# TECHNOLOGIES FOR IMPRESSION AND MANUFACTURING PROSTHESIS ON IMPLANTS: LITERATURE REVIEW

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## ABSTRACT

Rehabilitation with implants has been considered as the first choice for replacing missing teeth in Dentistry. Allied to this, materials and technologies associated with the reestablishment of aesthetics, function, quality and longevity for prosthetic restorations are constantly developing. The aim of this study was to describe the current state of technologies for printing and manufacturing implants over dentures taking into account the relevance, application and display. According to the reviewed literature, it appears that the various CAD/CAM systems (Computer-Aided Design/Computer-Aided Manufacturing) have been increasingly usewd in Implantology for the purpose of automating an originally manual process, aiming to reduce the duration of prostheses manufacturing process and increase its reliability. Studies show that the development of CAD/CAM system resulted in improved reproducibility, mechanical strength and aesthetics results of implant supported dentures, combined with better patient compliance. On the other hand, there are still limitations to be overcome such as high cost, problems with distortion and lower precision, compared to conventional printing, in some clinical situations.

**KEYWORDS:** Computer-Aided Design. Dental prosthesis. Implant-supported.

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DOI: https://doi.org/10.14436/2447-911x.16.1.084-092.oar

## INTRODUCTION

The success of implant supported prosthesis treatment is directly related to the accuracy of the record from the three-dimensional orientation of the implant. Errors in this process can cause dimensional inaccuracies, which, in turn, lead to treatment failure.[1-4]

The conventional technique for impression of the implants position presents some difficulties related to the number, angulation and depth of the implants, the setting time of the impression material and discomfort for the patient. Considering these limitations, technologies have been developed and studied with the purpose of obtaining more accurate, fast and practical impression methods. The CAD/CAM (Computer Aided Design / Computer Aided Manufacturing) system tools have been adapted to the implant design, both for the development of intraoral impression of the position of the implants and for the preparation of the prostheses themselves.[5,6]

The intraoral digital impression for conventional and implant-supported prostheses have several benefits such as patient acceptance, absence of distortion of the impression material, three-dimensional preview of the prosthetic space, virtual configuration of the restoration and emergency profile and shorter execution time of the denture.[2,4,7]

While on the one hand these new techniques can guarantee greater speed and precision for the accomplishment of the dental surgeon's work, as well as patient comfort, on the other hand, studies must advance in the search for safety in the quality of the restorations obtained from digital intra and extraoral impression and the applicability of these techniques.[4,7,8] Therefore, through a literature review, the objective of this work is to describe the current state of the technologies for impression and making prostheses over implants in view of their relevance, application and indication.

## LITERATURE REVIEW

### *Conventional impression for implant supported dentures*

Conventionally, an ideal impression technique should take the shortest time, be easy to perform, be inexpensive, be comfortable for the patient and present the best results. Despite the development of several technologies for dental practice, the literature still points to conventional intraoral impression with elastomeric material and individual trays, as a gold standard for production of the working cast.[4,8] However, conventional implant impression techniques are considered complex because they require the use of a variety of specific components.[4,9]

Scientific evidence and clinical observations have shown that the impression materials available today offer excellent dimensional reproduction.[9] So far, conventional elastomeric materials,

such as polyvinyl siloxane, have been used to impression dental implants and adjacent structures, producing highly accurate molds.[5,6] However, some factors influence the accuracy of implant impressions, such as the selected technique, the type of material and number, angulation and depth of the implants.[10,11]

For impression procedures in Implantology, two techniques are routinely indicated: the direct technique, or with open tray, and the indirect technique, or with closed tray. In order to carry out these procedures, it is necessary to use so-called transferor components that are coupled to the hexagon or head of the implants or to the different types of abutments, the fixation of which is made by through-bolts, integrated, or by juxtaposition.[11-13]

In the open tray technique, the transferors are connected to the abutment or directly to the implant through the screws. After the setting of the elastomeric material, transferors need to be unscrewed for removal of the mold. In the closed tray technique, the transferors remain in the mouth, being removed after the impression is made and repositioned in their respective places in the mold obtained. It is extremely important that they are placed in their correct position.[12,13]

The use of the open tray technique tends to exhibit greater dimensional accuracy in relation to the closed tray technique, however, the latter is very well indicated in cases where mouth opening is a limitation.[10]

In a study comparing these impression techniques for multiple implants, the authors showed that with the use of an open tray with elastomeric material and transferors attached to each other with acrylic resin, it is possible to precisely copy the relationship between the implants.[14] Phillips et al.[15], who tested the same techniques concluded that the distortions associated with the squared transferors used in the open tray technique were significantly lower than those of the closed tray with conical transferors. In addition, they emphasized that the union of the square transfer with acrylic resin had average results between the other two. The controversy among these studies confirms the difficulty in obtaining predictable and reproducible results with the conventional impression technique. Manual impression can be extremely susceptible to variations related to the operator and material.

An imprecise transfer results in maladjustment of the prosthetic part, which can lead to mechanical complications, such as loosening of the screw, fracture of the prosthesis and/or implant components.[9]

***New technologies for impression of implant position***

**CAD/CAM**

The CAD/CAM defines the design of a computer prosthetic structure (Computer Aided Design) followed by its manufacture by a milling machine (Computer Aided Manufacturing), and this technology was introduced in dentistry between the 1970s and 1980s. The objective of its development was to automate a manual process, aiming to reduce the time of manufacture of the prosthesis, increase the precision, improve the reproducibility, the mechanical resistance and the final esthetics.[4,7,16,17]

Since the introduction of CAD/CAM technology advances have been continuous and its indication has been widely expanded. In general, these systems consist of a data capture component (scanner to read the model), a design component (CAD - specific software), and a production component (machine tool for prosthesis or infrastructure as designed by the software - CAM).[7,10,18,19]

The first component is the basic prerequisite for other processes to occur. Thus, the three-dimensional data of the abutments and anatomical regions are collected through various technologies, such as laser scanning or optical cameras. Until recently, laboratory scanners were predominantly used for this scanning process. It starts from a conventional impression for obtaining a cast model, followed by the scanning using the laboratory scanner equipment. There are many systems that use this technology, such as Cerec 3D, Procera, Everest, DigiDent, Lava, Evolution 4D, Cercon, Neoshape, Etkon, and Pro 50.[10,16,19]

For the Implantology to take advantage of the advances provided by this technology, coded implant abutments were created around 1998. The cast model with coded abutments connected to the analogues of the implants is digitized to create a virtual model in three dimensions (3D), which allows the manufacture of the prostheses.[1,20] Sirona (Bensheim, Germany) was one of the first companies to develop these scanning bodies so that information about the implant (type, location, angulation and depth) is reproduced in the scanning process. This scanning body was originally intended for laboratory use, and is now also available for intraoral.[13]

**Oral** *Scanner*

The development recent in CAD/CAM is intraoral digital impression, which generates a three-dimensional virtual model (3D).[4,7,8,17] Thus the scanning process has become easier since computer assisted impression allows the dentist to acquire the data directly from the prepared abutments, without the need to do conventional impression, obtain the cast and die, and finally scan it using the laboratory scanner.[7,10,17]

Besides the comfort of the clinical management of devices for intraoral digital impression is the easiness of the next steps in the digital workflow. This is because the time required for the scan as well as the manufacturing process is reduced, and the potential errors that could occur, such as the distortion of the impression material and the master plaster model, have been eliminated.[4,10]

The CEREC system (AC-Bluecam-Sirona, Germany) was one of the first devices for intraoral digital impression. This system is based on the concept of "light triangulation" in which the crossing of three beams of linear light is used to locate a certain three-dimensional point. An opaque powder coating (zirconia dioxide) is used to allow uniform scattering of light and increase the accuracy of the scanner.[6,17,19] In 2012, Ominicam, Sirona's latest CAD/CAM development, was launched on the market, which promotes the capture of images from natural-color 3D footage and eliminates the need for powder application for scanning.

Another technology available is the parallel confocal imaging (iTero; Cadent), which uses laser and optical scanning to capture the surfaces and contours of teeth and gingival structures. There is also an intraoral digital impression system that has been developed from a laser imaging technology (E4D; D4D Technologies), which is also capable of scanning models by making conventional scanning impression. Finally, a digital impression system based on the principle of active or in-motion wavefront (optical) sampling has recently been introduced (Lava™ Chairside; 3M ESPE).[6,19]

To date, two digital impression systems, E4D and CEREC, are combined with an office milling machine, and CEREC can also send information to milling plants. Other available digital impression devices can only send data to machining centers.[19]

**Tabl 1:**

Main features of current digital impressions systems.

| SCANNER | MANUFACTURER | PRINCIPLE OF WORK | LIGHT SOURCE | IMAGING TYPE | POWDER REQUIRED | MILLING IN THE OFFICE |
|---|---|---|---|---|---|---|
| Cerec AC-Bluecam | Sirona Dental System | Light triangulation | Blue Laser | Photographing (multiple images) | Yes | Yes |
| Cerec AC-Omnicam | Sirona Dental System | Active wavefront sampling | Blue Laser | Filming (Video) | No | Yes |
| iTero | Cadent Inc | Parallel confocal image | Red Laser | Photographing (multiple images) | No | No |
| E4D | D4D Technologies | Laser image | Laser | Photographing (multiple images) | Sometimes | Yes |
| LavaTM C.O.S. | 3M ESPE | Active wavefront sampling | Pulsating blue light | Filming (Video) | Yes | No |

Another great difference among scanners is related to the transference of the data. There are open systems (with possibility of working with many CAD/CAM systems); closed systems with a specific platform; or "selectively open" for CAD/CAM systems chosen by the manufacturer.[6,19] Table 1 summarizes the key features of current digital impression systems.

A study tested the accuracy of three intraoral scanners, CEREC AC (Sirona), iTero (Cadente) and Lava™ C.O.S. (3M ESPE), through the impression of a master model in gypsum equipped with three cylinders of high precision. The distance between the centers and the angulation of the cylinders were determined and the values found were compared. They concluded that the Lava™ C.O.S. in combination with a high-precision scanning protocol resulted in smaller, less consistent errors among the three scanners. The authors took into account the difference in data acquisition technology, since the CEREC and iTero scanners are point-and-click systems, while the Lava™ C.O.S. is a video system. This fact may explain both the similarities between the CEREC and iTero measurements and the differences with the results of the Lava™ C.O.S.[21]

In another in vitro study, the accuracy of the scanners was defined by the terms 'veracity' and 'precision', where the veracity was defined by the mean of the measures found of the model in relation to the actual size of the object and precision by the mean deviation of the measurements of the model in relation to the actual size of the object. It was concluded that the accuracy of digital impression techniques with Cerec AC and Lava™ C.O.S. scanners was similar to conventional impression.[1]

An important advance in Implantology has occurred with the emergence of the intraoral impression technique from digitally coded healing abutments, which allow the impression of the implant to be performed without the need for conventional printing – either open or closed tray. With this new technique, soft tissue healing is not disturbed, the impression becomes much simplified. For this purpose, a digitally coded healing abutment equipped with all the necessary information upon the implant platform, hexagonal position and height of the healing abutment strap is used.[1,9]

This technique reduces the interval between taking the impression and delivering the final restoration. The use of these encoded healing abutments allows the supragingival impression to be made digitally and sent to the laboratory for the fabrication abutments and final restorations.[9,20]

## Current and future perspectives

The current moment is marked by the increasing appreciation of aesthetics. With this, the materials and technologies that are related to it, allied to the concepts of function, quality and longevity of prosthetic restorations, are constantly been improved. This evolution is also quite evident the area of Implantology, because nowadays the dentist is allowed to offer highly esthetic implant restorations, often in a short period of time.[4,7,10,17,22]

The CAD/CAM technology is a reality in modern Dentistry and, currently, there are different types of systems available. However, cost-benefit ratio is still an issue to be evaluated and dentists should take into account the workflow of your office and the type of system that will be used. Nonetheless, the high cost of acquiring a complete CAD/CAM system (E4D – D4D Technolog e o CEREC – Sirona) does not prevent the acquisition of printing systems that perform only the digitization of the tooth preparation or implants (Lava™ C.O.S. – 3M ESPE; iTero – Cadent).[19,22]

Dental or implant-supported restorations produced by CAD/CAM technology from intraoral impression have their computer-controlled manufacturing which minimizes human failures. Because of this, they have few disadvantages when compared to those produced by conventional techniques. Among them we can mention the need to learn how to handle the devices. For the digital impression of implants, some limitations are found, but these do not determine the contraindication of the technique, only imply the need to make some changes in the process. For example, in very deep implants that can't be scanned by intraoral cameras, it is necessary to perform a conventional impression for later digitization of the cast and die.[23]

In a study that evaluated the participants' perceptions regarding the two different implant impression techniques (conventional and intraoral digital), the authors concluded that digital impression was more efficient than conventional impression, based not only on the amount of time consumed for each technique, but also its practicality. Even when more than one scanning had to be performed, the re-scan time was significantly shorter than the new conventional impression. The level of difficulty judged by the participants was significantly lower for the digital technique compared to conventional implant impressions. Handling of the intraoral scanner appears to have less technical sensitivity than the handling of conventional impression molding materials. According to participants' responses, as conventional prints require more experience to obtain a quality emission achieved in digital impression, suggesting that the learning process for these are simpler.[23]

In contrast, the study developed by Al-Abdullah et al.[9] evaluated the accuracy of models obtained with the intraoral digital impression technique using coded print abutments compared to the models obtained with conventional implant molding techniques (open tray). The authors concluded that, within the limitations of the study, with models made from digital impression and coded abutments, a desired level of precision needed to restore multiple implants with 10 or 30 degrees convergence was not achieved. They related such finding to the fact that the protocol recommended by the manufacturer of the coded abutment used for transfer of the implants indicates that it should have height of at least 1mm above the gingival tissue for the visibility and ease of scanning, which did not happen in this study due the different angulations used.

Thus, it is expected that in the near future, these intraoral digital technologies aimed at making implant-supported restorations still under development can overcome these limitations.

## CONCLUSION

It is possible to consider as advantages that digital technologies to impress and fabricate a denture allow the reduction of the working time as well as they are better accepted by the patient. But, on the other hand, there are still limitations to be overcome, such as high cost and problems such as distortion of digital models and less precision compared to conventional impression in subgingival areas. Thus, it is necessary to validate scientific technologies for impression and implant prostheses, because it is fundamental to understand the impact that these new technologies can exert on the modification of conventional protocols well documented in the literature.

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How to cite: Alves KAF, Damasceno JE, Oliveira VMB, Bastos LGC, Cavalcanti AN. Technologies for impression and manufacturing prosthesis on implants: literature review. J Clin Dent Res. 2019 Jan-Apr;16(1):84-92.

Submitted: June, 18, 2018 - Revised and accepted: September 19, 2018

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