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APPLICATION AND SUCCESS OF DIGITAL TECHNOLOGY IN FIXED PROSTHODONTICS; A NARRATIVE REVIEW

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ABSTRACT

In terms of the clinical and technological viability of full digital workflows, the long-term outcomes, and the financial ramifications, it is critical to comprehend how the present digitalization trend is altering well-established procedures. The scientific literature was initially screened for data documenting the use of full digital workflows in fixed prosthodontics for treatment with tooth-borne or implant-supported fixed restorations in 2017.

In fully edentulous arches with multiple implants, conflicting evidence exists regarding the superiority of IOS over traditional impressions. Some studies suggest that IOS is either statistically significant or equally accurate as traditional methods, while others indicate the opposite. Factors such as scanner type, generation, operator experience, and implant angulation may influence scanning accuracy. However, the majority of scanners provide complete-arch accuracy values below the clinically acceptable threshold of 150 µm.

In conclusion, the evaluation of intraoral scanning (IOS) accuracy in implant-supported restorations reveals a nuanced landscape. In short-span implant edentulous locations, IOS accuracy has been compared to traditional impression accuracy, primarily focusing on prostheses supported by up to four implants in the same quadrant. While some studies show statistical superiority of traditional approaches, IOS devices exhibit varying degrees of accuracy, with deviations ranging from 27 to 66 µm. However, the clinical significance of these differences remains unclear.

Keywords: Digital Dentistry, Digital Technology, Fixed Prosthodontics, Case-Control.

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INTRODUCTION

The worldwide trend towards digitalization now dominates all areas of dentistry. Computerized dentistry, as a technique-focused field, has made novel clinical procedures and manufacturing methods possible, especially in fixed prosthodontics [1]. The advancement of dental technology is mostly driven by the development of computer-aided design and computer-aided manufacturing (CAD/CAM) methods. However, the use of intraoral scanners (IOS) has altered clinical processes in a big way in recent years [2]. The combination of these technologies has made it possible to do single-visit treatments for both implant-supported and tooth-borne monolithic fixed dental prostheses (FDPs) using full digital workflows [2].

Three primary work steps comprise complete digital protocols:

1. Using IOS to capture a 3D image of each patient's unique situation in the mouth.
2. Using dental software applications (CAD) for digital design and rapid prototyping, such as milling or 3D printing (CAM), in a fully virtual environment without the need for physical dental models (plaster casts).
3. Clinical delivery of the dental restoration [3].

The creation, transmission, and further processing of the generated IOS data (in Standard Tessellation Language [STL] format) are essential processes [4]. The digital workflow is linked to repeatable production in a streamlined procedure with less need for manual human involvement, as well as mechanically excellent monolithic restorations [5].

Historically, dental research has mostly concentrated on one of these three steps. Generally, the emphasis was on the accuracy and precision of in vitro studies, comparing various IOS systems or fast prototyping techniques for creating the final restorations. The dentistry literature needed clinical investigations, especially randomized controlled trials (RCTs) that looked into the whole digital process, with the exception of a few single case reports [6].

In terms of the clinical and technological viability of full digital workflows, the long-term outcomes, and the financial ramifications, it is critical to comprehend how the present digitalization trend is altering well-established procedures [7,8,9]. The scientific literature was initially screened for data documenting the use of full digital workflows in fixed prosthodontics for treatment with tooth-borne or implant-supported fixed restorations in 2017. This was done using a systematic review. The degree of evidence supporting comprehensive digital workflows was found to be poor in this study, as shown by the inclusion of just three papers examining single-unit restorations and the absence of any research at the time identifying multi-unit restorations [6].

The use of digital technology and software in dentistry is rapidly advancing. Both for IOS systems and the CAD/CAM industry, a plethora of innovative technologies and commercial solutions have been introduced in recent years. For the year 2022, a general PubMed search with the keyword "digital dentistry" returns 2070 articles. Just 953 of the techniques—or less than half—are found when the study is restricted to the year 2017 (the period of the initial evaluation). It would be interesting to find out if the percentage of qualitative clinical trials in fixed prosthodontics has grown in accordance with this trend, given the significant growth that has occurred in such a short amount of time

METHODS

Search strategy

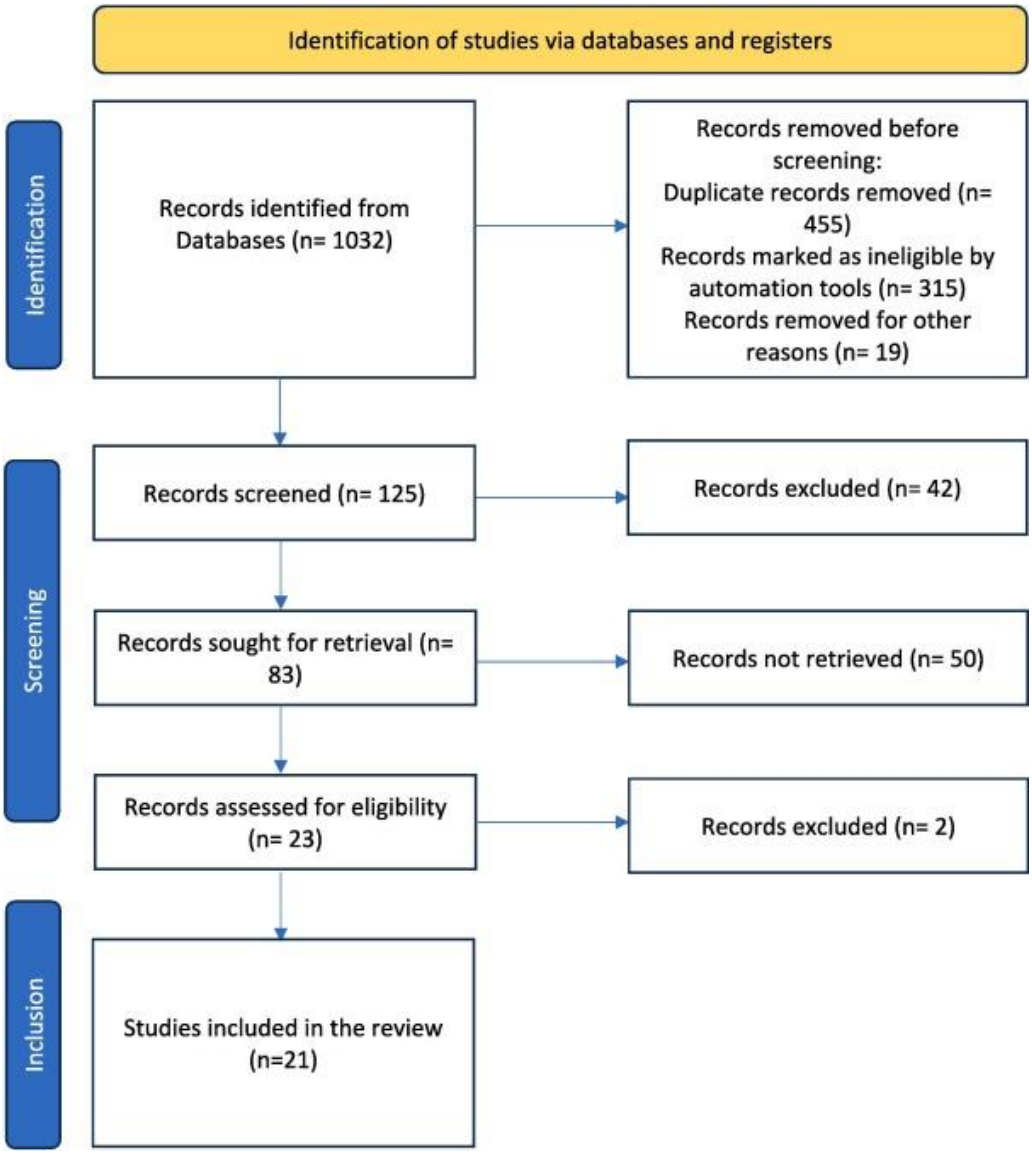
A computerized search was done for publications between January 1, 2019, and March 31, 2023. The year 2015 was chosen as the cut-off date because of the rapid advancements in dental CAD/CAM material science [19] and scanner hardware and software [20] during the previous five years. The combination of free-text terms was part of the search technique. The search keywords and the quantity of entries retrieved from a MEDLINE (PubMed) search were used.

In vitro research on intraoral digital implant impression accuracy, case series, prospective and retrospective clinical trials, and randomized control clinical trials (RCTs) were all included in this study. Included were in vitro and in vivo studies that compared the scanning effectiveness of various IOS devices. Included were studies that compared the accuracy of intraoral digitalization to traditional implant impressions. This study also includes reports on the success and longevity of lithium disilicate and monolithic zirconia restorations on implants made using an IOS impression method, as well as reports on fit correctness. Excluded from consideration were in vitro and in vivo investigations examining the firm correctness of restorations made by an indirect digital approach (lab scanning).

Additionally, case reports were not included. Only items written in English were found via the search. The reference lists of the included papers were examined in order to identify any publications that were overlooked further.

In this review, the following questions were raised and answered:

1.How accurate is the IOS at a single implant site?
2. What is the difference in IOS accuracy between traditional impression accuracy and short-span and fully edentulous implant sites?
3.What variables affect the accuracy of IOS?
4.How long do monolithic implant-supported restorations last, and how successful are they when made using the direct digital workflow?



RESULTS

A preliminary search turned up 483 references. Twenty one references met the criteria for inclusion in this evaluation after the exclusion criteria were applied.

IOS accuracy in short-span implant edentulous locations in comparison to traditional impression accuracy

Several studies have compared the IOS accuracy of different scanning equipment to the traditional impression accuracy with regard to implant-rehabilitated short-span edentulous sites. For short-span prostheses, supported by up to four implants in the same quadrant, the digital implant impression method has primarily been compared to an elastomeric impression technique [10,11,12] for in vitro accuracy. This method uses either addition-cure silicone materials in a single or dual mix technique or a polyether mono-phase method with custom trays [13,14,15, 16]. In the traditional impression method, implant impression posts were often unpainted. The majority of studies revealed statistical superiority of the traditional approach [17,18,19, 31]. However, depending on the scanner, the accuracy deviation of the IOS devices varied from 27 to 66 µm, whereas the conventional technique's deviation ranged from 26 to 49 µm [24, 25, 31]. We don't know how much of this statistical significance transfers into clinical relevance. The IOS deviation was reported to be 116 (± 94) µm in the research by Alsharbaty et al. [20, 21]. However, the calculation was done on the polyurethane milled castings that were made from the digital impressions, not 56 (± 29) µm for the traditional impression process. Consequently, it's possible that further variations in the milling procedure made

this disparity worse. Feine et al. [45] recently conducted an in vivo study. They found statistically significant differences in accuracy between digital and conventional impressions of partially edentulous sites with two adjacent implants. However, the authors were unable to determine whether these differences had any clinical significance. IOS accuracy in fully edentulous arches with multiple implants in comparison to conventional impression accuracy Over the last five years, much research has been conducted on the complete-arch IOS accuracy of multiple implant impressions. The gold standard for testing the accuracy of different scanners has been the traditional approach, which uses numerous implant impressions after splinting and elastomeric impression materials. There is conflicting information at the moment about whether one method is better than the other. According to existing research, IOS of fully edentulous arches with five or six implants is either statistically significant or equally more accurate than traditional elastomeric impressions taken using an open custom tray approach and impression post splinting [33, 34, 35]. This conclusion holds regardless of the scanner used, as various IOS technologies, including active triangulation and confocal microscopy, have been tested in the studies above. Since high-precision elastomeric materials were employed for both polyether (PE) and polyvinylsiloxane (PVS), the kind of impression material is also non-contributory. On the other hand, there is evidence that, for complete-arch implant rehabilitation, the splinted, open-tray, traditional elastomeric impression approach significantly outperforms the IOS impression in terms of statistical correctness [36,37, 38]. Once again, this result held regardless of the iOS device or impression substance used. The research design, the various IOS device software and hardware utilized, or the statistical analysis that was done may all be blamed for this lack of agreement. Still, it is not evident if statistical significance translates into clinical importance. However, there seems to be scientific proof in the literature that the traditional, non-splinted elastomeric impression technique—which uses an open or closed custom tray for complete-arch impressions—is inferior to the digital intraoral scanning method [39, 40, 41].

Factors affecting IOS accuracy in fixed implant-supported restorations:

A number of in vitro studies have been carried out to compare the accuracy of various scanning devices in terms of both complete-arch [23, 44, 48, 49, 50, 51, 52, 53, 54] and partial accuracy [43, 44, 45, 46, 47]. A very accurate reference laboratory scanner's scans were compared to the digital scans from the different IOS devices to ensure accuracy and trueness. Some scanner devices showed superior precision (low standard deviation) and higher complete-arch scanning accuracy compared to others, which implies that scanner type and generation might affect scanning accuracy. However, the majority of scanners from the latest generation provide complete-arch accuracy values that are below the 150 μm barrier, which is the highest value presently acceptable in clinical practice [45, 55, 56, 57, 58]. The literature has discovered and examined a number of clinical parameters that contribute to the worldwide variations in complete-arch intraoral scanning. In a study using an Active Wavefront Sampling (AWS) technology scanner (Lava COS), operator experience was one clinical parameter that was found to influence scanning accuracy [50]. However, more recent studies using newer generation scanners that used both AWS and Confocal Microscopy technology failed to verify this finding or determine the operator experience level that is clinically relevant [48, 60, 51]. Another clinical issue that has been thoroughly examined for its impact on the accuracy of digital impressions created from partial and complete-arch implants is implant angulation. Scanbody angulation did not affect scan accuracy in the great majority of investigations where single-part all-PEEK scanbodies were employed as scanning posts for both partial [21, 24, 25] and complete-arch [33, 39, 48, 52, 53] digital impressions. On the other hand, Baghani et al.'s investigation [52] revealed that scanbody angulation did, in fact, affect complete-arch scan accuracy. The PEEK-titanium scan bodies used in the research, maybe as a consequence of their interlocking, showed the lowest overall accuracy findings when compared to the all-PEEK and titanium scan bodies they were evaluated against. Gintaute et al. [53] conducted a further in vitro investigation in which they determined the correctness of the two implant mimics' location in partial, milled polyurethane casts that were digitally generated after IOS. After 91.3% and 99% of follow-up years, respectively, they reported a 1.9% biologic and 5.7% prosthetic occurrence rate. Positive outcomes on monolithic lithium disilicate CAD-CAM crowns are also reported in the literature. During a follow-up of two to three years, short-term in vivo trials showed a success rate of 89%–100% and a survival rate of 100% [5, 81]. Technical issues were

noted, including small chippings. Once again, biological difficulties were negligible.

Eleven studies (69%) examined the accuracy of the FDPs [56,57,58], five studies (32%) examined patient satisfaction [,20,21,27], and the majority of the found RCTs (12/16; 75%) focused on time efficiency as an economic key performance measure [53,54,55]. This demonstrates that, in addition to the traditional clinical metrics in fixed prosthodontics, such as assessments of marginal integrity and occlusion in the broader context of accuracy, patient-centred parameters are becoming more and more significant [55].

Complete digital processes might show a distinct advantage over traditional methods from an economic standpoint. This was true regardless of the restorations' size, whether they were single crowns or multiple units, and whether they were implant-supported or tooth-borne [21, 22, 23, 24, 25, 28, 29]. For the treatment of tooth-borne restorations, both workflows performed similarly in terms of accuracy, with a potential small benefit for established traditional methods over digital workflows [22,23,24,25]. Ultimately, the patients either evaluated the restorations from the digital processes higher or did not perceive any changes between FDPs created digitally and traditionally [60,61].
A happy patient and the effectiveness of the prosthetic treatment as a whole depend on the proper application of a workflow—digital or conventional—to the right indication [31]. A collaborative approach is especially crucial for digital processing; this applies to the dentist, dental assistants, and technicians in equal measure [32]. In (fixed) prosthodontics, the whole computerized process has the potential to revolutionize treatment.

However, the traditional approach is still the industry norm today. Both implant-supported and tooth-borne restorations have seen a rise in the digitization of specific workflow components in recent years. With the advent of CAD/CAM technology, this digital revolution in dentistry technology got underway. Consequently, a hybrid analogue-digital process has replaced the technical-dental procedure. Single crown indications strongly favour full digital processes with monolithic restorations and prefabricated titanium base abutments, particularly on implants in the posterior area [54]. Ideally, IOS has, therefore, closed the clinical gap [35]. Rapid, secure, and patient-friendly 3D capture of clinical situations has been made possible by the ongoing advancement of digital scanning technology [36, 37]. Because a standardized supra-mucosal localized scan body suffices instead of optically recording a unique preparation margin on the tooth, the use of IOS is especially advantageous in implant treatment. Digital bite registration is much simpler and more reliable for single-unit restorations than it is for multi-unit ones [38]. Lastly, the main motivator is economic reasons that provide high-quality restoration with shorter treatment times and lower manufacturing costs [39, 40].

CONCLUSION

In summary, the evaluation of intraoral scanning (IOS) accuracy in implant-supported restorations reveals a mixed landscape. While some studies suggest that IOS is comparable or even superior to traditional impression methods, conflicting evidence exists. Factors such as scanner type, operator experience, and implant angulation may influence scanning accuracy. Ultimately, the choice between digital and conventional workflows depends on various clinical and economic considerations, highlighting the need for a collaborative approach among dental professionals.

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