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Can digital impression methods eliminate the current problems of conventional impression techniques?

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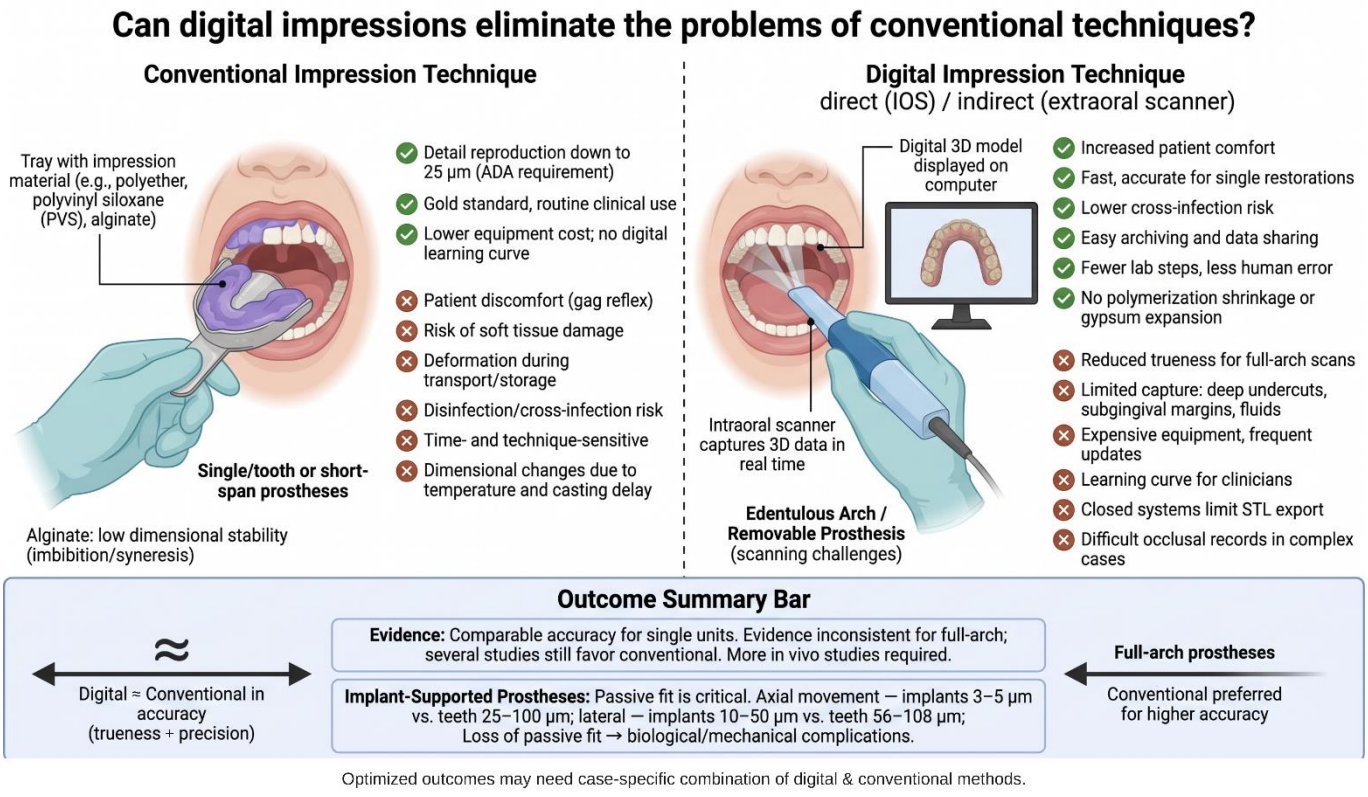
Abstract

Conventional impression materials remain a cornerstone of routine dental practice, yet they carry well-documented drawbacks, including a pronounced gag reflex, limited patient comfort, potential soft-tissue trauma, dimensional changes with temperature and elapsed time, the need for disinfection, cross-infection risk, and susceptibility to distortion during transport, storage, and laboratory handling. Digital impression systems have been introduced to overcome these limitations, and their use in dentistry—particularly in prosthodontics—continues to expand. This review compares conventional and digital impression techniques and examines whether digital workflows can resolve the shortcomings inherent to conventional methods. Conventional elastomers such as polyether and addition-type silicones offer excellent dimensional stability and detail reproduction and are currently regarded as the gold standard. Digital impressions, obtained with intraoral or extraoral scanners, provide clear advantages in patient comfort, procedure time, reduced cross-infection risk, elimination of polymerization shrinkage and gypsum expansion, and convenient digital archiving and transfer. However, their accuracy is influenced by scanning area, scanner sensitivity, operator experience, moisture, patient movement, and inter-implant distance. The reviewed literature indicates that intraoral scanners achieve clinically acceptable accuracy for single units and single-quadrant restorations, whereas evidence for full-arch and multiple implant-supported prostheses remains inconsistent, with several studies still favoring conventional impressions. Accuracy—comprising trueness and precision—is especially critical for passive fit in implant-supported restorations. Most comparative data derive from in vitro models that do not reproduce intraoral conditions such as saliva, blood, and patient movement, underscoring the need for further in vivo research. In conclusion, although the benefits of digital impressions are evident, their long-term clinical efficacy and safety require additional investigation, and technique selection should weigh accuracy, time efficiency, learning curve, and cost. A case-specific combination of digital and conventional approaches may offer added benefit.

Keywords: Digital impression, intraoral scanner, conventional impression, trueness and precision, prosthodontics

Graphical abstract



1. Introduction

Conventional impression materials are frequently used in dental practices. Digital impression systems have been developed to overcome the disadvantages of conventional impression materials. Studies have been conducted on the marginal and internal compatibility of restorations produced by the digital impression method compared to restorations produced using the conventional method, but the superiority of these two methods over each other is still unclear (1, 2). Owing to increasing technological developments, their use in dentistry is becoming increasingly widespread. To compare the advantages/disadvantages of conventional and digital impression methods, it is necessary to have knowledge about these two systems.

2. Conventional impression materials

Conventional impression materials are used to obtain negative impressions of hard and soft tissues. Impression materials are divided into two main groups according to their structural properties (3, 4):

1) **Non-elastic impression materials:** Zinc oxide eugenol, impression plaster, and impression compound
2) **Elastic impression materials**
   a) **Hydrocolloids:** Irreversible hydrocolloid (alginate) and reversible hydrocolloid (agar)
   b) **Elastomers:** Polysulfide, polyether, condensation-type silicone, addition-type silicone, and vinyl siloxane ether

The high dimensional stability of impression materials used in conventional impressions and the fact that they do not change after removal from the mouth are important factors in clinical success. According to the American Dental Association (ADA), elastomeric impression materials should be able to reproduce detail as fine as 25 µm. Current impression materials (including the irreversible hydrocolloid impression material alginate) allow this precision to be achieved (5).

The most commonly used impression materials in clinical practice are polyether and condensation- and addition-type silicones. Polyether and addition-type silicones exhibit excellent dimensional stability and precision. However, even though conventional impressions provide precise measurements, the change of these materials with temperature, the time between

taking and casting, and disinfection procedures can cause deterioration of the material structure. These conditions have a direct effect on the deterioration of the accuracy and precision of the impression taken (6).

The conventional impression method is a difficult and sensitive procedure for both patients and clinicians. The conventional impression method has some disadvantages due to material properties and during clinical use.

Disadvantages of conventional impressions

1. Nausea reflex that occurs during the impression,
2. Low patient comfort,
3. Damage that may occur in soft tissues,
4. The need for sterilization of the impressions in the process of obtaining the plaster model and the presence of the risk of cross-infection,
5. The possibility of the impression being subject to deformations during transport and storage, the need for precision in daily operations in the laboratory (7).

3. Digital impression

Since the advent of digital dentistry, its use has become quite widespread, especially in the field of prosthodontics. The digital impression technique is used in many areas, such as fixed prosthetic applications, removable partial dentures, total dentures, implant prostheses, and even maxillofacial prostheses (8, 9). Digital impressions can be obtained in two ways: a direct technique using an intraoral scanner, in which the clinician is active, or an indirect technique using an extraoral laboratory scanner, in which the technician is active.

1) Intraoral scanners:

Intraoral scanners (IOS) record images in two main ways.

a) IOS that capture still images of the teeth with a camera
b) IOS that record video, which is then reconstructed by computer software (10).

2) Extraoral scanners:

Laboratory-type extraoral scanners are divided into two groups: optical (non-contact) and mechanical (contact) scanners. Scanners with optical readers are frequently used in laboratories.

The accuracy of intraoral digital impression scanning decreases as the scanned area increases. For intraoral scanners, accuracy is clinically acceptable when the scanning coverage is less than half an arch, and the accuracy is better than that of an extraoral scanner. The accuracy demonstrated by extraoral scanners is nevertheless clinically acceptable (11). However, more studies comparing the accuracy of intraoral and extraoral scanners in vivo in full-arch measurements are needed (1, 11).

Digital impressions have many advantages compared to conventional impressions.

These advantages are as follows:

1. In single crowns and short-span fixed prostheses, intraoral digital impressions provide accuracy similar to that of conventional elastomeric impressions.
2. Impressions can also be archived digitally and superimposed with cross-sectional imaging data.
3. Increased patient comfort.
4. The time the clinician spends on difficult and lengthy impression procedures is reduced.
5. It enables the restoration to be produced in a shorter time and reduces the potential for error.
6. It reduces the risk of cross-infection.
7. Some systems have color scanning, color selection, and still photography capabilities (7).
8. Digital impressions eliminate laboratory production steps that may cause incompatibility between implants and fixed prostheses.
9. Obtaining digital impressions using an intraoral scanner completely eliminates the polymerization shrinkage of the impression materials and the expansion of plaster during polymerization.
10. Electronic files can be sent and stored digitally. This feature saves time, cost, and space (6, 12–14).

In addition to these advantages, there are also disadvantages of the digital impression method that need to be improved and corrected:

1. Reduced accuracy (trueness) of intraoral scanner data, especially in full-arch restorations.
2. Incomplete scanning of undercut areas.
3. The accuracy of digital measurements is adversely affected by factors such as the scanning area, scanner sensitivity, scanning speed and protocol, clinician experience, image resolution, movement of the patient during the procedure, presence of fluids such as blood and saliva, and increased distance between implants.
4. Difficulties in the use of scanner heads in some areas in terms of dimension.
5. Inability to computerize step data from deep subgingival margins.
6. Digital technology requires frequent updates.

7. Difficulty in obtaining occlusion information for complex prosthetic treatments.
8. Closed systems restrict the options for transferring standard tessellation language (STL) files (6, 10, 12, 13, 15).

The accuracy of digital scanner measurements consists of precision and trueness. The precision of a digital scanner indicates how closely repeated measurements agree with one another; the higher the precision, the more predictable the measurement. In digital scanners, trueness refers to how closely the measurement matches the actual value. High accuracy gives results close to or equal to the actual value of the measured object (16). Especially in implant-supported prostheses, the accuracy of the impression is essential for the passive fit required for success. Due to the elasticity of the periodontal ligament, the teeth can move 25-100 µm in the axial direction and 56-108 µm in the lateral direction, while the implants can move 3-5 µm in the axial direction and 10-50 µm in the lateral direction due to the absence of a periodontal ligament around the implant. Therefore, especially in screw-retained implant prostheses, failure to achieve passive alignment can cause various biological and mechanical complications in the early and late periods (12).

Conventional impressions show high detail accuracy and are currently used routinely and successfully. At present, clinical studies comparing conventional and digital impression techniques in vivo are lacking, but there are in vitro studies that measure the marginal and internal fit of dental restorations produced using these two techniques. Since most of the research on intraoral scanners is done with models, the experimental environment created is not exposed to any external factors such as saliva, blood, amount of mouth opening, movement of patients, moist environment of the mouth, compared to the real environment in the oral cavity. Therefore, more studies are needed to verify the measurements (11, 17). Since conventional impressions are considered the gold standard, it is considered useful to directly compare digital impressions with conventional impressions. For conventional impressions, digital impressions are usually compared with impressions taken with polyether and polyvinyl siloxane (18).

According to the results of a clinical study conducted by Atieh et al. (19), the digital impression method showed acceptable accuracy and precision in single-quadrant dental treatments, while the conventional impression method was more accurate and precise in full-arch prosthetic treatments. Giachetti et al. (18) concluded from a systematic review of the accuracy of digital impressions in fixed prosthetic restorations that high-precision conventional impressions were more accurate than in vivo digital impressions and that evidence on the in vivo performance of digital technologies is lacking and needs further study. According to the results of the study by Ender et al. (16), the accuracy of conventional and digital impressions was compared. They measured the precision and trueness of both conventional and digital full-arch impressions and reported that the digital intraoral impression method was less accurate and showed a completely different deviation pattern than the conventional impression method.

According to the results of a meta-analysis by Chochlidakis et al. (6), dental restorations produced with the digital impression technique showed statistically similar marginal discrepancies compared to restorations obtained with the conventional impression technique.

According to the systematic review by Karaca et al. (12) comparing conventional and digital impressions in implant-supported prostheses, when the articles comparing conventional and digital impression techniques were analyzed overall, 5 of the 12 articles stated that the digital impression technique was less accurate in implant impressions and 7 encouraged the use of digital impressions. However, they stated that more clinical studies are needed to evaluate the accuracy and suitability of intraoral scanners for clinical use.

In a systematic review of studies comparing digital and conventional impression methods, Ahmed et al. (14) stated that digital impressions show an accuracy level equivalent to conventional impressions. In addition, they stated that digital impressions have advantages such as time, patient comfort, and reduction of procedures. However, it is important to recognize that digital techniques have limitations and difficulties, such as the acquisition of the necessary equipment and software, cost, continuous updating of the system, and the need for the clinician to be experienced.

According to the results of a systematic review by Michelinakis et al. (20), for implant sites covering a single jaw quadrant, the accuracy of the digital impression was high, and the deviations in the implant position were within acceptable clinical limits. There was no consensus on the superiority of conventional, splinted, or personal tray impressions over digital IOS impressions for multiple implants placed in a completely edentulous arch. However, for full-arch cases, digital IOS impressions were reported to be less accurate than conventional open- or closed-tray impressions.

According to the results of a meta-analysis of eight clinical studies and 21 in vitro studies comparing digital and conventional impression methods for fixed crowns by Hasanzade et al. (21), they reported that there was no significant difference in marginal adaptation between the clinical groups obtained with conventional impression and digital impression, but the digital impression group had a significantly better internal adaptation than the conventional impression group. However, according to in vitro studies, there was no significant difference in internal adaptation between the groups obtained with conventional and digital impressions, and a significantly better marginal adaptation was observed for the digital impression group in the comparison of the conventional and digital impression groups.

In light of these data, it is stated that impression and fabrication techniques can affect the fitting accuracy of full-arch fixed restorations and that a fully

digital workflow can produce restorations with comparable or better marginal adaptation than other methods (21, 22).

The applicability of digital technologies may differ between generations. Since the younger generation of dentists grows up in a virtual-based environment, their social lives are greatly influenced by digital technologies, so their adaptation to digital innovations is easier. In a study by Joda et al. (23) comparing conventional open spoon and digital impressions in terms of time, difficulty, and preference between student and experienced dentists, 76% of the students preferred IOS, 48% of the experienced dentists favored conventional impressions, and 26% each preferred IOS or either technique.

Removable partial dentures (RPDs) and complete dentures with the aid of digital impressions are complex to fabricate and therefore their clinical application is limited. For the fabrication of these prostheses, impressions must cover not only the tooth space but also the soft tissues in contact with the minor and major connectors. It has been reported that saliva-covered flexible oral mucosa and smooth surface tissues can pose a challenge when taking intraoral digital impressions for removable partial or complete dentures. It has also been reported that the width of the dental arch may affect the precision of intraoral digital impressions, whereas the palatal vault height may have no effect on precision (8).

Li et al. (24) compared digital and conventional impressions on completely edentulous models and reported that intraoral scanners show comparable accuracy to conventional impression materials for edentulous arch impressions, regardless of the concepts used to express accuracy and precision.

Edentulous arches lack prominent structures, and the neighboring area varies little in height, preventing accurate image fusion when using intraoral scanners. To improve the scanning accuracy of the edentulous arch surface, tools called Scanning Aid for Edentulous Arch (SAEA) are used. The effect of SAEA on the scanning accuracy for edentulous arches is small, and more studies are needed on this topic (24).

Dentists should recognize the challenges and limitations of digital procedures; over-reliance on these tools without a deep understanding of digital principles can pose various risks (25).

4. Conclusion

In conclusion, the advantages of digital impressions over conventional impressions are clear, but more in vivo research is needed to determine their long-term efficacy and safety. All digital phases from planning to the end of prosthetic rehabilitation should be evaluated, and a choice of digital or conventional impression should be made, considering time efficiency, learning curve, accuracy, and economic factors. A combination of digital and conventional approaches tailored to the individual case may offer additional advantages.

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