

# Digital Versus Conventional Dental Impressions: A Comprehensive Review of Accuracy, Efficiency, Patient Comfort, and Clinical Applicability in Modern Dentistry

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## Abstract

Dental impressions play a critical role in restorative, prosthodontic, and implant dentistry by ensuring the accuracy, fit, and longevity of dental prostheses. With the evolution of digital dentistry, intraoral scanning technologies have emerged as a viable alternative to conventional elastomeric impression techniques. This review aims to comparatively evaluate digital and conventional dental impressions in terms of accuracy, efficiency, patient comfort, cost-effectiveness, and clinical applicability.

Digital impression systems offer several advantages, including enhanced patient comfort, reduced chairside time, improved workflow efficiency, and seamless integration with computer-aided design and manufacturing (CAD/CAM) technologies.

They allow real-time visualization, easy storage, and efficient communication between clinicians and laboratories. Advances in artificial intelligence and three-dimensional imaging have further strengthened the precision and diagnostic capabilities of digital systems. However, limitations such as high initial investment, technique sensitivity, learning curve, and challenges in recording subgingival margins and complex anatomical areas remain.

Conventional elastomeric impressions, despite being time-consuming and occasionally uncomfortable, continue to demonstrate consistent accuracy and reliability, particularly in complex clinical situations. Evidence from recent studies suggests that while digital impressions are increasingly comparable—and in certain cases superior—to traditional methods, both techniques have distinct advantages and limitations.

**Conclusion:** Neither digital nor conventional methods can be considered universally superior. A hybrid approach that integrates both techniques based on clinical requirements is recommended to optimize treatment outcomes, enhance patient experience, and adapt to the evolving landscape of modern dentistry.

**Key Words:** Digital impressions, conventional impressions, intraoral scanners, CAD/CAM, prosthodontics, dental accuracy

## Introduction

Accurate dental impressions are fundamental to the success of restorative, prosthodontic, and implant procedures, directly influencing the fit, function, and longevity of dental prostheses. Traditionally, elastomeric impression materials such as polysiloxane and polyether have been widely used due to their proven reliability and ability to capture fine anatomical details. However, these techniques are often associated with patient discomfort, technique sensitivity, and time-consuming workflows. The emergence of digital impression systems, particularly intraoral scanners, has revolutionized dental practice by offering a more efficient, patient-friendly, and technologically advanced alternative. Digital impressions enable the rapid acquisition of three-dimensional models, seamless integration with

computer-aided design and manufacturing systems, and improved data storage and communication.

Recent advancements in intraoral scanning technology have significantly enhanced accuracy, resolution, and workflow efficiency, making digital impressions increasingly comparable—and in some cases superior—to conventional methods. Studies have demonstrated improved precision, reduced chairside time, and higher patient satisfaction with digital approaches. Additionally, the integration of artificial intelligence, real-time feedback systems, and additive manufacturing technologies such as three-dimensional printing has further expanded the clinical applications of digital impressions. Despite these advantages, limitations remain, including high

initial costs, learning curve requirements, and challenges in capturing subgingival details or complex anatomical regions.

This review critically evaluates the current evidence comparing digital and conventional impression techniques in terms of accuracy, efficiency, patient comfort, cost-effectiveness, and clinical outcomes. It also explores technological advancements, practical limitations, and future directions, emphasizing the potential role of hybrid approaches that integrate both methods. While digital impressions are poised to become a cornerstone of modern dentistry, conventional elastomeric techniques continue to play a vital role in specific clinical scenarios. The future of dental impressions lies in the strategic integration of both technologies to optimize clinical outcomes and enhance patient care.

**Review**

Dental impressions play a pivotal role in the successful execution of restorative, prosthodontic, and implant dentistry, as they provide the foundational blueprint for the fabrication of indirect restorations. The ability to accurately reproduce the complex anatomical details of teeth and surrounding oral structures is essential for ensuring optimal marginal adaptation, occlusal harmony, functional stability, and long-term durability of dental prostheses. Any inaccuracies in the impression process can lead to ill-fitting restorations, compromised aesthetics, increased chairside adjustments, and potential biological complications, including periodontal inflammation and secondary caries. Consequently, the selection of an appropriate impression technique is a critical decision that directly influences

clinical outcomes and patient satisfaction.(1). Traditional methods involve using elastomeric materials like polysiloxane or polyether, which are mixed and placed in a tray before being inserted into the patient’s mouth. Once the material sets, it forms a flexible mold of the dental arch. The main advantages of elastomeric impressions include their long-standing reliability, high accuracy, and ability to capture fine details of a patient’s oral anatomy(2,3). However, the process can be time-consuming, messy, and uncomfortable for patients, with the potential for gagging or material distortion.

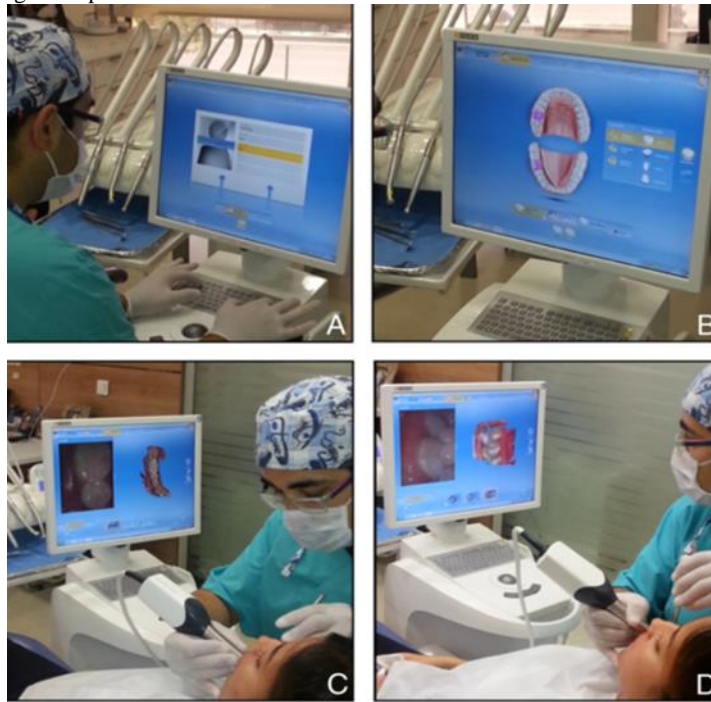
Digital impressions, on the other hand, utilize intraoral scanners to capture detailed images of a patient’s teeth and gums. The scanner sends these images to a computer system that creates a 3D digital model. Digital impressions eliminate the need for physical materials, reducing discomfort associated with traditional methods. They are faster, cleaner, and more convenient, with the added benefit of easily storing and sharing the data for further procedures(4). Early digital impressions suffered from accuracy issues and slow scanning times, but modern systems have addressed these limitations. The latest digital impression technologies, like intraoral scanners (e.g., 3Shape Trios, iTero, and Carestream) (5), offer higher resolution and precision, reducing the need for adjustments during restorative procedures. Newer systems utilize advanced software to help with real-time data analysis and feedback, optimizing the workflow and enhancing the speed of capturing precise dental impressions. This table highlights the main differences between the two types of impressions and can guide decisions on which method to use based on specific needs.

Feature	Digital Impressions	Conventional Impression
Accuracy	High accuracy due to advanced scanning technology. Less prone to human error and distortion.	Lower accuracy, especially if technique is not followed precisely. Potential for distortion and errors.
Efficiency	Faster process, immediate results. Scans are instantly available for review.	Slower, as it requires additional time for material setting and delivery to the lab.
Patient Comfort	More comfortable, less invasive.	uncomfortable due to the use of impression trays filled with material that may cause gagging or discomfort.
Cost	Initial investment in equipment is high, but long-term costs can be lower (fewer materials and fewer lab fees).	Lower initial investment but recurring costs for materials and lab fees.
Learning Curve	Requires specialized training to use the equipment effectively, but it can be mastered relatively quickly.	Requires experience and skill to avoid errors in technique, but generally easier to learn than digital systems.
Turnaround Time	Quick turnaround; immediate digital files can be sent to labs or used for in-office restorations.	Longer turnaround due to time required for material setting and delivery to the lab.
Storage & Accessibility	Digital files are easily stored, backed up, and shared electronically with labs or other specialists.	Physical models need storage space, and replication or shipping is more difficult.
Environmental Impact	More eco-friendly due to reduced use of disposable materials and shipping.	Less environmentally friendly due to use of plastic or alginate materials, which generate waste.
Reliability in Complex Cases	Reliable for complex cases due to high precision and ability to view and adjust scans in real-time.	May struggle with highly detailed or difficult impressions, requiring re-takes.

Digital impressions are now seamlessly integrated with CAD (Computer-Aided Design) and CAM (Computer-Aided Manufacturing) systems. This integration facilitates the immediate creation of digital models that can be directly used for the fabrication of crowns, bridges, and dentures(5,6). Additive manufacturing technologies, like 3D printing, are now used to create high-quality prosthetics with reduced production times and enhanced accuracy. Digital impressions eliminate the discomfort caused by traditional molds (e.g., tray impressions) and improve patient comfort by reducing gag reflexes and waiting times. (7,8) Digital impressions have been shown to provide superior fit when compared to conventional methods. For instance,

Abdeen et al. (2022) conducted a study comparing prostheses fabricated from 3D-printed models made from digital impressions versus traditional stone casts. The results showed that digital impressions consistently resulted in better fit, particularly in the anterior maxilla, where precision is crucial(11).Some studies even suggest that patients show a higher level of satisfaction with digital impressions compared to traditional methods. The ability to instantly view the 3D model of the patient's mouth allows both dentist and patient to visualize treatment plans, enhancing communication.

Numerous studies have compared the efficacy, accuracy, and patient comfort between traditional impressions and digital impressions.



**Figure 2:** (13) A.)Entering patient information B) Laboratory prescription, C) Upper and lower arch scanningD)Bite scanning

Studies(31,40,41,42) have shown that intraoral scanners (IOS) are revolutionizing dental practices with enhanced accuracy, efficiency, and patient comfort. Various brands, including 3Shape's TRIOS series and Dentsply Sirona's Primescan, have demonstrated high precision, with scan times typically ranging from 2-3 minutes continuous image capture and advanced software have simplified dental procedures, allowing for seamless integration with CAD/CAM systems and open data interfaces. Diagnostic applications have expanded, with IOS technology now being used to detect major oral diseases, tooth wear, caries, and plaques. The latest research emphasizes the transformative potential of IOS in enhancing dental diagnostics and treatment outcomes, while also highlighting ongoing developments to address existing challenges and further integrate AI and other advanced technologies into digital impression systems. For instance, Palantza et al. (2024) conducted an in vitro comparison of digital impressions using intraoral scanning devices versus conventional elastomeric materials. The study found that digital impressions achieved superior accuracy in many cases, particularly when using advanced scanning technologies. However, the study's limitations included a small sample size and a controlled laboratory environment that may not fully represent real-world clinical conditions. Similarly, Albayrak et al. (2021) evaluated the three-dimensional accuracy of full-arch implant impressions and found that digital impressions were significantly more accurate, especially for edentulous patients(11). This study's focus on a specific demographic limits the generalizability of the results, suggesting future research should include a broader range of patients. Amin et al. (2017) supported these findings, revealing that digital impressions outperformed conventional methods in terms of reliability and precision, although they acknowledged that digital impressions may struggle in cases with significant soft tissue distortion(16,18,19). Papaspyridakos et al. (2016) further reinforced the effectiveness of digital impressions for edentulous patients, but did not address the potential impact of operator experience on accuracy(1). Abdeen et al. (2022) compared prostheses fabricated from 3D-printed models made from digital impressions versus traditional stone casts, showing that digital impressions consistently resulted in better fit, particularly in the anterior maxilla(7). However, this study's small sample size and lack of diversity in the patient population highlight the

need for larger cohorts in future research. Iwamoto et al. (2023) demonstrated that digital impressions could achieve high accuracy in implant placement, critical for ensuring proper fit and function(13,15), yet did not explore the long-term outcomes of restorations made from digital impressions. Sampaio-Fernandes et al. (2024) found that digital impressions were highly accurate in an in vitro setting, but the controlled environment may not reflect real-world variability. Lastly, Awad et al. (2024) examined the effect of soft tissue thickness on the accuracy of both impression techniques, indicating that traditional methods may still be preferred in certain cases due to the challenges faced by digital impressions in such scenarios(10).

While both impression methods have their merits, there are limitations to each. Conventional elastomeric impressions, although precise, can be uncomfortable for patients, requiring longer chair time and the use of trays and setting materials. In addition, handling and storage conditions can impact the quality of the final cast, and the time-consuming nature of the process increases the risk of errors due to patient movement or material setting inconsistencies. Digital impressions, while fast and comfortable, may face challenges in specific clinical scenarios, particularly in capturing accurate impressions of subgingival areas, mobile teeth, or when dealing with patients who exhibit significant gag reflexes(11,30,31,36). Moreover, the high cost of intraoral scanners and the need for training and maintenance are notable barriers to widespread adoption, especially in smaller practices or less economically advanced regions. The choice between digital and conventional impressions can significantly impact clinical outcomes. Accurate impressions are essential for achieving a proper fit for dental prostheses, which affects not only the aesthetic appearance of the restoration but also its longevity and functionality. Digital impressions have been shown to provide superior fit when compared to conventional methods. Also study titled conducted by Ebid, Rady, and Abdel Hakim, to compare the accuracy of digital and conventional impression techniques for creating surgical guides used in implant placement(11,13,12).. The results demonstrated that digital impressions were more accurate than conventional ones in both constructing the surgical guide and positioning the implants, underscoring the advantages

of digital techniques in dental procedures. It aimed to compare the accuracy of digital and conventional impression techniques for creating surgical guides used in implant placement

As the field of digital dentistry continues to evolve, future advancements will likely address many of the current limitations. Research such as that by Christensen (2008) and Ahmed et al. (2024) suggests that digital impressions will increasingly become more precise and user-friendly as technology improves (12). The development of hybrid systems that combine the strengths of both digital and traditional methods may offer a more comprehensive solution, especially in complex clinical cases. Artificial intelligence (AI) and machine learning are beginning to play a role in improving the accuracy and efficiency of digital impressions. These technologies can analyze digital impressions in real-time, automatically detecting issues like occlusal discrepancies or anatomical anomalies, and suggesting corrections or treatment options. Future studies will likely explore how AI can assist in automating digital impression workflows and providing diagnostic support during procedures. While digital impression

systems offer undeniable benefits—speed, comfort, and the potential for precise 3D modelling—the current technology is still evolving. A major limitation identified in recent studies is the inconsistency in accuracy, especially when compared to conventional methods like elastomeric impressions. For instance, Sampaio-Fernandes et al. (2024) examined the trueness of extra oral digital impressions for full-arch implant impressions, finding that the digital system was accurate but still required improvements for certain clinical situations, such as the soft tissue thickness, as reported by Awad et al. (2024). Digital impressions also struggle in reproducing fine details in complex anatomical areas, such as the posterior arch, as observed by Abdeen et al. (2022) in their comparative study of 3D-printed models versus traditional stone casts.

Different intraoral scanners available are Carioscan, Trios 3 (3Shape), CS3600 (Carestream), Omnicam (Dentsply Sirona), TrueDefinition (Dentsply Sirona), iTero Element 5D (Align Technology), Shining 3D Aoralscan Elite



**Image 3(31).**

Studies have shown that intraoral scanners generally provide high precision and accuracy. For example, a systematic review found that factors such as scanner selection, operator skill, calibration, patient's oral anatomy, and ambient conditions significantly influence accuracy. The CS3600 scanner showed the best trueness in both partially and fully edentulous models. The workflow time for intraoral scanners varies by brand and model. For instance, the iTero Element 5D is known for its quick scanning process, often taking less than 5 minutes per arch. Most modern intraoral scanners, such as the Trios 3 and iTero Element 5D, offer wireless casting capabilities, allowing for seamless integration with digital workflows and easy data transfer. Intraoral scanners are widely accepted in orthodontic patients due to their non-invasive nature and ability to capture detailed digital impressions quickly. They are particularly useful for creating orthodontic models and aligners. Labs with Built-In TRIOS Systems Ensure compatibility and streamline workflow. Many modern labs accept digital files, but compatibility may vary based on software and scanner used. Various brands offer advanced intraoral scanners, each with unique user interfaces and features. Dentsply Sirona provides the CEREC software, known for its user-friendly interface, real-time feedback, cloud storage options, and seamless integration with other Dentsply Sirona products. Carestream Dental features CS ScanFlow, which includes an intuitive touchscreen, automatic updates, seamless integration with other systems, and high-resolution imaging. The 3Shape TRIOS series offers TRIOS Studio Apps, available in wireless and wired options, and includes AI-driven tools, real-time smile design, patient monitoring, and easy sharing of digital impressions. Align Technology offers the iTero Element software, which provides a real-time scan preview, AI-based occlusal analysis, color scanning, integration with Invisalign, and a user-friendly touchscreen interface. Planmeca's Romexis software is known for high-speed scanning, AI-driven artifact removal, real-time feedback, and seamless integration with Planmeca products. Medit offers Medit Link, which features cloud storage, an intuitive user interface, AI-enhanced scanning, and easy sharing of digital impressions with labs. Dental Wings provides the DWOS software, which includes an easy-to-use interface, real-

time visualization, cloud storage, and seamless integration with Dental Wings products. Shining 3D offers Aoralscan, which is known for high-resolution scanning, AI-driven artifact removal, real-time feedback, and an intuitive user interface. Kulzer provides the DDS-CAD software with Virtuo Vivo, featuring an ergonomic design, real-time feedback, high-speed scanning, and easy integration with Kulzer products. Finally, GC offers Aadv Lab Scan, which includes AI-driven scanning, real-time feedback, an easy-to-use interface, and seamless integration with GC products. These features collectively enhance the efficiency and accuracy of digital dental impressions, facilitating better clinical outcomes and patient experiences. 3Shape TRIOS Series has Accuracy: 20 – 40  $\mu\text{m}$  (0.02 – 0.04 mm) for full arch scans and Precision 10 – 50  $\mu\text{m}$  (0.01 – 0.05 mm) for full arch scans and has features of High-definition scans with natural color, AI-driven noise removal, and wireless operation and Dentsply Sirona Primescan for producing custom-made Invisalign aligners. For Carestream Dental CS 3600 both partially and fully edentulous models features are High precision, easy integration with other systems, and robust performance. Align Technology iTero Element 5D has High scanning accuracy for orthodontic treatments. These scanners provide high precision and accuracy, ensuring clinically acceptable and precise impressions. For instance, the 3Shape TRIOS series is known for its accuracy within 20-40  $\mu\text{m}$  for full arch scans. There has been a shift towards open data interfaces, enhancing interoperability with other dental systems. Some IOSs now include tools for caries detection using fluorescence technologies or near-infrared imaging like 3Shape TRIOS 4 and 5 scanners come equipped with built-in fluorescent technology that aids in the identification of potential caries during dental examinations. Similarly, the Align Technology iTero Element 5D uses Near Infrared Imaging (NIRI) to detect caries, providing real-time insights into a patient's oral health. Additionally, the Planmeca Emerald S scanner includes features designed specifically for caries detection. These advancements in IOS technology allow dentists to diagnose caries more effectively and provide timely treatment, ultimately improving patient outcomes. IOSs facilitate quantitative monitoring of tooth wear and soft-tissue dimensions. Developers are leveraging deep neural network-based approaches for precise tooth segmentation in intraoral scans, essential for orthodontic

applications. IOSs are now integrated with CAD/CAM systems, transforming them into platforms for diagnostics, patient communication, and treatment planning. Several leading companies offer advanced intraoral scanners with unique features and capabilities. 3Shape is renowned for its TRIOS series, which provides high accuracy, speed, and seamless integration capabilities. Align Technology is well-known for the iTero scanner, widely used in orthodontics. Dentsply Sirona offers the Primescan, which stands out for its precision and advanced features. Medit provides the i500 and i700 scanners, known for their ease of use and accuracy. Planmeca offers the Emerald S scanner, which is popular for its comprehensive features. Carestream Dental provides the CS 3800 scanner, which is noted for its reliability and performance. Vatech offers the EzScan, recognized for being user-friendly and efficient. Finally, Shining 3D provides the Aoralscan, known for its advanced imaging capabilities. These companies and their products are at the forefront of the digital dental industry, enhancing the capabilities and efficiency of dental practices. Intraoral scanners (IOS) provide numerous benefits but also come with certain challenges. The high initial investment (₹15,00,000 to ₹30,00,000) and maintenance costs (₹1,50,000 to ₹3,75,000 annually) can be substantial, making it a significant financial commitment for dental practices. The cost per digital impression (₹8,000 to ₹25,000) is much higher compared to traditional elastomeric impressions (₹300 to ₹1,000). Limited acceptance by some dental laboratories can result in additional costs for maintaining both digital and traditional methods. The learning curve requires investment in staff training and adjustments. IOS technology struggles with imaging deep gingival margins and subgingival areas, especially in the presence of saliva or blood, and is not always reliable for measuring post space depth. Reflective surfaces can interfere with scan accuracy, and human error remains a factor. Compatibility issues may arise if the digital impressions need processing by labs without compatible systems. Despite these challenges, the advancements in IOS technology, including improved accuracy, efficiency, patient comfort, open data interfaces, and diagnostic capabilities, along with integration with CAD/CAM systems and deep neural networks for precise tooth segmentation, enhance their utility in modern dental practices. The benefits may outweigh the disadvantages as technology continues to evolve and gain acceptance. Despite these limitations, there is a strong case for digital impressions becoming a cornerstone of modern dental practices. However, a key question remains: Can digital technologies fully replace elastomeric materials, or will they serve as complementary tools? The current evidence suggests that while digital impressions are effective for many routine cases, elastomeric materials still hold an essential place, especially for intricate and highly detailed impressions. According to Ahmed et al. (2024), the integration of both digital and conventional methods offers the best of both worlds, allowing clinicians to choose the appropriate technique based on the case at hand.

In conclusion, the future of dental impressions likely lies in the integration of both digital and traditional approaches. Digital technologies have the potential to revolutionize dentistry by improving patient comfort, reducing chair time, and increasing efficiency. However, the limitations in accuracy, cost, and the need for specialized training mean that elastomeric materials will continue to play a vital role in clinical practice. As the technology evolves, future studies should focus on improving the accuracy and reliability of digital impressions, particularly in complex clinical situations. Additionally, innovations such as advancements in intraoral scanners, software improvements, and better integration with CAD/CAM systems will help bridge the gap between digital and traditional methods. Ultimately, the continued development of digital impressions, alongside the refinement of elastomeric materials, will pave the way for more efficient, accurate, and patient-friendly dental care in the years to come. Thus, the future of dental impressions may lie in a hybrid approach, where both digital and elastomeric technologies coexist, each serving its purpose based on the specific clinical context. As we look to the future, the synergy between digital and elastomeric techniques promises a new era of precision, comfort, and

excellence in dentistry, with ongoing research and development crucial in overcoming existing limitations and enhancing the overall patient experience, while digital technologies have made significant strides in dentistry and offer numerous advantages over elastomeric impression materials, they are unlikely to fully replace elastomeric in the immediate future. However, as digital technologies continue to evolve, their integration into dental workflows will likely become more widespread, eventually reducing the reliance on traditional impression materials for many procedures. Digital impression technology is evolving rapidly with advancements in accuracy, patient comfort, and integration with CAD/CAM systems. Ultimately, while digital impressions are a leap forward in dental technology, the enduring relevance of traditional elastomeric methods proves that innovation and tradition can coexist to enhance patient outcomes. And the synergy between digital and elastomeric techniques promises a new era of precision, comfort, and excellence in dentistry.

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