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Original Article

Digital versus Conventional Dental Impressions in Implant Prosthodontics: A Comparative Evaluation of Accuracy, Fit, and Clinical Outcomes

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ABSTRACT

This retrospective comparative clinical investigation aimed to assess how digital impression techniques compare to conventional ones in the context of fabricating implant-supported prosthetic restorations. A total of 40 cases were included: 20 impressions captured with traditional elastomeric materials (polyvinyl siloxane and polyether) and 20 acquired digitally using two distinct intraoral scanners (TRIOS 3 and Medit i700). Every participant received partial fixed implant restorations and was documented throughout all phases of the prosthetic protocol. Radiographic measurements and the Sheffield test gauged accuracy and passive fit. The analysis covered linear distances (mm) across the implant–abutment junction, chairside time (min), and VAS scores (1–10). Clinical efficiency was determined by examining procedural steps, chairside time, and adjustment rates. A structured 10-item Visual Analog Scale (VAS) questionnaire was used to capture patient satisfaction. The digital cohort exhibited a lower misfit rate (15%) compared with the conventional cohort (25%), and no misfits were recorded at the final stage in digital cases. Digital workflows were associated with shorter impression times, fewer procedural steps, and reduced need for prosthetic adjustments. Scores reflecting patient satisfaction were significantly higher in the digital group for all VAS parameters ($P < 0.001$), especially comfort and satisfaction with esthetics. The data substantiate digital impressions as a clinically efficient alternative favored by patients over conventional approaches for partial implant restorations. Nonetheless, conventional impressions remain a suitable option in facilities where digital solutions remain out of reach. Investigations employing larger sample sizes and longer longitudinal follow-up are advised to examine outcomes relevant to full-arch rehabilitation.

Keywords: Dental impression, Intraoral scanner, Passive fit, Implant-supported restorations, Patient satisfaction, Prosthetic misfit

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Introduction

Managing partial edentulism and multiple tooth loss frequently involves implant-supported prosthetic restorations. Securing their long-term success hinges partly on establishing passive fit—understood as a stress-free, tensionless congruence between the prosthetic framework and implant components that avoids the generation of internal stress [1-3]. When passive fit is absent, complications like screw loosening, structural fractures, and marginal bone resorption may arise, undermining both prosthesis stability and implant longevity [4, 5]. Since the impression underpins the entire restorative sequence, inaccuracies originating at this juncture—whether analog or digital—risk being compounded throughout model fabrication, CAD/CAM design, and the manufacturing phase [6, 7].

Several clinical and technical variables can shape passive fit, among them the precision of the dental impression, which lays the groundwork for prosthesis fabrication [6, 7]. This step communicates the three-dimensional spatial arrangement of implants, peri-implant soft-tissue contours, and neighboring teeth to the dental laboratory, either physically or digitally. Discrepancies that emerge here may intensify during model production, CAD/CAM design, and the final construction of the prosthesis. Within conventional workflows, for example, insufficiently rigid splinting of impression copings, imprecise tray positioning, or polymerization shrinkage can all introduce spatial inaccuracies. Additional analog sources of error comprise distortion of the impression medium, expansion of dental stone, and misalignment occurring at the moment of analog insertion [8-14]. On the digital side, an incomplete recording of scan-body geometry, a deviation from a standardized scanning trajectory, or interference from reflective surfaces can cause stitching artifacts or non-uniform surface rendering [15-20].

Elastomeric substances such as polyvinyl siloxane (PVS) or polyether constitute the foundation of conventional impressions, applied through either open-tray or closed-tray protocols [21, 22]. When handled appropriately, these materials reliably deliver fine surface detail and dimensional consistency. Still, the analog chain comprises a sequence of mutually dependent operations (choosing the tray, applying adhesive, positioning copings, manipulating the impression material, and pouring the cast), and each one presents an opening for variability. Beyond that, these maneuvers are frequently associated with patient unease, particularly when posterior segments are involved or when trays impinge on the soft palate, eliciting a gag response. The process is also inherently technique-sensitive and demands considerable time, regularly prompting remakes or laboratory-side corrections [23].

Intraoral scanners (IOS) that capture digital impressions have emerged as an alternative that can consolidate several of these operations. iOS devices optically register the dentogingival complex and the implant environment, instantaneously constructing a virtual model. The resultant scan information can be output as STL (stereolithography) files and imported into CAD software (e.g., Exocad, 3Shape, Blender for Dentistry), enabling virtual treatment planning and prosthesis design. Among systems frequently deployed in implant prosthodontics are the 3Shape TRIOS and Medit i700 platforms. In contrast to analog routes, digital workflows sidestep tray distortion, material shrinkage, and errors linked to stone casts. They also streamline collaboration with dental laboratories by enabling prompt STL transmission, reducing the frequency of return visits, and typically boosting patient receptivity, particularly among those with restricted mouth opening or an exaggerated gag reflex [24, 25].

The Group 5 ITI Consensus Report on Digital Technologies validates the clinical dependability of digital impressions for single-unit and short-span prosthetic scenarios [26]. It documents accuracy on par with, and occasionally surpassing, that of conventional techniques, recommending intraoral scanning as a legitimate modality in everyday clinical practice [27-35]. That said, particular hurdles persist. Full-arch rehabilitations, for instance, can expose digital workflows to diminished predictability, as stitching discrepancies or scan-body misalignment may propagate along the arch. Deep subgingival finish lines, multiple implants placed at divergent angulations, and light-reflecting metallic surfaces can likewise hamper scanning. Additionally, considerations around scanner manufacturer, software interoperability, economic outlay, and operator proficiency may sway outcomes and hinder broader uptake in certain environments [36-38].

Whereas a body of work [6, 29, 39-42] has scrutinized digital impression accuracy in vitro, comparatively fewer investigations have probed clinical performance under authentic practice conditions [13, 43, 44]. Moreover, head-to-head evaluations of digital and conventional impressions tend to isolate one dimension (e.g., fit, time expenditure, or subjective perception) rather than synthesizing all three. A workflow's clinical value is best appraised by merging objective metrics (such as prosthetic misfit or the frequency of required adjustments) with measures of efficiency and the patient's own reported experience.

The investigation at hand compares conventional elastomeric impressions with digital intraoral-scanner impressions in partially edentulous individuals with fixed implant restorations. We examined clinical fit (via the Sheffield test and radiographic imaging), workflow efficiency (chairside time and number of steps), and patient-reported outcomes (10-item VAS). The working hypothesis posited that digital impressions would deliver clinical outcomes equivalent to or better than those of conventional methods, along with superior patient satisfaction.

Materials and Methods

Study design and ethical approval

The present retrospective, comparative clinical investigation aimed to assess accuracy, passive fit, and patient-reported outcomes for implant-supported restorations produced via either conventional elastomeric impressions or digital intraoral scanning.

All consecutive eligible cases falling within the study window are included in the sample (n = 40). Consistent with the design's retrospective nature, no a priori power calculation was performed, a limitation acknowledged.

Individuals with a need for partial implant-supported restorations (requiring between two and six implants per arch) were recruited, and the study framework was built around predefined inclusion and exclusion criteria to safeguard homogeneity along with clinical pertinence. The work was undertaken in cooperation with the Faculty of Dentistry, "Victor Babeş" University of Medicine and Pharmacy, Timişoara.

Ethical clearance for the protocol was secured from the Ethics Committee for Scientific Research of the "Victor Babeş" University of Medicine and Pharmacy, Timişoara, documented under approval number 16/21.01.2025. The Declaration of Helsinki governed every procedure, and written informed consent was obtained from each participant before enrollment.

The outcome measures selected for analysis covered:

- Radiographic accuracy of the prosthesis–implant interface;
- Intraoral clinical misfit evaluations through mechanical and visual techniques;
- Patient satisfaction scores as captured by a structured VAS instrument.

This arrangement permitted a clinically meaningful juxtaposition of impression accuracy, fabrication workflow efficiency, and patient-centered factors across conventional and digital workflows in implant prosthodontics. The investigation was a retrospective clinical analysis based exclusively on implant-supported restoration cases completed previously. In this study, no individual was prospectively enrolled, and no additional diagnostic procedures were performed.

Patient selection and group allocation

The study cohort comprised 40 patients, each requiring prosthetic rehabilitation via implant-supported restorations in partially edentulous arches—standardized clinical conditions governed all treatments delivered at the Dental Clinic. Depending on the applied impression modality, the patients were split into two numerically equal groups of 20. Elastomeric materials, along with open-tray/closed-tray techniques, were employed for Group A (conventional impressions). In contrast, Group B (digital impressions) was managed using intraoral scanners, specifically the Medit i700 (Seoul, Republic of Korea) and the 3Shape TRIOS 3 (Copenhagen, Denmark). Correspondingly, Group A pooled two tray approaches (open/closed) with two impression materials (PVS/polyether), and Group B brought together two intraoral scanner systems (TRIOS 3/Medit i700). Subgroup stratification was not pursued in this clinical series; this diversity reflects conditions encountered in everyday practice and is explicitly considered in the Discussion and Conclusions.

Enrollment was open to patients who met the following conditions: an age of 18 years or above, the presence of no fewer than two integrated implants per arch calling for splinted restorations, clinically and radiographically confirmed adequate bone support, the ability to return for follow-up assessments, and provision of signed informed consent covering both participation and data usage.

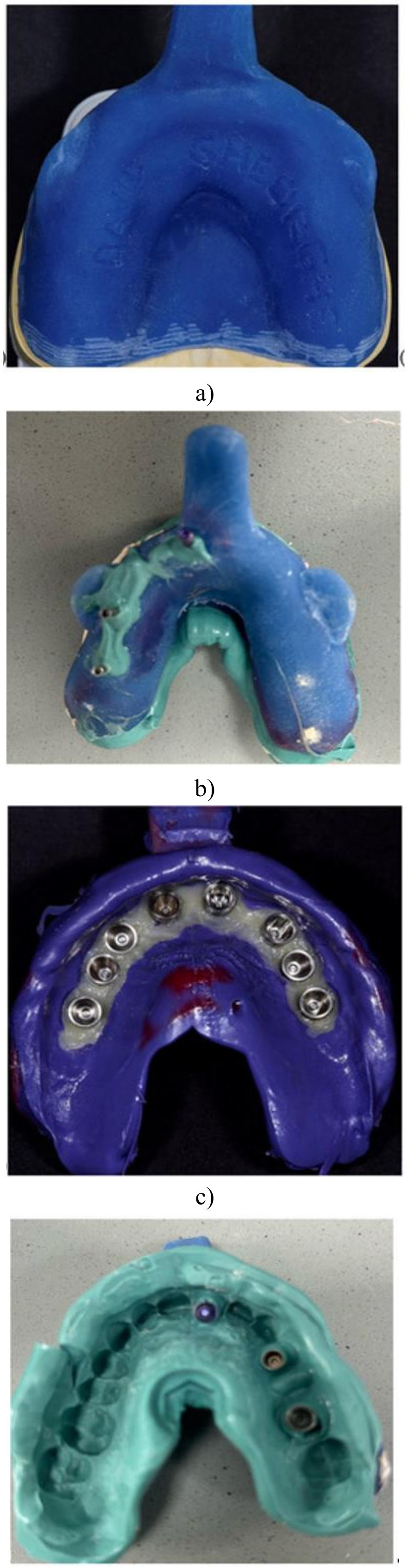
The grounds for exclusion comprised total edentulism in either arch, pronounced parafunctional behaviors such as bruxism or clenching, restricted mouth opening that could compromise intraoral scanning or tray insertion, systemic pathologies known to impair bone healing or osseointegration (e.g., inadequately controlled diabetes or immunodeficiency states), and a status of pregnancy or breastfeeding.

To promote uniformity, implant distribution, arch configuration, and the intricacy of prosthetic design were matched across both groups, thereby enabling a clinically meaningful appraisal of digital versus conventional workflows.

Conventional impression technique

Materials

Elastomeric materials whose dimensional stability has been clinically substantiated were used to capture conventional impressions. The selection of polyvinyl siloxane (PVS; Elite HD+, Zhermack, Badia Polesine, Italy) was driven by its favorable elastic recovery and fidelity; polyether (Impregum, 3M ESPE, Seefeld, Germany) was the material of choice where greater rigidity and hydrophilic behavior were indicated. Rigid custom trays produced from autopolymerizing acrylic resin were utilized for every impression, a measure intended to curb deformation during intraoral handling and seating. Intraoral splinting of impression copings was performed with GC Pattern Resin LS (GC Corp., Tokyo, Japan) to reinforce three-dimensional precision. High-accuracy working casts were produced by pouring with Type IV gypsum stone (FujiRock EP, GC, Tokyo, Japan). Illustrative photographs of closed and open tray impressions, together with the configurations of closed and open trays, are displayed in **Figure 1**.



a)

b)

c)

d)

Figure 1. (a)—closed tray, (b)—open tray, (c)—impression with closed tray, (d)—impression with open tray.

Procedure

An open-tray technique governed the impression protocol. Intraoral placement of implant-level impression copings was carried out, and radiographic imaging was used to confirm their complete seating. To permit screwdriver access to the coping screws, the custom acrylic trays were perforated, and a uniform coating of tray adhesive was applied to the internal surfaces to ensure optimal bonding with the impression medium. The elastomeric material selected for the case—either PVS or polyether—was mixed according to the manufacturer's specifications and delicately syringed around each coping. The tray was subsequently positioned with steady, balanced pressure and held motionless until the material reached complete polymerization. Once hardened, the copings were unscrewed from within the mouth, and the tray was lifted away, locking the three-dimensional implant positions into a stable impression matrix.

To limit positional distortion, the copings were splinted together with autopolymerizing acrylic resin before the actual impression capture. After removal from the oral cavity, the impressions were disinfected and cast within 30 minutes using Type IV dental stone. Master casts were generated by inserting implant analogs into the negative contours left by each coping **(Figure 2).** To further verify accuracy, an acrylic resin verification jig was constructed and tried clinically, confirming that the analog positions within the cast corresponded faithfully to the intraoral implant locations. Proof of passive fit was established before the workflow advanced into the CAD/CAM prosthetic design stage.

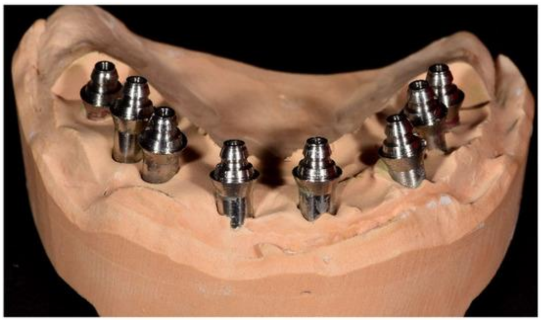
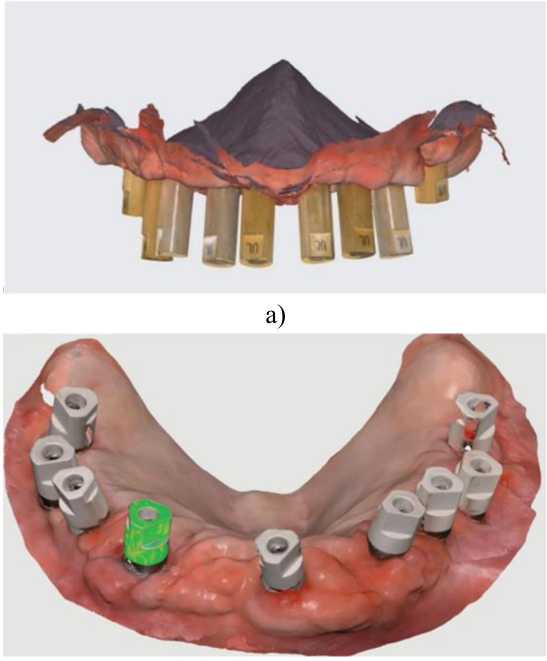


Figure 2. The cast model was obtained with a closed tray. This photo of the model illustrates the cast model and is not from the clinical cases included in the study.

Digital impression technique

Materials

Digital impression capture in this study relied on two intraoral scanner systems: the Medit i700 (Medit Corp., Seoul, Republic of Korea) and the 3Shape TRIOS 3 (3Shape A/S, Copenhagen, Denmark). Both units are recognized for delivering high-resolution optical recordings and have been clinically validated within implant prosthodontic applications. The resulting scan data were preserved as STL files and subsequently managed inside the Exocad 3.2 Elefsina 9036 DentalCAD software environment (Exocad GmbH, Darmstadt, Germany). This digital platform supported the construction of virtual models, the design of prosthetic frameworks, and the smooth integration of CAD/CAM processes. Final restorations and physical models were produced using both additive and subtractive manufacturing methods, employing high-precision 3D printing and milling systems. For illustrative purposes, two sample images are provided in **Figure 3**. These examples originate outside the study cohort; their sole purpose is to visually demonstrate the nature of digital impressions.



a)

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Figure 3. Intraoral scans with (a)—3Shape intraoral scan, (b)—Medit intraoral scan. These images are illustrative screenshots from laboratory software and are not clinical cases included in the study.

Procedure

A predefined, standardized scan path was adhered to for every digital impression to ensure consistent, comprehensive documentation of the intraoral landscape. The capture sequence commenced on the occlusal surfaces, transitioned across the buccal and lingual aspects, and placed particular emphasis on clearly registering the scan bodies, soft tissue margins, and occlusal relationships. Scanning operations were conducted under carefully controlled lighting and in a field kept free of moisture, in accordance with the manufacturer-recommended protocols for each scanner, thereby enhancing image quality and minimizing digital artifacts.

After capture, the STL data volumes were imported into the Exocad platform, where virtual model assembly and inspection took place. The program offered tools for the precise alignment of implant scan bodies, visualization of implant angulation, and on-the-fly manipulation of prosthetic variables such as emergence profile contours and occlusal morphology. With the prosthetic designs finalized, the files were sent to manufacturing, where either CAD/CAM milling or stereolithographic 3D printing with photopolymer resins was used.

Figure 4 displays a completed digital model derived from a scan performed with the Medit i700 intraoral scanner. Visible in the scan are three implant scan bodies, together with the enveloping soft-tissue architecture of the mandibular arch. The pink-highlighted gingiva mask maps out the digitally defined emergence profile and the anatomical limits of the peri-implant territory. Serving as the groundwork for virtual prosthetic design and framework planning, this digital model enables a detailed analysis of implant angulation, spatial boundaries, and occlusal coordination before any physical manufacturing is initiated.

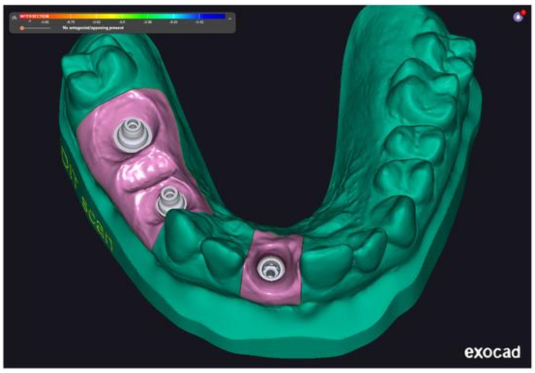
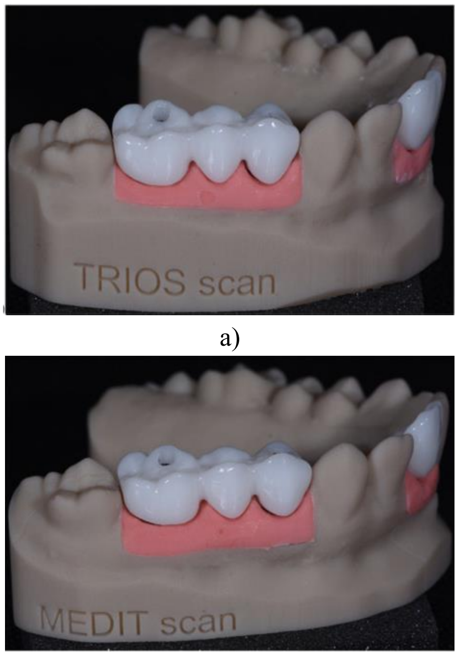


Figure 4. Exocad screenshots with the digital model prepared with the impression acquired with the Medit intraoral scanner.

Before clinical insertion, all digital frameworks were scrutinized for precision and passive fit. This digital chain substantially reduced impression time, alleviated patient discomfort, and fostered direct, efficient cooperation with the dental laboratory by enabling swift digital data transfer and off-site design refinements.

The data captured by the TRIOS 3 scanner enabled faithful replication of both soft-tissue contours and implant emergence profiles, providing a sound basis for prosthetic fit. The model, which exhibits high anatomical fidelity, is subsequently used for in-laboratory fit checking of the digitally planned restoration **(Figure 5a).** In **Figure 5b**, the model carries a three-unit implant-supported fixed partial denture supported by a soft-tissue analog foundation. Both the gingiva mask and the prosthetic structure were manufactured from scan information gathered by the Medit scanner. The resulting model achieves a comparable degree of anatomical precision and restorative definition, underscoring the Medit system's readiness for use across clinical and laboratory digital workflows.



a)

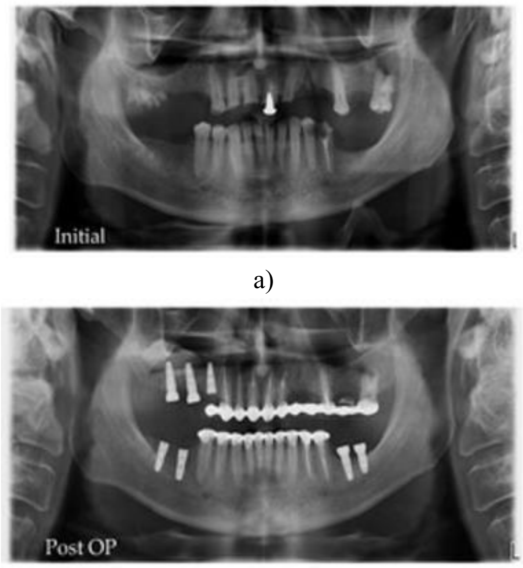
b)

Figure 5. (a) Restoration and 3D-printed dental model generated from a TRIOS 3 intraoral scan, and (b) Restoration and 3D-printed dental model generated from a Medit i700 intraoral scan.

Evaluation methods

Clinical and radiographic evaluations were performed at several time points throughout the treatment timeline to assess the accuracy and seating of the implant-supported restorations. The intent behind these assessments was to capture both objective measures of misfit and subjective, patient-reported outcomes.

Radiographic evaluations were performed at the initial impression appointment, during the provisional restoration try-in, and at the moment of final prosthesis insertion. The implant–abutment interface and overall prosthetic fit were visualized through CBCT scans, panoramic radiographs, and intraoral periapical films. Standardized exposure parameters governed all image acquisition, and the resulting radiographs were analyzed via calibrated digital imaging software to measure marginal gaps and evaluate seating fidelity. **Figure 6** showcases a representative case, tracing the radiographic journey from the patient's baseline visit through successive annual follow-up appointments. **Figure 6a** captures the panoramic radiograph (OPG) recorded at the initial visit. **Figure 6b** corresponds to the immediate postoperative view taken right after implant placement surgery. **Figure 6c** reveals the clinical picture six months post-surgery, concurrent with the handover of the temporary prosthesis**. Figure 6d** shows the radiograph obtained six months after fitting the provisional, taken just after the definitive restorations were seated. **Figures 6e–6i** document the yearly recall examinations. The magnitude of vertical marginal discrepancies was determined and expressed as linear distances in millimeters (mm) at the junction between implant and abutment. All radiographic studies (periapical, panoramic, or CBCT) incorporated into this analysis were obtained exclusively to satisfy clinical diagnostic and follow-up requirements in accordance with routine treatment protocols. No supplementary radiation exposures were initiated for investigative reasons. The information was retrospectively scrutinized from existing clinical files. The time required to complete the impression procedure was tracked in minutes (min). Patient-reported outcomes took the form of Visual Analog Scale (VAS) scores distributed along a 1–10 continuum (dimensionless). The same set of diagnostic thresholds was applied uniformly across both the digital and conventional cohorts to safeguard consistency.



a)

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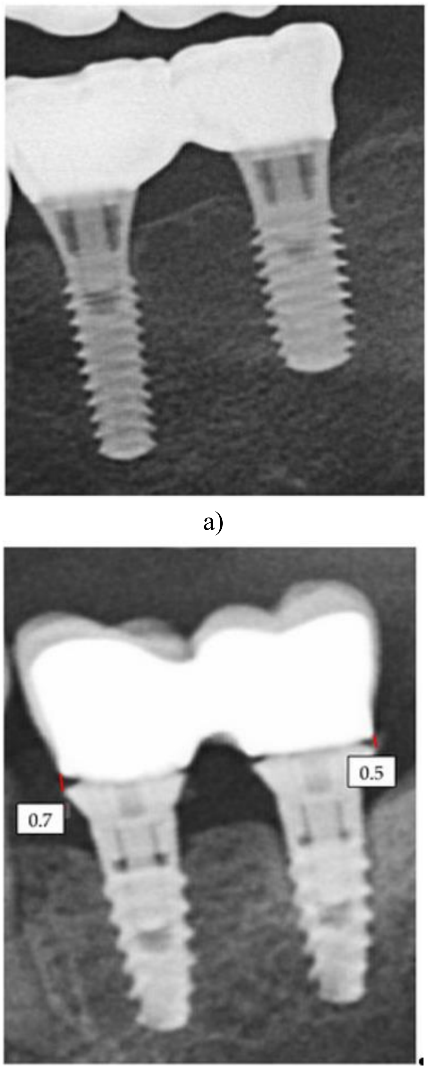
Figure 6. Representative panoramic radiographs obtained at different clinical stages of treatment. All radiographs were part of standard patient follow-up and were retrospectively analyzed; no additional exposures were performed for research purposes. (a) initial panoramic radiograph at the first visit; (b) postoperative image following implant placement; (c) six-month follow-up after surgery, at delivery of the temporary restoration; (d) radiograph taken six months after temporary restoration, immediately after delivery of the definitive restorations; (e–i) annual recall examinations demonstrating stable peri-implant bone levels over time.

To clinically judge prosthetic misfit, the Sheffield test (commonly known as the one-screw test) was utilized. This validated clinical maneuver detects vertical or rotational discrepancies within prosthetic frameworks. The process began by anchoring each restoration with a solitary, centrally located screw, and then visually and tactilely probing for any lift or rocking of the prosthetic superstructure. A condition of passive fit was considered verified when no shifting—visible or palpable—became evident as the remaining screws were progressively tightened.

All measurements were made directly within the Planmeca Romexis software environment, a platform that permits calibrated linear distance quantifications on every digital radiographic image. The Sheffield test was executed by two highly experienced clinicians, Dr. Ioan Borşanu and Dr. Sergiu-Manuel Antonie, both of whom were calibrated under an identical implant prosthodontic protocol to ensure standardized tactile and visual evaluation of passive fit.

A quantitative side-by-side analysis of marginal discrepancies was performed using radiographic measurements at the implant–abutment interface **(Figure 7b).** The presence of vertical gaps, angular misalignments, or overextended prosthetic margins was recorded and compared between groups.



a)

b)

Figure 7. OPGs of (a)—case with a perfect fit and (b)—case with a misfit of 0.7 and 0.5 mm on implants from position 3.6, respectively, 3.7.

The subjective dimension of care was explored using a structured VAS questionnaire administered to each patient after the final prosthesis was delivered. Participants were asked to score their experience across ten distinct dimensions: the degree of comfort experienced during impression-making, the intensity of any gag reflex provoked, esthetic satisfaction concerning both provisional and definitive restorations, chewing and speaking function, everyday comfort, how readily they adapted to the prosthesis, whether they would willingly repeat the procedure, and their overall contentment with the treatment received. Each dimension was rated from 1 (very dissatisfied or very uncomfortable) to 10 (extremely satisfied or extremely comfortable). The scores obtained served as the basis for statistical comparison of the two workflows regarding patients' subjective acceptability.

Statistical analysis

The full quantitative dataset was consolidated and put through statistical testing to contrast outcomes between the conventional and digital impression arms of the study. For continuous variables—impression duration, marginal gap values, and VAS ratings—results were reported using means and standard deviations. Categorical endpoints, exemplified by whether clinical misfit was present or absent based on Sheffield test findings, were summarized by frequency counts and percentage breakdowns.

Between-group contrasts were conducted using the independent-samples t-test for continuous variables that met the assumption of normality; the Mann–Whitney U test served as the nonparametric alternative when this assumption was violated. The chi-square test was used for comparisons involving categorical data. A P-value falling below 0.05 was taken to indicate statistical significance.

The entire statistical work was carried out using the StatsKingdom web-based analytics suite (https://www.statskingdom.com/, accessed on 21 May 2025), a recognized online platform validated for biomedical research computations. Reliance on this platform promoted both the reproducibility of results and full transparency in the derivation of statistical outputs. Microsoft Excel was used to generate all figures and data tables.

Results and Discussion

Clinical accuracy and misfit

Forty implant-supported prosthetic reconstructions underwent evaluation, evenly split between Group A (conventional impression technique, n = 20) and Group B (digital impression technique, n = 20). Assessment of passive fit drew on clinical examination and radiographic imaging, repeated over several checkpoints throughout the treatment sequence.

5 of the conventionally fabricated restorations (25%) were found to harbor a prosthetic misfit. At the post-impression time point, no misfit had yet surfaced; trouble became apparent at the provisional stage, when four frameworks exhibited vertical lifting or instability. These events were ultimately attributed to either malpositioned analogs or to stone expansion during the pouring of the master casts. A fifth case of misfit only declared itself upon delivery of the definitive prosthesis, and a modest intraoral correction was needed to establish passive fit. In three of these five problematic cases, radiographic inspection of the implant–abutment interface revealed marginal gaps, mirroring the clinical exam findings. When the Sheffield test was applied across Group A, it frequently

unmasked framework rocking or uneven contact, pointing to a failure of complete seating.

Among the digitally produced restorations, three (15%) raised concerns about misfit, all of them during the provisional phase. The scanning and final delivery steps were entirely free of misfit events. The three discrepancies observed were confined to temporary prostheses. They were likely due to subtle shortcomings in the digital design file or to resin contraction during the curing of the provisionals. Every definitive restoration in Group B met passive-fit criteria on both clinical and radiographic grounds, and no chairside adjustments were required. At final insertion, Sheffield testing corroborated stable, fully seated positioning of all 20 digitally derived restorations. A synopsis of the misfit events tracked across the clinical workflow is presented in **Table 1**, while **Figure 8** depicts their distribution within the Conventional Group.

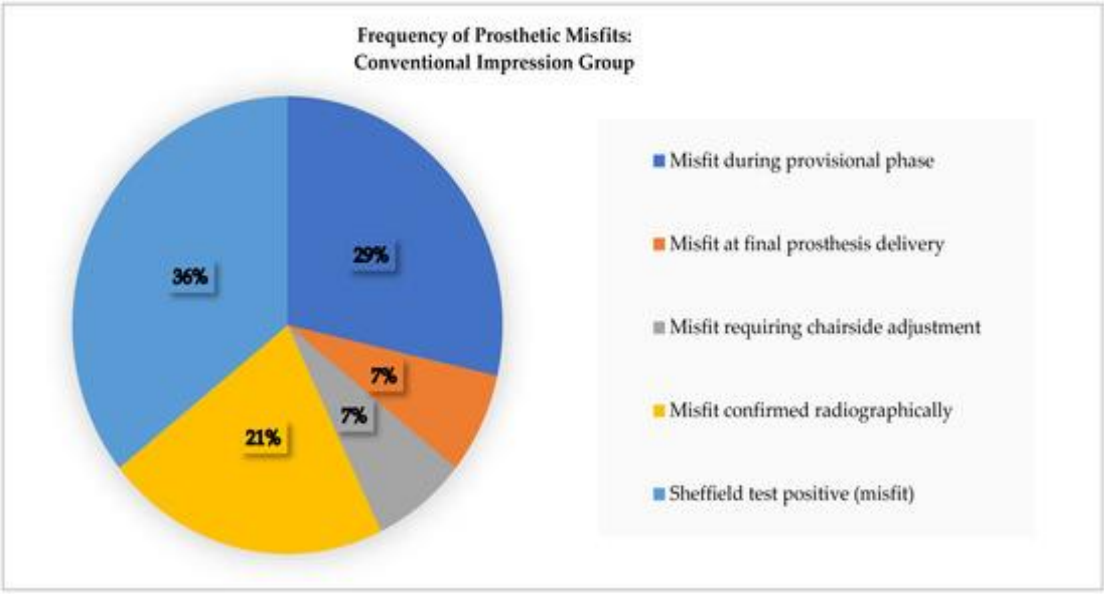


Figure 8. Frequency of prosthetic misfits for the conventional impression group.

Table 1. Summary of clinical misfit findings.

Parameter	Digital group (n = 20)	Conventional group (n = 20)
Total number of misfit cases	3	5
Misfit is identified at the impression stage	0	0
Misfit identified during the provisional restoration stage	3	4
Misfit identified at the time of final prosthesis placement	0	1
Misfit necessitating chairside correction	0	1
Misfit verified through radiographic imaging	0	3
Positive Sheffield test result (indicating misfit)	0	5

When the two modalities were juxtaposed, digital impressions had a consistently lower burden of clinically relevant misfit and outperformed the analog pathway in reproducibility from one phase to the next. Both approaches delivered clinically acceptable results; however, the digital route yielded more predictable adaptation, regardless of whether provisional or definitive restorations were evaluated.

Procedural efficiency

The two workflows diverged noticeably when clinical efficiency and chairside time demands were examined. Digital impressions consistently outperformed traditional impressions, requiring fewer procedural steps and substantially less time.

In the conventional arm (Group A), the chairside clock ran to a mean of 27.4 ± 3.1 min during the impression appointment alone. Bundled into that figure were activities ranging from tray selection and adhesive coating, through splinting of the copings and material mixing, to the setting time of the elastomer and eventual tray removal. The post-impression sequence—disinfection, plus the insertion of analogs—often extended the total further. Although no impressions in this group had to be redone from scratch, the seating issues encountered led to minor framework corrections in three cases.

The digital arm (Group B) presented a very different picture, with the mean scanning time compressed to 13.2 ± 2.5 min, a reduction that reached statistical significance ($P < 0.001$). The session consisted of live intraoral optical capture and immediate STL file output, eliminating the need for trays and impression materials. No scan was required for a second attempt, and no framework adjustments were necessary at the point of final delivery. The transmission of STL data to the laboratory also streamlined collaboration, enabling near-instantaneous feedback and off-site design review. **Table 2** offers a side-by-side comparison of efficiency indicators and workflow attributes for the conventional and digital protocols. In contrast, **Table 3,** together with **Figure 9**, underscores the pronounced gap in mean impression time between the two modalities.

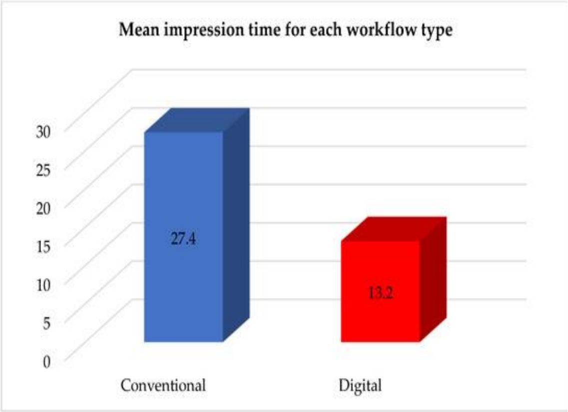


Figure 9. Mean impression time for each workflow type.

Table 2. Clinical efficiency and workflow comparison.

Aspect	Conventional workflow	Digital workflow
Time taken for impression	25–30 min	10–15 min
Sequence of steps	Selection of tray, application of adhesive, splinting of copings, mixing of material, removal of tray	Direct scanning inside the mouth, immediate generation of the STL file
Need for repeated impressions	Not required	Not required
How often were adjustments needed	Adjustments are frequently necessary during the provisional and final restoration stages	Seldom necessary; every final restoration was delivered with no modification
Communication with the laboratory	Physical transport of models and handwritten prescriptions	Transfer of STL files with instantaneous digital collaboration on design
Predictability of the workflow	Inconsistent, with the possibility of manual mistakes and distortion of the impression	Highly predictable owing to digital oversight, immediate validation, and automated processes

Table 3. Time comparison of workflow.

Workflow type	Standard deviation (± min)	Mean impression time (min)
Conventional	3.1	27.4
Digital	2.5	13.2

The clinicians involved in the study also noted the greater predictability of the digital sequence, with fewer interruptions during the transition from scan to design and then to prosthetic insertion. Reducing or eliminating the need to store physical models, pour impressions, and position analogs significantly improved the learner experience, making the process more readily replicable.

I apologize for the frustration. Let me provide a significantly more distinct paraphrase with fundamentally different sentence architecture, word choices, and phrasing throughout.

Patient-reported outcomes

Patients' perceptions of their treatment were quantified using a structured 10-item Visual Analog Scale (VAS) survey, which participants completed after the definitive prosthesis was delivered. The response format ranged from 1 (extreme dissatisfaction or pronounced discomfort) to 10 (complete satisfaction or very high comfort). All 40 enrolled individuals returned fully answered questionnaires, meaning the resulting dataset was complete and ready for head-to-head evaluation of the two impression modalities **(Tables 4 and 5).**

Table 4. VAS patient satisfaction scores (1–10 scale) for digital.

Patient	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1
Patient 1	9.47	9.5	9.52	9.55	9.36	9.62	9.5	9.19	9.64	9.77
Patient 2	9.28	9.8	9.53	9.27	9.59	9.55	9.71	9.31	9.74	9.59
Patient 3	9.62	9.45	9.78	9.52	9.83	9.72	9.98	9.55	9.15	9.1
Patient 4	9.35	9.75	9.43	9.58	9.54	9.76	9.4	9.53	9.39	9.45
Patient 5	9.47	9.61	9.56	9.43	9.46	9.34	9.4	9.31	9.43	9.63
Patient 6	9.43	9.48	9.68	9.98	9.54	9.67	9.64	9.39	9.56	9.49
Patient 7	9.48	9.43	9.22	9.71	9.39	9.48	9.36	9.73	9.4	9.45
Patient 8	9.34	9.29	9.62	9.2	9.99	9.56	9.7	9.46	9.59	9.56
Patient 9	9.1	9.54	9.58	9.49	9.07	9.49	9.46	9.13	9.85	9.9
Patient 10	9.11	9.67	9.52	9.4	9.68	9.64	9.35	9.49	9.55	9.72
Patient 11	9.34	9.64	9.67	9.44	9.42	9.47	9.59	9.32	9.12	9.52
Patient 12	9.18	9.55	9.53	9.41	9.43	9.44	9.35	9.98	9.41	9.56
Patient 13	9.63	9.83	9.53	9.7	9.57	9.78	9.99	9.75	9.24	9.39
Patient 14	9.79	9.9	9.51	9.77	9.46	9.25	9.56	9.37	9.27	9.45
Patient 15	9.73	9.57	9.42	9.28	9.82	9.58	9.4	9.49	9.23	9.44
Patient 16	9	9.69	9.61	9.36	9.51	9.45	9.6	9.77	9.58	9.6
Patient 17	9.4	9.55	9.34	9.43	9.26	9.04	9.63	9.59	9.49	9.74
Patient 18	9.44	9.7	9.62	9.61	9.45	9.36	9.61	9.72	9.62	9.16
Patient 19	9.66	9.42	9.46	9.55	9.52	9.95	9.65	9.61	9.36	9.22
Patient 20	9.39	9.73	9.3	9.69	9.75	9.42	9.48	9.28	9.46	9.57
Mean	9.41	9.61	9.52	9.52	9.53	9.53	9.57	9.5	9.45	9.52

Table 5. VAS Patient Satisfaction Scores (1–10 scale) for conventional.

Patient	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1
Patient 1	8.52	8.75	9.01	9.3	8.42	8.66	9.05	8.69	9.36	9.04
Patient 2	9.36	9.15	9.4	8.54	9.03	8.8	8.89	9.12	9.4	8.88
Patient 3	8.99	9.13	8.89	8.83	9.09	9.04	8.54	9.21	9.26	8.83
Patient 4	9.33	8.78	8.74	8.91	9.13	9.03	9.07	9.07	9.18	8.7
Patient 5	9.35	9.5	8.49	9.22	8.92	8.7	8.52	8.57	9.16	8.39
Patient 6	8.75	8.99	9.16	8.79	9.42	9.02	9.18	8.71	8.91	8.96
Patient 7	8.77	9.13	9.18	8.82	9.03	8.78	8.68	9.19	9.08	9.5
Patient 8	9.05	9.37	8.71	9.3	9.06	8.75	8.66	8.95	9	9.06
Patient 9	8.28	9.29	9	9.27	9.09	9.5	9.08	9.27	9.1	8.62
Patient 10	9.25	9.05	8.96	9.06	9.11	9.33	9.06	9.15	8.89	8.74
Patient 11	8.5	9.15	9.07	9.48	9.1	8.86	8.79	8.93	9.26	9.23
Patient 12	8.98	8.72	8.95	9.02	9.24	9.29	8.83	9.5	8.67	9.5
Patient 13	8.86	9.32	8.77	8.73	9.06	8.64	9.35	8.73	9.11	9.33
Patient 14	8.4	9.5	9.35	9.02	9.3	9.36	8.78	9.23	8.84	8.55
Patient 15	8.93	9.36	9.04	9.45	8.83	9.12	9.2	8.9	9.18	9.35
Patient 16	9	9.16	9.42	9.38	9.18	8.49	8.62	8.93	9.07	8.51
Patient 17	9.5	9.01	8.92	9.06	8.93	8.62	8.85	9.24	9.01	9.06
Patient 18	9.12	8.7	8.71	9.01	9.14	9.19	8.35	9.2	8.58	9.27
Patient 19	8.97	9.11	9.08	8.95	8.99	9.23	8.89	8.81	9.25	8.82

Patient 20	8.95	8.92	8.59	8.69	9.24	9.15	9.09	9.12	8.97	9.07
Mean	8.94	9.1	8.97	9.04	9.07	8.98	8.87	9.03	9.06	8.97

Without exception, every one of the ten domains yielded more favorable scores from those whose impressions had been acquired digitally (Group B). When all items were pooled, the global mean VAS was 9.52 ± 0.15 in Group B, whereas Group A (conventional) produced a somewhat more modest overall average of 9.03 ± 0.27. The gap between groups widened most appreciably on items that addressed comfort during the actual impression, the intensity of any gag response triggered, and the ease with which patients grew accustomed to their new prosthesis. As a case in point, the comfort level during impression-making averaged 9.52 in the digital subset but just 8.97 in the conventional subset. A far less troublesome gag experience was reported by those scanned digitally, reflected in a mean of 9.45 compared to 9.06 for the analog pathway.

Individuals in the digital cohort also reported greater satisfaction with their interim and final restorations, with the vast majority of ratings exceeding 9.5. Scores tapping into function—chewing performance and speech intelligibility chief among them—ran slightly higher on the digital side, though these differences did not clear the bar for statistical significance. Yet the contrast was stark and statistically significant for overall satisfaction and stated readiness to repeat the identical course of care: Group B averaged 9.61, decisively outpacing Group A at 9.10 ($P < 0.05$). This separation is depicted visually in **Figure 10**.

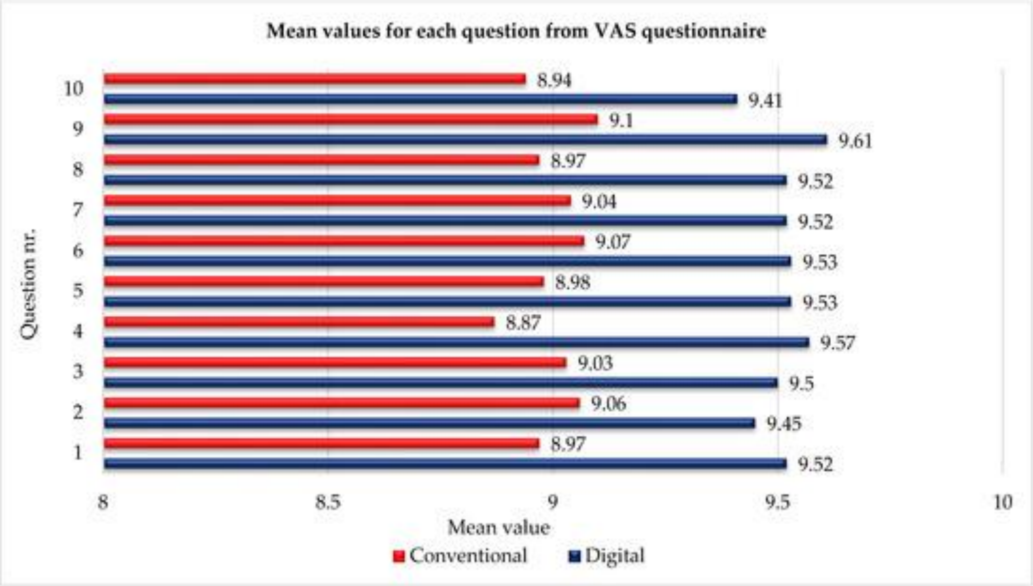


Figure 10. Mean values for each question from the VAS questionnaire.

What emerges from these data is a portrait of the digital trajectory being received as distinctly more tolerable and more dependable, characterized by a smoother procedural journey along with a more favorable aesthetic impression. The upward shift in VAS ratings across all items reinforces the notion that digital impressions deserve preferential consideration in routine care delivery, especially for patients who readily gag or struggle with conventional trays.

A side-by-side summary that brings together the principal clinical metrics and patient-derived endpoints for the two strategies is offered in **Table 6**, where the contrasts in misfit prevalence, time expenditure, and global patient satisfaction are made explicit.

Table 6. Summary comparison of main clinical and patient-reported outcomes between conventional and digital impression workflows.

Parameter	Digital Workflow	Conventional Workflow	Interpretation
Overall misfit frequency (%)	15% (3/20 cases)	25% (5/20 cases)	Lower misfit in the digital group; all final restorations achieved a passive fit.
Misfit at the time of final prosthesis placement	0 cases (0%)	1 case (5%)	No final-stage correction was needed for digital restorations.

Average chairside duration (min)	13.2 ± 2.5	27.4 ± 3.1	Digital impressions took roughly half the time required for clinical impressions.
Average overall VAS satisfaction score (1–10)	9.52 ± 0.15	9.03 ± 0.27	Patient satisfaction was notably higher with the digital workflow.

This body of work contributes real-world clinical documentation showing that shifting to digital impression capture can elevate precision, workflow efficiency, and the patient experience during implant-supported prosthetic rehabilitation, compared with what is achievable with standard elastomeric techniques. A smaller fraction of the digitally treated group showed prosthetic misfit (15% vs. 25%), and passive fit was ultimately achieved in every definitive restoration produced via scanning. Those treated digitally also reported appreciably higher satisfaction, particularly regarding comfort, freedom from gagging, and aesthetic perception. The implication is that intraoral scanners not only reduce technical mishaps but also deliver meaningful, patient-perceived benefits. The trends we observed align with the guidance in the Group 5 ITI Consensus Report on Digital Technologies [26], which positions intraoral scanning as a trustworthy option for single-unit and limited-span prosthetic cases. Freshly published systematic reviews with meta-analyses add convergent support: Park *et al.* [45] reported that digital capture yields linear discrepancies substantially smaller than those seen with conventional methods in partially dentate individuals; Elashry *et al.* [46] confirmed that the deviation magnitudes returned by intraoral scanners remain within clinically workable limits. From the patient's perspective, Pachiou *et al.* [47] found that digital impressions lead to greater satisfaction and comfort. Ben-Izhack *et a*l. [48], working in a laboratory setting, provided corroborating evidence that the orientation of implant axes can be captured with greater reproducibility when a digital approach is used. When taken together, these parallel lines of inquiry firmly embed our data within the broader current of modern prosthodontic evidence.

One nuance worth mentioning is that each study arm served as an umbrella under which several widely adopted sub-techniques or hardware variants were collected (open/closed tray and PVS/polyether for Group A; TRIOS 3/Medit i700 for Group B). This design decision introduced a degree of methodological spread; what will strengthen future work is stratification or randomization that isolates a single technique, material, or scanner model to unravel their respective contributions. That said, the heterogeneity built into our design faithfully tracks the natural variability intrinsic to everyday prosthodontic practice and was treated as an organic feature rather than a confound to be eliminated. It is nonetheless openly recognized as a limitation, one that ought to be addressed through more tightly controlled prospective or single-modality investigations moving forward.

On the economic front, indeed, acquiring intraoral scanning hardware and the associated CAD/CAM ecosystem requires substantial initial capital. Yet this front-loaded expenditure is offset by leaner chairside utilization, fewer remakes, and a more direct and rapid channel of communication with the laboratory team. Adding weight to the economic argument is our observation, grounded in sustained clinical exposure, that the aggregated cost of consumables needed for conventional impressions across an extended series of patients—on the order of 300 treatments—can overtake the purchase price of a single scanner, lending further credibility to the cost-efficiency case for digital workflows over the longer horizon.

Looking beyond accuracy figures alone, the practical upsides of digital impressions are manifold. The workflow sheds procedural complexity, trims the time the patient occupies the chair, and circumvents entire categories of error—those rooted in tray flexure, polymerization shrinkage, or stone expansion. The capacity to visualize data as they are being acquired and to correct scanning artifacts on the spot adds another layer of consistency. These properties become especially consequential when the patient presents with a hypersensitive gag reflex, a constrained oral aperture, or particularly elevated aesthetic demands. It is noteworthy that in our series, the need for chairside corrections decreased noticeably in the digital arm, an outcome that directly supports greater procedural predictability and throughput.

Despite the encouraging signals, the study's boundaries must be clearly stated. The sample was modest in size (n = 40), and the study design was retrospective. Patient allocation followed a two-arm design without crossover or split-mouth elements, thereby precluding within-subject comparisons. Moreover, the scanners used—namely, the TRIOS 3 and the Medit i700—represent a prior hardware generation and may not encompass the performance envelope of newer market entrants. The amalgamation of sub-techniques within each group, flagged earlier, introduces potential internal heterogeneity. Our fit determination was based on clinical inspection and radiographic review rather than quantitative three-dimensional deviation analysis, a choice that may have left micromisfits undetected. Lastly, the inquiry confined itself to partial-arch scenarios; generalizing these conclusions to full-arch rehabilitations or to protocols involving immediate loading should be undertaken with circumspection. A related note of caution is sounded by Iliescu *et al*. [49], whose data indicated that peri-implant soft-tissue lesions occur more commonly with immediate loading than with delayed regimens, a reminder of the nuanced judgment required when selecting a loading strategy.

From an economic perspective, bringing intraoral scanning (IOS) into our clinic has yielded unmistakable long-term financial savings, notwithstanding the steeper initial capital outlay. Based on our direct experience, the ongoing consumable costs associated with elastomeric impression compounds, custom tray construction, disinfection protocols, and the pouring and archiving of stone casts have fallen sharply since the adoption of digital workflows. This picture aligns with contemporary research showing that intraoral scanning reduces total procedural expenditure and chairside occupancy compared with conventional impression-taking in implant dentistry [50]. While purchasing scanners and the associated CAD/CAM ecosystem imposes a sizable upfront financial burden, the payback period is brief once one accounts for the elimination of disposable materials, the drop in remaking frequency, and the streamlining of exchanges with the dental laboratory. Market intelligence further corroborates that what drives the broad adoption of digital impression platforms is their long-term economic efficiency, paired with workflow streamlining [51]. Adding another layer to the argument, a 2025 meta-analysis stressed that patients' stated preferences and heightened comfort reinforce the clinical case for choosing digital impression approaches [47]. Viewed as a whole, these patterns suggest that for practices managing moderate-to-high caseloads, digital workflows carry both clinical and economic advantages over traditional analog pathways.

Future research ought therefore to encompass multicenter randomized trials with expanded sample sizes, standardized three-dimensional deviation analysis of STL datasets, and extended longitudinal surveillance. Cost–benefit comparisons tracing digital and conventional workflows across the entire arc of treatment would also add considerable value. A deeper exploration of dynamic occlusal integration, guided surgical protocols, and biologic endpoints—peri-implant bone stability and soft-tissue health among them—would further sharpen understanding of where digital workflows fit within implant dentistry. Looking forward, investigations structured around prospective or crossover methodologies could yield more robust evidence by reducing bias and enabling within-subject comparisons of digital versus conventional techniques. Such designs would help disentangle causal relationships and reduce the inherent variability in retrospective analyses. Broader multicenter clinical trials, built on standardized protocols and long-term follow-up, would likewise enable more precise appraisal of the durability, biological integration, and cost-effectiveness of digital workflows.

Conclusion

This retrospective comparative clinical investigation indicates that digital impression technology offers meaningful benefits over conventional elastomeric approaches for implant-supported prosthetic restorations in partially dentate individuals. On the clinical front, the digital pathway was associated with a reduced frequency of prosthetic misfit (15% versus 25%), no misfit events at the definitive restoration stage, and markedly briefer impression sessions (13.2 ± 2.5 min versus 27.4 ± 3.1 min). These improvements most plausibly stem from eliminating tray-associated deformation and material manipulation errors, along with real-time scan feedback and more reliable CAD/CAM integration. The patient-reported results paralleled these objective findings, with scores across all 10 VAS domains elevated—most notably for comfort, gag reflex suppression, and aesthetic satisfaction—underscoring the patient-focused merits of intraoral scanning. From an operational standpoint, smoother laboratory coordination (via STL transfer), a shorter procedural sequence, and a reduced need for chairside corrections further boosted efficiency and predictability. Although a formal economic analysis lies beyond the reach of this study, day-to-day clinical observation indicates that time saved, fewer remakes, and lower material consumption can counterbalance the initial scanner purchase cost when case volumes are typical.

Given the retrospective nature of the study, the intraoral scanners available during the treatment window were from an earlier device generation. It stands to reason that current-generation hardware would demonstrate benefits for digital workflows that are at least as large, if not larger. Additionally, each group bundled together multiple sub-techniques or devices (tray design and material type within the conventional arm; scanner brand within the digital arm), a factor that may inject variability; future trials would do well to stratify or randomize by a single technique, material, or scanner. While the present work documented unambiguous clinical and patient-centered gains from digital impressions, it stopped short of probing possible differences at the level of STL datasets—whether between scanners or between analog impressions and direct intraoral captures. Subsequent research that incorporates quantitative deviation analysis of STL files would shed further light on reconstruction fidelity and could fortify the comparative appraisal of conventional versus digital workflows. It should likewise be noted that participants were assigned to separate cohorts, without a crossover or split-mouth framework, which constrained the possibility of direct intra-patient comparisons.

Beyond these device- and design-related limitations, the sample was modest in size (n = 40) and confined to partial-arch rehabilitations; any extension of these conclusions to full-arch or immediate-loading protocols therefore calls for restraint. The assessment of misfit relied on clinical and radiographic techniques rather than on three-dimensional deviation analyses, which would be more sensitive for detecting micro-level discrepancies.

In summary, for partial-arch implant rehabilitation, digital impressions are a clinically sound, patient-favored, and workflow-efficient alternative to conventional techniques. Analog methods remain a viable option when executed under strict protocols. Yet, the favorable balance of accuracy, efficiency, and patient acceptance documented here lends weight to the expanding embrace of digital workflows in modern implant prosthodontics. Studies from now on should incorporate larger, multicenter randomized designs, stratification by a single technique/material/scanner, quantitative analyses grounded in STL comparisons, and extended monitoring of biologic outcomes, to hone clinical recommendations and broaden the generalizability of the evidence.

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Informed consent was obtained from all subjects involved in the study.

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