JOMDI

Journal of Medical and Dental Investigations

J Med Dent Invest 2026; 7(S1): e260828
https://doi.org/10.5577/jomdi.e260828

Review Article Open Access

An overview of intraoral scanners and computer-aided design software programs used in scan design stages in digital dentistry

Muhammed Burak Süzen[1], **Hayriye Yasemin Yay Kuşçu**[2]

[1] Adıyaman University, Faculty of Dentistry, Department of Prosthodontics, Adıyaman, Türkiye
[2] Mehmet Akif Ersoy University, Faculty of Dentistry, Department of Prosthodontics, Burdur, Türkiye

Received: 15 July 2026
Revised: 8 August 2026
Accepted: 23 August 2026
Published: 27 August 2026

Correspondence:

Dr. Muhammed Burak SÜZEN
Adıyaman University, Faculty of Dentistry,
Department of Prosthodontics,
Adıyaman, Türkiye.
E-mail: muh.rak02@gmail.com

How to cite this article:

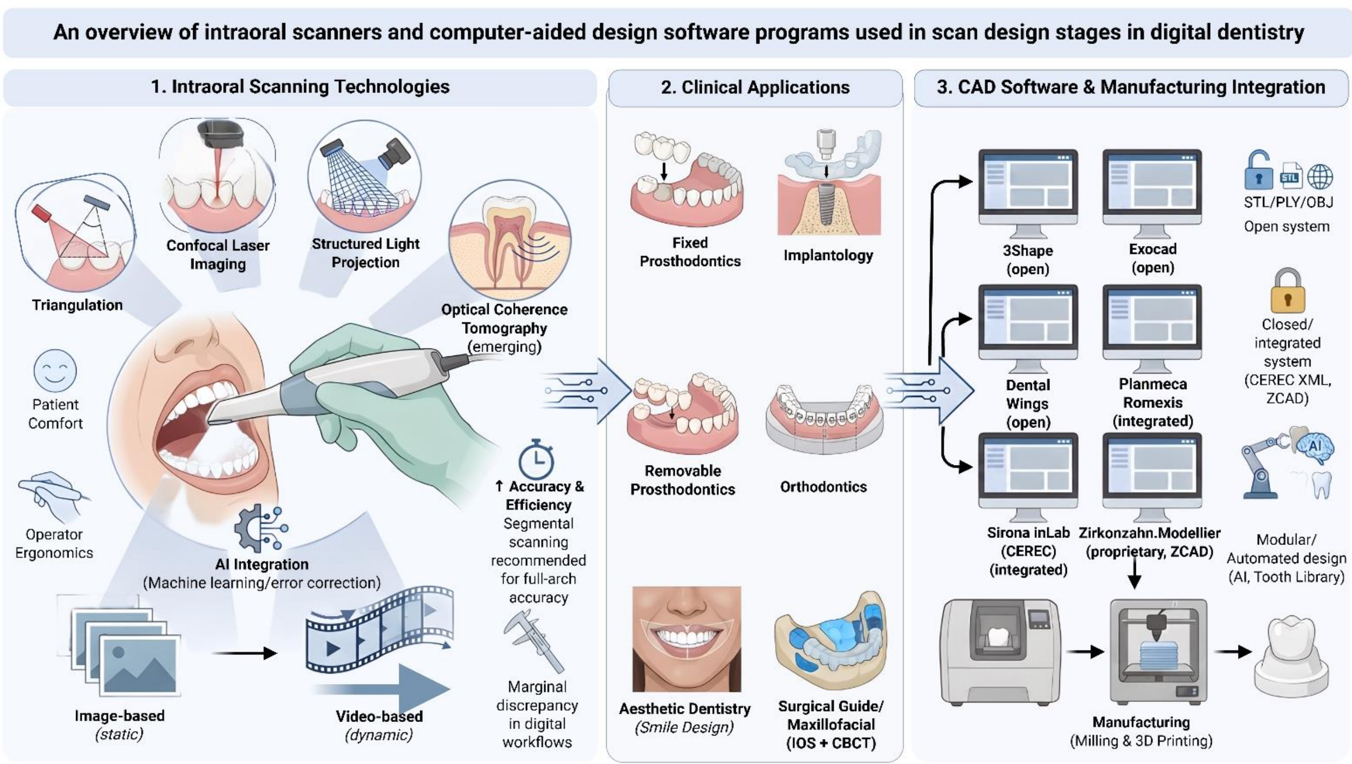
Süzen MB, Yay Kuşçu HY. An overview of intraoral scanners and computer-aided design software programs used in scan design stages in digital dentistry. *J Med Dent Invest*. 2026;7(S1):e260828.
https://doi.org/10.5577/jomdi.e260828

Abstract

In prosthetic dental treatments, obtaining the negative of the prepared area in the most accurate way directly affects the success of the restoration to be made. Therefore, it is necessary to give importance to the impression material and the impression technique used. Impression materials have undergone changes over the years in order to record the most accurate and sensitive detail. Studies have tried to improve many physical and chemical properties of the impression material. Despite this, it should not be forgotten that there are numerous external factors such as the skill of the clinician, environmental conditions, and storage conditions for the impression to be obtained. Developments in computer-aided design and computer-aided manufacturing (CAD/CAM) technology have significantly increased the use of these systems in dentistry in recent years. In dentistry, many companies in the market aim to minimize the problems that may occur in the laboratory and clinical environment by adding intraoral or extraoral scanners to CAD/CAM systems. The first step of dental CAD-CAM systems is digital scanning with an intraoral or laboratory scanner. This step is followed by the construction phase of restorations with digital design and production devices on the computer. Therefore, the success of these restorations depends largely on the accuracy and precision of the scanning devices. This review will discuss CAD/CAM systems and intraoral scanners and software programs.

Keywords: Digital dentistry, intraoral scanners, CAD/CAM systems, digital impression, scanning accuracy, digital workflow

Graphical abstract



Representative IOS devices: TRIOS 4, Medit i700 (open) | Primescan, Zirkonzahn S600 (closed)
No single study compares all systems under one standardised protocol; no ranking is implied.

1. Introduction

Digital dentistry, defined as the integration of digital technologies in the diagnosis, treatment planning, application, and production stages, has emerged as a contemporary approach that not only replaces traditional methods but also enhances clinical efficiency, patient comfort, and treatment timelines (1, 2).

The advent of digital dental applications can be traced back to the early 1980s when Dr. François Duret developed the first dental computer-aided design (CAD)/computer-aided manufacturing (CAM) system. This groundbreaking technology enabled computer-assisted design and production of dental restorations, setting the stage for the evolution of digital workflows in clinical practice (3). Rapid advancements in digital imaging systems, intraoral scanners (IOS), and 3D printing technologies, particularly in the 2000s, have further facilitated the widespread adoption of digital methods in clinical settings (4, 5).

Currently, digital dental workflows encompass a broad spectrum of clinical applications, including fixed and removable prostheses, orthodontic analyses, implant-supported restorations, temporomandibular joint assessments, and maxillofacial prosthetic production (6). The development of intraoral scanners has revolutionized the process of capturing dental impressions, providing more accurate, faster, and more comfortable methods than conventional impression techniques. These digital impressions can be seamlessly integrated into CAD systems for precise design and fabrication (7).

Despite the notable benefits associated with digital systems, their widespread implementation remains contingent on factors such as device cost, learning curve, and required technical infrastructure. Nevertheless, with technological advancements and growing user experience, digital methods have become increasingly routine in both clinical and laboratory settings (8).

2. Intraoral scanners: Technology and clinical applications

Intraoral scanners (IOS) have emerged as vital digital tools in contemporary dentistry, providing an alternative to conventional impression materials by capturing intraoral anatomical structures using optical systems. Over time, IOS systems have become indispensable in restorative procedures, implant-supported restorations, orthodontic analyses, and even surgical guide design, and aesthetic dentistry (1, 6, 7).

2.1 Scanning technologies and working principles

Modern IOS systems are distinguished by their diverse imaging principles, including laser projection, confocal imaging, and structured light systems. These scanners utilize movable scanning heads to digitize intraoral data, converting them into a three-dimensional model that can subsequently be integrated into CAD software for the creation of various restorative designs (3, 5).

IOS systems operate primarily in two modes: image-based and video-based. Image-based systems compile sequential static images to form a complete model, whereas video-based systems capture continuous, real-time data to generate a dynamic 3D representation (9).

IOS systems rely on optical methods to acquire 3D data of intraoral structures, utilizing advanced imaging techniques to convert surface data into high-resolution digital models. These systems effectively streamline treatment planning and prosthetic fabrication by integrating digital data into CAD workflows. The clinical accuracy and reliability of IOS systems are largely contingent upon the scanning technology employed and the algorithms utilized in data processing (3, 5, 10).

2.1.1 Triangulation-based scanning

Among the widely employed scanning methods in intraoral scanner systems, active triangulation is particularly prominent. This technique involves projecting a light source (commonly structured light or a laser) onto the target surface. A camera positioned at a specific angle detects the reflected light. The resulting geometric configuration forms a triangle, allowing for precise three-dimensional calculations.

Triangulation is particularly effective in capturing hard tissues, such as enamel. However, due to its sensitivity to light scattering, it may exhibit limitations when scanning soft tissues, leading to potential inaccuracies (5, 11).

2.1.2 Confocal laser imaging

Confocal laser imaging is a sophisticated optical technique commonly employed in advanced IOS systems. This method employs a focused beam that registers only light from a specific focal point while excluding signals from surrounding areas. The result is a high depth resolution with minimal image noise.

A notable advantage of confocal imaging is its ability to accurately capture intricate surface details without the need for drying or powdering the scanned area. This technique is particularly effective for complex anatomical structures, including undercuts, grooves, and subgingival margins (3, 6).

2.1.3 Structured light projection

Structured light projection involves projecting a predefined light pattern (e.g., lines or grids) onto the surface to be scanned. The deformation of this pattern is then analyzed using cameras to generate a three-dimensional geometry.

One of the primary advantages of this technique is its reduced sensitivity to patient movement, making it particularly suitable for the pediatric and geriatric populations. However, reflective surfaces, saliva, and blood can interfere with the light pattern, potentially compromising the accuracy of the scan (7, 9).

2.1.4 Optical Coherence Tomography (OCT) – Emerging technology

Although not yet widely integrated into commercially available IOS systems, Optical Coherence Tomography (OCT) represents a promising advancement. OCT leverages light interference to achieve high-resolution, cross-sectional imaging, not only of surface structures but also of subsurface tissues.

Experimental studies using OCT-based IOS prototypes have demonstrated the capacity of the system to visualize both gingival and periodontal tissues with remarkable clarity. This makes it particularly valuable for soft tissue analysis, periodontal assessments, and detecting subgingival margins, where conventional scanning methods may falter (2, 10).

2.1.5 Data acquisition modes: Static imaging vs. video-based scanning

Current intraoral scanner systems operate using two primary data acquisition modes: static (image-based) and video-based scanning.

- **Static imaging:** In this mode, the device captures sequential high-resolution images and stitches them together using software algorithms. Although the resulting 3D model can achieve high precision, the process is time-consuming and susceptible to misalignment errors if patient movement occurs.
- **Video-based scanning:** This mode generates a continuous stream of data, creating a real-time 3D model. Although faster than static imaging, video-based scanning is more sensitive to patient movement and requires advanced stabilization and filtering algorithms to maintain scanning accuracy (9, 10).

2.1.6 Image stitching and artificial intelligence integration

The conversion of raw scan data into a cohesive 3D model relies on image stitching algorithms. However, in full-arch scans, overlapping images can cause stitching errors, resulting in inaccurate or distorted models.

To mitigate these issues, contemporary IOS systems increasingly employ artificial intelligence (AI) and machine learning (ML) algorithms. These systems detect and correct data inconsistencies in real-time, minimizing the risk of distortion and ensuring more accurate alignment of scanned segments (8, 11, 12).

3. Clinical applications of intraoral scanners

Intraoral scanners (IOS) have become indispensable in contemporary dentistry, with applications in various specialties, including prosthodontics, orthodontics, implantology, and maxillofacial rehabilitation (11, 13). The adoption of IOS technology has accelerated owing to advancements in scanning accuracy, ergonomic design, and user-friendly interfaces.

3.1 Fixed prosthodontic treatments

IOS is extensively utilized in fixed prosthodontics, including single crowns, short-span bridges, and full-arch restorations. The technology facilitates the precise recording of prepared tooth surfaces and surrounding anatomical structures, allowing for highly accurate digital impressions.

Studies have reported that digital impressions obtained using IOS yield superior marginal adaptation and internal fit compared to conventional impressions, particularly in complex full-mouth rehabilitations (12).

3.2 Implant applications

In implant dentistry, intraoral scanners are frequently employed to capture the precise position and angulation of implants using reference markers known as scan bodies. This method eliminates many of the deformation risks associated with conventional impression materials and provides rapid, accurate data collection.

Despite its advantages, challenges remain in obtaining accurate scans in full-arch implant restorations due to potential errors in segmental stitching. To address this, segmental scanning protocols have been recommended, focusing on individual quadrants to enhance accuracy (7, 8).

3.3 Removable prosthodontic treatments

The application of IOS in removable prosthodontics, such as removable partial dentures (RPDs) and complete dentures, is more limited. The challenge lies in capturing soft tissues in a functional state, as IOS are primarily designed for hard tissues.

Nevertheless, recent advancements in scanner resolution and data processing algorithms have improved the accuracy of soft tissue capture, particularly in partially edentulous patients (12).

3.4 Orthodontic applications

IOS technology has gained significant traction in orthodontics, facilitating treatment planning, appliance fabrication, and progress monitoring. By replacing conventional plaster models with digital scans, IOS systems enhance workflow efficiency and enable remote treatment planning through tele-orthodontics.

Additionally, digital arch length analysis, Bolton analysis, and occlusal assessments can be performed with increased precision, thereby reducing the risk of treatment errors (10, 14).

3.5 Aesthetic dentistry and digital smile design

Intraoral scanners (IOS) have introduced new dimensions to aesthetic dentistry by facilitating digital smile design (DSD) processes. By integrating AI and machine learning, IOS systems enable clinicians to create patient-specific and facially driven treatment plans.

The combination of extraoral photographs with intraoral scans allows the development of highly accurate digital mock-ups. This integration ensures that anterior restorations, such as laminate veneers, inlays, and onlays, exhibit optimal morphological and aesthetic alignment (5).

3.6 Surgical guide production and maxillofacial rehabilitation

Recent advancements in integrating IOS data with Cone Beam Computed Tomography (CBCT) have significantly impacted surgical guide production. IOS systems can now accurately capture implant sites, anatomical structures, and surrounding tissues, enabling precise digital planning for implant placement and periodontal surgery.

In maxillofacial rehabilitation, IOS systems simplify the digitization of complex defect morphologies, allowing for the design of patient-specific prostheses with enhanced accuracy and reduced laboratory time (2).

4. Overview of leading intraoral scanner brands and their features

Currently, the market offers a diverse range of IOS devices, each distinguished by its scanning technology, data processing algorithms, and user interface. The selection of a scanner often depends on factors such as clinical precision, ergonomic design, and patient comfort (3, 5, 7).

4.1 CAD/CAM compatibility and data formats

Integration with CAD/CAM systems and support for universal data formats are critical considerations when selecting an IOS system. Modern devices typically support open or closed data formats, which affect workflow flexibility.

4.1.1 Open systems

Devices such as TRIOS 4 and Medit i700 use open formats (e.g., STL, PLY, OBJ), enabling compatibility with third-party software such as Exocad, Blender4Dental, and 3Shape Dental System (3).

4.1.2 Closed systems

Primescan and Zirkonzahn S600 utilize proprietary formats (e.g., CEREC XML, ZCAD), restricting direct data flow to specific CAD/CAM systems (2).

4.2 Patient comfort and operator experience

The ergonomic design of IOS systems significantly affects both patient comfort and clinician efficiency. Devices with lighter, more compact scanning heads reduce muscle activation and fatigue during consecutive scanning, which is relevant both for operator ergonomics and for patients with limited tolerance (15, 16).

4.2.1 Handpiece ergonomics and intraoral tolerance

Handpiece weight differs measurably between devices and configurations: the wired Medit i700 has been reported at 280 g and its wireless version at 328 g, and the heavier wireless configuration produced significantly greater muscle activation and fatigue in the arm, neck and shoulder during consecutive scanning (15). Compact handpieces improve access in the posterior regions and in patients with limited mouth opening.

However, Primescan and Zirkonzahn S600 feature larger scanning heads to accommodate higher data processing capabilities, which may prolong the scanning time and trigger gag reflexes in sensitive patients (17).

5. CAD systems in digital dentistry

CAD systems in digital dentistry serve as a bridge between intraoral scanning data and the fabrication of final restorations. These systems vary in terms of their functionality, workflow integration, and design capabilities.

5.1 3Shape dental system

The 3Shape Dental System is recognized for its comprehensive suite of applications, ranging from prosthetic and implant design to orthodontic analysis. It supports various data formats and has a modular architecture, making it a versatile tool for dental laboratories and clinics (18, 19).

- **Applications:** Single crowns, bridges, implant restorations, and full-arch rehabilitations.
- **Data Processing:** Advanced AI-driven algorithms facilitate occlusal analysis, contact area mapping and margin delineation (20).
- **Chairside Module:** The TRIOS Design Studio allows clinicians to complete intraoral scanning, design, and manufacturing in a single session (18).
- **Esthetics and Morphology:** Automated design algorithms reproduce anatomical contours and proximal and occlusal contact schemes, although manual refinement of the automated design is generally still required (20).

5.2 Exocad DentalCAD

Exocad DentalCAD is widely regarded for its open-system architecture and intuitive user interface. It is particularly suited for novice users while still offering advanced tools for experienced designers (19, 21).

- **Versatility:** Supports fixed prostheses, implant restorations, removable dentures, and smile design.
- **Integration:** Seamlessly connects with multiple scanner brands to enhance workflow flexibility.
- **Modular Structure:** Users can add specialized modules for implant planning, virtual articulation, and orthodontic analysis as needed (22).
- **Licensing:** The software is offered both as a perpetual licence with an optional upgrade contract and as a subscription-based licence, with add-on modules licensed separately (22).

5.3 Dental Wings

Dental Wings is predominantly employed in laboratory settings for its robust modeling capabilities and precise prosthetic design features (23).

- **Data Management:** Cloud-based data storage allows for remote access and case sharing between clinicians and laboratories (24).
- **Data Format:** STL-based, ensuring compatibility with third-party systems while maintaining data integrity.
- **Applications:** Focuses primarily on fixed prostheses, with limited capabilities for removable dentures and orthodontics.
- **Clinical Utility:** Studies indicate that restorations designed using Dental Wings exhibit marginal and internal adaptation within clinically accepted limits (23).

5.4 Planmeca Romexis CAD/CAM

Planmeca Romexis CAD/CAM software is specifically developed for seamless integration with Planmeca imaging and milling systems, making it a comprehensive solution for clinical digital workflows (25).

- **Workflow Integration:** The system consolidates various stages of digital workflow, from radiological imaging to prosthetic design and production, within a single software environment (25).
- **Implant Planning:** The software supports implant planning directly on CBCT data, together with the design of tooth- and mucosa-supported surgical guides (25).
- **Customizability:** The CAD module offers adjustable design parameters for both permanent and temporary restorations, catering to diverse clinical needs (25).
- **Interoperability:** Although optimised for Planmeca hardware, the software supports import and export of clinical data in standard formats and direct transfer of patient data to third-party software (25).
- **Clinical Outcomes:** In vitro and prospective clinical studies of the Planmeca chairside chain report marginal discrepancies within the clinically accepted range, comparable to or lower than those of other chairside systems evaluated under the same conditions (26-28).

5.5 Sirona inLab (CEREC)

Sirona inLab is a comprehensive CAD/CAM solution designed for in-office, chairside production of restorations. It is particularly advantageous for clinics aiming to deliver same-day dental treatments (29).

- **Integrated Workflow:** The system allows for digital scanning, design, and milling within a single appointment, thereby reducing overall treatment time (29).
- **Optical Scanning Precision:** High-resolution optical scanners capture detailed surface topography, ensuring precise marginal and internal fit for restorations (30).
- **Biogenic Design Module:** InLab's biogenic module analyzes adjacent tooth morphology to create anatomically accurate restorations (31).
- **Interoperability:** The software is optimised for Dentsply Sirona manufacturing units, while STL export of design data is available through the separate inLab CAD Interface module (32).
- **Clinical Validation:** Clinical trials indicate that ceramic restorations produced using inLab exhibit morphology, occlusion and esthetics comparable to laboratory-fabricated restorations (33).

5.6 Zirkonzahn.Modellier

Zirkonzahn.Modellier is a laboratory-centric CAD software developed for use exclusively with Zirkonzahn scanning and milling systems. It is particularly effective in complex prosthetic cases requiring anatomical precision (2).

- **Target Applications:** Ideal for full-arch restorations, implant-supported frameworks, and intricate gingival contour designs (5).
- **Data Handling:** The software employs the proprietary ZCAD format, maintaining data integrity but restricting compatibility with external CAM systems (2).
- **Morphological Libraries:** Zirkonzahn.Modellier includes extensive tooth morphology libraries, for anatomical customization of the restoration design (34).
- **Internal Compatibility:** The closed-system approach limits third-party integration but maintains a consistent data format across the manufacturer's own scanning, design and milling units (34).
- **Clinical Efficacy:** Research indicates that restorations fabricated using Zirkonzahn.Modellier demonstrate marginal discrepancies within the clinically accepted range (35).

6. Scanning and modeling performance

Scanning accuracy, defined by trueness and precision, is a critical parameter in digital dentistry, influencing the overall quality of CAD/CAM-generated restorations. Because no study has evaluated all of the systems described above under a single standardised protocol, the available evidence is summarised below according to the level at which it was generated rather than as a ranking between products (36).

- **Determinants of scanning accuracy:** Scanning accuracy is not a fixed property of a given device but the result of interacting operator-, patient- and device-related factors, including scanning strategy, scan extension, operator experience, ambient conditions and the optical properties of the scanned surfaces (14). Accuracy decreases as the scanned span increases, and partial-arch scans remain consistently more accurate than complete-arch scans across current scanner generations (30, 36).

- **Accuracy of the design software:** Far fewer studies isolate the contribution of the CAD software itself. In a controlled comparison of three laboratory CAD programs designing an identical three-unit fixed partial denture, 3Shape Dental System achieved the highest trueness at the margins, axial walls and occlusal surface, followed by Exocad and inLab version 16 (19).

- **Automated design:** Automated design functions in 3Shape Dental Manager and exocad DentalCAD generate clinically usable proximal and occlusal contact schemes, although manual post-processing of the automated proposal remained necessary in both systems (20).

- **Complete-workflow comparisons:** Where entire scan-design-mill chains have been compared under identical conditions, differences between systems are measurable but remain within clinically accepted limits. Crowns produced with the Planmeca chain showed a lower absolute marginal discrepancy than those produced with the CEREC chain on the same cadaver full-arch scan, with all values below the clinical acceptability threshold (26, 27). A prospective clinical study comparing an analogue workflow with three CAD-CAM systems likewise reported comparable marginal and internal fit across the digital groups (28).

- **Morphological reproduction:** Biogeneric reconstruction, implemented in the CEREC and inLab environment, reproduced the original occlusal morphology significantly more closely than conventional wax-ups ($p < 0.0001$), and chairside-designed crowns were comparable to laboratory-fabricated crowns in morphology, occlusion and esthetics (31, 33).

- **Laboratory systems:** Marginal discrepancies within the clinically accepted range have been reported for restorations designed in Dental Wings (23) and in Zirkonzahn (35), although these studies evaluated single systems rather than head-to-head comparisons. No investigation has assessed all of the CAD systems described in this chapter under one standardised protocol, and the findings summarised above therefore permit no overall ranking between them.

7. Software architecture and user experience

The system architecture and user interface play pivotal roles in the clinical applicability and learning curve of CAD software in digital dentistry (21).

- **3Shape Dental System:** The open architecture accommodates a variety of scanners and milling units, fostering interoperability (18). Consistent with this, users with limited design experience have been shown to favour simplified or automated interfaces, whereas experienced technicians prefer step-guided professional software (21).

- **Exocad:** Prioritizes modularity, allowing users to expand capabilities with implant planning, digital articulation, and orthodontic modules. Its modular, open structure places it between simplified automated programs and fully parametric laboratory software in terms of user experience (21).

- **Dental Wings:** Optimized for laboratory use, the interface prioritizes data processing and archiving, and supports cloud-based data sharing between clinic and laboratory.

- **Planmeca Romexis:** The software is optimised for consistent data flow across Planmeca devices while also supporting import and export in standard formats and data transfer to third-party software (25).

- **Sirona inLab (CEREC):** The user interface is designed for seamless chairside use, integrating scanning, design, and milling within a single software environment (29).

- **Zirkonzahn.Modellier:** The interface caters to experienced technicians, offering advanced parameter settings for detailed anatomical modeling, a design approach that corresponds to the professional, step-guided software category preferred by experienced operators (21).

8. Clinical compatibility and indication support

The clinical applicability of CAD software is determined by its ability to effectively handle diverse prosthetic indications and treatment modalities (18).

- **3Shape Dental System:** Supports single crowns, fixed partial dentures, implant-supported frameworks, and orthodontic appliances. Advanced modules facilitate digital smile design and surgical guide planning (37).
- **Exocad:** Extensively used for full-arch restorations, telescopic crowns, and removable prostheses. Integration with face scanners and jaw motion data supports functional and esthetic analysis (22).
- **Dental Wings:** Primarily focused on fixed prosthetics but limited in orthodontic and removable denture applications. Data sharing via STL supports collaboration between clinic and laboratory (24).
- **Planmeca Romexis:** Supports implant planning and surgical guide fabrication directly on CBCT data (25).
- **Sirona inLab (CEREC):** Tailored for single-visit dentistry, encompassing temporary crowns, bridges, and anterior restorations (29).
- **Zirkonzahn.Modellier:** Suited for complex, multi-unit prosthetics, including gingival profiling and emergence profile design (35).

9. Manufacturing integration and compatibility

The integration of CAD software with manufacturing systems is essential to maintain workflow continuity and enhance production efficiency. The key factors include CAM compatibility, file format support, and single-visit production capabilities (18).

- **3Shape Dental System:** Supports open formats, such as STL, PLY, and OBJ, enabling integration with multiple milling units and 3D printers. Chairside design modules extend the same platform to clinical production (37).
- **Exocad:** Offers extensive CAM compatibility, integrating seamlessly with leading manufacturers like Dentsply Sirona, Amann Girrbach, and vhf. Its open, vendor-neutral architecture allows use with third-party scanners, milling machines and 3D printers (22).
- **Dental Wings:** Although primarily optimized for laboratory production, its STL-based data export permits integration with a range of CAM devices (24). Its post-processing tools are oriented towards laboratory production rather than chairside workflows.
- **Planmeca Romexis:** Optimised for production on Planmeca PlanMill units, while also supporting export in standard formats for use with third-party CAM systems (25).
- **Sirona inLab (CEREC):** Facilitates in-office, single-visit production through CEREC milling units. STL export of design data requires the separate inLab CAD Interface module (32).
- **Zirkonzahn.Modellier:** Employs the proprietary ZCAD format, maintaining data consistency across Zirkonzahn devices (34). The proprietary format restricts direct compatibility with external CAM systems (35).

10. Discussion

This review comprehensively examines intraoral scanners (IOS) and CAD software systems, focusing on their technological capabilities, clinical applications, and user experiences in digital dentistry. The findings emphasize that digital workflows offer significant advantages in terms of accuracy, patient comfort, and production efficiency compared to conventional methods (1, 2). IOS systems employing triangulation, confocal imaging, and structured light projection have demonstrated marked improvements in scanning accuracy and repeatability (7, 11). However, limitations persist in full-arch scans, where accuracy decreases as the scanned span increases (14, 30). While open-architecture systems, such as Exocad and 3Shape, facilitate multi-vendor integration and enhanced workflow flexibility, manufacturer-integrated systems, such as Sirona inLab and Planmeca Romexis, are optimised for in-house processing while still supporting standard-format export, in the case of inLab through a separate interface module (22, 25, 32, 37). Simplified and automated interfaces are preferred by users with limited design experience, whereas platforms such as Zirkonzahn.Modellier cater to experienced operators by providing extensive parameter settings for complex prosthetic designs (21, 34). CAM compatibility remains a critical factor in optimizing digital workflows. Exocad's extensive CAM support and 3Shape's chairside production capabilities exemplify systems that bridge design and fabrication (22, 37). CAD software applications extend beyond basic restorative procedures to include orthodontic analysis, implant planning, and digital smile design. However, achieving optimal outcomes in these advanced applications requires precise data acquisition and alignment, underscoring the importance of well-calibrated scanning systems and trained operators (1, 9).

11. Conclusion

The integration of digital technologies in dentistry has transformed clinical workflows, particularly in prosthetic and restorative treatments. Intraoral scanners and CAD software have emerged as essential tools that provide enhanced diagnostic accuracy, patient comfort, and treatment efficiency. However, achieving consistent clinical outcomes requires a comprehensive understanding of the system capabilities, scanning protocols, and manufacturing integration.

Clinical Recommendations:

Digital impression systems should be prioritized for fixed prosthetics to minimize measurement inaccuracies and optimize the marginal fit (6, 13). Segmental scanning and advanced algorithms should be considered in full-arch cases, where accuracy is lower than in partial-arch scans (30). Open-architecture CAD systems may be preferable in academic settings, as they allow integration with a wider range of laboratory equipment (22, 37). Systems offering guided scanning protocols and automated design proposals are better suited to operators with limited experience (21).

Future Research Directions:

1. Continued research on AI-enabled data processing is needed to improve real-time error detection during intraoral scanning.
2. Developing advanced scanning algorithms for soft tissue capture will significantly improve prosthesis adaptation and esthetic outcomes.
3. Assessing the impact of ambient light, humidity, and patient movement on the scanning accuracy can inform the development of more effective scanning protocols.
4. Implementation of real-time data analysis and operator feedback during scanning can further reduce errors and standardize workflows.

Disclosures

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – M.B.S.; Design – M.B.S.; Supervision – M.B.S., H.Y.Y.K.; Materials – H.Y.Y.K.; Data collection &/or processing – M.B.S., H.Y.Y.K.; Analysis and/or interpretation – M.B.S., H.Y.Y.K.; Literature search – M.B.S., H.Y.Y.K.; Writing – M.B.S.; Critical review – M.B.S., H.Y.Y.K.

Declaration of Generative AI and AI-Assisted Technologies: During the preparation of this work, FigureLabs was used to create the graphical abstract, and the AI figure-generation feature in BioRender was used for subsequent text edits to the figure. The author(s) then reviewed, edited, and verified all visual and scientific content for accuracy and take(s) full responsibility for the final published material.

Conflict of Interest: There is no any conflict of interest.

Funding: There is no any funding.

References

1. Ahmed S, Hawsah A, Rustom R, et al. Digital impressions versus conventional impressions in prosthodontics: a systematic review. *Cureus*. 2024;16(1):e51537. https://doi.org/10.7759/cureus.51537
2. Zimmermann M, Mehl A, Mörmann WH, Reich S. Intraoral scanning systems: a current overview. *Int J Comput Dent*. 2015;18(2):101-129.
3. Ahlholm P, Sipilä K, Vallittu P, Jakonen M, Kotiranta U. Digital versus conventional impressions in fixed prosthodontics: a review. *J Prosthodont*. 2018;27(1):35-41. https://doi.org/10.1111/jopr.12527
4. Ting-Shu S, Jian S. Intraoral digital impression technique: a review. *J Prosthodont*. 2015;24(4):313-321. https://doi.org/10.1111/jopr.12218
5. Chochlidakis KM, Papaspyridakos P, Geminiani A, Chen CJ, Feng IJ, Ercoli C. Digital versus conventional impressions for fixed prosthodontics: a systematic review and meta-analysis. *J Prosthet Dent*. 2016;116(2):184-190. https://doi.org/10.1016/j.prosdent.2015.12.017
6. Shah N, Thakur M, Gill S, et al. Validation of digital impressions' accuracy obtained using intraoral and extraoral scanners: a systematic review. *J Clin Med*. 2023;12(18):5833. https://doi.org/10.3390/jcm12185833
7. Michelinakis G, Apostolakis D, Kamposiora P, Papavasiliou G, Özcan M. The direct digital workflow in fixed implant prosthodontics: a narrative review. *BMC Oral Health*. 2021;21(1):37. https://doi.org/10.1186/s12903-021-01398-2
8. Sawase T, Kuroshima S. The current clinical relevancy of intraoral scanners in implant dentistry. *Dent Mater J*. 2020;39(1):57-61. https://doi.org/10.4012/dmj.2019-285
9. Kihara H, Hatakeyama W, Komine F, et al. Accuracy and practicality of intraoral scanners in dentistry: a literature review. *J Prosthodont Res*. 2020;64(2):109-113. https://doi.org/10.1016/j.jpor.2019.07.010

10. Ender A, Mehl A. Accuracy of complete-arch dental impressions: a new method of measuring trueness and precision. *J Prosthet Dent*. 2013;109(2):121-128. https://doi.org/10.1016/S0022-3913(13)60028-1
11. Li J, Moon HS, Kim JH, Yoon HI, Oh KC. Accuracy of impression-making methods in edentulous arches: an in vitro study encompassing conventional and digital methods. *J Prosthet Dent*. 2022;128(3):479-486. https://doi.org/10.1016/j.prosdent.2020.09.038
12. Hasanzade M, Aminikhah M, Afrashtehfar KI, Alikhasi M. Marginal and internal adaptation of single crowns and fixed dental prostheses by using digital and conventional workflows: a systematic review and meta-analysis. *J Prosthet Dent*. 2021;126(3):360-368. https://doi.org/10.1016/j.prosdent.2020.07.007
13. Karaca S, İnan Ö. İmplant destekli protezlerde konvansiyonel ve dijital ölçü: sistematik derleme. *Selcuk Dent J*. 2021;8(3):888-894. https://doi.org/10.15311/selcukdentj.781806
14. Abduo J, Elseyoufi M. Accuracy of intraoral scanners: a systematic review of influencing factors. *Eur J Prosthodont Restor Dent*. 2018;26(3):101-121.
15. Son K, Lee JM, Kim JW, Jin MU, Lee KB. How does the consecutive use of intraoral scanners affect musculoskeletal health? A preliminary clinical study. *Eur J Med Res*. 2024;29(1):329. https://doi.org/10.1186/s40001-024-01895-4
16. Al-Hassiny A, Végh D, Bányai D, et al. User experience of intraoral scanners in dentistry: transnational questionnaire study. *Int Dent J*. 2023;73(5):754-759. https://doi.org/10.1016/j.identj.2023.04.002
17. Ender A, Mehl A. In-vitro evaluation of the accuracy of conventional and digital methods of obtaining full-arch dental impressions. *Quintessence Int*. 2015;46(1):9-17. https://doi.org/10.3290/j.qi.a32244
18. Alghazzawi TF. Advancements in CAD/CAM technology: options for practical implementation. *J Prosthodont Res*. 2016;60(2):72-84. https://doi.org/10.1016/j.jpor.2016.01.003
19. Lee YS, Kim SY, Oh KC, Moon HS. A comparative study of the accuracy of dental CAD programs in designing a fixed partial denture. *J Prosthodont*. 2022;31(3):215-220. https://doi.org/10.1111/jopr.13406
20. Bernauer SA, Wieland P, Zitzmann NU, Joda T. Feasibility testing of the automatic design of three-unit implant fixed dental prostheses with different dental CAD software: a pre-clinical pilot trial. *J Clin Med*. 2025;14(1):233. https://doi.org/10.3390/jcm14010233
21. Lee DH, Mai HN, Win TT, Rana S, Lee HJ, Jang SW. Comparison of different CAD software on user experience and satisfaction. *Int Dent J*. 2023;73(Suppl):S45-S46. https://doi.org/10.1016/j.identj.2023.07.677
22. exocad GmbH. DentalCAD. Accessed May 13, 2026. https://exocad.com/our-products/dentalcad
23. Sannino G, Gloria F, Schiavetti R, Ottria L, Barlattani A. Dental Wings CAD/CAM system precision: an internal and marginal fit experimental analysis. *Oral Implantol (Rome)*. 2009;2(3):11-20.
24. Dental Wings Inc. DWOS software: instructions for use, version 4.1. Accessed May 13, 2026. https://ifu.dentalwings.com/ifu/dwos/29-0100_DWOS%20Software_v4.1-EN.pdf
25. Planmeca Oy. Planmeca Romexis dental software. Accessed May 13, 2026. https://www.planmeca.com/dental-software/planmeca-romexis/
26. Vág J, Nagy Z, Bocklet C, et al. Marginal and internal fit of full ceramic crowns milled using CADCAM systems on cadaver full arch scans. *BMC Oral Health*. 2020;20(1):189. https://doi.org/10.1186/s12903-020-01181-9
27. Sadid-Zadeh R, Katsavochristou A, Squires T, Simon M. Accuracy of marginal fit and axial wall contour for lithium disilicate crowns fabricated using three digital workflows. *J Prosthet Dent*. 2020;123(1):121-127. https://doi.org/10.1016/j.prosdent.2018.11.003
28. Sanchez-Lara A, Hosney S, Lampraki E, et al. Evaluation of marginal and internal fit of single crowns manufactured with an analog workflow and three CAD-CAM systems: a prospective clinical study. *J Prosthodont*. 2023;32(8):689-696. https://doi.org/10.1111/jopr.13675
29. Zaruba M, Mehl A. Chairside systems: a current review. *Int J Comput Dent*. 2017;20(2):123-149.
30. Ender A, Zimmermann M, Mehl A. Accuracy of complete- and partial-arch impressions of actual intraoral scanning systems in vitro. *Int J Comput Dent*. 2019;22(1):11-19.
31. Kollmuss M, Jakob FM, Kirchner HG, Ilie N, Hickel R, Huth KC. Comparison of biogenerically reconstructed and waxed-up complete occlusal surfaces with respect to the original tooth morphology. *Clin Oral Investig*. 2013;17(3):851-857. https://doi.org/10.1007/s00784-012-0749-6
32. Dentsply Sirona. inLab Software: dental CAD software. Accessed May 13, 2026. https://www.dentsplysirona.com/en-us/discover/discover-by-brand/inlab-cad-software.html
33. Kollmuss M, Kist S, Goeke JE, Hickel R, Huth KC. Comparison of chairside and laboratory CAD/CAM to conventional produced all-ceramic crowns regarding morphology, occlusion, and aesthetics. *Clin Oral Investig*. 2016;20(4):791-797. https://doi.org/10.1007/s00784-015-1554-9
34. Zirkonzahn GmbH. Zirkonzahn.Software: CAD/CAM software. Accessed May 13, 2026. https://zirkonzahn.com/us/cad-cam-systems/cad-cam-software
35. Ameri N, Siadat H, Shamshiri AR, Alikhasi M. A comparative evaluation of implant supported zirconia framework gap of two CAD/CAM systems. *J Dent Med (Tehran Univ Med Sci)*. 2016;29(2):77-82.
36. Mehl A, Ender A, Mörmann W, Attin T. Accuracy testing of a new intraoral 3D camera. *Int J Comput Dent*. 2009;12(1):11-28.
37. 3Shape A/S. Dental System: dental CAD design software for labs. Accessed May 13, 2026. https://www.3shape.com/en-us/software/dental-system