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Diagnostic Accuracy and Clinical Success of Digital Applications in Fixed Prosthodontics: A Narrative Review

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Abstract: Digital technologies such as intraoral scanners, IOS, CAD/CAM, and 3D printing are increasingly used in fixed prosthodontics to replace traditional workflows. This narrative review assessed works published between 2020 and 2025 on the efficiency, accuracy, outcomes, and survival of restorations, and how the restorations were fabricated. Research indicates that IOS systems and Impressions Trays systems offer accuracy and precision comparable to, or superior to, elastomeric impressions for single tooth crowns and short-span prostheses; but, they are less reliable for long-span and complete mouth restorations. CAD/CAM systems used to crown patients from digital impressions provide crowns with clinically acceptable marginal fits. CAD/CAM milled crowns of zirconia have been found to have a slightly closer fit than 3D printed restorations. Digital workflows reduce chairside time by 30-45% and are highly preferred by patients as the procedures are lower in discomfort and gagging. Clinical studies show more than 90% survival rates at 5 years, with monolithic zirconia performing very well. There remains, however, a lack of long-term and full arch reliability on digital fixed prosthodontics. Digital fixed prosthodontics is a more efficient and patient-friendly approach to traditional fixed prosthodontics.

Keywords: Digital dentistry, CAD/CAM, 3D printing, Prosthodontics

INTRODUCTION

The developments of new technologies such as digital imaging systems, CAD/CAM, and seamless digital workflows have redefined fixed prosthodontics. These innovations have resulted in increased efficiency, comfort, and diagnostic precision. Digital impressions are much more comfortable, and eliminating trays and setup helps control the gag reflex and anxiety [1]. CAD/CAM systems can manufacture restorations and facilitate direct clinician and lab communication, saving time and money [2]. More recent reviews report that digital workflows have improved patient satisfaction and overall treatment success compared to traditional methods [3, 4]. However, there are still concerns about the accuracy of digital long-span scans and the marginal fit of prostheses fabricated through CAD. This review evaluates the current understanding of the diagnostic accuracy and clinical effectiveness of digital workflows in crowns, bridges, and implant-supported restorations, and weighs current findings against historical reporting.

Objective of the study

This narrative review focuses on digital fixed prosthodontics from the years 2020 and 2025. We assess the accuracy of digital impressions of tinnitus and the precision of digital impressions of IOS to analog ones. We further evaluate the restoration of patients produced by digital workflows compared to traditional methods on the clinical and patient-centered outcomes in terms of fit, survival, and restoration. We lastly assess the chair time, costs, and patient satisfaction. We further consider the zero checklist workflows and define workflows in fixed prosthodontics on workflow and outcomes.

Materials and Methods

The publications from the year 2019 - 2025 were targeted in the databases of PubMed, Google Scholar, Cochrane Library, and Science Direct. Using the terms “intraoral scanner,” “CAD/CAM,” “digital workflow,” “fixed prosthodontics,” “crown,” “bridge,” “implant restoration,” “accuracy,” “fit,” and “clinical performance” in the range of data was assessed. Considered for inclusion were only peer-reviewed studies, reviews, and clinical works. Data available in clinical, in vitro, and in vivo studies on digital and conventional workflows were collected. Implants done by the patients and restoration were the parameters of interest. Marginal and internal fit of the restorations, rate of restoration survival and success, time of procedure, and patient satisfaction are parameters recorded. To summarize important study results, relevant data were put in tables.

Results and Discussion

Improvement in impression accuracy, trueness, and precision

Recent investigations, Zarbakhsh *et al.* (2021), are consistent. IOS impressions are more accurate than conventional impressions for single crowns and short-span cases. Park *et al.* (2025), Gehrke *et al.* (2024), and Kaitatzidou *et al.* (2024) reached similar conclusions about other cases. Kaitatzidou *et al.* (2024) in a meta-review and Park *et al.* (2025) did not notice differences within the marginal and internal fit range for short-span restorations [5-7]. Yet, rest arch accuracy is a grave problem: Pesce *et al.* (2025) argued for combining rest conclusions. It makes bold claims about the accuracy of complete-arch scans, noting the distinction of other studies that suggest a drop in performance on long-span cases [8, 9]. In contrast, Pesce *et al.* (2025) present studies of digital rest performance under clinical performance standards, and other studies drop performance on long-span cases. Their), and long-span case rest performances. Uh, complete-arch scans, Pesce *et al.* (2025) on tilted full-arch scans. 3Shape Trios were found to be more accurate than other scanners. Gehrke *et al.* (2024) agree with the suggested studies. IOS scans are as precise as conventional implant impressions on single-implant and short-span cases. The accuracy of full-arch implant scans is greatly improved by splinting the scan bodies [10, 11].

The marginal fit and internal fit of crowns made by CAD/CAM

Seshan *et al.* (2025) find crowns created through direct intraoral scans have significantly better marginal fit than indirect model-based scans [12]. Dry digital impressions (direct or indirect) are known for yielding a fit better than traditional comparable methods [8]. In their meta-analysis of single crown studies, for instance, Manisha *et al.* (2023) discovered that the marginal gaps in crowns constructed with digital impressions were nearly invariably smaller. But in many instances, the change was negligible. Regardless of the workflow employed, the J Prosthet Dent 2024 investigation revealed no discernible variation in fit for single-unit prostheses [13].

Fabrication technologies - milling vs 3D printers

Digital fabrication encompasses additive (3D printing) and subtractive methods (milling). A review conducted in 2025 determined that for crowns made from zirconia and feldspar, the milled ones had a higher accuracy in marginal fit than the 3D printed resin ones. Although the difference in fit was less than 120 microns, which is considered clinically acceptable [7]. Restorations that have been milled are also found to have much tighter adaptation than those that have been printed. The most important aspect of the research is the observation made by the study of a 29% decrease in chairside time with the use of digital workflows [14].

Treatment time and efficiency: Digital workflows save time on tasks and procedures, which makes them advantageous. IOS impressions were quicker on both partial and full-arch compared to conventional. Hung *et al.* (2025) reported that full IOS protocols for implant crowns were ~45% faster than rubber-tray impressions, taking 350s compared to 641s.

Patient experience: Comfort and accommodation show that the patient favoured the more digital method. Within the distractors, Hung *et al.* (2025) reported that more patients with digital impressions for dentures experienced less anxiety, pain, and nausea than with the rest. Other reports explain that bulky stuff makes one more prone to motion sickness, and trays and setting materials [15] complicate the problem.

Clinical outcomes and success rates: Lemos *et al.* (2024) reported that a systematic review on all-ceramic prostheses, CAD, and CAM digitally resulted in around 90-91% of the restorations surviving. Attending to conventional metallic ceramo, restorations seem to face almost no challenges. Almost 100% of the zirconia survived. With 5 years of attending to the veneered ones, around 95.8% were prone to failures. Chipping was the primary failure on the rest that were layered for implant crowns [16].

According to studies, both digitally made single-implant crowns and conventionally made single-implant crowns had about 100% implant survival and 96% success rates in both cases, which were viewed as equivalent outcomes to an RCT 4 years later [17]. Hashemi *et al.* (2024) showed that in partial-arch implant FPDs, fully digital crowns had analogs regarding biological and technical complications. A monothetic analysis of implant crowns below 2 years had a less than 2% failure rate of complications. As shown, no significant evidence supports either method on peri-implant health and survival [18, 19].

The 2025 scoping review of Jain *et al.* on prostheses did show that in CAD/CAM and 3D prosthesis printing, milled zirconia restorations had higher performance than 3D printed restorations. Milled and 3D printed both accomplished an acceptable clinical fit. Most importantly, the review pointed out that regardless of which method was adopted, digital workflows drastically lowered actual chairside time by almost 29%, which proved time-saving in practice.

The table below outlines representative results from selected studies on accuracy, fit, time, satisfaction, and survival.

Table 1. Summary of Key Findings

Category	Author & Citation	Purpose / Methods	Samples / Participants	Key Results
Accuracy (Trueness & Precision)	Zarbakhsh <i>et al.</i> (2021) [5]	In vitro RCT comparing IOS vs rubber impressions for single crowns	Single-crown typodont models	IOS is significantly more accurate (p<0.0001).
	Park <i>et al.</i> (2025) [6]	Compare digital vs conventional implant impressions	Implant models	Digital had a lower 3D deviation (better trueness).

Marginal Fit of CAD/CAM Restorations	Kaitatzidou <i>et al.</i> (2024) [7]	Meta-review of digital vs conventional fit	Single/short-span crowns	No significant differences in marginal/internal fit.
	Pesce <i>et al.</i> (2025) [8]	Review of full-arch accuracy	Full-arch scans	Digital accuracy within thresholds, but long-span occasionally inferior.
	El-Refay <i>et al.</i> (2025) [9]	Tilted full-arch IOS accuracy	IOS systems	3Shape Trios trueness ~38 µm, superior to others.
	Gehrke <i>et al.</i> (2024) [10, 11]	IOS vs conventional implant impressions	Single-implant and full-arch	Comparable accuracy; splinting scan bodies improved full-arch IOS.
	Seshan <i>et al.</i> (2025) [12]	Compare direct vs indirect IOS	Single crowns	Direct IOS better marginal fit.
	Manisha <i>et al.</i> (2023) [13]	Meta-analysis of single crowns	Clinical trials	Digital showed smaller marginal gaps (not always significant).
Fabrication Technology (Milling vs 3D Printing)	Stamatin <i>et al.</i> (2025)	Scoping review CAD/CAM vs 3D printing	Milled zirconia vs 3D printed resins	Milled slightly more accurately; all <120 µm (clinically acceptable).
	Cioloa Holban <i>et al.</i> (2025) [14]	Scoping review on CAD/CAM & 3D printing	Zirconia, feldspathic, and resin restorations	Milled restorations had slightly tighter adaptation; digital workflows reduced chairside time by ~29%.
	Jain <i>et al.</i> (2025)	Scoping review	Zirconia vs 3D printed	Both acceptable fit; digital workflows reduced chairside time by ~29%.
Treatment Time & Efficiency	Siqueira <i>et al.</i> (2021) [2]	Systematic review of RCTs	Multiple studies	iOS is faster for partial- and full-arch.
	Hung <i>et al.</i> (2025) [15]	RCT, implant impressions	Implant crown patients	IOS ~45% faster (350s vs 641s).
Patient Experience	Almadani <i>et al.</i> (2025) [4]	Clinical study	Prosthetic patients	84% preferred IOS; more comfort, less gagging.
	Hung <i>et al.</i> (2025) [15]	Clinical trial	Implant patients	IOS caused less anxiety, nausea, and pain.
Clinical Outcomes / Survival	Lemos <i>et al.</i> (2024) [16]	Systematic review (5-year)	CAD/CAM ceramics	Survival ~90–91%, comparable to conventional.
	Pesce <i>et al.</i> (2025) [8]	Review	Monolithic vs veneered zirconia	Monolithic ~100% survival; veneered 95.8% (chipping main failure).
	Saravi <i>et al.</i> (2021) [17]	RCT (4-year follow-up)	Single-implant crowns	Both workflows 100% implant survival, ~96% crown success.
	Hashemi <i>et al.</i> (2024) [18]	Clinical study	Partial-arch implant FPDs	Similar biological/technical complications across workflows.

The IOS now achieves an accuracy on par with or better than conventional elastomeric impressions for single crowns and short-span restorations. Supporting independent research validates the conclusions outlined in this review. Abduo *et al.* demonstrated that IOS had acceptable clinical trueness and precision for single-unit restorations. However, complete-arch scans were more sensitive to technique and system variations [20]. Cated, Nedelcu also confirmed that while digital impressions had an excellent level of reproducibility for quadrant scans, accuracy decreased as the length of the arch increased [21]. These findings, too, are in keeping with the earlier findings of Patzelt *et al.* who found great diversity in the results of different scanners and advocated caution in interpreting results about long-span applications. This evidence suggests that IOS can replace conventional methods for single crowns and short-span prostheses, although the technique remains perfect for complete-arch applications [22].

Much research has been done on the lateral and internal gaps of digital CAD/CAM restorations developed from IOS data. Various reports claim crowns made using digital technology are usually within clinically acceptable limits and sometimes even better than conventionally made prostheses [23]. The most recent meta-analyses that consider all available research data agreed with these findings and stated that there are only small and clinically insignificant differences in margins between digital and conventional methods [24]. On the other hand, gaps are more common with complex or longer preparations, suggesting that there are still case selection and operator control limitations even in the current digital age

Patient experience and treatment efficiency greatly lack ambiguity in the evidence. Several randomized trials and patient-reported outcomes studies indicate that digital impressions take less chair time and are more favorably received by patients than traditional impressions. Patients state that they experience less gag reflex, more comfort, and less anxiety because of the procedure when IOS is used. The justification for the digital approach to clinical practice is strengthened by the replication of these findings across a range of groups.

The gap in performance between subtractive (milling) and additive (3D printing) techniques remains relatively unresearched. Laboratory studies indicate better marginal adaptation of milled restorations than 3D-printed restorations [25]. High-resolution 3D printing has improved so that margins of provisional and definitive printed restorations are accepted within clinically acceptable limits [26]. Both methods boast technology that saves and reduces clinic time compared to traditional methods, emphasizing the fully digital approach used in the clinic [27].

Concerning clinical outcomes, evidence suggests that restorations produced by digital workflows have the same survival and complication rates in the short to medium term as conventional prostheses. Systematic reviews indicate that the 5-year survival rate for CAD-CAM restorations is over 90% in individuals, and the failure modes are the same as traditional prostheses. However, the data concerning > 5-year survivorship and implant-supported restorations made entirely through digital methods, as well as definitive restorations made through other additive technologies, are sparse, and that makes the extrapolation of these data to clinical practice beyond the early results very worrisome.

Limitations

There is considerable variation across study designs, scanner models, strategies for scanning, and how outcomes are measured, making it difficult to compare studies directly. There is a large portion of in vitro literature. While it represents a controlled environment, it is less likely to be clinically accurate than a scenario involving real-world saliva, soft tissue mobility, and patient motion. More to the point, the relatively recent technological progress means older studies are likely outdated in assessing more recent devices. The differing definitions of trueness, precision, and marginal fit also add to the limitations of evidence synthesis across studies. Last, the available data on the long-term survival of the restorations fabricated through digital workflow, particularly for full-arch implant reconstructions, is still insufficient.

Strengths

Multiple systematic reviews and randomized trials conclude that IOS provides at least equivalent accuracy and clinical performance compared to conventional techniques for single-tooth and short-span cases. The reproducibility of patient-centered outcomes, particularly greater comfort and shortened treatment times, further reinforces these findings. Moreover, comparative laboratory studies across different scanners and fabrication technologies enable clinicians to make tailored evidence-based decisions for specific systems and clinical situations.

Future recommendations

Future research endeavors should focus on defining and standardizing methodologies for assessing impression accuracy to harmonize the definitions of trueness, precision, and the ratio of the fit and marginal fit to minimize heterogeneity. Clinical trials that extend beyond five years of follow-up are needed to assess the true survival and complication rates of restorations made using digital and hybrid workflows. Evidence on complete-arch and implant-supported prostheses should include studies on protocols designed to reduce error accumulation. More direct comparisons of milling and high-resolution 3D printing of different restorative materials will help establish the clinical applicability of additive manufacturing for definitive restorations.

Conclusion

It has been shown that in Fixed Prosthodontics as in the case of all digital workflows, accuracy, fit, and survival in all-digital workflows, intraoral scanners have been shown to have no ill effects on patient outcome, streamlining processes and improving efficiency vis-a-vis conventional methods. CAD, CAM, and 3D printing clearly have acceptable marginal rest position discrepancies. 3D printing and intraoral scanners enabled digital workflows that substantially decrease chairside time, and the overwhelming feedback from the patients is that the ease and comfort are unparalleled. The struggles are long span and full arch cases. As of now, evidence on rest period discrepancies is missing. More evidence is needed on the 3D printed restorations. Also, less evidence is available on 3D printed restorations. More evidence is needed on the long-term restorations. The workflows above are clinically proven to be efficient and focused on patient experience. They stand proven and provide an alternative to conventional workflows. As technology advances, the workflows above will likely dominate restorative practices heavily.

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