ORIGINAL ARTICLE

ACCURACY OF INTRAORAL SCANNERS VERSUS TRADITIONAL IMPRESSIONS: A RAPID UMBRELLA REVIEW

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ABSTRACT

Purpose

This study aimed to (1) report the trueness and precision of intraoral scanning (IOS) in dentistry based on recent secondary sources and to (2) appraise the reporting quality of the titles and abstracts of the included literature.

Materials and methods

This rapid overview searched the PubMed/Medline and Cochrane Database of Systematic Reviews in March 2021 to identify reviews reporting on the accuracy of IOS. The reference list from the eligible studies was also screened for identification of other potentially eligible studies. The inclusion criteria consisted of English language systematic reviews or meta-analyses published between 2019 and 2021. The exclusion criteria were primary studies, narrative review, and extraoral scanners. The assessment of reporting quality of abstracts of systematic reviews was performed using the reporting checklist PRISMA extension for Abstracts (PRISMA-A). This was a self-funded research project.

Results

Out of the full text screened 25 records, 11 reviews were included. Most studies supported the IOS approach being as precise and accurate as the conventional one. Only one study significantly favored the conventional approach over the IOS, and two studies abstained from making a recommendation. The IOS was significantly superior to the traditional technique in terms of patient preference and time efficiency. After applying PRISMA-A, recommendations for improvements on titles and abstracts of future reviews of IOS and conventional impressions are provided.

Conclusion

Laboratory data indicated similar accuracy between IOS and conventional impressions, whereas clinical data found the same in less than 4-unit fixed dental prostheses. For more extensive definitive fixed solutions or removable prostheses, the conventional approach is recommended. IOS was superior in terms of patient preference and time reduction. More clinical trials are required to determine the clinical effectiveness of incorporating IOS in broader scenarios. Better quality of reporting secondary sources abstract is advised.

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KEYWORDS

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BACKGROUND

Digital technologies in medicine and dentistry have enabled clinicians to improve diagnostic and intervention outcomes in terms of efficiency, quality, and patient experience.[1-5] For more than a century, in dentistry, conventional dental impression-taking has consisted of depositing impression material in an impression tray that is intraorally transported until it sets copying the negative of the structures of interest. Moreover, intraoral scanners (IOS) for digital impressions could improve the quality of oral rehabilitations.[4,5] Compared to the conventional option, IOSs produce dental impressions through stitching various three-dimensional pictures until a three-dimensional object is obtained. Techniques for obtaining better digital impressions have been recommended.[6,7] It might be enticing to know the current status of the IOS to the late majority and laggard technology-adopter dental clinicians.

The Preferred Reporting Items for Systematic reviews and Meta-Analyses for abstracts (PRISMA-A) was introduced in 2013 to assist authors in providing an abstract that allows for a fast evaluation of review validity, an explicit description of findings, peer review before publication or conference collection, and easy retrieval after an electronic search.[8,9] The checklist provides a guide for authors to condense their systematic review into the basics for an abstract that will appeal to a wide range of readers.

Rapidly assessing and comparing the accuracy and clinical validity of IOS and conventional impressions reported by recent systematic reviews and meta-analysis is essential for supporting decisions to implement or not newer technologies. Also, it is valuable to explain the distinctions between both approaches, emphasizing the benefits and drawbacks of each. Moreover, it is pertinent to assess and compare the reporting quality of the summary of these secondary reports. Thus, this study had two aims:

- To report the trueness and precision of IOS in dentistry based on recent secondary sources.
- To appraise the reporting quality of the titles and abstracts of the included literature.

MATERIALS AND METHODS

The overarching research question of this rapid umbrella review was, what is the accuracy of IOS in dentistry based on secondary studies data, and what is their abstract reporting completeness?

Two electronic databases, Medline via PubMed and the Cochrane Database of Systematic Reviews, were searched to retrieve studies published from January 2020 to March 2021. The inclusion criteria were systematic reviews and meta-analyses about IOS in dentistry published after December 2019 in English language. The exclusion criteria were primary studies, narrative reviews, and extraoral scanners. Thereby, the applied search strategy in March 2021 (second week) was: (((intraoral OR "intra-oral" OR "intra oral") AND (scan*)) OR ((digital) AND (scan* OR impression*))) AND ((systematic* AND review*) OR ("meta-analysis" OR meta-analysis OR "meta analysis")). The reference list from the potentially eligible studies was screened for identification of other recent eligible studies.

Rapid reviews are secondary studies that synthesize knowledge in a narrow timeframe without being as rigorous as systematic reviews to enable rapidity.[10] In contrast, umbrella reviews are tertiary studies that use existing systematic reviews as the analytic unit.[11,12] These methodologies have recently been combined to produce rapid umbrella reviews.[13,14] Additionally, the assessment of reporting quality of abstracts of the included systematic reviews in the present review was performed by two reviewers (NAA and a research assistant) supervised by a third reviewer author (KIA) using the reporting checklist PRISMA extension for Abstracts (PRISMA-A).[8] Table 1 exemplifies the modified version of the PRISMA-A used in this study. This version introduced by the authors consisted of adding an item for reporting the manual search (3b) besides the electronic search (3a) to extract more information, and the reporting of the title was divided into systematic review (1a) and meta-analysis (1b) to be more specific.

Neither a sample size calculation, ethics committee approval, nor use of informed consent was performed since the nature of this review study does not require any of them.

The outcomes measured where defined as per the Glossary of Digital Dental Terms. Precision is the reproducibility of agreement between independent measured scores, trueness is the closeness or deviation of agreement between the mean value from a set of measured scores and a reference value, and accuracy is the closeness or deviation of agreement between a measured score and a reference value.

RESULTS

The Medline/PubMed database retrieved 45 and 19 records in 2020 and 2021, respectively, whereas the Cochrane Database of Systematic Reviews retrieved 5 and 2 records. The two reviewers selected 25 records as eligible after abstract screening and a third reviewer verified them. No additional records were identified after screening the reference list from the potentially eligible studies. Further full-text screening between two reviewers' agreement (Cohen's kappa) was 0.74 (substantial agreement) initially, and 14 records were selected after consensus. The third review author determined that 11 secondary studies met the criteria. Thus, the two main reasons for excluding 14 full texts were: not reporting on accuracy of IOS or focused on marginal

Table 1. The proposed modified version PRISMA for abstracts checklist item by section (uppercase words) and topic/item.

Title and purpose	
	1a. Title mentions a systematic review 1b. Title mentions a meta-analysis 2. Objective state participants, intervention, comparator, and outcomes
Methods	
	3a. Information sources include electronic databases and dates searched 3b. Information sources include manual/hand search conducted 4. Eligibility criteria for inclusion of reports
Results	
	6. Included studies describing their number and type, and relevant characteristics of studies 7. Synthesis of results reports the main outcomes, and confidence intervals, in case of meta-analysis 8. Description of the effect includes direction and effect direction and size relevant to clinicians
Discussion	
	9. Strengths and limitations of evidence summary 10. Interpretation of the results and recommendations for clinicians
Other	
	11. Funding for the review 12. Registration number and registry name

adaptation of fixed dental prostheses (FDPs) and single crowns.

Included Studies Characteristics

Four secondary studies included clinical studies only,[15-19] none included laboratory studies only, and the majority (7/11) included both types of studies. All included studies assessed trueness or accuracy. In addition, three studies assessed patient preference,[15-17] and time was evaluated in three reports.[16-18]

These studies included fully dentate,[19] (cc) partially[15-17,20-22] and fully- edentulous scenarios.[20-24,25] Most secondary studies contained dental implant scenarios.[17,21-25]

Main Outcomes Measured

Most secondary studies reported that digital impressions have accuracy comparable to conventional dental impressions. Two studies[16,22] reported that IOS was comparable to the conventional technique in single abutments or implants, contiguous implants, or three-unit FDPs or implant-supported fixed dental prostheses (ISFDPs). However, one study[21] favoured the conventional approach significantly in partially edentulous scenarios with implants.

Another trend was that completely edentulous scenarios with implants with IOS are comparable to conventional impressions.[21,23,25] This was also true in completely edentulous scenarios without implants but only when bony structures had attached mucosa since mobile tissues resulted in significant unfavorable accuracy compared to conventional methods.[20]

All studies reporting on patient preference significantly favoured the digital approach.[15-17]

Regarding the working time, two studies[16,18] reported comparable results between IOS and conventional methods, whereas one study reported a significant reduction in time when using IOS.[17]

Factors Affecting Intraoral Impressions

The factors considered to influence accuracy on the included secondary sources were consistent: type of scanner, scanner head size, scanning strategy/pattern, depth of placement, scan-body design, scan-body material, inter-implant distance, inter-implant angulation, and operator experience.[20,22,23,25]

Assessment of Abstracts Completeness of the Included Literature

The complete results of the PRISMA-A tool applied to the included secondary studies are available in Table 2. Regarding the PRISMA-A evaluation per study, the highest abstract

Table 2. Summary of PRISMA for abstracts completeness reporting: each included study evaluated with our modified version of the checklist.

Study ID	PRISMA-A topics/items														R #	R%
	1a	1b	2	3a	3b	4	5	6	7	8	9	10	11	12		
Fueki 2021	√	x	√	x	√	x	x	x	√	x	√	√	x	x	6	42.9
Rasaie 2021	√	x	√	x	√	√	x	√	√	x	√	√	x	x	8	57.1
Giachetti 2020	√	x	√	√	x	x	x	√	√	√	√	x	x	x	7	50.0
Papaspyridakos 2020	√	√	√	x	√	√	x	√	x	√	√	x	x	x	8	57.1
Wulfman 2020	√	x	√	x	x	√	x	√	√	x	x	x	x	x	5	35.7
Arcuri 2020	√	x	√	x	x	√	x	√	√	√	√	√	x	x	8	57.1
Bandiaky 2020	√	√	√	√	√	x	√	√	√	√	x	x	x	x	9	64.3
de Oliveira 2020	x	√	√	√	√	x	x	√	√	√	x	x	x	x	7	50.0
Carneiro Pereira 2020	√	x	√	√	x	√	x	√	√	√	√	√	x	x	9	64.3
Cicciu 2020	√	x	√	√	x	x	x	x	√	√	√	x	x	x	6	42.9
Garcia-Gil 2020	√	x	√	√	√	√	x	√	√	x	√	x	x	x	8	57.1

R #, number of reported items; R%, reported percentage; Study ID, first author last name and publication year.
For detailed PRISMA-A topics/items refer to Table 1. Title and purpose: Items 1a, 1b, and 2; methods: Items 3a, 3b, and 4; results: Items 6, 7, and 8; discussion: Items 9 and 10; other: Items 11 and 12.

completeness score was 9 (64.3%),[16,25] and six of the 11 studies (54.5%) complied with 8 (57.1%) or 9 (64.3%) topics/items. The remaining included studies complied with less than 50.1% of the reporting of topics/items. Three[16,17,21] out of 11 studies reported a meta-analysis (Table 2). The partially or completely reported items per study averaged 7.4 out of 14 assessed items with a standard deviation (SD) of 1.3, which proportionally corresponded to 52.6 ± 9.2%. Regarding the PRISMA-A evaluation per topic/item, item 2 was completed by all studies, followed by items 1a and 7 with 92.3% (Figure 1). Out of the six studies that mentioned the number of databases consulted, two-thirds included three databases, and one-third included four (Table 3). The five studies that provided the name of consulted databases included Medline/PubMed, four Cochrane, three Embase.

The compliance summary was above 50% for the topics/items 1a, 2, 3a, 3b, 4, 6, 7, 8, and 9 (Figure 1). Item 2 had the highest compliance with 100%, whereas items 11 (funding) and 12 (registration) were the lowest with 0% compliance. The mean of the items/topics that included 11 studies complied with was 5.8 ± 3.7 (52.6 ± 33.9%).

DISCUSSION

This rapid overview of secondary evidence fulfilled its two aims. All included secondary sources were recent and most reported comparable accuracy between IOS and conventional impression in reconstructive dentistry. There are some reservations for extensive impressions as most data was generated from laboratory studies.[20-25] It seems that clinical evidence is scarce by not having a standardized evaluation for the framework adaptation,[23] which could result in methodological heterogeneity. A few secondary sources had comparable outcomes between both impressions approaches in clinical cases with single-unit, two-unit (non-cantilevered), and three-unit implant-supported or tooth-borne fixed solutions.[16,18,22] Among the advantages of IOS over convectional impressions, and simplified lab procedures were reported in partial removable dental prosthesis and implant-supported complete fixed dental prosthesis clinical scenarios.[15,21] Caution is advised in cases where inter-implant angles are greater than 15°.[25] Other considerations are that full-digital PRPDs are restricted to tooth-bounded cases (ie, Kennedy Class III and IV).[15] Moreover, accuracy results differed among the various IOS.[20] For instance, active wavefront sampling is more accurate than the other type of IOS.[26] Additionally, it must be considered that the wavefront sampling technology requires dusting (a powdered substance). However, most of the IOS provide satisfactory accuracy. Certainly, larger scanner head size, and specific scanning strategies have improved the accuracy of IOS,[20] among other influencing factors.[22,23,25] The only study that determined that

Figure 1. Graph of PRISMA for abstracts compliance distribution: each of the 14 items of our modified version of the checklist is presented as percentages across all included studies. Score: 0 = not reported, 1 = partially or fully reported. PRISMA-A topics/items description is available in Table 1. Title and purpose: Items 1a, 1b, and 2; methods: Items 3a, 3b, and 4; results: Items 6, 7, and 8; discussion: Items 9 and 10; other: Items 11 and 12.

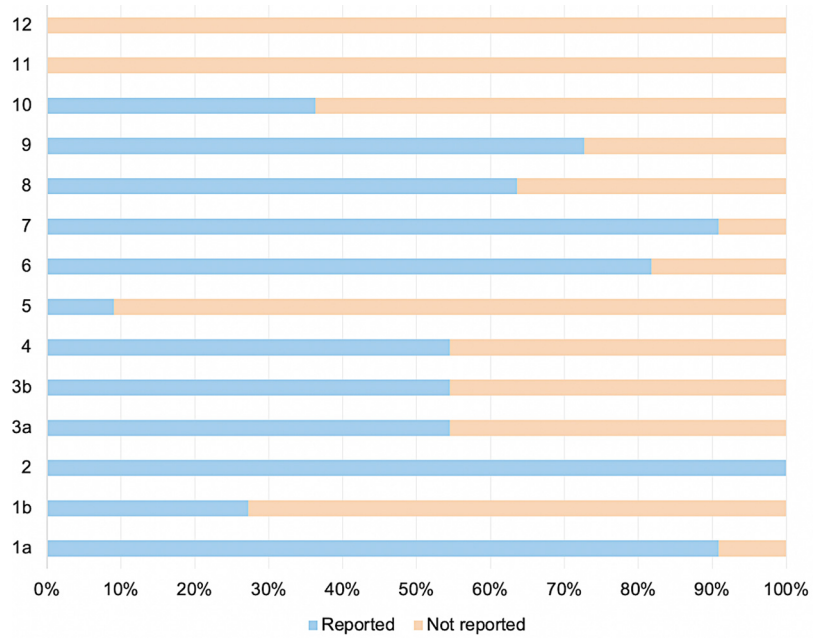

Table 3. Information sources of included studies: electronic databases and manual/hand search consultation.

Study ID	Number and name of electronic databases	Manual search
Fueki 2021	NR	NR
Rasaie 2021	NR	Yes
Giachetti 2020	4: PubMed, Cochrane Library, Web of Science, and Embase	NR
Papaspyridakos 2020	NR	Yes
Wolfman 2020	NR	NR
Arcuri 2020	NR	NR
Bandiaky 2020	3: NR	Yes
de Oliveira 2020	3: Medline, Embase, and Cochrane Library	Yes
Carneiro Pereira 2020	4: Medline/PubMed, Scopus, Web of Science, and Cochrane Library	NR
Cicciu 2020	3: Elsevier, PubMed, and Embase	NR
Garcia-Gil 2020	3: Medline/PubMed, Cochrane Library, and Lilacs	NR

NR, not reported; Study ID, first author's last name and publication year.

IOS had significantly less accuracy than conventional impression included clinical scenarios with complete dentition.[19] Patient significantly preferred the IOS over the conventional approach.[15-17] IOS had similar[16,18] and significantly superior results[17] reported than conventional methods in terms of time efficiency.

Both average scores per study and per item/topic were slightly above 50%. Consequently, this rapid overview has shown that based on the PRISMA-A tool, there is a need for improvement in the completeness of abstract reporting in secondary studies comparing accuracy between IOS and conventional impressions.

Additional Bibliometrics

Three publications were associated with authors from Italy,[18,19,24] two from each France[16,23] and Brazil,[17,25] and the remaining four records were single publications from Spain, US, Iran, and Japan. Thus, most of the studies (6/11) originated from the European continent.

In terms of the number of authors per publication, three reports were published by three authors,[20,23,25] two reports[16,21] were published by seven authors, other two reports[17,19] by four authors. The remaining reports had 5,[22] 6,24 8,[15] and 11 authors.[18] The average of authors per secondary publication was 5.5, and the range varied as much as from 3 to 11 authors.

According to the journal classification based on Scopus metrics, 10 of the included records were considered in the top 2 quartile categories. Out of these, five records were published in the top 10% journals, such as the *Journal of Prosthetic Dentistry*,[16,23,25] *Clinical Oral Implants Research*,[17] and *Journal of Prosthodontic Research*.[15] Thus, the overall quality of the included reviews can be considered moderate-high. However, the reader is advised to interpret these score criteria with caution since the journal classification does not necessarily reflect the individual publication quality.[27,28]

Strengths and Limitations of this Tertiary Study

The limitations of this rapid umbrella review are the same as any rapid review, which relies on rapidly collecting the data from the available literature without an extensive methodological appraisal.[29] However, it seems that the main conclusions from rapid and systematic reviews are not significantly different.[30] The hybrid nature of this study permitted conducted an umbrella review to summarize recent systematic reviews and metanalysis.[11,31]

Additionally, this study included a partial assessment that evaluated the reporting of the abstracts of the included secondary studies using the PRISMA-A tool[8,9] with a slight modification introduced in the present study. Another limitation in this study prevails from including secondary studies as the unit of study, which mostly concluded that more clinical primary studies are needed to determine the superiority of one impression approach over the other. Thus, caution is recommended when adopting IOS for definitive impressions in cases where several-unit FDPs involve long-edentulous spans or mobile soft tissues in the partial or fully edentulous population, especially in mandibular arches. Lastly, we propose that clinician-scientists provide more evidence from clinical trials, which are required to evaluate the efficacy and usefulness of IOS in relation to traditional impressions.

We are aware that digital technologies will expand its range of applications offering improved outcomes to what we commonly perform with traditional methods.[3,32] However, the traditional impressions still have their place in reconstructive dentistry.

CONCLUSIONS

Based on the findings of this rapid overview, the following conclusions were drawn:

1. Most of the laboratory data from recent secondary sources comparing intraoral scanners and conventional impressions found similar accuracy in simulated clinical scenarios.
2. Clinical data of secondary sources supports both impressions approaches in scenarios for definitive single-unit up to three-unit fixed dental reconstructions.
3. There is evidence that patients significantly prefer intraoral scanners to conventional impressions.
4. Better quality of reporting secondary sources abstracts and high-quality prospective trials with standardized methodologies are required to determine the clinical effectiveness of intraoral scanners involving extensive fixed and removable reconstructions in partially- and fully edentulous prospects.

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CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Kelvin I. Afrashtehfar: Conceptualization, Methodology, Resources, Writing - Review & Editing, Supervision, Project administration; **Naden A. Alnakeb**: Validation, Investigation, Writing - Original Draft, Visualization, Funding acquisition; **Mansour K. M. Assery**: Investigation, Resources, Writing - Original Draft.

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