided design/computer-assisted manufacture (CAD/CAM) zirconia suprastructure
  - for those in the control group, using a conventional pathway: a standardized titanium abutment plus a porcelain- fused- to-metal crown
- The start of the implant prosthetic treatment was established as the baseline.
- Time-efficiency analysis was defined as the primary outcome, and was measured for every single clinical and laboratory work step in minutes.
- Statistical calculations with Wilcoxon rank sum test

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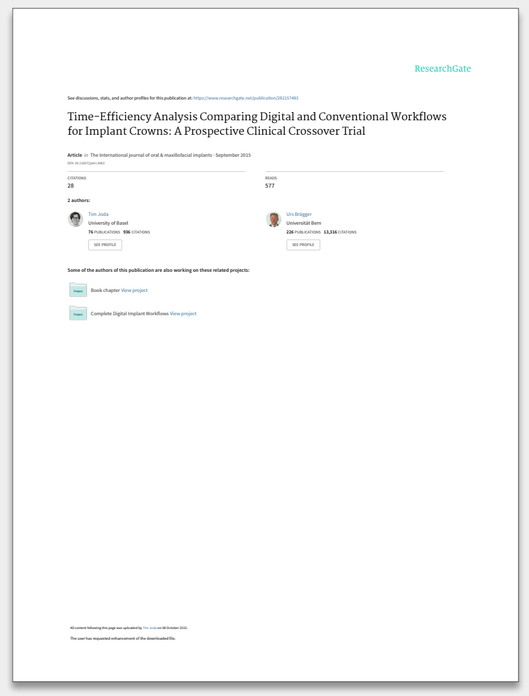

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Time-Efficiency Analysis Comparing Digital and Conventional Workflows for Implant Crowns: A Prospective Clinical Crossover Trial

Article in The International journal of oral & maxillofacial implants · September 2015

DOI: 10.11607/jomi.3963

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Article summary of:

“Time-Efficiency Analysis Comparing Digital and Conventional Workflows for Implant Crowns: A Prospective Clinical Crossover Trial”

iTero™

Results:

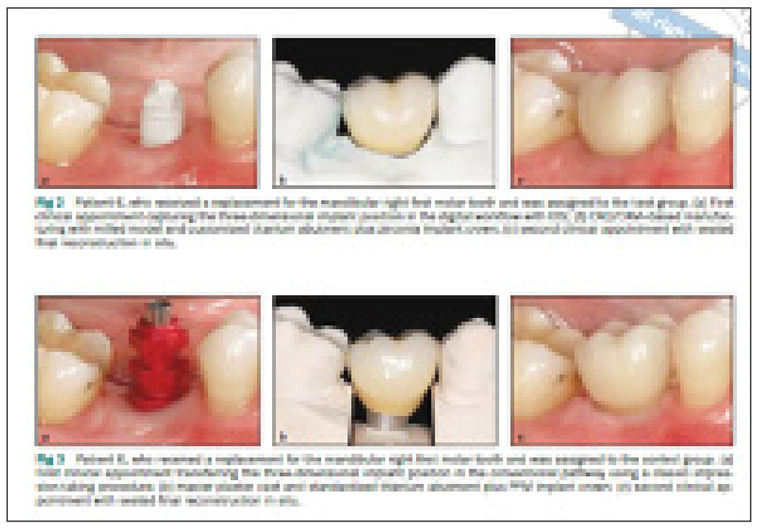
All crowns could be provided within two clinical appointments, independent of the manufacturing process.

The mean total production time, as the sum of clinical plus laboratory work steps, was significantly different.

The mean ± standard deviation (SD) time was 185.4 ± 17.9 minutes for the digital workflow process and 223.0 ± 26.2 minutes for the conventional pathway (P = .0001).

Therefore, digital processing for overall treatment was 16% faster.

Detailed analysis for the clinical treatment revealed a significantly reduced mean ± SD chair time of 27.3 ± 3.4 minutes for the test group compared with 33.2 ± 4.9 minutes for the control group (P = .0001). Similar results were found for the mean laboratory work time, with a significant decrease of 158.1 ± 17.2 minutes for the test group vs 189.8 ± 25.3 minutes for the control group (P = .0001).



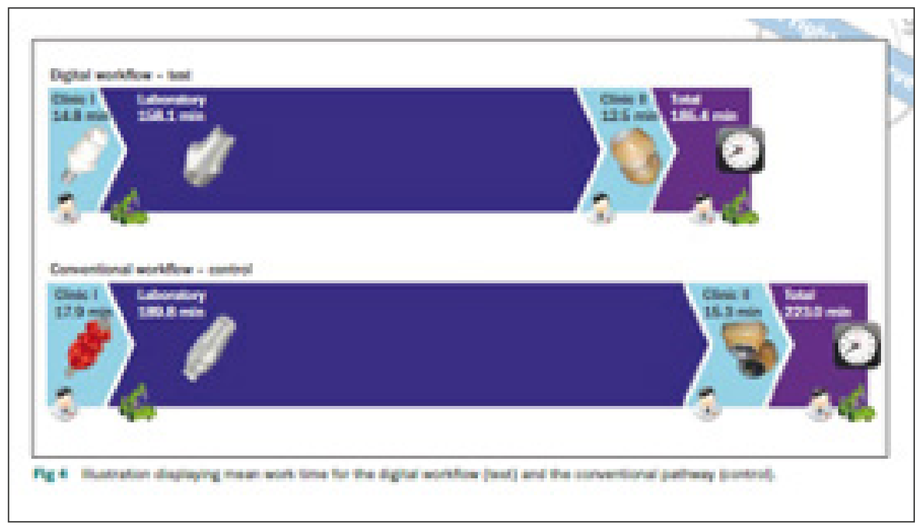
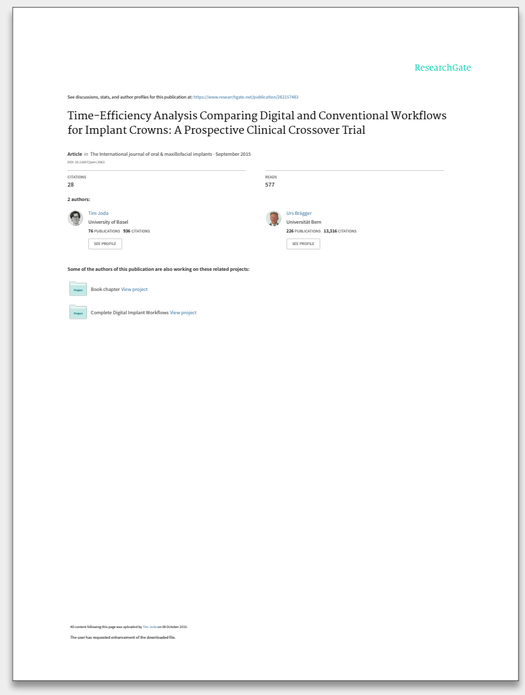


Fig 4 Illustration displaying mean work time for the digital workflow (test) and the conventional pathway (control).

Conclusion:

This investigation shows that the digital workflow seems to be more time-efficient than the established conventional production pathway for fixed implant-supported crowns. Both clinical chair time and laboratory manufacturing steps could be effectively shortened with the digital process of intraoral scanning plus CAD/CAM technology.

Article: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Article summary of:

“Accuracy of full-arch digital impressions: an in vitro and in vivo comparison.”

iTero™

Objectives:

Comparison of full-arch digital impressions to conventional impressions in vitro and in vivo.

Materials and methods:

Reference structure: A straight metal bar fixed between the second upper molars in the mouth of a voluntary patient and a corresponding polymer model.

The following digitalization methods were applied:

- The maxilla was digitized in vivo 12 times with the iTero Element™ scanner (P-SCAN);
- The maxilla was captured in vivo 12 times by conventional impression and the impression was digitized by a desktop scanner (P-IMP);
- The impressions were poured and the 12 referring gypsum master-casts were scanned with the same desktop scanner (P-CAST)
- The polymer model was digitized in vitro 12 times with the iTero Element scanner (M-SCAN);
- The polymer model was captured in vitro 2 times by conventional impression and the impression was digitized by a desktop scanner (M-IMP);
- The impressions were poured and the 12 referring gypsum master-casts were scanned with the same desktop scanner (M-CAST).

Datasets were exported and metrically analyzed (Geomagic Control X) to determine three dimensional length aberration and angular distortion versus the reference structure Mann-Whitney U test was implemented to detect differences ($p < 0.05$).

Article:

Clinical Oral Investigations
https://doi.org/10.1007/s00784-019-02965-2

ORIGINAL ARTICLE

Check for updates

Accuracy of full-arch digital impressions: an in vitro and in vivo comparison

Christine Keul[1] · Jan-Frederik Güth[1]

Received: 11 January 2019 / Accepted: 16 May 2019

Abstract
Objectives Comparison of full-arch digital impressions to conventional impressions in vitro and in vivo.
Materials and methods A straight metal bar was fixed between the second upper molars as a reference structure in the mouth of a voluntary patient and a corresponding polymer model. The following digitalization methods were applied: (1) the maxilla was digitized in vivo 12 times with the iTero Element (P-SCAN); (2) the maxilla was captured in vivo 12 times by conventional impression and the impression was digitized by a desktop scanner (P-IMP); (3) the impressions were poured and the 12 referring gypsum master-casts were scanned with the same desktop scanner (P-CAST); (4) the polymer model was digitized in vitro 12 times with the iTero Element (M-SCAN); (5) the polymer model was captured in vitro 12 times by conventional impression and the impression was digitized by a desktop scanner (M-IMP); (6) the impressions were poured and the 12 referring gypsum master-casts were scanned with the same desktop scanner (M-CAST). Datasets were exported and metrically analyzed (Geomagic Control X) to determine three-dimensional length aberration and angular distortion versus the reference structure. Mann–Whitney *U* test was implemented to detect differences ($p < 0.05$).
Results For multiple accuracy parameters, P-SCAN and M-SCAN showed similar or superior results compared to the other digitalization methods. The following length deviations were found: M-SCAN (~ 55 to 80 µm), M-IMP (110 to 329 µm), M-CAST (88 to 178 µm), P-SCAN (~ 67 to 76 µm), P-IMP (125–320 µm), and P-CAST (92–285 µm).
Conclusions Within the limitations of this study, the iTero-scan seems to be a valid alternative to conventional impressions for full arches.
Clinical relevance Intraoral scanners are more and more used in daily routine; however, little is known about their accuracy when it comes to full-arch scans. Under optimum conditions, the direct digitalization using the iTero Element intraoral scanning device results in the same and for single parameters (arch width and arch distortion) even in higher accuracy than the indirect digitalization of the impression or the gypsum cast using a desktop scanner.

Keywords Digital impression · Accuracy · Full-arch impression · iTero Element · Metrology analysis

Introduction

Intraoral scanning supplements more and more the well-established conventional impressions using elastomers and the subsequent indirect digitalization of the impressions itself or the resulting casts. Therefore it can be meanwhile considered as a common entry to dental computer-aided design/computer-aided manufacturing (CAD/CAM) processes [1]. Virtual models are the basis for all steps in the digital workflow that enables a wide range of innovative diagnosis and rehabilitation options for a patient-centered treatment [2–4].

The available intraoral digitalization systems are working on optical measuring principles [5, 6] to digitize the intraoral structures directly in the patient's mouth [7, 8]. This avoids different working steps, like the selection of the proper impression tray, application of the adequate impression technique, disinfection, transport, and fabrication of dental gypsum casts. Besides the understandable enthusiasm for intraoral

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Published online: 27 May 2019

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Authors:
Christine Keul,
Jan-Frederik Güth

Reference:
Clin Oral Investig. 2019 May 27

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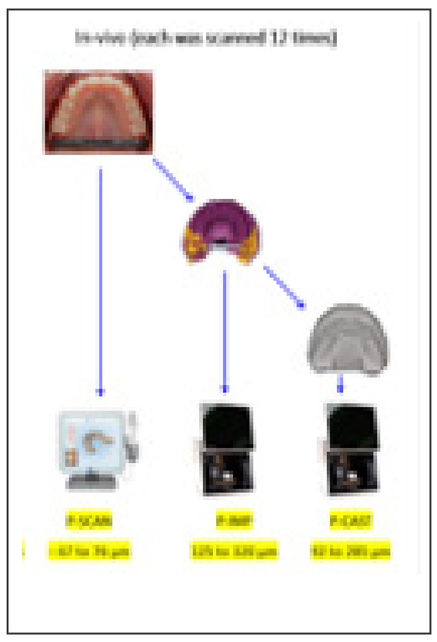
Article summary of:

"Accuracy of full-arch digital impressions: an in vitro and in vivo comparison."

iTero™

Results:

For multiple accuracy parameters, P-SCAN (iTero scan) and M-SCAN (iTero™ scan of polymer model) showed similar or superior results compared to the other digitalization methods.



CLINICAL RELEVANCE:

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The following length deviations were found:

	Substrate	Captured with	Digitized with	
M-SCAN	Polymer model	iTero	N/A	-55 to 80 µm
M-IMP	Polymer model	Conventional impression	Desktop scanner	110 to 329 µm
M-CAST	Polymer model	Casted conventional impression	Desktop scanner	88 to 178 µm
P-SCAN	Maxilla	iTero	N/A	- 67 to 76 µm
P-IMP	Maxilla	Conventional impression	Desktop scanner	125-320 µm
P-CAST	Maxilla	Casted conventional impression	Desktop scanner	92-285 µm

Conclusion:

Within the limitations of this study, the iTero™ scan seems to be a valid alternative to conventional impressions for full arches

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Article summary of:

“A new method to measure the accuracy of intraoral scanners along the complete dental arch: A pilot study.”

iTero™

Purpose:

The purpose of this study is to assess the accuracy of three intraoral scanners along the complete dental arch and evaluate the feasibility of the assessment methodology for further in vivo analysis.

Materials and methods:

A specific measurement pattern was fabricated and measured using a coordinate measuring machine for the assessment of control distances and angles. Afterwards, the pattern was placed and fixed in replica of an upper jaw for their subsequent scans (10 times) using 3 intraoral scanners, namely iTero Element™ scanner, 3shape Trios 3 scanner, and 3M True Definition scanner. 4 reference distances and 5 angles were measured and compared with the controls. Trueness and precision were assessed for each Intraoral scanner: trueness, as the deviation of the measures from the control ones, while precision, as the dispersion of measurements in each reference parameter. These measurements were carried out using software for analyzing 3-dimensional data. Data analysis software was used for statistical and measurements analysis (a=.05).

Results:

Significant differences (P<.05) were found depending on the intraoral scanner used. Best trueness values were achieved with iTero Element scanner (mean from 10 ± 7 µm to 91 ± 63 µm) while the worst values were obtained with 3shapeTrios 3 scanner (mean from 42 ± 23 µm to 174 ± 77 µm). Trueness analysis in angle measurements, as well as precision analysis, did not show conclusive results.

Article:

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A new method to measure the accuracy of intraoral scanners along the complete dental arch: A pilot study

Mikel Iturrate[1*], Erlantz Lizundia[2,3], Xabier Amezua[4], Eneko Solaberrieta[4]

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[2]Department of Graphic Design and Engineering Projects, Bilbao Faculty of Engineering, University of the Basque Country UPV/EHU; Bilbao, Spain
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[4]Department of Graphic Design and Engineering Projects, Gipuzkoa Faculty of Engineering, University of the Basque Country UPV/EHU; Donostia - San Sebastián, Spain

PURPOSE. The purpose of this study is to assess the accuracy of three intraoral scannees along the complete dental arch and evaluate the feasibility of the assessment methodology for further *in vivo* analysis. **MATERIALS AND METHODS.** A specific measurement pattern was fabricated and measured using a coordinate measuring machine for the assessment of control distances and angles. Afterwards, the pattern was placed and fixed in replica of an upper jaw for their subsequent scans (10 times) using 3 intraoral scanners, namely iTero Element1 , Trios 3, and True Definition. 4 reference distances and 5 angles were measured and compared with the controls. Trueness and precision were assessed for each IOS: trueness, as the deviation of the measures from the control ones, while precision, as the dispersion of measurements in each reference parameter. These measurements were carried out using software for analyzing 3-dimensional data. Data analysis software was used for statistical and measurements analysis (a=.05). **RESULTS.** Significant differences (P<.05) were found depending on the intraoral scanner used. Best trueness values were achieved with iTero Element1 (mean from 10 ± 7 µm to 91 ± 63 µm) while the worst values were obtained with Trios3 (mean from 42 ± 23 µm to 174 ± 77 µm). Trueness analysis in angle measurements, as well as precision analysis, did not show conclusive results. **CONCLUSION.** iTero Element1 was more accurate than the current versions of Trios3 and True Definition. Importantly, the proposed methodology is considered reliable for analyzing accuracy in any dental arch length and valid for assessing both trueness and precision in an *in vivo* study. ***[J Adv Prosthodont 2019;11:331-40]***

KEYWORDS: Intraoral scanner; Accuracy; Trueness; Digital impression; Computer-aided design and computer-aided manufacturing (CAD/CAM)

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Received July 10, 2019 / Last Revision October 8, 2019/ Accepted December 12, 2019

The work was partially supported by the Country Council of Gipuzkoa (Grant number 70/19).

INTRODUCTION

For intraoral scanners (IOS) to prevail over the conventional method, they must be easy-to-use and more efficient devices, and, especially, they must provide more accurate dental impressions for any restoration case. Accuracy is a requirement in any dental specialty, although it is certain that in some particular cases, the maximum allowable deviations are more restrictive. Prosthodontics is one of these specialties in which accuracy requirements are most demanding. This means that restorations fabricated from digital impressions must fit without causing any long-term clinical complications, i.e. with passive fit.[1] So far, the limits of the passive fit

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Mikel Iturrate, Erlantz Lizundia, Xabier Amezua, Eneko Solaberrieta

Reference: J Adv Prosthodont. 2019 Dec;11(6):331-340.

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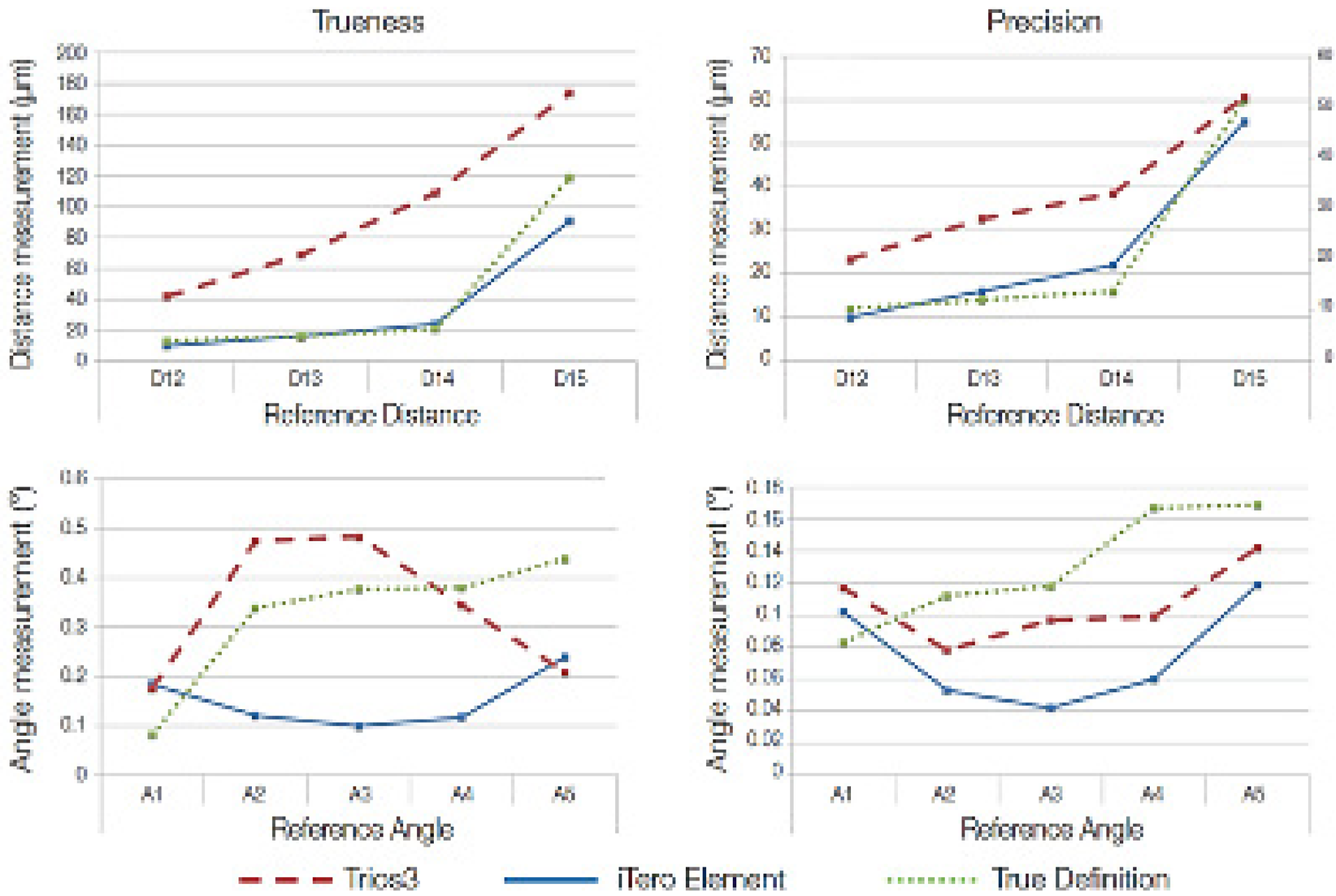
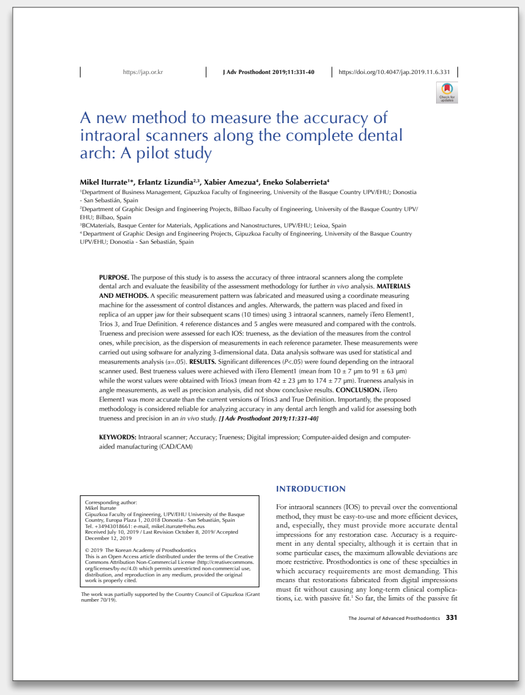


Conclusion:

iTero Element was more accurate than the 3shape Trios 3 scanner and 3M True Definition scanner. Importantly, the proposed methodology is considered reliable for analyzing accuracy in any dental arch length and valid for assessing both trueness and precision in an in vivo study.

Article:



https://jap.or.kr | J Adv Prosthodont 2019;11:331-40 | https://doi.org/10.4047/jap.2019.11.6.331

A new method to measure the accuracy of intraoral scanners along the complete dental arch: A pilot study

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PURPOSE. The purpose of this study is to assess the accuracy of three intraoral scanners along the complete dental arch and evaluate the feasibility of the assessment methodology for further *in vivo* analysis. **MATERIALS AND METHODS.** A specific measurement pattern was fabricated and measured using a coordinate measuring machine for the assessment of control distances and angles. Afterwards, the pattern was placed and fixed in replica of an upper jaw for their subsequent scans (10 times) using 3 intraoral scanners, namely iTero Element1, Trios 3, and True Definition. 4 reference distances and 5 angles were measured and compared with the controls. Trueness and precision were assessed for each IOS: trueness, as the deviation of the measures from the control ones, while precision, as the dispersion of measurements in each reference parameter. These measurements were carried out using software for analyzing 3-dimensional data. Data analysis software was used for statistical and measurements analysis (α=.05). **RESULTS.** Significant differences (P<.05) were found depending on the intraoral scanner used. Best trueness values were achieved with iTero Element1 (mean from 10 ± 7 µm to 91 ± 63 µm) while the worst values were obtained with Trios3 (mean from 42 ± 23 µm to 174 ± 77 µm). Trueness analysis in angle measurements, as well as precision analysis, did not show conclusive results. **CONCLUSION.** iTero Element1 was more accurate than the current versions of Trios3 and True Definition. Importantly, the proposed methodology is considered reliable for analyzing accuracy in any dental arch length and valid for assessing both trueness and precision in an *in vivo* study. *[J Adv Prosthodont 2019;11:331-40]*

KEYWORDS: Intraoral scanner; Accuracy; Trueness; Digital impression; Computer-aided design and computer-aided manufacturing (CAD/CAM)

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INTRODUCTION

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Article summary of:

“Randomized controlled clinical trial of digital and conventional workflows for the fabrication of zirconia-ceramic fixed partial dentures. Part III: Marginal and internal fit”

Objectives:

The purpose of the third part of this clinical study was to test whether the fit of zirconia 3-unit frameworks for fixed partial dentures fabricated with fully digital workflows differed from that of metal frameworks fabricated with the conventional workflow.

Materials and methods:

- 10 patients
- 4 fixed-partial-denture frameworks were fabricated for the same abutment teeth
- Digital workflows were applied for the fabrication of 3 zirconia frameworks with Lava, iTero™ scanner, and Cerec infiniDent systems
- Conventional workflow included a polyether impression, manual waxing, the lost-wax technique, and the casting of a metal framework.
- Test : For each participant
  - 3 FPDs were digitally fabricated, and 1 FPD was conventionally fabricated.
  - The sequence of the FPD assessment was randomly allocated according to a computer-generated list.
  - To reduce operator bias, the investigators generated and evaluated the replicas without being able to distinguish among the digitally fabricated FPDs under investigation.

Article:

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THE JOURNAL OF PROSTHETIC DENTISTRY

CLINICAL RESEARCH

Randomized controlled clinical trial of digital and conventional workflows for the fabrication of zirconia-ceramic fixed partial dentures. Part III: Marginal and internal fit

Goran I. Benic, PD Dr med dent,[a] Irena Sailer, Prof Dr med dent,[b] Marco Zeltner, Dr med dent,[c] Janine N. Gütermann,[d] Mutlu Özcan, Prof(NL) Dr med dent,[e] and Sven Mühlemann, Dr med dent[f]

ABSTRACT

Statement of problem. Trials comparing the overall performances of digital and conventional workflows in restorative dentistry are lacking.

Purpose. The purpose of the third part of this clinical study was to test whether the fit of zirconia 3-unit frameworks for fixed partial dentures fabricated with fully digital workflows differed from that of metal frameworks fabricated with the conventional workflow.

Material and methods. In each of 10 participants, 4 fixed-partial-denture frameworks were fabricated for the same abutment teeth according to a randomly generated sequence. Digital workflows were applied for the fabrication of 3 zirconia frameworks with Lava, iTero, and Cerec infiniDent systems. The conventional workflow included a polyether impression, manual waxing, the lost-wax technique, and the casting of a metal framework. The discrepancies between the frameworks and the abutment teeth were registered using the replica technique with polyvinyl siloxane. The dimensions of the marginal discrepancy ($Discrepancy_{marginal}$) and the internal discrepancy in 4 different regions of interest ($Discrepancy_{shoulder}$, $Discrepancy_{axial}$, $Discrepancy_{line}$, and $Discrepancy_{occlusal}$) were assessed using a light microscope. Post hoc t tests with Bonferroni correction were applied to detect differences (α=.05).

Results. $Discrepancy_{shoulder}$ was 96.1 ±61.7 μm for the iTero, 106.9 ±96.0 μm for the Lava, 112.2 ±76.7 μm for the Cerec infiniDent, and 126.5 ±91.0 μm for the conventional workflow. The difference between the iTero and the conventional workflow was statistically significant (P=.029). $Discrepancy_{occlusal}$ was 153.5 ±66.8 μm for the iTero, 203.3 ±127.9 μm for the Lava, 179.7 ±63.1 μm for the Cerec infiniDent, and 148.8 ±66.8 μm for the conventional workflow. $Discrepancy_{occlusal}$ was significantly lower for the conventional workflow than for the Lava and the Cerec infiniDent workflows (P<.01). The iTero resulted in significantly lower values of $Discrepancy_{occlusal}$ than the Lava and the Cerec infiniDent workflows (P<.01).

Conclusions. In terms of framework fit in the region of the shoulder, digitally fabricated zirconia 3-unit frameworks presented similar or better fit than the conventionally fabricated metal frameworks. In the occlusal regions, the conventionally fabricated metal frameworks achieved a more favorable fit than the CAD-CAM zirconia frameworks. (J Prosthet Dent 2018;■:■■)

Funding: This work was supported by the Clinic of Fixed and Removable Prosthodontics and Dental Material Science, Center of Dental Medicine, University of Zurich, Switzerland, and by a research grant from the Institut Straumann AG, Basel, Switzerland.
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[f]Senior Teaching and Research Assistant, Clinic of Fixed and Removable Prosthodontics and Dental Material Science, Center of Dental Medicine, University of Zurich, Zurich, Switzerland.

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Goran I. Benic, Irena Sailer, Marco Zeltner, Janine N. Gütermann, Mutlu Özcan and Sven Mühlemann

Reference:
J Prosthet Dent. 2019 Mar;121(3):426-431

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Article summary of:

"Randomized controlled clinical trial of digital and conventional workflows for the fabrication of zirconia-ceramic fixed partial dentures. Part III: Marginal and internal fit"

iTero™

Results:	Conventional	iTero	Lava	CEREC infiniDent
Discrepancy shoulder	126.5 ±91.0 mm	96.1 ±61.7 mm	106.9 ±96.0 mm	112.2 ±76.7 mm
Discrepancy occlusal	148.8 ±66.8 mm	153.5 ±66.8 mm	203.3 ±127.9 mm	179.7 ±63.1 mm

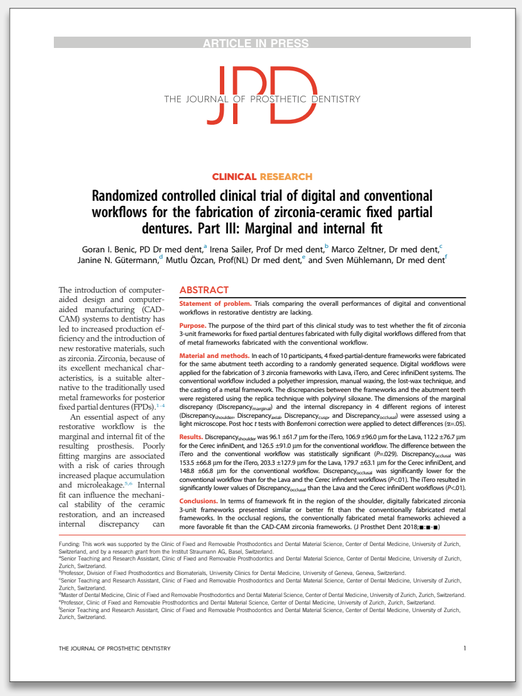
The difference between the the iTero™ scanner and the conventional workflow was statistically significant (P=.029).

The iTero™ scanner resulted in significantly lower values of Discrepancy occlusal than the Lava and the Cerec infini Dent workflows (P<.01).The difference between iTero and Conventional was not statistically significant.

Conclusion:

In terms of frameworks presented similar or better fit than the conventionally fabricated metal frameworks. In the occlusal regions, the conventionally fabricated metal frameworks achieved a more favorable fit than the CAD-CAM zirconia frameworks.

Article: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THE JOURNAL OF PROSTHETIC DENTISTRY

CLINICAL RESEARCH

Randomized controlled clinical trial of digital and conventional workflows for the fabrication of zirconia-ceramic fixed partial dentures. Part III: Marginal and internal fit

Goran I. Benic, PD Dr med dent,[a] Irena Sailer, Prof Dr med dent,[b] Marco Zeltner, Dr med dent,[c] Janine N. Gütermann,[d] Mutlu Özcan, Prof(NL) Dr med dent,[e] and Sven Mühlemann, Dr med dent[f]

ABSTRACT

Statement of problem. Trials comparing the overall performances of digital and conventional workflows in restorative dentistry are lacking.

Purpose. The purpose of the third part of this clinical study was to test whether the fit of zirconia 3-unit frameworks for fixed partial dentures fabricated with fully digital workflows differed from that of metal frameworks fabricated with the conventional workflow.

Material and methods. In each of 10 participants, 4 fixed-partial-denture frameworks were fabricated for the same abutment teeth according to a randomly generated sequence. Digital workflows were applied for the fabrication of 3 zirconia frameworks with Lava, iTero, and Cerec infiniDent systems. The conventional workflow included a polyether impression, manual waxing, the lost-wax technique, and the casting of a metal framework. The discrepancies between the frameworks and the abutment teeth were registered using the replica technique with polyvinyl siloxane. The dimensions of the marginal discrepancy ($Discrepancy_{marginal}$) and the internal discrepancy in 4 different regions of interest ($Discrepancy_{shoulder}$, $Discrepancy_{axial}$, $Discrepancy_{cusp}$, and $Discrepancy_{occlusal}$) were assessed using a light microscope. Post hoc t tests with Bonferroni correction were applied to detect differences (α=.05).

Results. $Discrepancy_{shoulder}$ was 96.1 ±61.7 μm for the iTero, 106.9 ±96.0 μm for the Lava, 112.2 ±76.7 μm for the Cerec infiniDent, and 126.5 ±91.0 μm for the conventional workflow. The difference between the iTero and the conventional workflow was statistically significant (P=.029). $Discrepancy_{occlusal}$ was 153.5 ±66.8 μm for the iTero, 203.3 ±127.9 μm for the Lava, 179.7 ±63.1 μm for the Cerec infiniDent, and 148.8 ±66.8 μm for the conventional workflow. $Discrepancy_{occlusal}$ was significantly lower for the conventional workflow than for the Lava and the Cerec infiniDent workflows (P<.01). The iTero resulted in significantly lower values of $Discrepancy_{occlusal}$ than the Lava and the Cerec infiniDent workflows (P<.01).

Conclusions. In terms of framework fit in the region of the shoulder, digitally fabricated zirconia 3-unit frameworks presented similar or better fit than the conventionally fabricated metal frameworks. In the occlusal regions, the conventionally fabricated metal frameworks achieved a more favorable fit than the CAD-CAM zirconia frameworks. (J Prosthet Dent 2018;■:■■■)

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THE JOURNAL OF PROSTHETIC DENTISTRY 1

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Article summary of:

“Trueness of 12 intraoral scanners in the full-arch implant impression: a comparative in vitro study”

iTero™

Objectives:

The aim of this in vitro study was to assess and compare the trueness of 12 different Intraoral scanners in FA implant impression.

Materials and methods:

- A stone-cast model of a totally edentulous maxilla with 6 implant analogues and scanbodies (SBs) was scanned with a desktop scanner (Freedom UHD®) to capture a reference model (RM), and with 12 Intraoral scanners :
  - ITERO ELEMENTS 5D®;
  - PRIMESCAN® and OMNICAM®;
  - CS 3700® and CS 3600®;
  - TRIOS3®; i-500®;
  - EMERALD S® and EMERALD® VIRTUO VIVO® and DWIO®;
  - RUNEYES QUICKSCAN®.
- Ten scans were taken using each Intraoral scanner, and each was compared to the RM, to evaluate trueness.
- A mesh/mesh method and a nurbs/nurbs method were used to evaluate the overall trueness of the scans;
- Linear and cross distances between the SBs were used to evaluate the local trueness of the scans.
- The analysis was performed using reverse engineering software (Studio®, Geomagics Magics®,Materialise).
- A statistical evaluation was performed.

In this in vitro study, a type IV gypsum model was used. This model represented a totally edentulous maxilla with 6 implant analogues in positions #11, #14, #16, #21, #24 and #26 (right and left central incisors, first premolars and first molars) and high-precision non-reflective polyether-ether-ketone (PEEK) SBs (Megagen®, Daegu, South Korea) screwed on

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BMC Oral Health

RESEARCH ARTICLE Open Access

Trueness of 12 intraoral scanners in the full-arch implant impression: a comparative in vitro study

Francesco Guido Mangano[1*], Oleg Admakin[1], Matteo Bonacina[2], Henriette Lerner[3], Vygandas Rutkunas[4] and Carlo Mangano[5]

Abstract

Background: The literature has not yet validated the use of intraoral scanners (IOSs) for full-arch (FA) implant impression. Hence, the aim of this in vitro study was to assess and compare the trueness of 12 different IOSs in FA implant impression.

Methods: A stone-cast model of a totally edentulous maxilla with 6 implant analogues and scanbodies (SBs) was scanned with a desktop scanner (Freedom UHD®) to capture a reference model (RM), and with 12 IOSs (ITERO ELEMENTS 5D®, PRIMESCAN® and OMNICAM®, CS 3700® and CS 3600®, TRIOS3®, i-500®, EMERALD S® and EMERALD®, VIRTUO VIVO® and DWIO®; RUNEYES QUICKSCAN®). Ten scans were taken using each IOS, and each was compared to the RM, to evaluate trueness. A mesh/mesh method and a nurbs/nurbs method were used to evaluate the overall trueness of the scans; linear and cross distances between the SBs were used to evaluate the local trueness of the scans. The analysis was performed using reverse engineering software (Studio®, Geomagics Magics®, Materialise). A statistical evaluation was performed.

Results: With the mesh/mesh method, the best results were obtained by CS 3700® (mean error 30.4 μm) followed by ITERO ELEMENTS 5D® (31.4 μm), i-500® (32.2 μm), TRIOS 3® (36.4 μm), CS 3600® (36.5 μm), PRIMESCAN® (38.4 μm), VIRTUO VIVO® (43.8 μm), RUNEYES® (44.4 μm), EMERALD S® (52.9 μm), EMERALD® (76.1 μm), OMNICAM® (79.6 μm) and DWIO® (98.4 μm). With the nurbs/nurbs method, the best results were obtained by ITERO ELEMENTS 5D® (mean error 16.1 μm), followed by PRIMESCAN® (19.3 μm), TRIOS 3® (20.2 μm), i-500® (20.8 μm), CS 3700® (21.9 μm), CS 3600® (24.4 μm), VIRTUO VIVO® (32.0 μm), RUNEYES® (33.9 μm), EMERALD S® (36.8 μm), OMNICAM® (47.0 μm), EMERALD® (51.9 μm) and DWIO® (69.9 μm). Statistically significant differences were found between the IOSs. Linear and cross distances between the SBs (local trueness analysis) confirmed the data that emerged from the overall trueness evaluation.

Conclusions: Different levels of trueness were found among the IOSs evaluated in this study. Further studies are needed to confirm these results.

Keywords: Intraoral scanner, Full-arch implant impression, Scanbody, Trueness, Comparative study

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Article summary of:

"Trueness of 12 intraoral scanners in the full-arch implant impression: a comparative in vitro study"

iTero™

Results:

Two methods of comparison were used:

1 - Mesh/mesh evaluation method

2 - Nurbs/nurbs evaluation method

Ranking (starting from best)	Mesh/Mesh Method	Nurbs/Nurbs Method
1	CS 3700® (mean error 30.4 µm)	ITERO ELEMENTS 5D® (mean error 16.1 µm)
2	ITERO ELEMENTS 5D® (31.4 µm),	PRIMESCAN® (19.3 µm),
3	i-500® (32.2 µm),	TRIOS 3® (20.2 µm),
4	TRIOS 3® (36.4 µm),	i-500® (20.8 µm),
5	CS 3600® (36.5 µm),	CS 3700® (21.9 µm),
6	PRIMESCAN® (38.4 µm),	CS3600® (24.4 µm),
7	VIRTUO VIVO® (43.8 µm),	VIRTUO VIVO® (32.0 µm),
8	RUNEYES® (44.4 µm),	RUNEYES® (33.9 µm),
9	EMERALD S® (52.9 µm),	EMERALD S® (36.8 µm),
10	EMERALD® (76.1 µm),	OMNICAM® (47.0 µm),
11	OMNICAM® (79.6 µm)	EMERALD® (51.9 µm)
12	DWIO® (98.4 µm).	DWIO® (69.9 µm).

Statistically significant differences were found between the Intraoral scanners. Linear and cross distances between the SBs (local trueness analysis) confirmed the data that emerged from the overall trueness evaluation.

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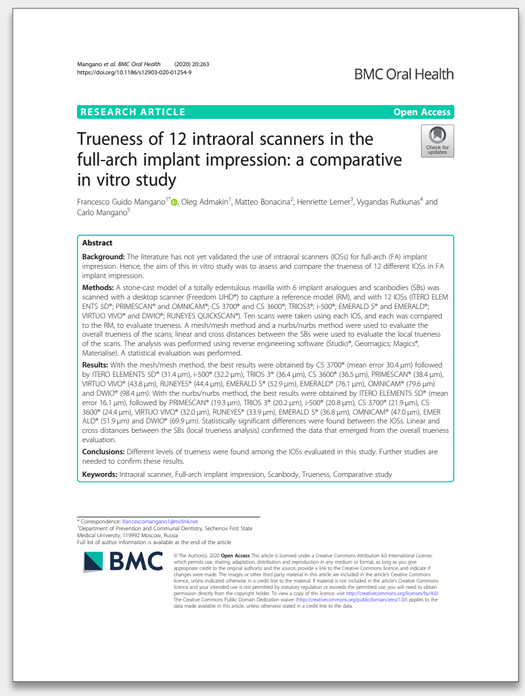

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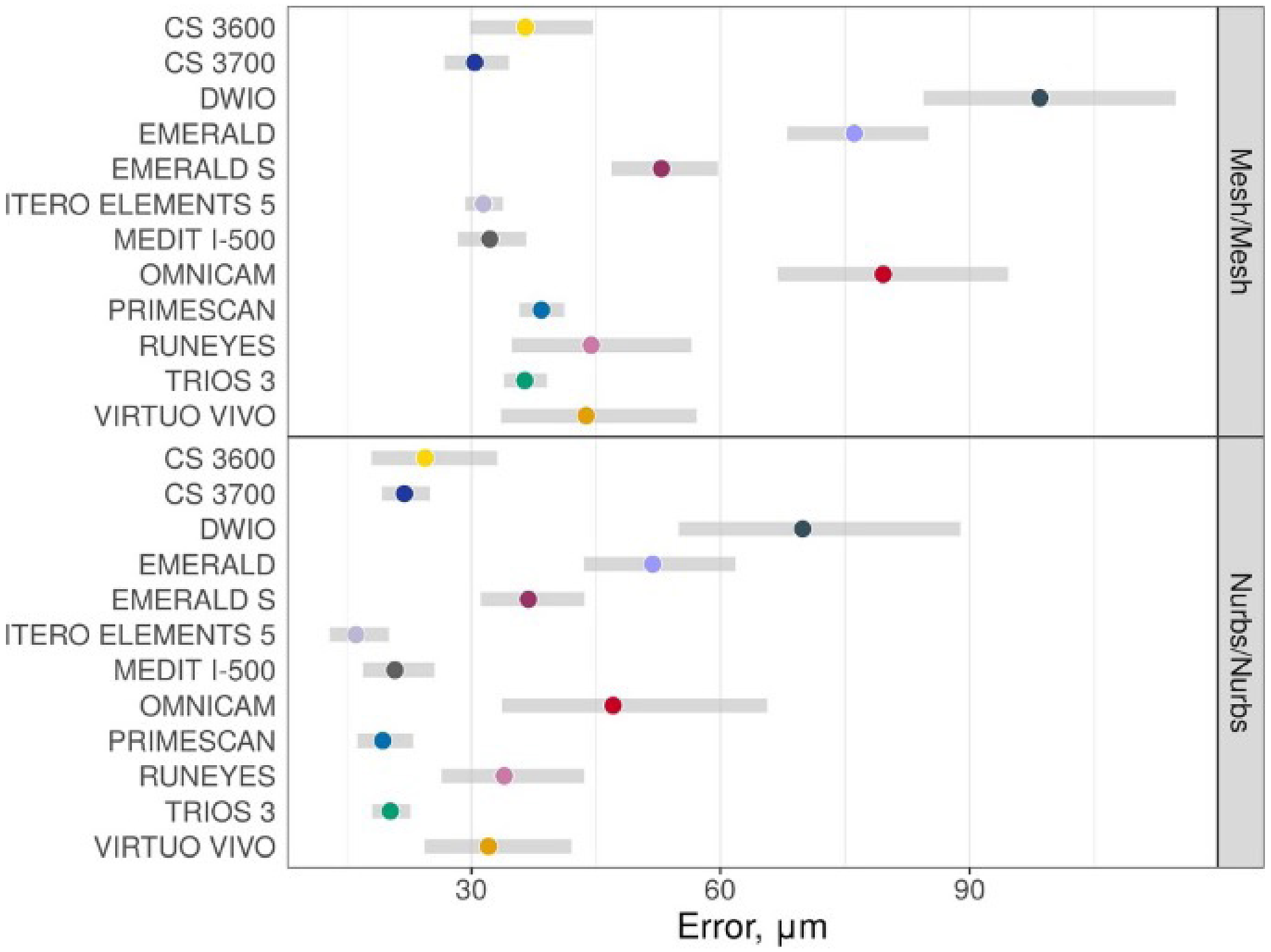

Fig. 3 Estimated mean errors (in µm, with 95% CIs) for mesh/mesh and nurbs/nurbs evaluations

Conclusion:

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Article summary of:

“Diagnostic validity of early proximal caries detection using near-infrared imaging technology on 3D range data of posterior teeth”

iTero™

Executive summary

- This study analysed potential of early proximal caries detection using 3D range data of teeth consisting of near-infrared reflection(NIRR) images.
- iTero Element™ 5D imaging system with the iTero NIRI technology mode activated can detect initial defects in the enamel with higher sensitivity than BWR, but it cannot, in contrast to BWR, support a reliable recommendation for or against invasive therapy when the EDJ is exceeded.
- Unlike other devices for caries diagnosis that use 850 nm LEDs as an infrared light source, the iTero Element 5D imaging system does not show any reflection artefacts caused by a smooth dental surface.
- Images acquired with the iTero NIRI technology scanner present light scattered in depth mainly at dentin and irregularities in enamel, without being superimposed by superficial specular reflections.
- The novel approach to entirely measure the dental arch from different directions can be an attractive option for the development of future diagnostic applications. It would be possible to calculate the complete surface texture for the entire 3D data set from the multitude of individual images.

Aim of the study

The aim of this study was to compare the diagnostic performance of the iTero Element 5D imaging system for the detection of early proximal caries with that of bitewings.

Materials and methods

- Two hundred fifty extracted permanent molars and premolars were selected from a pool of extracted teeth of anonymous patients.
- The samples were cleaned of any residues using manual scalers and assigned a unique identification number (ID).
- Using a lock-and-key fixation method, the teeth were divided into pairs, the tooth pairs were arranged to mimic the natural proximal contact area as closely as possible.
- Coupled sample pairs were fixed on a metal plate and then scanned with the iTero Element 5D imaging system with the iTero NIRI technology.
- The tooth pairs were radiographed without proximal contact for this study, to avoid hindering the evaluation of the radiographs by overlapping in the area of the proximal contacts and to enable the best possible radiographic diagnosis. All radiographs were taken using a Heliodent DS Dental X-ray unit (Sirona, Bensheim, Germany, 60 kV, 7 mA, 200 mm FHA cone, 0.08 s) and a digital charged-coupled device (CCD) sensor (Intra-Oral II CCD sensor, Sirona, Bensheim, Germany, sensor size 30.93×40.96×7.0 mm).

Article:

Clinical Oral Investigations (2022) 26:543–553
https://doi.org/10.1007/s00784-021-04032-1

ORIGINAL ARTICLE

Diagnostic validity of early proximal caries detection using near-infrared imaging technology on 3D range data of posterior teeth

Friederike Litzenburger[1] · Katrin Heck[1] · Dalia Kaisarly[1] · Karl-Heinz Kunzelmann[1]

Received: 9 April 2021 / Accepted: 9 June 2021 / Published online: 12 October 2021
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Abstract
Objectives This in vitro study analysed potential of early proximal caries detection using 3D range data of teeth consisting of near-infrared reflection images at 850 nm (NIRR).
Materials and methods Two hundred fifty healthy and carious permanent human teeth were arranged pairwise, examined with bitewing radiography (BWR) and NIRR and validated with micro-computed tomography. NIRR findings were evaluated from buccal, lingual and occlusal (trilateral) views according to yes/no decisions about presence of caries. Reliability assessments included kappa statistics and revealed high agreement for both methods. Statistical analysis included cross tabulation and calculation of sensitivity, specificity and AUC.
Results Underestimation of caries was 24.8% for NIRR and 26.4% for BWR. Overestimation was 10.4% for occlusal NIRR and 0% for BWR. Trilateral NIRR had overall accuracy of 64.8%, overestimation of 15.6% and underestimation of 19.6%. NIRR and BWR showed high specificity and low sensitivity for proximal caries detection.
Conclusions NIRR achieved diagnostic results comparable to BWR. Trilateral NIRR assessments overestimated presence of proximal caries, revealing stronger sensitivity for initial caries detection than BWR.
Clinical relevance NIRR provided valid complement to BWR as diagnostic instrument. Investigation from multiple angles did not substantially improve proximal caries detection with NIRR.

Keywords X-ray microtomography · Sensitivity and specificity · Reproducibility of results · Dental caries · Near-infrared imaging · Near-infrared reflection

Introduction

The number of diagnostic methods available to dentists for caries detection has multiplied in recent years. Due to new preventive and microinvasive therapy strategies, there is an increasing need to be able to detect and correctly assess caries at an early stage [1, 2]. With the established procedures of visual inspection and bitewing radiography, both healthy tooth structure and advanced cavitated lesions can be correctly identified [3–5]. However, early proximal caries is not detected adequately [6]. In the context of new therapeutic approaches, high sensitivity for early caries detection is desirable, necessitating other diagnostic methods for the detection and assessment of initial lesions with high accuracy.

Over the last three decades, numerous techniques have been developed and investigated to meet this challenge. Most techniques, such as quantitative light-induced fluorescence, laser fluorescence, electrical conductance, impedance spectroscopy and photothermal radiometry, are well suited for the assessment of smooth surfaces [7]. Lesions in the proximal region can be visualized by transillumination with visible light or optical coherent tomography (OCT), although OCT devices are currently so expensive that there will be no system available for general dental practice under economic conditions in the foreseeable future. Transillumination with near-infrared (NIR) light is expected to make approximal caries visible and has been protected by a patent for wavelengths above 795 nm [8]. Theoretically, it should also be possible to visualize caries by reflection of NIR light. There are already commercially available devices for this method, e.g., VistaCam (Dürr Dental, Bietigheim-Bissingen,

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Reference:
Clin Oral Investig.
2022 Jan;26(1):543-553.

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iTero™

Materials and methods

Fig. 1 – The application of the three-dimensional near-infrared reflection scanner is visualized by a monitor with the appropriate software (a). The tooth is illuminated either with a white LED (b) or a red laser (c)

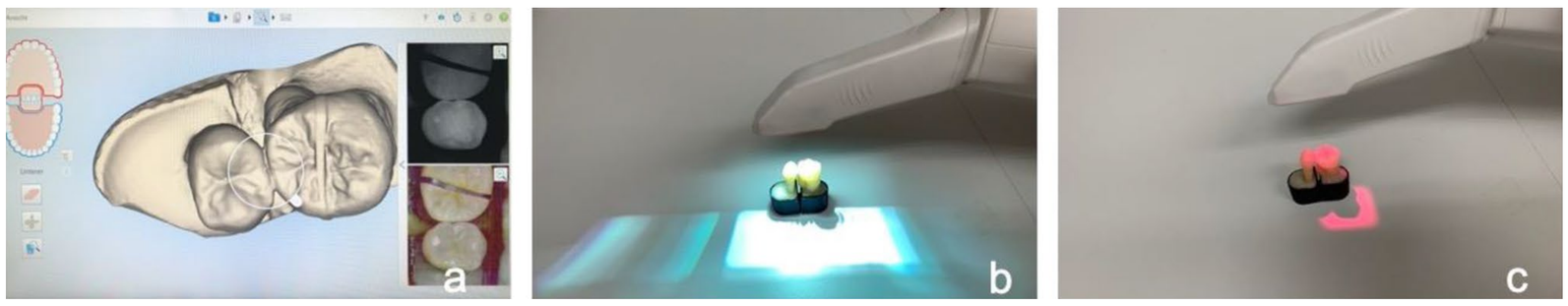


Fig. 2 – The teeth were fixed with composite material in three dimensionally printed specimen holders. (a) Maleholder, (b) female holder and (c) two specimens connected by amagnetic female-male key-lockjoint

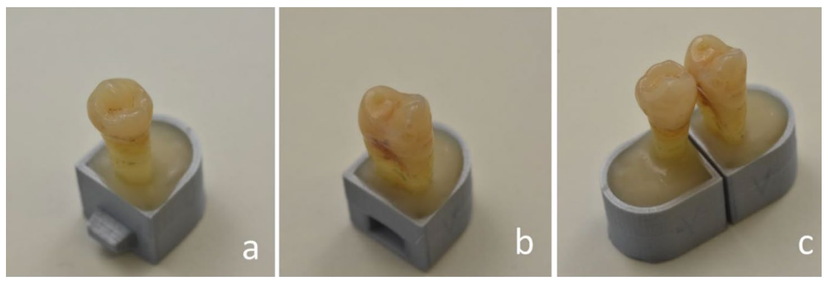
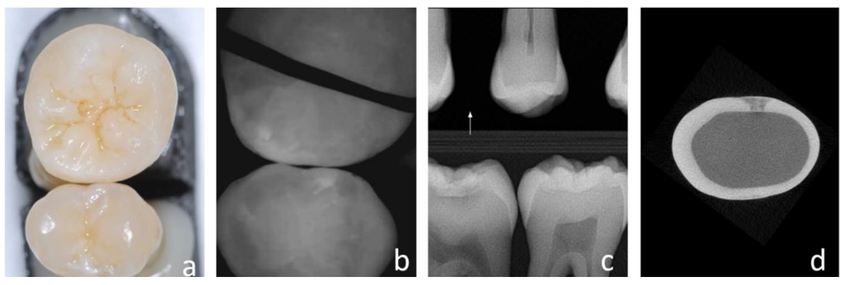


Fig. 3 – A non-cavitated caries lesion in a premolar that is visually undetectable (a). The caries lesion is visible with NIRR (white spot) and the black line marks the tooth that is not in the region of interest (b). The lesion was undetectable using X-rays and the arrow marks the side of interest (c). Micro-computed tomography reveals the presence of an initial dentin lesion (d)



Results

Table 1 – Cross-table for the ratings of three-dimensional near-infrared reflection scans at 850 nm from the occlusal viewpoint (NIRR occlusal) and from trilateral evaluation (NIRR trilateral) as well as from digital bitewing radiography (BWR) and micro-computed tomography (µCT) using the Marthaler classification (score 0 to 4) and describing findings that were not assessable (na).

		BWR						NIRR occlusal		NIRR trilateral		
		0	1	2	3	4	na	0	1	0	1	Total
µCT	0	154	0	0	0	0	4	132	26	119	39	158
	1	19	0	0	0	0	0	14	5	12	7	19
	2	23	2	2	1	0	1	19	10	16	13	29
	3	24	4	7	6	0	1	27	15	19	23	42
	4	0	0	1	0	1	0	2	0	2	0	2
	Total	220	6	10	7	1	6	194	56	168	82	250

Article:

Clinical Oral Investigations (2022) 26:543–553
https://doi.org/10.1007/s00784-021-04032-1

ORIGINAL ARTICLE

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Friederike Litzenburger[1] · Katrin Heck[1] · Dalia Kaisarly[1] · Karl-Heinz Kunzelmann[1]

Received: 9 April 2021 / Accepted: 9 June 2021 / Published online: 12 October 2021

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Keywords X-ray microtomography · Sensitivity and specificity · Reproducibility of results · Dental caries · Near-infrared imaging · Near-infrared reflection

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Over the last three decades, numerous techniques have been developed and investigated to meet this challenge. Most techniques, such as quantitative light-induced fluorescence, laser fluorescence, electrical conductance, impedance spectroscopy and photothermal radiometry, are well suited for the assessment of smooth surfaces [7]. Lesions in the proximal region can be visualized by transillumination with visible light or optical coherent tomography (OCT), although OCT devices are currently so expensive that there will be no system available for general dental practice under economic conditions in the foreseeable future. Transillumination with near-infrared (NIR) light is expected to make approximal caries visible and has been protected by a patent for wavelengths above 795 nm [8]. Theoretically, it should also be possible to visualize caries by reflection of NIR light. There are already commercially available devices for this method, e.g., VistaCam (Dürr Dental, Bietigheim-Bissingen,

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Results

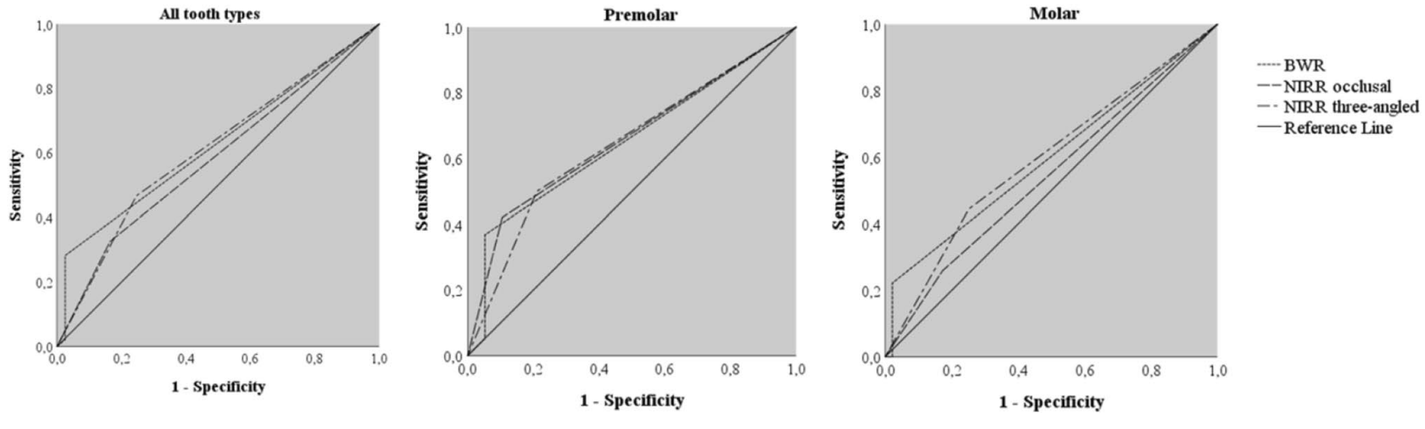
Table 2 – Inter- and intra-examiner reliability (linear weighted K values) for ratings of three-dimensional near-infrared reflection scans at 850 nm from the occlusal viewpoint (NIRR occlusal) and from trilateral evaluation (NIRR trilateral) as well as from digital bitewing radiography (BWR) with 0.95 confidence intervals (CI)

		Inter-examiner	Intra-examiner	
		Examiner 1 vs. Examiner 2	Examiner 1	Examiner 2
NIRR occlusal	κ	0.97	0.82	0.76
	Lower 0.95 CI	0.93	0.74	0.66
	Upper 0.95 CI	1.00	0.91	0.86
NIRR trilateral	κ	0.96	0.69	0.65
	Lower 0.95 CI	0.92	0.59	0.55
	Upper 0.95 CI	0.99	0.79	0.75
BWR	κ	0.85	0.90	0.91
	Lower 0.95 CI	0.76	0.85	0.85
	Upper 0.95 CI	0.93	0.96	0.97

Table 3 – Sensitivity, specificity, false-positive (FP) value, false-negative (FN) value and area under the receiver operating characteristic curve (AUC) for evaluation of three-dimensional near-infrared reflection scans at 850 nm from the occlusal viewpoint (NIRR occlusal)

		Sensitivity	Specificity	FP	FN	AUC
NIRR occlusal	All samples	0.33 (0.23–0.42)	0.84 (0.78–0.89)	0.16 (0.11–0.22)	0.67 (0.57–0.74)	0.58 (0.51–0.66)
	Premolars	0.42 (0.26–0.58)	0.89 (0.76–1.03)	0.11 (−0.03–0.24)	0.58 (0.42–0.73)	0.66 (0.51–0.80)
	Molars	0.26 (0.14–0.38)	0.83 (0.76–0.89)	0.17 (0.11–0.24)	0.74 (0.62–0.81)	0.54 (0.45–0.64)
NIRR trilateral	All samples	0.47 (0.37–0.57)	0.75 (0.69–0.82)	0.25 (0.18–0.31)	0.53 (0.43–0.61)	0.61 (0.54–0.68)
	Premolars	0.50 (0.34–0.66)	0.79 (0.61–0.97)	0.21 (0.03–0.39)	0.50 (0.34–0.67)	0.65 (0.50–0.79)
	Molars	0.44 (0.31–0.58)	0.75 (0.68–0.82)	0.25 (0.18–0.32)	0.56 (0.42–0.64)	0.60 (0.51–0.69)
BWR	All samples	0.27 (0.17–0.36)	1.00 (1.00–1.00)	0.00 (0.00–0.00)	0.73 (0.64–0.80)	0.63 (0.55–0.70)
	Premolars	0.33 (0.18–0.49)	1.00 (1.00–1.00)	0.00 (0.00–0.00)	0.67 (0.51–0.81)	0.65 (0.50–0.80)
	Molars	0.22 (0.11–0.33)	1.00 (1.00–.100)	0.00 (0.00–0.00)	0.78 (0.67–0.84)	0.60 (0.50–0.69)

Fig. 4 – Receiver operating characteristic curves (ROCs) for carious lesions for all tooth types and separated into premolar and molar groups. The graphs show equal area under the ROCs for near-infrared reflection assessment from the occlusal viewpoint (NIRR occlusal), from three angles (NIRR trilateral) and for evaluation of bitewing radiography (BWR) ($p < 0.05$)



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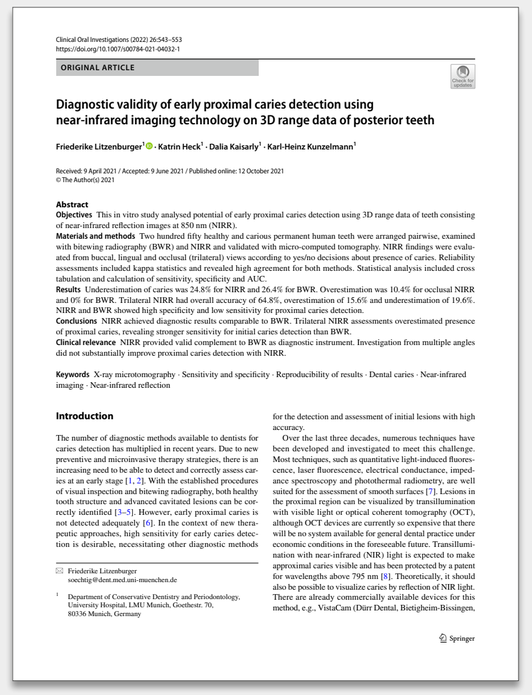

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ORIGINAL ARTICLE

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Clin Oral Investig.
2022 Jan;26(1):543-553.

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Conclusion:

- The iTero Element™ 5D imaging system achieved diagnostic results comparable to those of BWR. NIRR with and without the trilateral information can detect initial defects in the enamel with higher sensitivity than BWR, but it cannot, in contrast to BWR, support a reliable recommendation for or against invasive therapy when the EDJ is exceeded.
- Enamel cracks do not result in a therapeutic consequence, this observation is of secondary clinical importance.
- Unlike other NIRR devices for caries diagnosis that use 850 nm LEDs as a light source, the iTero Element 5D imaging system does not show any reflection artefacts caused by a smooth dental surface.
- Images acquired from the NIRR scanner present light scattered in depth mainly at dentin and irregularities in enamel, without being superimposed by superficial specular reflections, as has been observed for other NIRR diagnostic devices.
- The novel approach to entirely measure the dental arch from different directions can be an attractive option for the development of future diagnostic applications.
- It would be possible to calculate the complete surface texture for the entire 3D data set from the multitude of individual images.

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Article summary of:

“In Vitro Comparison of Three Intraoral Scanners for Implant—Supported Dental Prostheses”

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Executive summary

Comparison study of three intraoral scanners used in oral implant rehabilitation: Planmeca Planscan scanner, Medit i500 scanner, iTero Element™ Plus series.

- iTero scanner shows the best results, which confirmed a high stability pattern in this comparison of the quality of the different readings randomized to specific clinical situations.
- iTero™ scanner was found to be the most accurate (26.00 µm), followed by the Medit scanner (35.90 µm) and Planmeca Planscan scanner (57.30 µm).
- Trueness was slightly better for total rehabilitation than for partial rehabilitation iTero™ scanner, reflecting the great progress made by the latest generation of intraoral scanners.

Aim of the study

The aim of this study was to evaluate the accuracy of three intraoral scanners used in oral implant rehabilitation, using an extraoral scanner as a reference and varying the scanning area.

Planmeca PlanScan

iTero Element Plus Series

Medit i500 scanner

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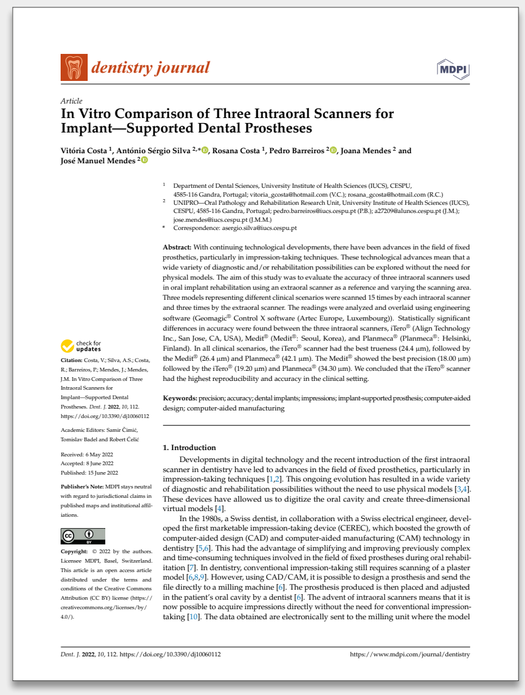

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In Vitro Comparison of Three Intraoral Scanners for Implant—Supported Dental Prostheses

Vitória Costa [1], António Sérgio Silva [2,*], Rosana Costa [1], Pedro Barreiros [2], Joana Mendes [2] and José Manuel Mendes [2]

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Abstract: With continuing technological developments, there have been advances in the field of fixed prosthetics, particularly in impression-taking techniques. These technological advances mean that a wide variety of diagnostic and/or rehabilitation possibilities can be explored without the need for physical models. The aim of this study was to evaluate the accuracy of three intraoral scanners used in oral implant rehabilitation using an extraoral scanner as a reference and varying the scanning area. Three models representing different clinical scenarios were scanned 15 times by each intraoral scanner and three times by the extraoral scanner. The readings were analyzed and overlaid using engineering software (Geomagic® Control X software (Artec Europe, Luxembourg)). Statistically significant differences in accuracy were found between the three intraoral scanners, iTero® (Align Technology Inc., San Jose, CA, USA), Medit® (Medit®; Seoul, Korea), and Planmeca® (Planmeca®; Helsinki, Finland). In all clinical scenarios, the iTero® scanner had the best trueness (24.4 µm), followed by the Medit® (26.4 µm) and Planmeca® (42.1 µm). The Medit® showed the best precision (18.00 µm) followed by the iTero® (19.20 µm) and Planmeca® (34.30 µm). We concluded that the iTero® scanner had the highest reproducibility and accuracy in the clinical setting.

Keywords: precision; accuracy; dental implants; impressions; implant-supported prosthesis; computer-aided design; computer-aided manufacturing

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Citation: Costa, V.; Silva, A.S.; Costa, R.; Barreiros, P.; Mendes, J.; Mendes, J.M. In Vitro Comparison of Three Intraoral Scanners for Implant—Supported Dental Prostheses. *Dent. J.* **2022**, *10*, 112. https://doi.org/10.3390/dj10060112

Academic Editors: Samir Čimić, Tomislav Badel and Robert Celić

Received: 6 May 2022
Accepted: 8 June 2022
Published: 15 June 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

Developments in digital technology and the recent introduction of the first intraoral scanner in dentistry have led to advances in the field of fixed prosthetics, particularly in impression-taking techniques [1,2]. This ongoing evolution has resulted in a wide variety of diagnostic and rehabilitation possibilities without the need to use physical models [3,4]. These devices have allowed us to digitize the oral cavity and create three-dimensional virtual models [4].

In the 1980s, a Swiss dentist, in collaboration with a Swiss electrical engineer, developed the first marketable impression-taking device (CEREC), which boosted the growth of computer-aided design (CAD) and computer-aided manufacturing (CAM) technology in dentistry [5,6]. This had the advantage of simplifying and improving previously complex and time-consuming techniques involved in the field of fixed prostheses during oral rehabilitation [7]. In dentistry, conventional impression-taking still requires scanning of a plaster model [6,8,9]. However, using CAD/CAM, it is possible to design a prosthesis and send the file directly to a milling machine [6]. The prosthesis produced is then placed and adjusted in the patient's oral cavity by a dentist [6]. The advent of intraoral scanners means that it is now possible to acquire impressions directly without the need for conventional impression-taking [10]. The data obtained are electronically sent to the milling unit where the model

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iTero™

Materials and methods

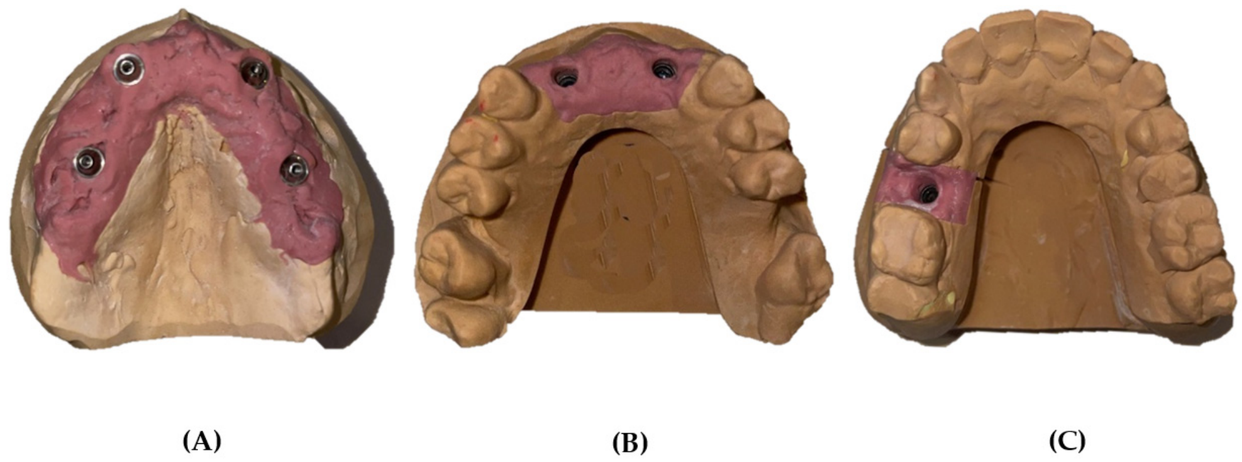
Table 1 – Information about the intraoral scanner systems.

System	Manufacturer	Scanning Technology	Scan Protocol	Acquisition	Powder Application	Export
iTero- Element Plus Series	Align Technology	Parallel confocal microscopy	OPB	Video Sequence	No	STL/OBJ/PLY
i500	Medit	Triangulation technique	OPB	Video Sequence	No	STL/OBJ/PLY
Planscan	Planmecca	Confocal microscopy and optical coherence tomography	OPB	Video Sequence	No	STL/OBJ/PLY

O = Occlusal; P = Palatal; B = Bucal.

Three representative plaster models made in the laboratory. (A) Completely edentulous jaw rehabilitated with four implants. (B) Partially edentulous jaw rehabilitated with two implants. (C) Partially edentulous jaw rehabilitated with one implant. Three ZrGEN-MegaGen AANISR4013, four ZrGEN-MegaGen, and AMUASR4013 scan bodies were used in the respective analogs to enable scanning and location of the implants.

Figure 1 – Three representative plaster models made in the laboratory. (A) Completely edentulous jaw rehabilitated with four implants. (B) Partially edentulous jaw rehabilitated with two implants. (C) Partially edentulous jaw rehabilitated with one implant.



The models were fixed to the rotating base that was moved so that the model could be read at various angles. This procedure was repeated three times for each model. The images obtained were named and saved in an STL file for subsequent analysis. Subsequently, the readings were entered into Geomagic® Control X software (version 2018. 1.1; Artec Europe, Luxembourg), where the structures were superposed to select a reference dataset.These models were used as a guide for measurement of the veracity of all intraoral scanner.

Figure 2 – S600 ARTI extraoral scanner used in the laboratory.

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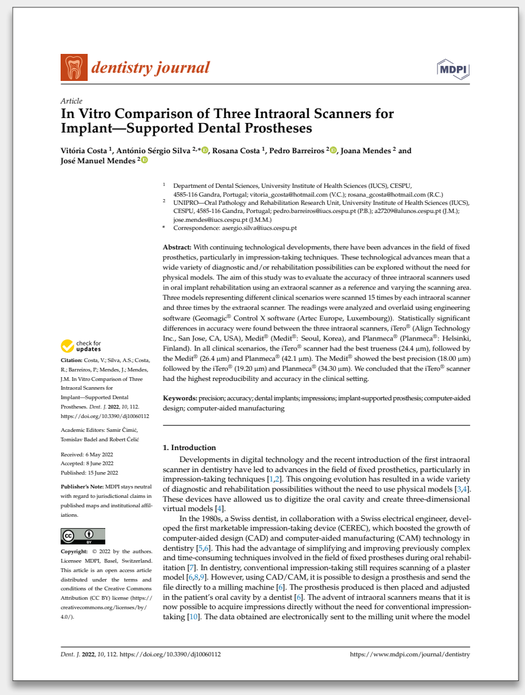

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Academic Editors: Samir Čimić, Tomislav Badel and Robert Ćelić

Received: 6 May 2022
Accepted: 8 June 2022
Published: 15 June 2022

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iTero™

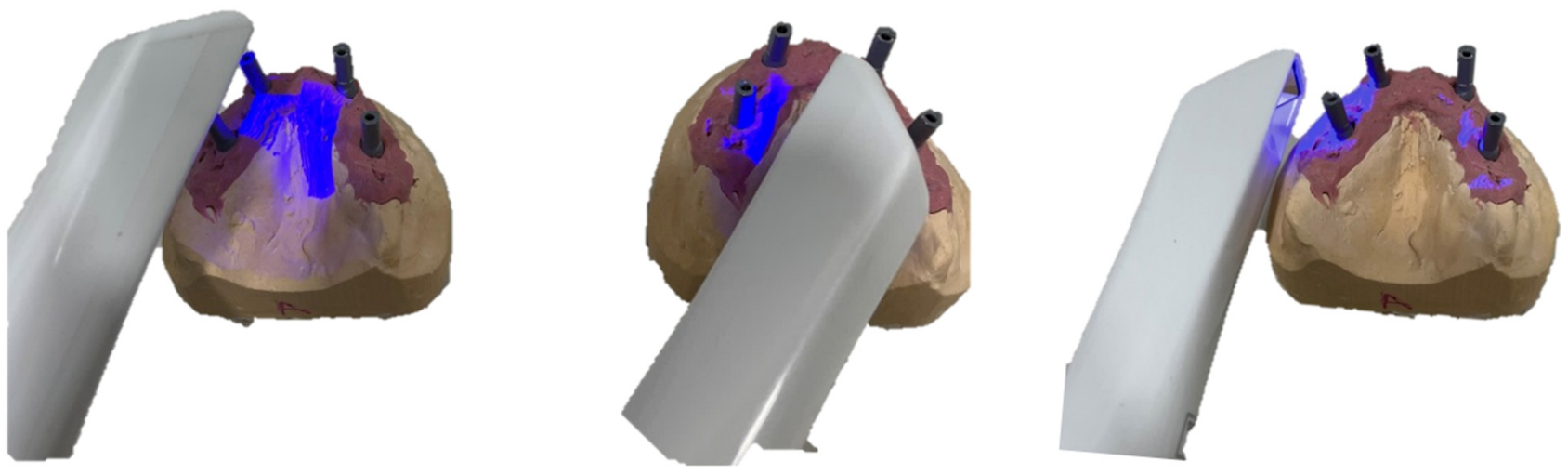
Scanning technique

1: **iTero Element™ Plus Series:** The iTero Element Plus Series is a device that does not require opacification and features color scanning. The acquisition method of this device is based on parallel confocal microscopy. The scanning procedure with iTero started from the occlusal surface, rolling to palatal and buccal surface.

2: **Medit i500 scanner:** Using the triangulation technique to acquire 3D images. The image is based on a color video enabling the distinction between teeth, soft tissue and tartar. It does not require the use of powder for scanning. This allows data to be exported in several formats (STL/OBJ/PLY), giving the operator freedom of choice. The scanning strategy for the Medit scanner group was performed by zigzag movement, from occlusal to palatal and buccal surface.

3: **Planmeca PlanScan scanner:** Based on the principle of confocal microscopy and optical coherence tomography, this system uses a blue light with real-time and color streaming video. No opacification is required for scanning. This open system facilitates the conversion of acquired files into STL readable by all CAD systems. The scanning technique from Planmeca Planscan started first from the occlusal, rotating to the palatal and then rotating across the distal proximal to reach the buccal side.

Figure 3 – Scanning technique used by intraoral scanners.



To evaluate the accuracy of these devices, the models were scanned 15 times per scanner with a 10-min interval to allow for cooling, resulting in a total of 135 virtual 3D mod.

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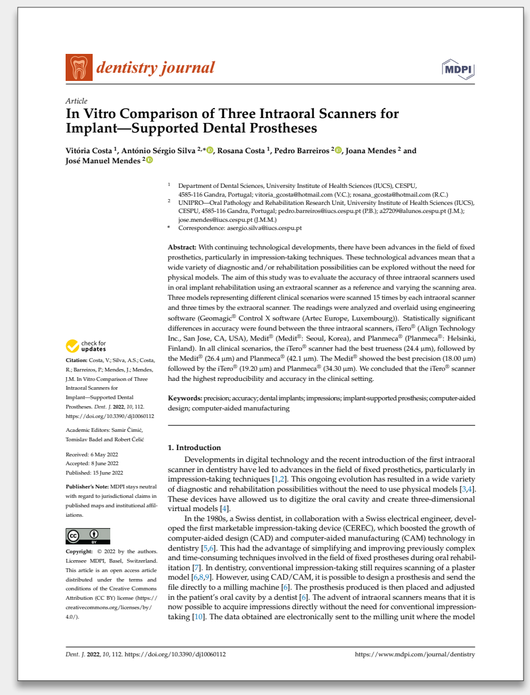

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Vitória Costa [1], António Sérgio Silva [2,*], Rosana Costa [1], Pedro Barreiros [2], Joana Mendes [2] and José Manuel Mendes [2]

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Keywords: precision; accuracy; dental implants; impressions; implant-supported prosthesis; computer-aided design; computer-aided manufacturing

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iTero™

Results

The color maps indicated the displacements between overlapped structures. The same colorimetric parameters were set for the different models; the maximum deviation ranged from 100 µm to–100 µm, with the best results ranging between 30 µm and −30 µm (green; Figures 4 and 5).

Figure 4 – Colorimetric maps comparing the trueness of three intraoral scanning.

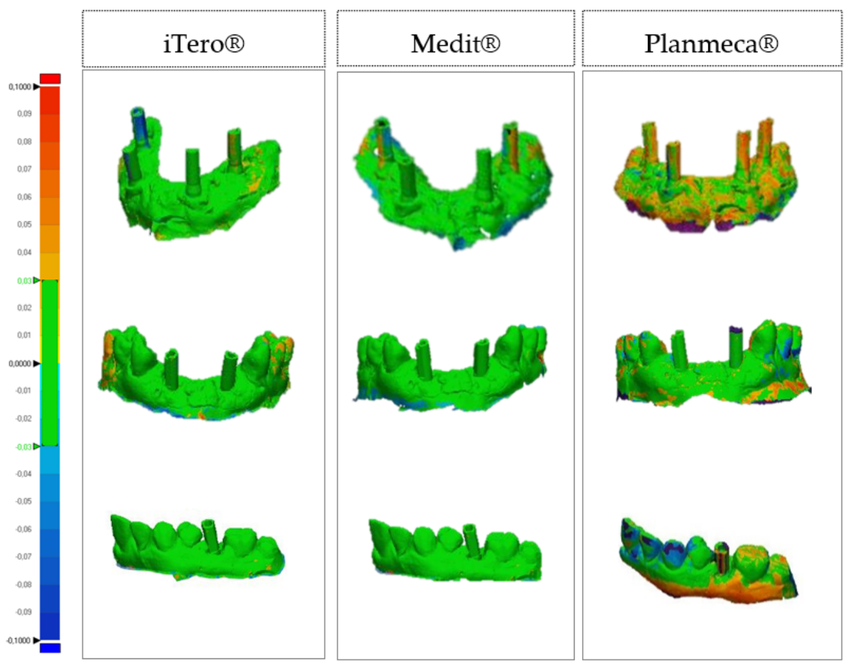
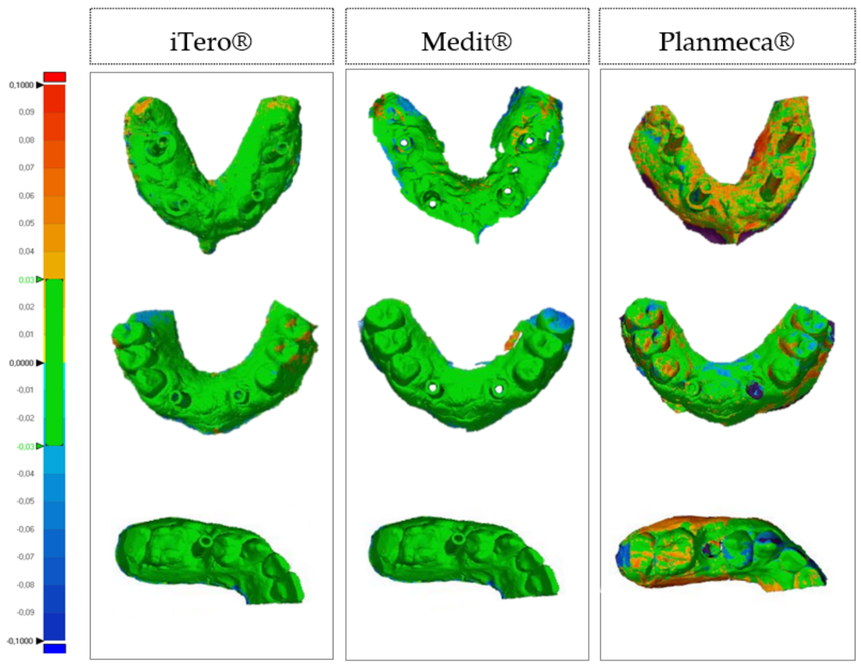


Figure 5 – Colorimetric maps comparing the precision of three intraoral scanning models.



In this study, the trueness values were lower (iTero™ scanner, 24.40 µm) in representative situations of fully edentulous patients rehabilitated with four implants than those in single implant rehabilitations (iTero™ scanner, 24.90 µm). Contrary to what some authors have reported, they found an increase in error with an increase in the area scanned.

Table 2 – Comparison of root mean square values for trueness according to type and model of scanner by two-way analysis of variance.

				Two-Way Analysis of Variance		
	Model A	**Model B**	**Model C**	**Scanner**	**Model**	**Interaction**
iTero®	0.0244 (0.0017)	0.0244 (0.0047)	0.0249 (0.0012)	$F_{(2,126)} = 675.53$ $p < 0.001$ $\eta^2 = 0.92$	$F_{(2,126)} = 58.13$ $p < 0.001$ $\eta^2 = 0.48$	$F_{(4,126)} = 17.77$ $p < 0.001$ $\eta^2 = 0.36$
Medit®	0.0379 (0.0028)	0.0329 (0.0041)	0.0264 (0.0030)			
Planmeca®	0.0507 (0.0028)	0.0469 (0.0017)	0.0421 (0.0019)			

Data are presented as the mean and standard deviation in millimeters. $p < 0.001$, statistically significant difference between scanners and between brands, Tukey's test.

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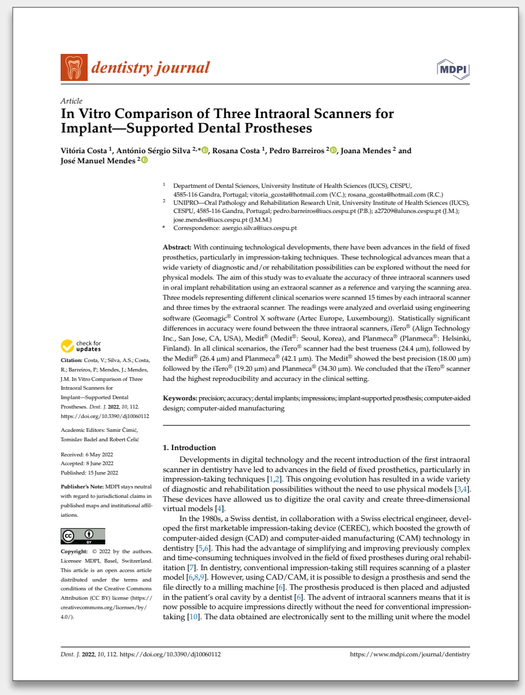

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In Vitro Comparison of Three Intraoral Scanners for Implant—Supported Dental Prostheses

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Keywords: precision; accuracy; dental implants; impressions; implant-supported prosthesis; computer-aided design; computer-aided manufacturing

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Article summary of:

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Results

We obtained statistically significant differences in precision between the different scanners and models. For oral rehabilitation with one implant, Medit scanner had the lowest precision value at 18.00 µm, followed by the iTero™ scanner (19.2 µm) and Planmeca PlanScan scanner (34.3 µm).

Table 3 – Comparison of root mean square values for trueness according to type and model of scanner by two-way analysis of variance.

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iTero®	0.0260 (0.0039)	0.0250 (0.0025)	0.0192 (0.0042)	$F_{(2,117)} = 593.52$ $p < 0.001$ $\eta^2 = 0.91$	$F_{(2,117)} = 218.95$ $p < 0.001$ $\eta^2 = 0.79$	$F_{(4,117)} = 24.01$ $p < 0.001$ $\eta^2 = 0.45$
Medit®	0.0359 (0.0052)	0.0268 (0.0052)	0.0180 (0.0020)			
Planmeca®	0.0573 (0.0034)	0.0530 (0.0018)	0.0343 (0.0027)			

Data are presented as the mean and standard deviation in millimeters. $p < 0.001$, statistically significant difference between scanners and between brands, Tukey’s test.

Conclusion:

- iTero™ scanner was found to be the most accurate (26.00 µm), followed by the Medit scanner (35.90 µm) and Planmeca PlanScan scanner (57.30 µm).
- iTero scanner shows the best results, which confirmed a high stability pattern in this comparison of the quality of the different readings randomized to specific clinical situations. Trueness was slightly better for total rehabilitation than for partial rehabilitation (iTero™ scanner), reflecting the great progress made by the latest generation of intraoral scanners.

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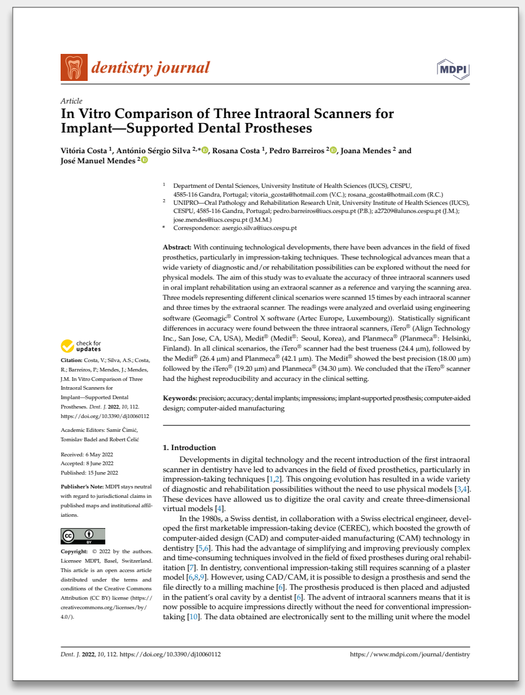

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Article summary of:

“Intraoral scanning reduces procedure time and improves patient comfort in fixed prosthodontics and implant dentistry: a systematic review”

iTero™

Executive summary

- Intraoral scanner is faster than conventional impressions, independent of the size of the scanned area.
- Intraoral scanner can improve the patient experience in the dental office measured by overall preference and comfort.
- Intraoral scanner as part of a digital workflow can provide reliable prosthodontic outcomes.
- In this study iTero Element™ scanner shows the highest results in patient comfort among the scanners tested.
- A recently published study showed that digital impressions are more efficient and cost-effective than standard impressions.

About the study

The present study is a systematic review. It was conducted with the primary objective of assessing whether intraoral scanning can reduce working times and improve patient-reported outcomes compared to conventional impressions. The secondary objective of this review was to determine whether the Intraoral scanner procedure was effective, based on prosthodontic outcomes. The review included 17 research papers with data from 430 intraoral scans and 370 conventional impressions performed on 437 patients.

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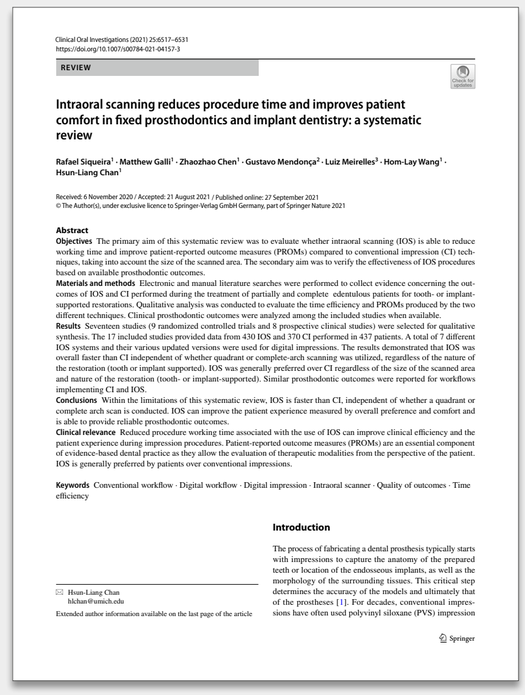

Clinical Oral Investigations (2021) 25:6517–6531
https://doi.org/10.1007/s00784-021-04157-3

REVIEW

Intraoral scanning reduces procedure time and improves patient comfort in fixed prosthodontics and implant dentistry: a systematic review

Rafael Siqueira[1] · Matthew Galli[1] · Zhaozhao Chen[1] · Gustavo Mendonça[2] · Luiz Meirelles[3] · Hom-Lay Wang[1] · Hsun-Liang Chan[1]

Received: 6 November 2020 / Accepted: 21 August 2021 / Published online: 27 September 2021

Abstract
Objectives The primary aim of this systematic review was to evaluate whether intraoral scanning (IOS) is able to reduce working time and improve patient-reported outcome measures (PROMs) compared to conventional impression (CI) techniques, taking into account the size of the scanned area. The secondary aim was to verify the effectiveness of IOS procedures based on available prosthodontic outcomes.
Materials and methods Electronic and manual literature searches were performed to collect evidence concerning the outcomes of IOS and CI performed during the treatment of partially and complete edentulous patients for tooth- or implant-supported restorations. Qualitative analysis was conducted to evaluate the time efficiency and PROMs produced by the two different techniques. Clinical prosthodontic outcomes were analyzed among the included studies when available.
Results Seventeen studies (9 randomized controlled trials and 8 prospective clinical studies) were selected for qualitative synthesis. The 17 included studies provided data from 430 IOS and 370 CI performed in 437 patients. A total of 7 different IOS systems and their various updated versions were used for digital impressions. The results demonstrated that IOS was overall faster than CI independent of whether quadrant or complete-arch scanning was utilized, regardless of the nature of the restoration (tooth or implant supported). IOS was generally preferred over CI regardless of the size of the scanned area and nature of the restoration (tooth- or implant-supported). Similar prosthodontic outcomes were reported for workflows implementing CI and IOS.
Conclusions Within the limitations of this systematic review, IOS is faster than CI, independent of whether a quadrant or complete arch scan is conducted. IOS can improve the patient experience measured by overall preference and comfort and is able to provide reliable prosthodontic outcomes.
Clinical relevance Reduced procedure working time associated with the use of IOS can improve clinical efficiency and the patient experience during impression procedures. Patient-reported outcome measures (PROMs) are an essential component of evidence-based dental practice as they allow the evaluation of therapeutic modalities from the perspective of the patient. IOS is generally preferred by patients over conventional impressions.

Keywords Conventional workflow · Digital workflow · Digital impression · Intraoral scanner · Quality of outcomes · Time efficiency

Introduction

The process of fabricating a dental prosthesis typically starts with impressions to capture the anatomy of the prepared teeth or location of the endosseous implants, as well as the morphology of the surrounding tissues. This critical step determines the accuracy of the models and ultimately that of the prostheses [1]. For decades, conventional impressions have often used polyvinyl siloxane (PVS) impression

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Siqueira R, Galli M, Chen Z, Mendonça G, Meirelles L, Wang HL, Chan HL

Reference:
Clin Oral Investig. 2021 Dec;25(12):6517-6531.

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Article summary of:

“Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries”

Executive summary

- The non-inferiority hypothesis of NILR compared to BWR in detecting proximal caries was approved.
- A team of observers experienced in NILR imaging evaluated the two methods with higher accuracy and agreement levels compared to individual dentists in their clinical settings, who were less experienced with the NILR method.
- NILR had higher sensitivity than BWR in the detection of early enamel lesions and comparable sensitivity to BWR in detecting lesions that involved the DEJ.
- Matching between the NILR findings and the clinical direct observation was found in 34/35 lesions that were limited to the enamel and in 23/24 of the lesions with DEJ involvement. This represents a sensitivity of 97% and 96%, respectively.

Aim of the study

The aim of the clinical study was to compare the detection of proximal caries with near-infrared light reflection (NILR) versus bitewing radiography (BWR).

Introduction

Near infrared light imaging (NILR) to aid in early caries detection

- When using NILR technology, teeth are illuminated with the near-infrared light and the reflection is registered and presented as a grayscale image. Within this image, sound enamel, which is transparent to light, appears dark and the carious lesion, which scatters and reflects the near-infrared light, appears brighter on the dark background of the surrounding enamel.

Article:

Journal of Dentistry 116 (2022) 103861

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Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries: A multicenter prospective clinical study conducted in private practices

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ARTICLE INFO

Keywords:
Bitewing radiography
Caries detection
Intraoral scan
Near-infrared
Near-infrared light reflection
Proximal caries

ABSTRACT

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https://doi.org/10.1016/j.jdent.2021.103861
Received 5 September 2021; Received in revised form 12 October 2021; Accepted 19 October 2021
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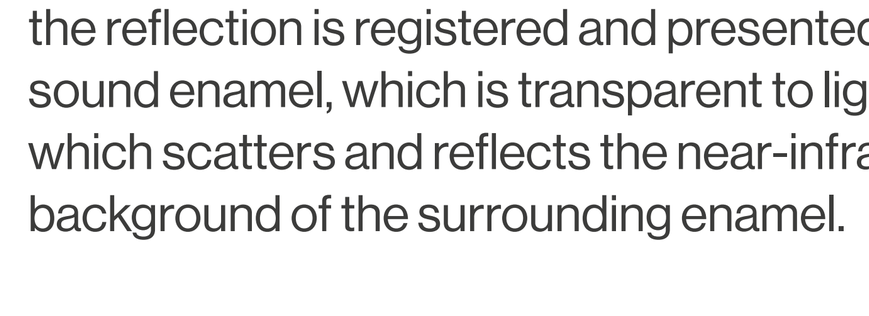

Figure 1 – Screenshot of the “View mode” of the iTero Element 5D scanner. When the simulated loupe is positioned over a given area of the color 3D model, the corresponding 2D NILR gray-tone image is presented next to the color 3D image of the same teeth.

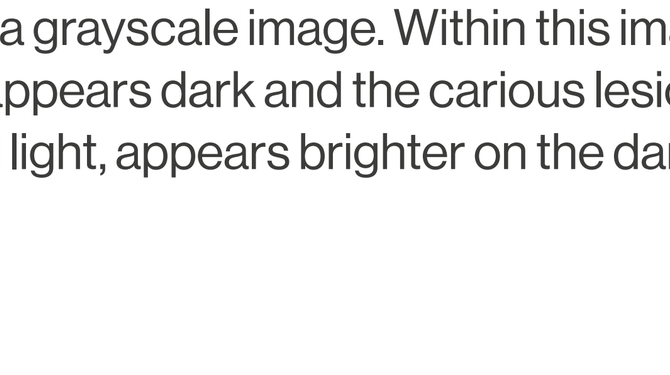

Figure 2 – Mesial surface of tooth #15 with a carious lesion detected by NILR. The lesion (arrow) is of triangular shape and does not reach the DEJ and was recorded as an early enamel lesion. B. Mesial surface of tooth #16 with a carious lesion detected by NILR. The lesion is trapezoid in shape (arrow) reaching the DEJ and was recorded as a lesion involving the DEJ.

Article summary of:

“Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries”

Materials and methods

- 100 patients were included in the study (n = 20 per each clinic).
- The actual sample size that was used in the study was 3499 non-treated proximal surfaces of molars and premolars. Previously restored surfaces, non-proximal surfaces and anterior teeth were excluded from the present study analysis.
- Clinical examination and BWRs used during this study were those that are used as the standard of care in the diagnosis of proximal caries in each of the participating clinics.
- Full scans of the maxillary and mandibular arches of each subject using the iTero Element™ 5D imaging system were obtained. The resulting 3D scans included a NILR image in gray scale, which was automatically presented next to the 3D image of a given tooth/pair of teeth.
- The interpretation of the NILR and BWR images was done by each of the individual dentists and by the expert team.
- To minimize bias, NILR or BWR images were interpreted by the dentist in alternating order: either the NILR image first and the BWR second or vice versa. In each case, the operator assessed and documented the findings of the first diagnostic method (BWR or NILR imaging) before performing the second method.
- For each subject, the dentist graded carious lesions in the BWR and the NILR scan according to American Dental Association (ADA) staging guidelines for BWR.
- The data that was clinically acquired by the dentists was transferred for parallel evaluation by the expert team as anonymized, unmatched NILR scan and BWR datasets.
- The expert team consisted of five dentists who had been recruited and trained by the sponsor (Align Technology, Tempe, AZ, USA) for research and development purposes. They had 2 years of experience in evaluating thousands of NILR images of carious lesions, prior to the present study
- Analysis of sensitivity, specificity, and accuracy was done independently of a similar analysis of the data as interpreted by the individual dentists
- Sensitivity, specificity, and accuracy values were calculated for NILR scan vs. BWR, which was referred to as “ground truth”
- The non-parametric two-sided McNemar’s Chi-Square test was used for paired nominal data. This test enables the comparison of the detection proportions between the two methods.

Article:

Journal of Dentistry 116 (2022) 103861

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https://doi.org/10.1016/j.jdent.2021.103861
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Study design[1]

Multicenter study

- 5 sites in Canada and Germany
- 100 patients, 3499 proximal surfaces included

Real-world evidence

- More relevant to daily clinical practice
- Broad inclusion: patients not pre-selected
- Study taking place under true clinical conditions

Phase I and phase II

- Phase I: NIRI vs. BWX
- Phase II: NIRI and BWX vs. caries excavation

1. Metzger, Z., Colson, D. G., Bown, P., Weihard, T., Baresel, I., & Nolting, T. (2021). Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries: a multicenter prospective clinical study conducted in private practices. Journal of dentistry, 103861. Advance online publication. https://doi.org/10.1016/j.jdent.2021.103861 (Accessed: 31 October 2021).

Multicenter study[1]

- **15 sites in Canada and Germany**
  (Doctor/Trial Site):
  – Dr. Dana Colson, Canada
  – Dr. Peggy Bown, Canada
  – Dr. Tim Nolting, Germany
  – Dr. Ingo Baresel, Germany
  – Dr. Timo Weihard, Germany
- **Advantage[2]**
  – Quicker recruitment of patients
  – Larger sample sizes for more generalizable findings

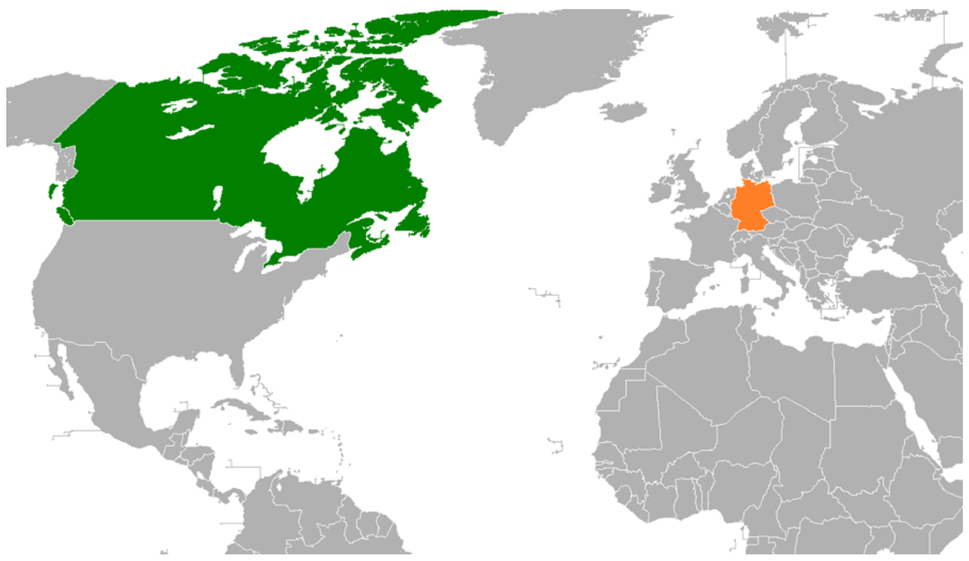

Figure 3 – Source: Wikipedia (2021) Canada-Germany relations. Available at: https://en.wikipedia.org/wiki/Canada%E2%80%93Germany_relations

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2. Lippi, G., von Meyer, A., Cadamuro, J., Simundic, A. & for the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) Working Group for Preanalytical Phase (WG-PRE) (2020). PREDICT: a checklist for preventing preanalytical diagnostic errors in clinical trials. Clinical Chemistry and Laboratory Medicine (CCLM), 58(4), 518-526. https://doi.org/10.1515/cclm-2019-1089. (Accessed: 31 October 2021).

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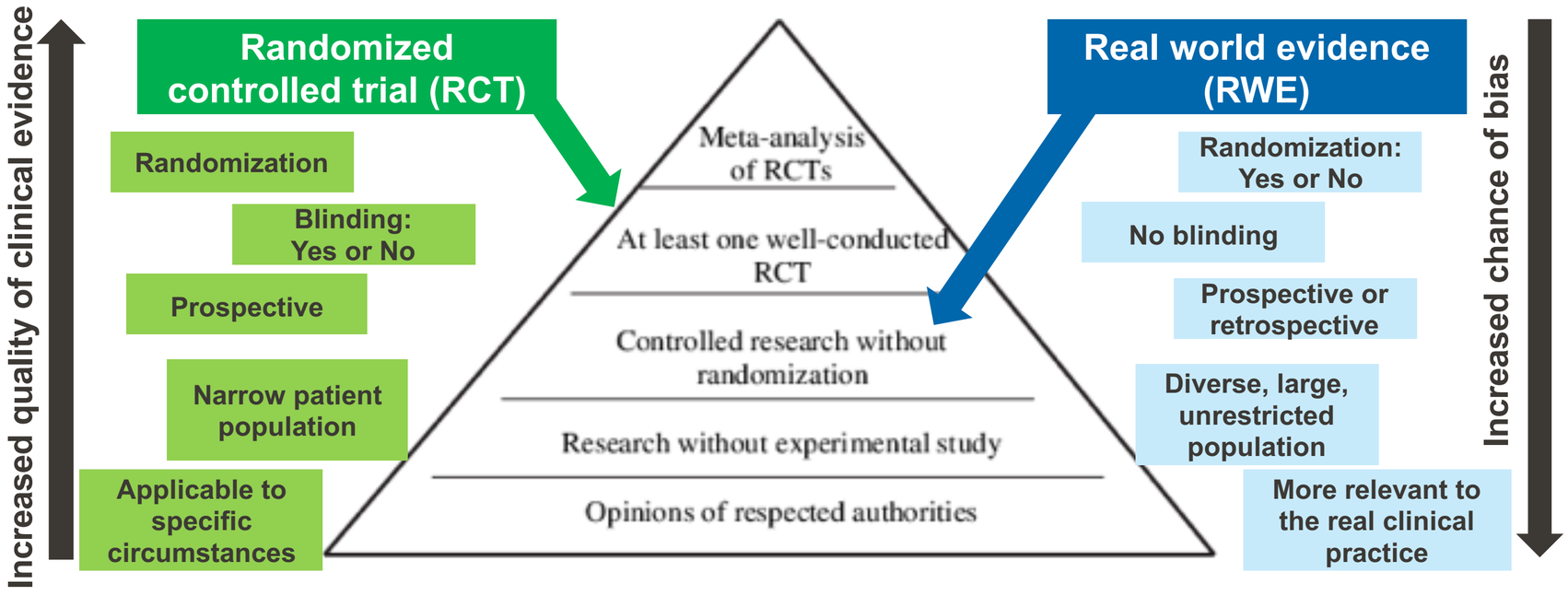
What is real-world evidence (RWE)?

- RWE is defined as "clinical evidence derived from analysis of data collected in non-RCT setting".[1]

Figure 4 – The hierarchy of evidence (source: Mantzoukas, 2012[2])



1. Makady, A., de Boer, A., Hillege, H., Klungel, O., Goettsch, W., & (on behalf of GetReal Work Package 1) (2017). What Is Real-World Data? A Review of Definitions Based on Literature and Stakeholder Interviews. Value in health : the journal of the International Society for Pharmacoeconomics and Outcomes Research, 20(7), 858–865. https://doi.org/10.1016/j.jval.2017.03.008 (Accessed: 01 November 2021).
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Study design[1]

Data acquisition was performed by 5 dentists in their individual clinical settings. This included BWR and NILR scans. A total of 3499 proximal surfaces of molars and premolars were included in the present study.

Caries detection was done

a) by each of the individual dentists and

b) the same images were also examined by a team of 5 dentists who had a vast experience in interpretation of NILR images and provided an agreed-upon interpretation of the same data.

Analysis of sensitivity, specificity and accuracy was performed for the results obtained by both evaluation groups. In 59 of the cases direct observation was possible during caries excavation, thus allowing validation of the diagnosis made using BWR and NILR.

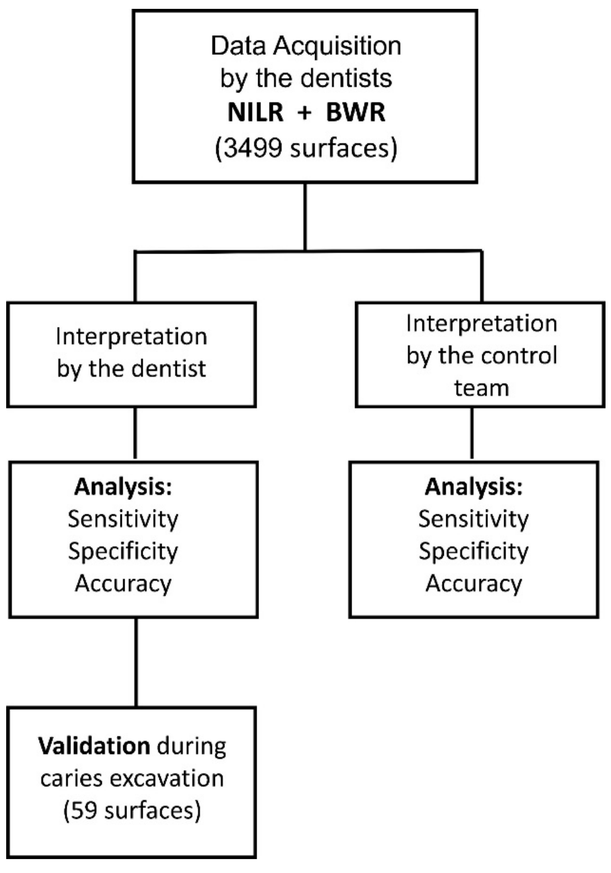

Figure 5 – Flowchart of the experimental design.

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Study design: Phase I and Phase II[1]

Phase I

- Sample: 100 patients
  – 3,499 posterior proximal surfaces
- Comparison: NIRI vs. BWX
- Outcome measure: accuracy

Phase II

- Sample: 59 cases/lesions (carious teeth surfaces)
- Comparison: NIRI and BWX vs. caries excavation
- Outcome measure: sensitivity

Figure 5

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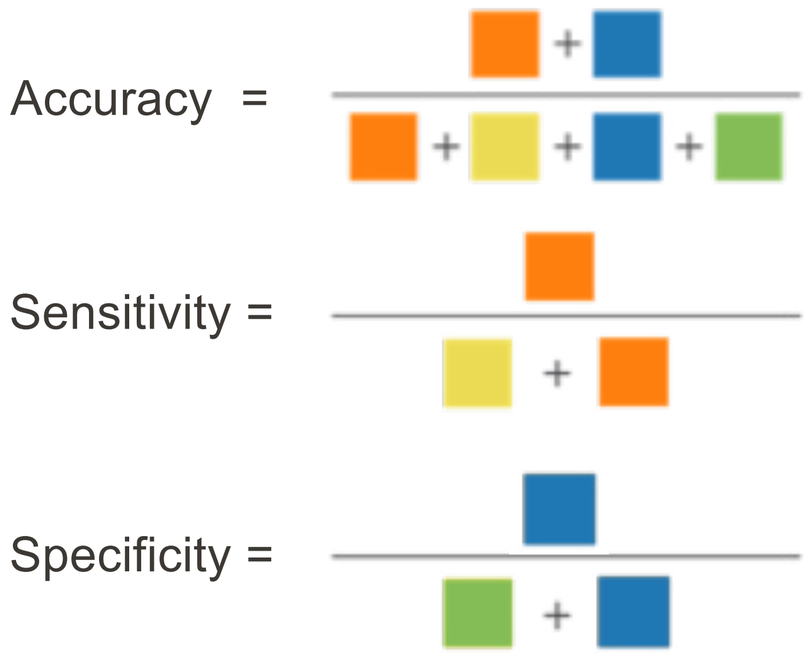
Accuracy, sensitivity, and specificity

Figure 6

	BWX Positive*	BWX Negative**
NIRI Positive	**Correct** True positive	**Wrong** False positive
NIRI Negative	**Wrong** False negative	**Correct** True negative

Figure 7



- **Sensitivity**: “the percent correctly predicted to have the disease”
- **Accuracy:** “how correct a diagnostic test identifies and excludes a given condition”
- **Specificity:** “the percent correctly predicted to be disease-free”

* Positive: caries present, **Negative: caries absent

1. Parikh, R., Mathai, A., Parikh, S., Chandra Sekhar, G., & Thomas, R. (2008). Understanding and using sensitivity, specificity and predictive values. Indian journal of ophthalmology, 56(1), 45–50. Available at: https://doi.org/10.4103/0301-4738.37595 (Accessed: 13 October 2021).

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Results: Accuracy of NILR detection of early enamel lesions was 88% and that of carious lesions involving the dentino-enamel junction (DEJ) was 97%. Accuracy was found to be higher at 96% and 99%, respectively, when the same data were examined by the expert team. Direct observation during caries-excavation treatment suggested that NILR detected early enamel lesions that were not detectable with BWR alone.
Conclusions: Within the limitations of the present study, NILR was more sensitive than BWR in detecting early enamel lesions and comparable to BWR in detecting lesions that involved the DEJ.
Clinical relevance: Reflected near-infrared light images that are generated simultaneously with 3D intra-oral scanning may be used reliably for detection, screening, and monitoring of proximal caries, thus potentially minimizing the traditional use of ionizing radiation.

1. Introduction

Diagnosis of early carious lesions in pits and fissures is based mainly on visual-tactile detection of the lesions. Such methods are not effective when early lesions in proximal surfaces of molars and premolars are considered [1]. Bitewing radiography (BWR) has been used for many decades as the standard of care for the detection of early proximal lesions, yet this traditional method has its limitations. A meta-analysis

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https://doi.org/10.1016/j.jdent.2021.103861
Received 5 September 2021; Received in revised form 12 October 2021; Accepted 19 October 2021
Available online 24 October 2021

Authors:
Zvi Metzger, Dana G. Colson, Peggy Bown, Timo Weihard, Ingo Baresel, Tim Nolting

Reference:
J Dent. 2022 Jan; 116:103861.

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Article summary of:

“Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries”

Phase I results[1]

When compared to the “ground truth” of BWR, the sensitivity of NILR detection of early enamel caries was 51.6% and the specificity was 90.4%. The sensitivity of NILR detection of carious lesions with DEJ involvement was 84.8% and specificity was 97.1%. The findings represent an accuracy of 88.6% for early enamel lesions and 96.9% for lesions with DEJ involvement. A statistically significant difference was found between the detection ability of NILR and BWR ($p < 0.0001$)

Table 1 – NIRI demonstrated 96% accuracy in detecting dentinal interproximal caries when compared to BWX.

	Accuracy
DEJ* involvement	96,9%
Early enamel lesions	88,6%

Phase I results[1] – Dentist reported results

Table 2 – Numbers of carious (positive) and non-carious (negative) proximal surfaces of posterior teeth, as recorded by five dentists in their clinical environment.

Depth of Lesion	Detection Method	NILR Positive	NILR Negative
Early Enamel	BWR Positive	81	76
	BWR Negative	314	2965
DEJ involvement	BWR Positive	56	10
	BWR Negative	98	3335

Table 3 – Sensitivity, specificity, and accuracy of caries detection by NILR when compared to a “ground truth” of BWR. Evaluation by five individual dentists.

	Early Enamel Lesions	DEJ Involvement
Sensitivity	51.6%	84.8%
Specificity	90.4%	97.1%
Accuracy	88.6%	96.9%
Two-Sided McNemar’s Chi-Square test (p-value)	< 0.0001[a]	< 0.0001[a]
Asymptotic Non-Inferiority Test (p-value)	< 0.0001[b]	< 0.0001[b]
One-Sided Binominal test (p-value)	< 0.0001[c]	< 0.0001[c]
Kappa Coefficient	0.24[d]	0.50[e]

* DEJ: dentino-enamel junction

1. Metzger, Z., Colson, D. G., Bown, P., Weihard, T., Baresel, I., & Nolting, T. (2021). Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries: a multicenter prospective clinical study conducted in private practices. Journal of dentistry, 103861. Advance online publication. https://doi.org/10.1016/j.jdent.2021.103861 (Accessed: 31 October 2021).

Article:

Journal of Dentistry 116 (2022) 103861

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.elsevier.com/locate/jdent

Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries: A multicenter prospective clinical study conducted in private practices

Zvi Metzger [a,*], Dana G. Colson [b], Peggy Bown [c], Timo Weihard [d], Ingo Baresel [e], Tim Nolting [f]

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ARTICLE INFO

Keywords:
Bitewing radiography
Caries detection
Intraoral scan
Near-infrared
Near-infrared light reflection
Proximal caries

ABSTRACT

Objectives: The aim of the present prospective multicenter clinical study was to compare the detection of proximal caries with near-infrared light reflection (NILR) versus bitewing radiography (BWR).

Materials and methods: Intraoral scans were performed on 100 patients in five dental clinics using an intraoral scanner (iTero Element 5D, Align Technology, Tempe, AZ, USA) that includes a near-infrared light source (850 nm) and sensor. Reflected near-infrared light images of posterior teeth were used by the individual dentists to detect proximal caries and the results were compared to the BWRs. In a total of 3499 proximal surfaces of molars and premolars which were examined, 223 carious lesions were detected by BWR, while NILR detected 549 carious lesions. Caries detection using both methods was also done by an expert team of five dentists, highly experienced in NILR image interpretation, who used the same sets of clinically-obtained data. Sensitivity, specificity, and accuracy were calculated for caries detection by both the dentists and the expert team. Fifty-nine of the detected carious lesions were clinically treated and the observations during caries excavation were compared with those done with NILR and BWR. Statistical analysis to compare between NILR and BWR diagnosis was performed using non-parametric two-sided McNemar’s Chi-Square test with the significance level set at $p < 0.05$. Kappa coefficients were calculated to assess the level of agreement between the two caries detection methods.

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https://doi.org/10.1016/j.jdent.2021.103861
Received 5 September 2021; Received in revised form 12 October 2021; Accepted 19 October 2021
Available online 24 October 2021
0300-5712/

Authors:

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Reference:

J Dent. 2022 Jan; 116:103861.

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Article summary of:

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iTero™

Phase I results[1] – Dentist reported results

Table 4 – Numbers of carious (positive) and non-carious (negative) proximal surfaces of posterior teeth as detected and recorded by a expert team using the same database as collected and used by the five individual dentists (Table 2).

Type of Lesion		NILR Positive	NILR Negative
Early Enamel	BWR Positive	76	28
	BWR Negative	106	3216
DEJ involvement	BWR Positive	62	8
	BWR Negative	11	3418

Table 5 – Sensitivity, specificity, and accuracy of caries detection by NILR when compared to a "ground truth" of BWR. Evaluation by a expert team, using the same database as collected and used by the 5 dentists (Tables 2,3).

	Early Enamel Lesions	DEJ Involvement
Sensitivity	73.0%	88.5%
Specificity	96.8%	99.6%
Accuracy	96.0%	99.4%
Two-Sided McNemar's Chi-Square test (p-value)	<0.0001[a]	0.65 (>0.05)[b]
Asymptotic Non-Inferiority Test (p-value)	<0.0001[c]	<0.0001[c]
One-Sided Binominal test (p-value)	<0.0001[d]	0.32 (>0.05)[e]
Kappa Coefficient	0.51[f]	0.86[g]

Article:

Journal of Dentistry 116 (2022) 103861

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.elsevier.com/locate/jdent

Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries: A multicenter prospective clinical study conducted in private practices

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ARTICLE INFO

Keywords:
Bitewing radiography
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Objectives: The aim of the present prospective multicenter clinical study was to compare the detection of proximal caries with near-infrared light reflection (NILR) versus bitewing radiography (BWR).
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Conclusions: Within the limitations of the present study, NILR was more sensitive than BWR in detecting early enamel lesions and comparable to BWR in detecting lesions that involved the DEJ.
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https://doi.org/10.1016/j.jdent.2021.103861
Received 5 September 2021; Received in revised form 12 October 2021; Accepted 19 October 2021
Available online 24 October 2021
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Authors:
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J Dent. 2022 Jan; 116:103861.

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Article summary of:

“Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries”

iTero™

Phase II results[1] validation during excavation

The iTero™ NIRI technology of the iTero Element 5D imaging system was 66% more sensitive* than bite-wing X-rays (BWX) for proximal lesions detection

Table 6 – NIRI showed 66% higher sensitivity than BWX when compared against the clinical evaluation of posterior proximal lesions observed during caries debridement.

	NIRI sensitivity	BWX sensitivity
All lesions (average)	**96%**	**30%**
DEJ* involvement	97%	54%
Early enamel lesions	96%	14%

* DEJ: dentino-enamel junction

1. Metzger, Z., Colson, D. G., Bown, P., Weihard, T., Baresel, I., & Nolting, T. (2021). Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries: a multicenter prospective clinical study conducted in private practices. Journal of dentistry, 103861. Advance online publication. https://doi.org/10.1016/j.jdent.2021.103861 (Accessed: 31 October 2021).

Conclusion:

- The non-inferiority hypothesis of NILR compared to BWR in detecting proximal caries was approved
- NILR had higher sensitivity than BWR in the detection of early enamel lesions and comparable sensitivity to BWR in detecting lesions that involved the DEJ

Article:

Journal of Dentistry 116 (2022) 103861

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.elsevier.com/locate/jdent

Reflected near-infrared light versus bite-wing radiography for the detection of proximal caries: A multicenter prospective clinical study conducted in private practices

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https://doi.org/10.1016/j.jdent.2021.103861
Received 5 September 2021; Received in revised form 12 October 2021; Accepted 19 October 2021
Available online 24 October 2021

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Reference:

J Dent. 2022 Jan; 116:103861.

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Article summary of:

“Accuracy of the Intraoral Scanner for Detection of Tooth Wear.”

Executive summary

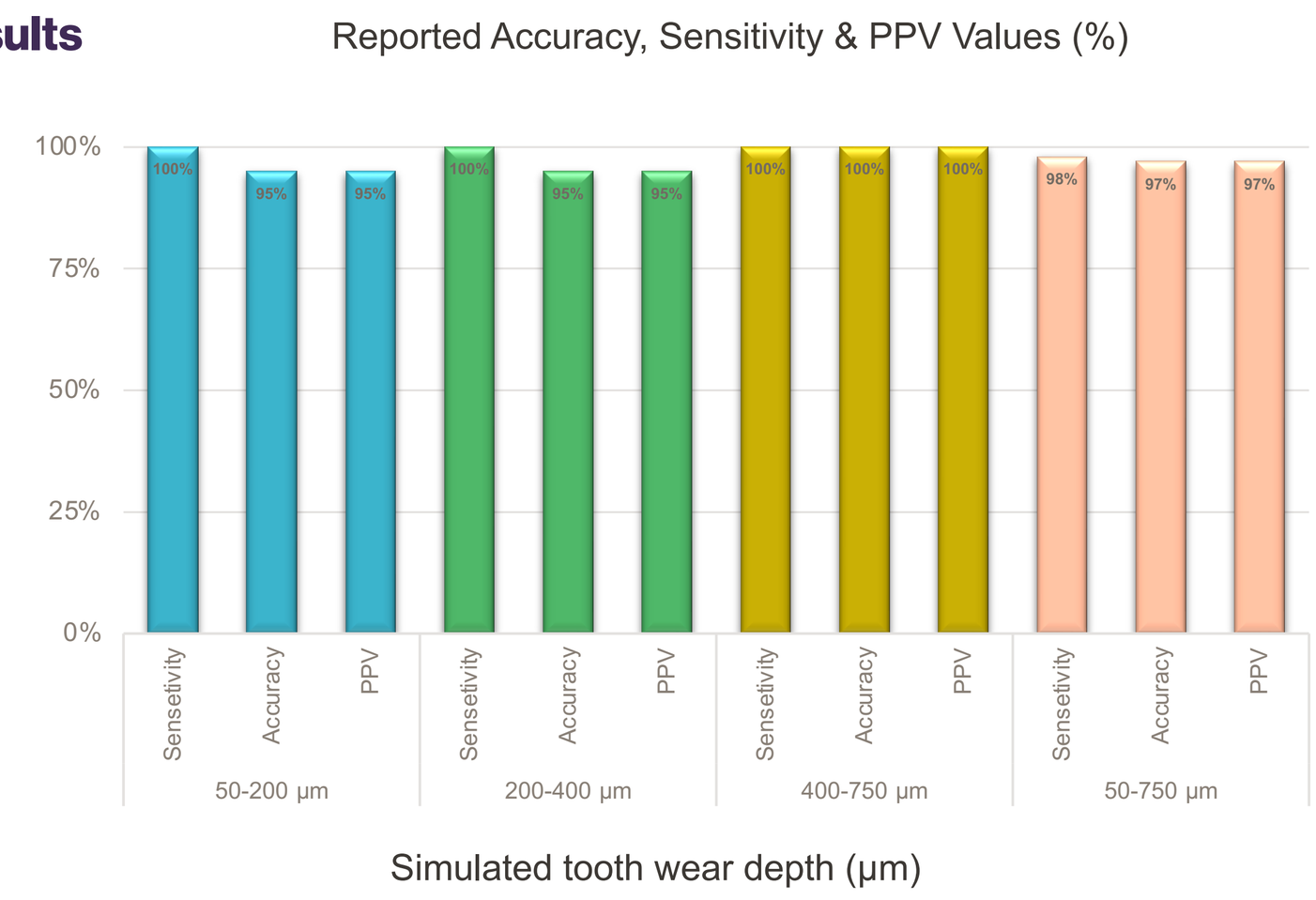
- **Background:** Tooth wear is often discovered when it has progressed to such an extent that it can be observed clinically. At this point, though, more conservative or preventive measures to halt its progression are usually no longer feasible
- **Aim:** Study the accuracy of the intraoral scanner for detection of dimensional changes in natural enamel by using micro-computed tomography (micro-CT) as a gold standard
- **Methodology:** Minimal (50-750 µm) tooth wear was simulated in 20 extracted sound human first upper premolars
- **Results:** In the detection of experimental tooth surface loss in-vitro, the specificity, PPV, and accuracy of the iTero intraoral scanner was 98%, 98%, and 97% respectively

Materials and methods

Twenty upper premolars were extracted in sound condition. They were then abraded to simulate tooth wear using 200-grit silicon carbide paper (20 strokes per tooth). iTero™ TimeLapse technology feature was used to overlay this record with the reference scan

Micro-CT was chosen as the gold standard due to its low discrepancy and small voxel size (18.313 mm). All samples were initially imaged with a micro-CT scanner (SkyScan 1173, Bruker) and an intraoral scanner (iTero Element™ 2 scanner) for reference data

Results



Article:

INTERNATIONAL DENTAL JOURNAL 73 (2023) 56–62

Scientific Research Report

Accuracy of the Intraoral Scanner for Detection of Tooth Wear

Somsak Mitrirattanakul [a], *Siew Peng Neoh* [b], *Jirasin Chalarmchaichaloenkit* [c], *Chirasit Limthanabodi* [c], *Chocktipat Trerayapiwat* [c], *Natdanai Pipatpajong* [c], *Norravit Taechushong* [c], *Rochaya Chintavalakorn* [b,*]

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ARTICLE INFO

Article history:
Received 24 February 2022
Received in revised form
6 June 2022
Accepted 7 June 2022
Available online 2 August 2022

Key words:
Tooth wear
Intraoral scanner
Micro-computed tomography
Abrasion
iTero Element® 2
Accuracy

ABSTRACT

Objective: The aim of this work was to study the accuracy of the intraoral scanner for detection of tooth wear in natural teeth by using micro-computed tomography (micro-CT) as a gold standard.
Materials and methods: Twenty premolars were prepared, fixed in acrylic blocks, and scanned with an intraoral scanner (iTero Element® 2) and micro-CT for baseline reference images before artificial tooth wear induction. The samples were then scrubbed with abrasive sandpaper 20 times and scanned with the intraoral scanner. They were then superimposed with the reference images utilising the "TimeLapse" feature of the scanner until the abraded area appeared yellow, indicating tooth surface loss in the 50-200 μm range. The same samples were then rescanned by micro-CT to measure the actual tooth surface loss. This procedure was repeated for the subsequent experimental tooth surface loss of 200-400 μm range (orange areas) and 400-750 μm range (red areas). The collected data were analysed for sensitivity, positive predictive value (PPV), and accuracy. Level of statistical significance was set at .05.
Results: In the detection of experimental tooth surface loss, the specificity, PPV, and accuracy of the intraoral scanner were 98%, 98%, and 97%, respectively.
Conclusions: The iTero® intraoral scanner can be recommended to be a suitable screening tool for tooth wear in routine dental practice.

Introduction

Tooth wear is a prevalent issue commonly encountered in the oral health care system.[1,2] It is a general condition caused by many factors such as ageing, behaviour, and socioeconomic status, leading to the loss of dental hard tissue (enamel and dentine).[3–5] The aetiology of tooth wear can be classified into mechanical wear, which encompasses abrasion, attrition, and abfraction, and chemical wear in the form of erosion.[6]

Abrasion is a type of extrinsic mechanical wear caused by non-tooth objects. It is usually due to incorrect or excessive oral hygiene practices, a coarse diet, or habits such as nail or pen biting.[5,6] The clinical characteristics of abrasion are scooping or pitting of the tooth surface, most often seen in the cervical areas. Normally, functional cusps (ie, palatal cusps of upper molars and buccal cusps of lower molars) are more likely to be worn out from function faster than other surfaces.[6]

Conversely, attrition is a form of intrinsic mechanical wear, caused by tooth-to-tooth contact during clenching and/or bruxism,[3] resulting in the loss of dental hard tissue.[6] Clinical characteristics of attrition appear as flat occlusal surfaces corresponding to the morphology of an opposing tooth, without a cupping or scooping pattern.[6]

Abfraction, another form of intrinsic mechanical wear, propagates from flexural stresses at the cervical area of tooth structure. It is exacerbated by harmful occlusal forces that do not pass through the long axis of the tooth.[5,6] Abfraction may

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https://doi.org/10.1016/j.identj.2022.06.004
0020-6539/

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Topic:

Patient monitoring.

Reference:

Int Dent J. 2022 Aug 2:S0020-6539(22)00116-2.

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Article summary of:

“Clinical validation of near-infrared imaging for early detection of proximal caries in primary molars.”

iTero™

Executive summary

The study aimed to validate the effectiveness of iTero™ NIRI technology (Near Infra-Red Imaging) against visual inspection (VI) for detecting early-stage proximal caries in primary molars among 126 patients aged 3–12 years

- **Results:** iTero™ NIRI exhibited higher accuracy (82.89%) and sensitivity (74.10%), but lower specificity (90.97%) compared to VI, which had 71.64% accuracy, 43.88% sensitivity, and 97.14% specificity
- **Conclusions:** Given iTero™ NIRI’s high sensitivity in detecting proximal caries, it may improve detection rate in primary molars vs. VI
- **Clinical implications:** The authors recommends using iTero™ NIRI in conjunction with bite-wing radiography to enhance the detection of proximal caries in primary molars

Aims of the study

The aim of this study was to validate iTero™ NIRI technology (Near Infra-Red Imaging) in comparison with visual inspection (VI) for early detection of proximal caries in primary molars

Introduction

- Proximal caries, a common chronic disease in children, is typically identified by pediatric dentists through clinical examination, often in advanced stages. Detection relies on dentists’ experience and skills
- The most common diagnostic method is bite-wing radiography (BWR), which provides clear images of proximal caries. However, excessive use of BWR can lead to potential health risks from ionizing radiation
- iTero™ NIRI technology (Near Infra-Red Imaging) is a promising new technology that uses specific near-infrared light to create digital images of enamel, dentin, and caries at different brightness levels. In previous studies iTero™ NIRI showed potential for improving diagnostic accuracy in caries detection

Article:

Journal of Dentistry 138 (2023) 104658

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.elsevier.com/locate/jdent

Clinical validation of near-infrared imaging for early detection of proximal caries in primary molars

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ARTICLE INFO

Keywords:
Near-infrared
Proximal caries
Early diagnosis
Pediatric dentistry
Bitewing radiography

ABSTRACT

Objectives: The aim of this study was to validate the near-infrared imaging (NIRI) in comparison with visual inspection (VI) for early detection of proximal caries in primary molars.
Methods: VI and intraoral scans were performed on 126 patients aged 3–12 years with at least one non-cavitied and non-restored proximal tooth surface, who were scheduled for bite wing radiography (BWR) as part of their standard care. Teeth with signs of proximal cavities, restorations or residual caries were excluded in this study. BWR, a gold standard to diagnose proximal caries in primary molars, was used to validate the findings of NIRI and VI. The accuracy, sensitivity, specificity and the area under the curve (AUC) of NIRI and VI were calculated.
Results: The accuracy, sensitivity and specificity of NIRI were 82.89%, 74.10% and 90.97%, while those of VI were 71.64%, 43.88% and 97.14%, respectively. NIRI showed higher accuracy and sensitivity, and lower specificity ($P < 0.001$). The AUC of NIRI was higher than that of VI (0.826 vs 0.706; $P < 0.05$).
Conclusions: NIRI showed higher sensitivity and lower specificity compared with VI when detecting proximal caries in primary molars. Therefore, it is recommended to use NIRI in combination with BWR to improve the detection rate of proximal caries in primary molars.
Clinical significance: In children, there is a high incidence of proximal caries in primary molars, which require high technical sensitivity for detection. NIRI shows high sensitivity in detecting proximal caries, which may improve their detection rate in primary molars.
The clinical trial registration number: ChiCTR2300070916

1. Introduction

Proximal caries is one of the most common chronic diseases in children [1]. The detection of proximal caries in primary molars is mostly based on pediatric dentists’ clinical examination and generally happens when they progress to chalky or ink-dip stage. Therefore, proximal caries are occult and their detection is highly dependent on the experience of dentists, which require high technical skills [2].
The most commonly used method to diagnose proximal caries is bite wing radiography (BWR). BWR has the advantage of clearly displaying proximal caries. The average young child or adolescent has 4.5 intraoral exposures per examination, mostly due to the use of BWR. However, up to 75% of cancer cases attributed to dental radiography are caused by lax collimation and noncompliance with selection criteria [3]. Therefore, the use of X-ray detection is not recommended as a routine dental examination procedure because of potential health risks associated with ionizing radiation [4,5].
Near-infrared imaging (NIRI) is a new technology and has the potential to improve the diagnostic accuracy of caries detection [6]. The principle of NIRI involves the use of near-infrared light of specific band that can penetrate the sound enamel but is scattered and reflected by dentin and unsound enamel. The reflected light is captured by a sensor to create a digital image of the enamel, dentin and caries in different brightness levels [7]. Zvi Metzger *et al.* demonstrated that the sensitivity

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https://doi.org/10.1016/j.jdent.2023.104658
Received 24 May 2023; Received in revised form 9 August 2023; Accepted 10 August 2023
Available online 18 August 2023

Authors:

Jingwei Cao , Yuwen Fang, Yue Liao , Yan Wang , Ran Yang, Yang Zhang , Qiong Zhang, Jing Zou.

Topic:

Caries detection in primary teeth.

Reference:

Journal of Dentistry. 2023 Aug.

This text is lifted from the article.

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Article summary of:

“Clinical validation of near-infrared imaging for early detection of proximal caries in primary molars.”

iTero™

Materials and methods

- 126 patients aged 3–12, with non-cavitied and non-restored proximal teeth, underwent visual inspection and intraoral scans prior to bite wing radiography (BWR) as part of standard care
- BWR, the gold standard for diagnosing proximal caries in primary molars, was used for validation
- Accuracy, sensitivity, specificity, and AUC of iTero™ NIRI and VI were assessed

Results

- The accuracy, sensitivity and specificity of NIRI were 82.89%, 74.10% and 90.97%, while those of VI were 71.64%, 43.88% and 97.14%, respectively
- NIRI showed higher accuracy and sensitivity than VI (P < 0.001)

Conclusion & Clinical Implications

- iTero™ NIRI technology (Near Infra-Red Imaging) offers high accuracy and sensitivity in early proximal caries detection without radiation
- It’s recommended to combine iTero™ NIRI with BWR for more precise diagnosis and treatment, preventing potential overtreatment due to iTero™ NIRI’s high sensitivity

Article:

Journal of Dentistry 138 (2023) 104658

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.elsevier.com/locate/jdent

Clinical validation of near-infrared imaging for early detection of proximal caries in primary molars

Jingwei Cao [a], Yuwen Fang [a], Yue Liao [a], Yan Wang [a], Ran Yang [a], Yang Zhang [b], Qiong Zhang [a,1], Jing Zou [a,1,*]

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ARTICLE INFO

Keywords:
Near-infrared
Proximal caries
Early diagnosis
Pediatric dentistry
Bitewing radiography

ABSTRACT

Objectives: The aim of this study was to validate the near-infrared imaging (NIRI) in comparison with visual inspection (VI) for early detection of proximal caries in primary molars.
Methods: VI and intraoral scans were performed on 126 patients aged 3–12 years with at least one non-cavitied and non-restored proximal tooth surface, who were scheduled for bite wing radiography (BWR) as part of their standard care. Teeth with signs of proximal cavities, restorations or residual caries were excluded in this study. BWR, a gold standard to diagnose proximal caries in primary molars, was used to validate the findings of NIRI and VI. The accuracy, sensitivity, specificity and the area under the curve (AUC) of NIRI and VI were calculated.
Results: The accuracy, sensitivity and specificity of NIRI were 82.89%, 74.10% and 90.97%, while those of VI were 71.64%, 43.88% and 97.14%, respectively. NIRI showed higher accuracy and sensitivity, and lower specificity ($P < 0.001$). The AUC of NIRI was higher than that of VI (0.826 vs 0.706; $P < 0.05$).
Conclusions: NIRI showed higher sensitivity and lower specificity compared with VI when detecting proximal caries in primary molars. Therefore, it is recommended to use NIRI in combination with BWR to improve the detection rate of proximal caries in primary molars.
Clinical significance: In children, there is a high incidence of proximal caries in primary molars, which require high technical sensitivity for detection. NIRI shows high sensitivity in detecting proximal caries, which may improve their detection rate in primary molars.
The clinical trial registration number: ChiCTR2300070916

1. Introduction

Proximal caries is one of the most common chronic diseases in children [1]. The detection of proximal caries in primary molars is mostly based on pediatric dentists’ clinical examination and generally happens when they progress to chalky or ink-dip stage. Therefore, proximal caries are occult and their detection is highly dependent on the experience of dentists, which require high technical skills [2].

The most commonly used method to diagnose proximal caries is bite wing radiography (BWR). BWR has the advantage of clearly displaying proximal caries. The average young child or adolescent has 4.5 intraoral exposures per examination, mostly due to the use of BWR. However, up to 75% of cancer cases attributed to dental radiography are caused by lax collimation and noncompliance with selection criteria [3]. Therefore, the use of X-ray detection is not recommended as a routine dental examination procedure because of potential health risks associated with ionizing radiation [4,5].

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https://doi.org/10.1016/j.jdent.2023.104658
Received 24 May 2023; Received in revised form 9 August 2023; Accepted 10 August 2023
Available online 18 August 2023

Authors:

Jingwei Cao , Yuwen Fang, Yue Liao , Yan Wang , Ran Yang, Yang Zhang , Qiong Zhang, Jing Zou.

Topic:

Caries detection in primary teeth.

Reference:

Journal of Dentistry. 2023 Aug.

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Article summary of:

"Differences in maxillomandibular relationship recorded at centric relation when using a conventional method, four intraoral scanners, and a jaw tracking system: A clinical study"

iTero™

Executive summary

- Digital systems including intraoral scanners (IOSs) and optical jaw tracking systems can be used to acquire the maxillomandibular relationship at the centric relation (CR). However, the discrepancy of the maxillomandibular relationship recorded at the CR position when using digital methods remains uncertain
- The purpose of this clinical study was to compare the accuracy of the maxillomandibular relationship recorded at the CR position using a conventional procedure, 4 different IOSs, and an optical jaw tracking system
- The results showed that the iTero™ intraoral scanner had the highest trueness value (0.14 ±0.09 mm)

Materials and methods

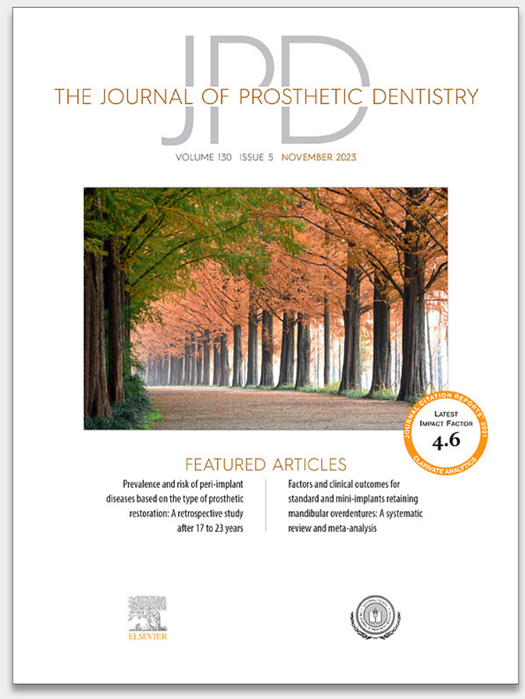
- A fully dentate volunteer was chosen
- Six groups were created: conventional procedures (CNV) and four intraoral scanner (IOS) groups (TRIOS4, iTero intraoral scanner, i700, Primescan), along with a group using a jaw tracking system (Modjaw)
- CR record obtained for mandibular cast mounting, which was then digitized using a scanner (T710) for reference scans
- Virtual casts were created for each group, and 36 measurements were taken on both reference and experimental scans to calculate discrepancies

Results

Trueness rankings from high to low for the scanners were as follows:

- iTero intraoral scanner (0.14 ± 0.09 mm) > Modjaw (0.20 ± 0.04 mm) > TRIOS4 (0.22 ± 0.09 mm) > i700 (0.40 ± 0.22 mm) > Primescan (0.26 ± 0.13 mm)
- iTero intraoral scanner, Modjaw, and TRIOS4 groups showed no significant difference in trueness ($P > .05$)
- The i700 and Primescan groups demonstrated significantly lower trueness compared to the iTero intraoral scanner group ($P < .05$)

Article:



Authors:

Marta Revilla-León, Rubén Agustín-Panadero Jonathan M. Zeitler, Abdul B. Barmak, Burak Yilmaz, John C. Kois, Jorge Alonso Pérez-Barquero.

Topic:

Jaw relation registration.

Reference:

The Journal of Prosthetic Dentistry. 2023 Jan.

This text is lifted from the article.

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Article summary of:

“Trueness and precision of complete arch dentate digital models produced by intraoral and desktop scanners: an ex-vivo study.”

iTero™

Executive summary

- The research aimed to evaluate the accuracy of different intraoral scanners and two other digitization methods when scanning teeth and soft tissue in human jaws
- For mandibular teeth, the PVS method had significantly better trueness than Medit i700 and Primescan
- For maxillary teeth, the PVS method and iTero Element™ 5D Intraoral scanner had significantly better precision than Medit i700
- For the palate, the iTero Element™ 5D and Trios 4 had significantly better trueness than PVS and stone

Aim of the study

The study aimed to compare the trueness and precision of intraoral scanners (Emerald S, iTero Element™ 5D, Medit i700, Primescan, and Trios 4) and two indirect digitization techniques for both teeth and soft tissue on fresh mandibular and maxillary cadaver jaws.

Materials and methods

- A fully dentate cadaver’s maxilla and mandible were scanned using an ATOS industrial scanner to create a master model
- These jaws were then scanned 8 times by each intraoral scanner (IOS)
- Additionally, eight polyvinylsiloxane (PVS) impressions were taken and digitized with a Medit T710 desktop scanner
- Stone models were then produced and scanned with the desktop scanner
- All IOS, PVS, and stone models were compared to the master model to calculate surface deviations for mandibular teeth, maxillary teeth, and palate

Results

- For mandibular teeth, the PVS method’s trueness was only significantly better than the Medit i700 and Primescan
- The iTero Element™ 5D scanner and Trios 4 exhibited significantly higher trueness in the palate compared to digitized PVS impressions and stone models
- The iTero Element™ 5D scanner demonstrated higher precision for maxillary teeth compared to the Medit i700

Conclusion:

All investigated IOSs and indirect digitization could be used for complete arch scanning in mandibular and maxillary dentate arches. However, direct optical digitization is preferable for the palate due to the low accuracy of physical impression techniques for soft tissues.

Article:

Journal of Dentistry 139 (2023) 104764

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.elsevier.com/locate/jdent

Trueness and precision of complete arch dentate digital models produced by intraoral and desktop scanners: An *ex-vivo* study

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ARTICLE INFO

Keywords:
Intraoral scanner
Trueness
Accuracy
Conventional impression
Cadaver

ABSTRACT

Objectives: The study aimed to compare the trueness and precision of five intraoral scanners (Emerald S, iTero Element 5D, Medit i700, Primescan, and Trios 4) and two indirect digitization techniques for both teeth and soft tissues on fresh mandibular and maxillary cadaver jaws.

Methods: The maxilla and mandible of a fully dentate cadaver were scanned by the ATOS industrial scanner to create a master model. Then, the specimens were scanned eight times by each intraoral scanner (IOS). In addition, 8 polyvinylsiloxane (PVS) impressions were made and digitized with a Medit T710 desktop scanner. Stone models were then poured and again scanned with the desktop scanner. All IOS, PVS, and stone models were compared to the master model to calculate the mean absolute surface deviation for mandibular teeth, maxillary teeth, and palate.

Results: For mandibular teeth, the PVS trueness was only significantly better than the Medit i700 ($p < 0.001$) and Primescan ($p < 0.05$). In maxillary teeth, the PVS trueness was significantly better than all IOSs ($p < 0.05$–0.001); the stone trueness was significantly better than Emerald S ($p < 0.01$), Medit i700 ($p < 0.001$) and Primescan ($p < 0.01$). In the palate, PVS and stone trueness were significantly lower than the iTero Element 5D ($p < 0.01$) and Trios 4 ($p < 0.01$). Stone trueness was significantly lower than the Medit i700 ($p < 0.05$). The precision in the palate was significantly lower for PVS and stone than for Emerald S ($p < 0.01$, $p < 0.05$), iTero Element 5D ($p < 0.01$, $p < 0.01$), Primescan ($p < 0.001$, $p < 0.001$), and Trios 4 ($p < 0.001$, $p < 0.01$). Significant differences in trueness between the IOSs were observed only in the mandibular teeth. The Medit i700 performed worse than Emerald S ($p < 0.01$) and iTero Element 5D ($p < 0.01$). For mandibular teeth, the Medit i700 was significantly more precise than Primescan ($p < 0.01$) and the Emerald S ($p < 0.05$). The Trios 4 was significantly less precise than Emerald S ($p < 0.05$). The precision of Medit i700 was significantly worse than iTero Element 5D ($p < 0.01$) for maxillary teeth, as well as the Primescan ($p < 0.01$) and Trios 4 ($p < 0.05$) for the palate.

Conclusions: In general, indirectly digitized models from PVS impressions had higher trueness than IOS for maxillary teeth; precision between the two methods was similar. IOS was more accurate for palatal tissues. The differences in trueness and precision for mandibular teeth between the various techniques were negligible.

Clinical significance: All investigated IOSs and indirect digitization could be used for complete arch scanning in mandibular and maxillary dentate arches. However, direct optical digitization is preferable for the palate due to the low accuracy of physical impression techniques for soft tissues.

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https://doi.org/10.1016/j.jdent.2023.104764
Received 6 July 2023; Received in revised form 21 September 2023; Accepted 25 October 2023
Available online 26 October 2023

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Clinton Stevens,
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Mark Ludlow,
Madison Sharp,
Christian Brenes,
Anthony Mennito,
Walter Renne

Topic:

Palatal scanning accuracy.

Reference:

Journal of Dentistry
2023 Oct 26:139:104764.

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Article summary of:

“Comparison of treatment time for single implant crowns between digital and conventional workflows for posterior implant restorations: A randomized controlled trial.”

iTero™

Executive summary

Digital workflows with iTero Element™ 5D® were 39.2% more timesaving than the conventional protocol for the implant single crown treatment in data acquisition and laboratory steps.

Aim of the study

- This randomized controlled trial aimed to compare the treatment time of single-implant crowns for both digital and conventional workflows
- In addition, prostheses made of polymer-infiltrated ceramic-network and lithium disilicate were compared in each group

Materials and methods

- A total of 40 patients (n=40) who needed a single-implant crown on posterior regions were considered and randomly divided into digital workflows (n=20) with an intraoral scanner (IOS, iTero Element™ 5D®, Align Technology) and conventional workflows (n=20) with impressions using polyether (Impregum™ Penta™, 3M ESPE)
- Each group was again distributed into 2 subgroups based on the crown materials used: PICN (n=10) and LS2 (n=10)
- Treatment time was calculated for both digital and conventional workflows
- Analysis was done at 5% confidence interval (p-value <0.05). An independent two-sample t-test was used to compare treatment time between the groups
- Any of the implant crowns that had to be remade in each subgroup, were evaluated by the Fisher Exact test

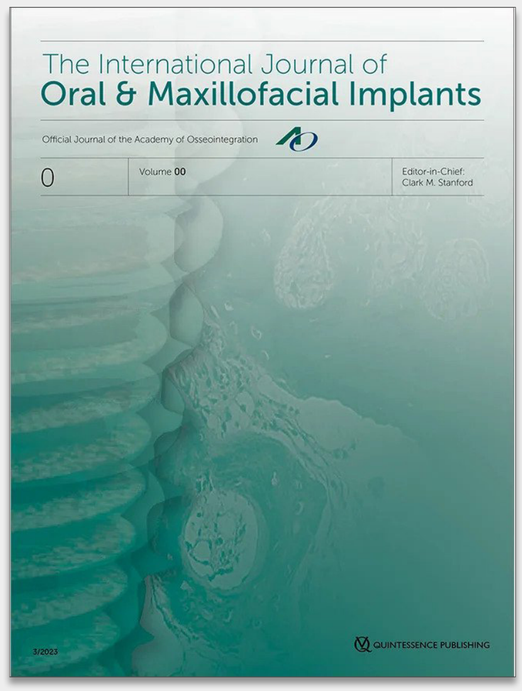
Results

- The entire process of digital workflows required 104.31 ± 20.83 minutes and conventional workflows required 153.48 ± 16.35 minutes
- Digital workflows were 39.2% more timesaving than the conventional protocol for the implant single crown treatment

Conclusion:

- Both digital and conventional workflow protocols can achieve a successful outcome of single-implant monolithic crowns in posterior areas
- The digital protocol using iTero Element™ 5D® yielded a greater time saving over the conventional procedure in data acquisition and laboratory steps
- In contrast, the time for a clinical try-in and delivery were similar

Article:



Authors:

Worapat Jarangkul, Chatchai Kunavisarut, Tim Joda, Suchaya Pomprasertsuk-Damrongsri

Topic:

Efficiency

Reference:

Int J Oral Maxillofac Implants 2023 Nov 1;0(0).

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Article summary of:

“Accuracy, Time, and Comfort of Different Intraoral Scanners: An In Vivo Comparison Study”

iTero™

Executive summary*,**

- Patients reported that the iTero Lumina™ scanner provided a more comfortable and painless scanning experience compared to the iTero Element™ 5D imaging system.
- The iTero Lumina scanner was associated with a perceived decrease in scanning duration, enhancing overall patient satisfaction compared to iTero Element 5D scanner.
- The advanced technology of the iTero Lumina scanner offered better visualization of dental impressions, contributing to higher patient preference.
- All three evaluated intraoral scanners (IOSs) - iTero Lumina scanner, iTero Element 5D imaging system, and TRIOS Color – demonstrated acceptable accuracy in capturing dental arch measurements with minimal differences.

Aim of the study

The study aimed to compare the accuracy of three intraoral scanners—iTero Lumina scanner, iTero Element 5D imaging system, and TRIOS Color—in capturing full-arch digital impressions and to evaluate patient experiences during the scanning procedures.

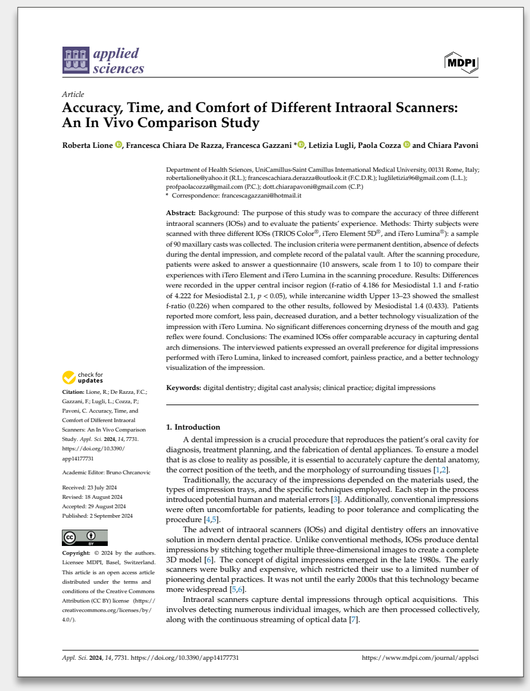
Materials and methods

- Thirty adults (15 males, 15 females; mean age 24.5 ± 4.3 years) with complete permanent dentition were selected for the study. Each participant underwent maxillary arch scanning using three different IOSs: TRIOS Color, iTero Element 5D imaging system, and iTero Lumina scanner, resulting in a total of 90 digital dental casts. The inclusion criteria ensured the absence of caries, periodontal diseases, supernumerary teeth, and required complete records of the palate.
- The scanning protocol was standardized to ensure consistency. Each scan began from the occlusal surface of the left second upper molar, progressing across the occlusal, palatal, and buccal surfaces, and concluding at the right second molar. The palatal vault was fully recorded in each scan. An experienced examiner with five years of orthodontic practice performed all scans.
- Patient experience was assessed by administering a questionnaire immediately following scanning with iTero Lumina scanner and iTero Element 5D scanner. 3Shape TRIOS was not included in this part of the study. This questionnaire included 10 questions about patient comfort, pain levels, scanning duration, and visualization quality for both the iTero Element 5D imaging system and iTero Lumina scanner. Using the data from the patients’ satisfaction surveys, a paired t-test was used to analyze the differences between iTero Element and iTero Lumina.

* Please refer to the full text for claims substantiation and complete study information.

** The study included testing iTero Element scanner, iTero Lumina scanner and 3Shape Trios for accuracy, and only compared iTero Element scanner and iTero Lumina scanner for patient satisfaction scores

Article:



applied sciences

MDPI

Article

Accuracy, Time, and Comfort of Different Intraoral Scanners: An In Vivo Comparison Study

Roberta Lione, Francesca Chiara De Razza, Francesca Gazzani *, Letizia Lugli, Paola Cozza and Chiara Pavoni

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Abstract: Background: The purpose of this study was to compare the accuracy of three different intraoral scanners (IOSs) and to evaluate the patients’ experience. Methods: Thirty subjects were scanned with three different IOSs (TRIOS Color®, iTero Element 5D®, and iTero Lumina®): a sample of 90 maxillary casts was collected. The inclusion criteria were permanent dentition, absence of defects during the dental impression, and complete record of the palatal vault. After the scanning procedure, patients were asked to answer a questionnaire (10 answers, scale from 1 to 10) to compare their experiences with iTero Element and iTero Lumina in the scanning procedure. Results: Differences were recorded in the upper central incisor region (f-ratio of 4.186 for Mesiodistal 1.1 and f-ratio of 4.222 for Mesiodistal 2.1, $p < 0.05$), while intercanine width Upper 13–23 showed the smallest f-ratio (0.226) when compared to the other results, followed by Mesiodistal 1.4 (0.433). Patients reported more comfort, less pain, decreased duration, and a better technology visualization of the impression with iTero Lumina. No significant differences concerning dryness of the mouth and gag reflex were found. Conclusions: The examined IOSs offer comparable accuracy in capturing dental arch dimensions. The interviewed patients expressed an overall preference for digital impressions performed with iTero Lumina, linked to increased comfort, painless practice, and a better technology visualization of the impression.

Keywords: digital dentistry; digital cast analysis; clinical practice; digital impressions

check for updates

Citation: Lione, R.; De Razza, F.C.; Gazzani, F.; Lugli, L.; Cozza, P.; Pavoni, C. Accuracy, Time, and Comfort of Different Intraoral Scanners: An In Vivo Comparison Study. *Appl. Sci.* **2024**, *14*, 7731. https://doi.org/10.3390/app14177731

Academic Editor: Bruno Chrcanovic

Received: 23 July 2024
Revised: 18 August 2024
Accepted: 29 August 2024
Published: 2 September 2024

1. Introduction

A dental impression is a crucial procedure that reproduces the patient’s oral cavity for diagnosis, treatment planning, and the fabrication of dental appliances. To ensure a model that is as close to reality as possible, it is essential to accurately capture the dental anatomy, the correct position of the teeth, and the morphology of surrounding tissues [1,2].

Traditionally, the accuracy of the impressions depended on the materials used, the types of impression trays, and the specific techniques employed. Each step in the process introduced potential human and material errors [3]. Additionally, conventional impressions were often uncomfortable for patients, leading to poor tolerance and complicating the procedure [4,5].

The advent of intraoral scanners (IOSs) and digital dentistry offers an innovative solution in modern dental practice. Unlike conventional methods, IOSs produce dental impressions by stitching together multiple three-dimensional images to create a complete 3D model [6]. The concept of digital impressions emerged in the late 1980s. The early scanners were bulky and expensive, which restricted their use to a limited number of pioneering dental practices. It was not until the early 2000s that this technology became more widespread [5,6].

Intraoral scanners capture dental impressions through optical acquisitions. This involves detecting numerous individual images, which are then processed collectively, along with the continuous streaming of optical data [7].

Authors:

Lione, R., De Razza, F. C., Gazzani, F., Lugli, L., Cozza, P., & Pavoni, C. (2024).

Topic:

Patient experience, Accuracy

Reference:

Applied Sciences, 14(17), 7731.

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Article summary of:

"Accuracy, Time, and Comfort of Different Intraoral Scanners: An In Vivo Comparison Study"

iTero™

Satisfaction survey responses for iTero Element and iTero Lumina.

	iTero Element		iTero Lumina		p	Difference	95% Confidence	
	M	SD	M	SD			Lower	Upper
Q1: "Comfort"	**5.1**	**0.9**	**7.3**	**1.3**	**	**−2.2**	**−3.2**	**−1.2**
Q2: "Stress"	2.5	1.1	2.3	1.2	NS	0.2	−0.9	1.3
Q3: "Pain"	**4.1**	**1.0**	**2.6**	**0.9**	**	**1.5**	**0.6**	**2.4**
Q4: "Mouth dryness"	4.6	1.1	4.3	1.0	NS	0.3	−0.7	1.3
Q5: "Gag reflex"	4.5	2.8	3.8	2.6	NS	0.7	−19	3.3
Q6: "Experience"	**7.2**	**0.9**	**8.4**	**1.2**	*	**−1.2**	**−2.2**	**0.2**
Q7: "Duration"	**6.1**	**0.8**	**8.1**	**0.7**	***	**−2.0**	**−2.8**	**−1.2**
Q8: "Technology"	**6.0**	**1.1**	**7.9**	**0.8**	**	**−1.9**	**−2.8**	**−0.9**
Q9: "Communication"	6.1	0.7	7.0	1.1	*	−0.9	−1.8	−0.1
Q10: "General satisfaction"	8.1	0.7	8.9	0.4	*	−0.8	−1.5	−0.1

M: media, SD: standard deviation, p: p-value, * <0.5, ** <0.01 *** <0.001, NS: not significant.

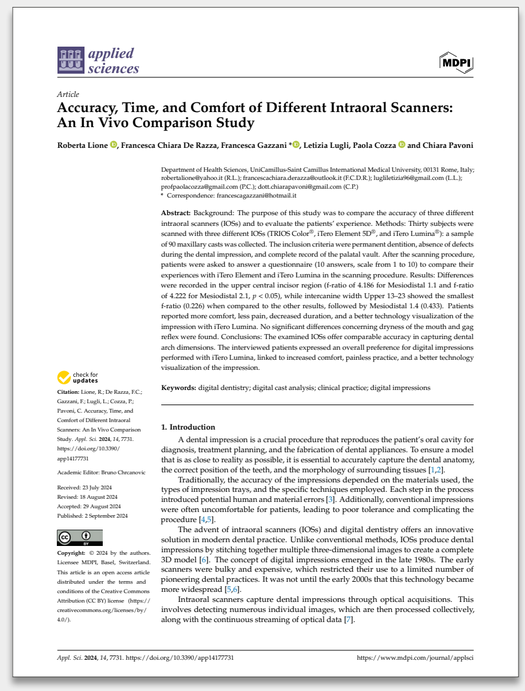
Results

- Accuracy: Statistical analysis revealed minimal differences in accuracy among the three IOSs. Slight variations were observed in the upper central incisor region, but these differences were not clinically significant. Overall, all scanners provided clinically acceptable accuracy in capturing dental arch dimensions.
- Patient experience: Survey responses indicated a clear preference for the iTero Lumina scanner compared to the iTero Element 5D imaging system. Patients reported higher comfort levels, less pain, shorter perceived scanning durations, and better visualization of impressions with the iTero Lumina scanner. No significant differences were noted between the two iTero models regarding mouth dryness and gag reflex.

Conclusion:

The study concluded that while the iTero Lumina scanner, iTero Element 5D imaging system, and TRIOS Color intraoral scanners exhibit clinically acceptable accuracy in capturing dental arch dimensions. The iTero Lumina scanner and iTero Element 5D scanner were compared in terms of patient comfort and satisfaction. Patients showed a distinct preference for the impressions taken with the iTero Lumina scanner, citing increased comfort, a painless experience, and enhanced visualization of the impression as key reasons for their preference.

Article:



applied sciences — MDPI

Article

Accuracy, Time, and Comfort of Different Intraoral Scanners: An In Vivo Comparison Study

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Abstract: Background: The purpose of this study was to compare the accuracy of three different intraoral scanners (IOSs) and to evaluate the patients' experience. Methods: Thirty subjects were scanned with three different IOSs (TRIOS Color®, iTero Element 5D®, and iTero Lumina®) a sample of 90 maxillary casts was collected. The inclusion criteria were permanent dentition, absence of defects during the dental impression, and complete record of the palatal vault. After the scanning procedure, patients were asked to answer a questionnaire (10 answers, scale from 1 to 10) to compare their experiences with iTero Element and iTero Lumina in the scanning procedure. Results: Differences were recorded in the upper central incisor region (f-ratio of 4.186 for Mesiodistal 1.1 and f-ratio of 4.222 for Mesiodistal 2.1, $p < 0.05$), while intercanine width Upper 13-23 showed the smallest f-ratio (0.226) when compared to the other results, followed by Mesiodistal 1.4 (0.433). Patients reported more comfort, less pain, decreased duration, and a better technology visualization of the impression with iTero Lumina. No significant differences concerning dryness of the mouth and gag reflex were found. Conclusions: The examined IOSs offer comparable accuracy in capturing dental arch dimensions. The interviewed patients expressed an overall preference for digital impressions performed with iTero Lumina, linked to increased comfort, painless practice, and a better technology visualization of the impression.

Keywords: digital dentistry; digital cast analysis; clinical practice; digital impressions

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Citation: Lione, R.; De Razza, F.C.; Gazzani, F.; Lugli, L.; Costa, P.; Pavoni, C. Accuracy, Time, and Comfort of Different Intraoral Scanners: An In Vivo Comparison Study. *Appl. Sci.* **2024**, *14*, 7731. https://doi.org/10.3390/app14177731

Academic Editor: Bruno Chrcanovic

Received: 23 July 2024
Revised: 18 August 2024
Accepted: 29 August 2024
Published: 2 September 2024

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1. Introduction

A dental impression is a crucial procedure that reproduces the patient's oral cavity for diagnosis, treatment planning, and the fabrication of dental appliances. To ensure a model that is as close to reality as possible, it is essential to accurately capture the dental anatomy, the correct position of the teeth, and the morphology of surrounding tissues [1,2].

Traditionally, the accuracy of the impressions depended on the materials used, the types of impression trays, and the specific techniques employed. Each step in the process introduced potential human and material errors [3]. Additionally, conventional impressions were often uncomfortable for patients, leading to poor tolerance and complicating the procedure [4,5].

The advent of intraoral scanners (IOSs) and digital dentistry offers an innovative solution in modern dental practice. Unlike conventional methods, IOSs produce dental impressions by stitching together multiple three-dimensional images to create a complete 3D model [6]. The concept of digital impressions emerged in the late 1980s. The early scanners were bulky and expensive, which restricted their use to a limited number of pioneering dental practices. It was not until the early 2000s that this technology became more widespread [5,6].

Intraoral scanners capture dental impressions through optical acquisitions. This involves detecting numerous individual images, which are then processed collectively, along with the continuous streaming of optical data [7].

Appl. Sci. 2024, 14, 7731. https://doi.org/10.3390/app14177731 https://www.mdpi.com/journal/applsci

Authors:

Lione, R.,
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& Pavoni, C.
(2024).

Topic:

Patient experience,
Accuracy

Reference:

Applied Sciences,
14(17), 7731.

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Article summary of:

“Full arch accuracy of intraoral scanners with different acquisition technologies: an in vitro study”

iTero™

Executive summary*

- iTero Lumina™ scanner showed the lowest trueness error (0.04%) and precision error (0.0320%) among all tested scanners.
- According to ADA/ANSI 132 guidelines, iTero Lumina™ scanners achieved a 99.6% acceptable scan ratio for long-span restorations, outperforming other scanners included in the study. Improved ratio of acceptable scans may reduce retakes, thereby minimizing patient discomfort, enhancing patient experience, and lowering the time and costs associated with repeated procedures.
- iTero Multi-Direct Capture™ (MDC) technology decouples the scanner’s field of view (FOV) from the wand size, enabling a larger FOV without increasing size of the wand. Increased FOV minimizes stitching and reduces potential misalignment errors. This improves scan reliability for long-span restorations compared to scanners using confocal and structured-light technologies.

Aim of the study

This in vitro study, conducted on a dentate stone model, aimed to evaluate and compare the trueness, precision, and overall accuracy of intraoral scanners (IOS) using Multi-Direct Capture (MDC), confocal imaging, and structured light technologies. The objective was to determine their performance in full-arch scanning under controlled conditions based on ADA/ANSI Standard 132 protocols for “long-distance accuracy”.

Materials and methods

This in vitro study assessed five IOSs:

	Manufacturer	Technology	Field of view
iTero Lumina™	Align Technologies, San Jose, CA, USA	Multi-direct capture	21×15mm @0mm 36×27mm @10mm
TRIOS 5	3Shape, Copenhagen, Denmark	Confocal imaging	15.9×15.3mm@ Near focus 19.5×18.8mm @Far focus
CS3800	Carestream Dental, Atlanta, GA	Confocal imaging	16×14mm
i700	Medit, Seoul, South Korea	Structured light	15×13mm (Standard tip)
AS260	Alliedstar, Shanghai, China	Structured light	16×14mm (L) 12x12mm (S)

Table 1. Optical technology and field of view specifications of the included scanners.

* Please refer to the full text for claims substantiation and complete study information.

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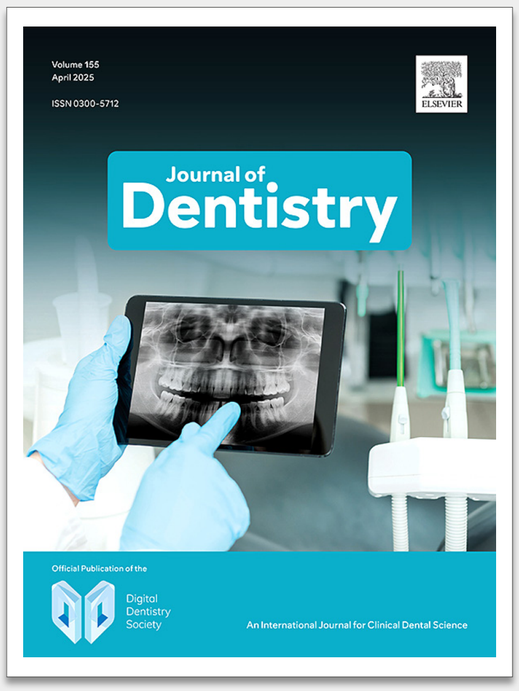

Authors:

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Topic:

Full arch accuracy

Reference:

Journal of Dentistry,
Volume 156,
2025,
105703,
ISSN 0300-5712

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“Full arch accuracy of intraoral scanners with different acquisition technologies: an in vitro study”

iTero™

A dentate cast model embedded with metal spheres was scanned to evaluate accuracy against coordinate measuring machine (CMM) reference data.

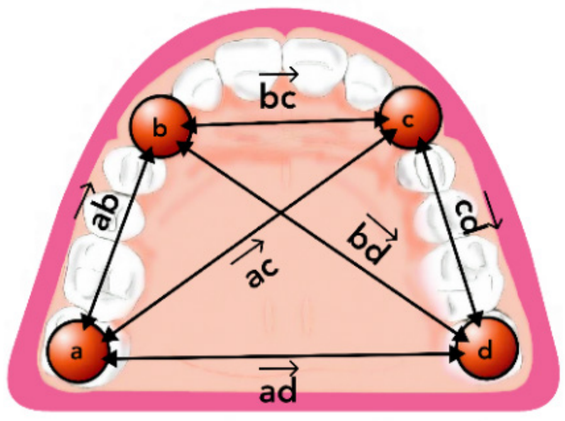

Fig 1. Dentate cast model with four metal spheres.

Metrics: Linear deviation, total bias, and plane deviation were analyzed. Operator variability was also studied using statistical models to compare performance across different users.

Dataset: A total of 441 STL files were generated, comprising scans from three operators for each scanner, and evaluated using statistical software with significance set at $p < 0.05$.

Results

Linear deviation: iTero Lumina™ scanner showed the lowest trueness error (0.04%) and precision error (0.0320%), surpassing all other scanners.

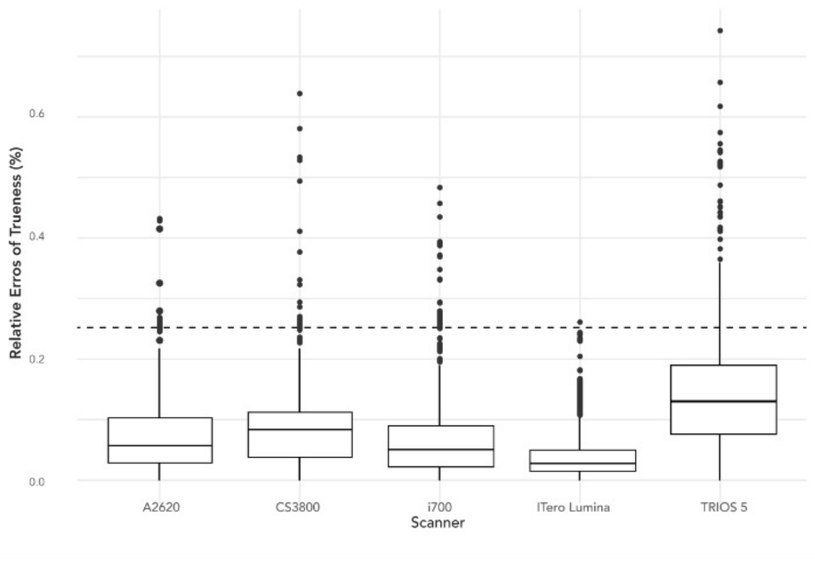

Fig. 2. Relative error of trueness of linear dimensions measured from intraoral scan data (relative error in percentage).

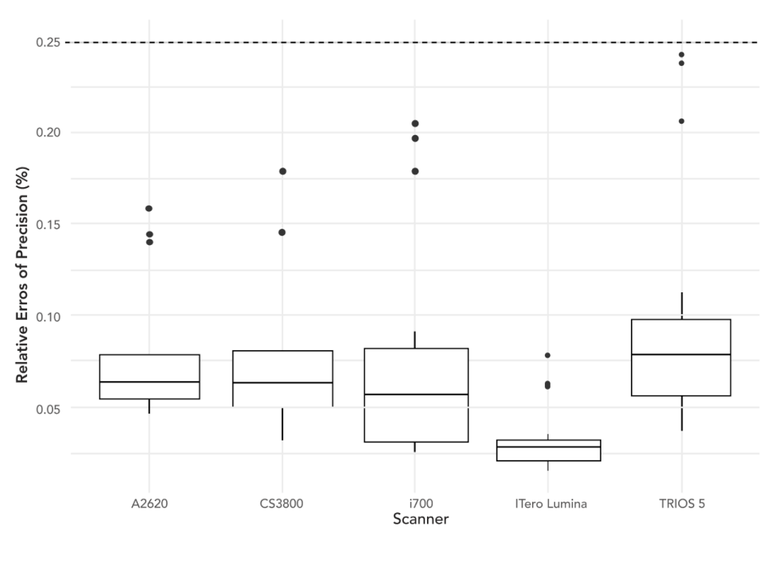

Fig. 3. Shows the relative error of precision, representing consistency across repeated measurements. Inter-operator variability: The iTero Lumina™ scanner displayed minimal variability between different operators.

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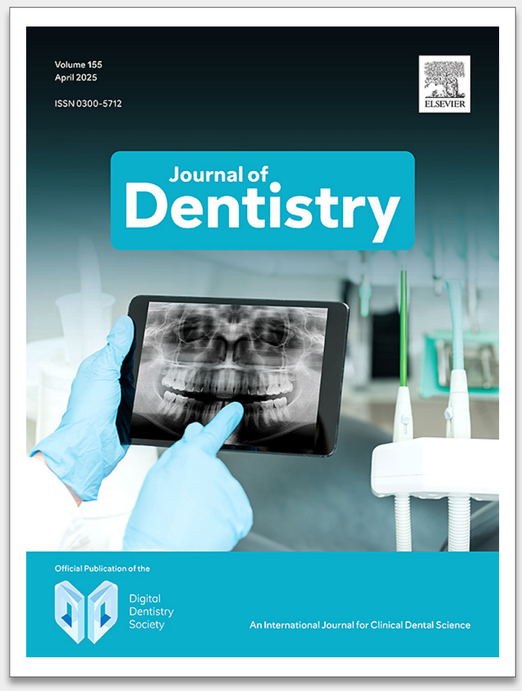

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Article summary of:

“Full arch accuracy of intraoral scanners with different acquisition technologies: an in vitro study?”

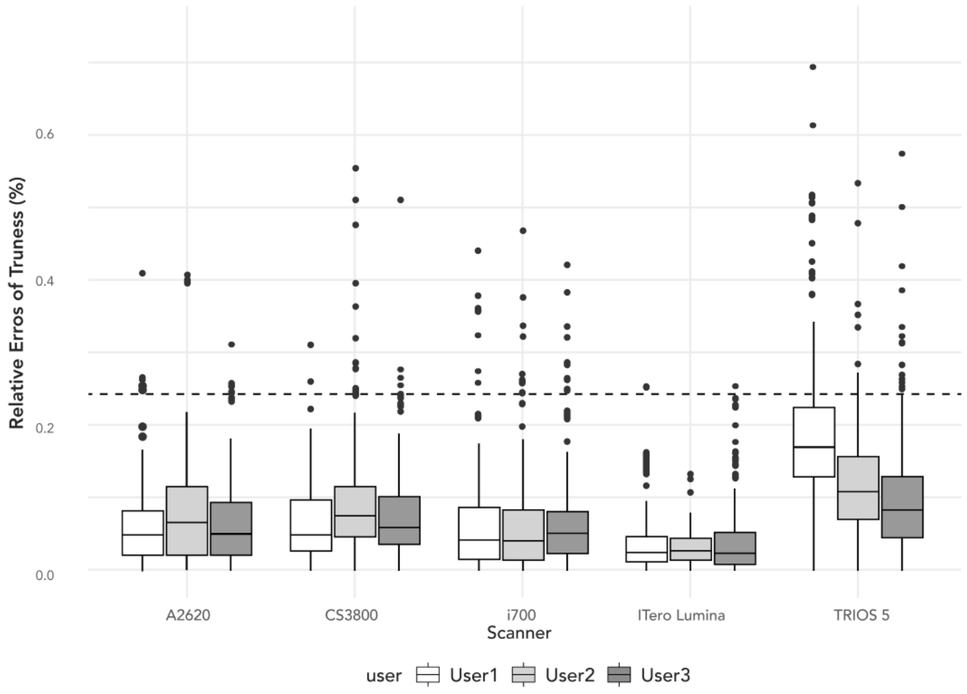

Fig. 4. Inter-operator variability comparison of relative error of trueness.

Conclusion:

The iTero Lumina™ scanner, powered by iTero Multi-Direct Capture™ technology, demonstrated lower linear relative errors in trueness and precision compared to confocal and structured-light technologies, particularly for long-span scans. MDC technology is a shift from conventional IOS limitations, suggesting that future intraoral scanners could achieve desktop-scanner-level precision while preserving ergonomic compact wand designs.

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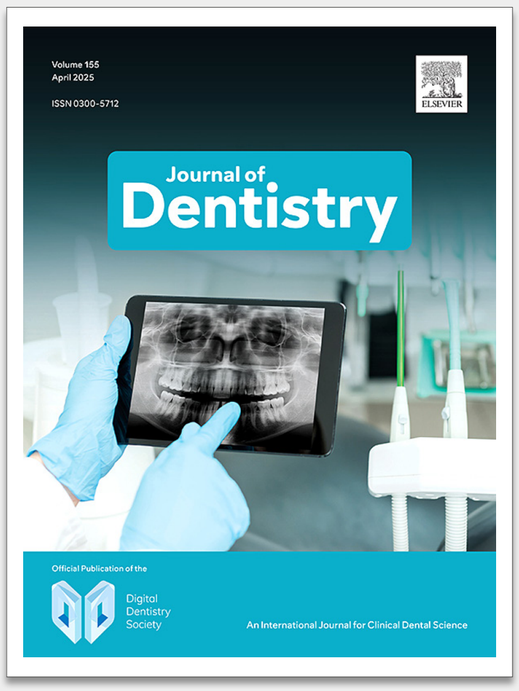

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