Review Article

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Dentistry Section

Implant Impression Techniques using Different Materials and Methods: A Review

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ABSTRACT

Dental implants have emerged as the treatment of choice for restoring missing teeth in situations that require functional and aesthetic replacements. Reproduction of the position and orientation of intraoral implants by means of an accurate impression in the definitive cast is the first step in achieving a passively fitting multi-implant supported prosthesis, to decrease the mechanical and biological complication of the prosthesis. The accuracy of the impression making procedure in the usage of osseointegrated implants used for the rehabilitation of fully and partially edentulous patients is a very important factor for the long-term success of dental implants. It has been reported that the precision of implant impressions is affected by various factors such as impression materials, impression technique, splinting of impression posts, impression level and depth, as well as the angle of the implants. Also, the incompatibility between implant and prosthesis, which may occur as a result of an incorrect impression, may cause problems such as screw loosening, screw fracture, loss of osseointegration and even implant fracture. In recent research, there are many articles and reviews about implant impressions. Although the authors found consistent results in many studies, there are differences of opinion on some issues. In general, polyether and additional type silicones were found to be successful in the conventional impression technique. Digital impression technique, on the other hand, has been found as successful as conventional measurement techniques in some studies. Controversial results have been obtained about the number of implants and their angulation. In general, the direct open tray splinted impression method is recommended for four or more implants, while there was no difference between the direct or indirect method for three or less implants.

Keywords: Conventional impression, Custom tray, Digital dentistry, Intraoral digital impression, Slicone elastomers

INTRODUCTION

The accuracy of the impression making procedure in the usage of osseointegrated implants used for the rehabilitation of fully and partially edentulous patients is a very important factor for the long-term success of dental implants [1]. Intraosseous implants lack the effect of periodontal ligament support to compensate for the stresses caused by defects and irregularities in prosthetic restorations. If the fit of the restoration does not create a static load on the prosthetic system or the surrounding tissue, it is called passive fit. It was previously reported that lack of passive fit can lead to both biological and mechanical complications such as screw loosening, fracture of implant fragments and occlusal mismatch [2-4].

Recent studies have showed that the accuracy of implant impressions is affected by many factors such as impression material, impression technique, splinting of impression posts, impression level and depth, as well as the angle of the implants [2,5,6]. It was reported that incompatibility between implant parts and prosthesis, which may occur as a result of an incorrect impression, may cause problems such as screw loosening, screw fracture, loss of osseointegration and even implant fracture [6]. The purpose of this review was to highlight the difficulties that the clinicians may encounter while making an implant impression, and to provide information about the appropriate materials and techniques for making impressions with the least error, with guidance of previous studies on this subject.

FACTORS AFFECTING IMPRESSION ACCURACY IN FIXED PROSTHESIS OVER IMPLANTS

The main purpose of the implant-supported prosthesis should be to minimise the incompatibility in order to prevent possible complications. Factors affecting impression accuracy are as follows:

- Impression techniques
- Impression materials
- Implant number and angle
- Implant placement depth [2]

Impression Techniques

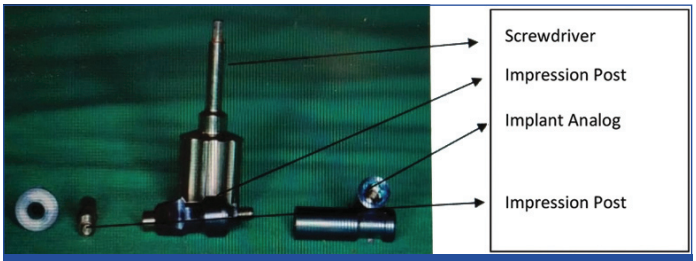
Different ways have been used to achieve the best results in multiple implant cases, the best technique is not established yet, and may differ from case to case. The aim is to make it as easy as possible to cause less discomfort to the patient and, most importantly, to provide the highest accuracy [7-9].

Today, there are three techniques for implant impressions:

- Direct impression technique (open tray impression technique)
- Indirect impression technique (closed tray or transfer impression technique).
- Digital impression technique [9]

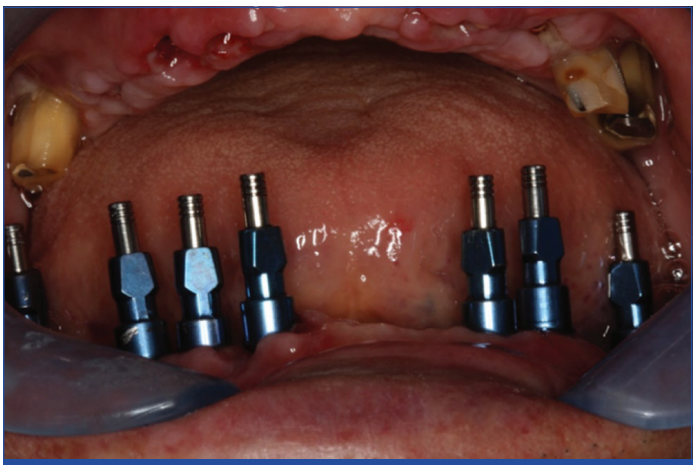
Direct Impression Technique (Open Tray Impression Technique): In the direct impression technique, the impression post is attached to the dental implant and it is important that the impression post is longer than the body of the screw when making the impression [Table/Fig-1]. After the impression material, the screw is loosened in order to remove the impression post from the impression material. The implant analog is then fixed onto the impression post using the same screw. Then the impression is ready to be poured [2,10-12]. The direct impression technique allows the impression piece to be removed while removing the impression material from the mouth to prevent the impression post from being placed back into the negative within the impression material [12]. On the other hand, placing the implant analog on the impression post while it is

in the impression material can cause rotational stress, resulting in a real error and permanent deformation of the impression [13].



[Table/Fig-1]: Implant impression components.
Splinted and non splinted direct impression technique

The splinted direct impression technique is applied by splinting the impression posts before making the impression in order to increase accuracy and prevent distortion when combining implant analog with the relevant impression post. It was reported that if the impression posts are not splinted [Table/Fig-2], it may cause rotational distortion when combining them with their analogues [9,14]. It was stated that many materials such as light cured composite resin, impression plaster, orthodontic wire, acrylic resin and autopolymerised acrylic resin are used as splint material [8,15].



[Table/Fig-2]: Open tray impression posts placed on the lower jaw to control custom tray.

Autopolymerised acrylic resin is most commonly used for splinting impression posts. In a study, it was stated that the dimensional shrinkage of the resin was one of the most important disadvantages to be considered, and it was stated that the total shrinkage ranged from approximately 6.5% to 7.9%, and it was reported that approximately 80% of the total shrinkage occurred within the first 17 minutes [16]. It was also stated that such shrinkage can cause distortion in the impression by applying pressure to the impression post in the impression material [17]. Additionally, it has been stated that the splint material should be of the same thickness [Table/Fig-3], otherwise it may show different shrinkage behavior and lead to different results [18].

[Table/Fig-3]: Splinting impression posts with autopolymerised acrylic resin.

When Martínez-Rus F et al., compared the direct impression technique without splint and the impression technique taken with two splint materials, and the direct impression technique with a sectioned acrylic resin splint and plastered customised metal bar, it was reported that the splinting technique provided more accurate results [8]. In a study by Papaspyridakos P et al., direct impression technique with and without splinting was used for each arch in 13 edentulous arches, and it was reported that significantly better results were obtained in impressions using the splinting technique [19]. In a study by Stimmelmayr M et al., the same results were reported with mean differences between the original model and impression models of 0.124 (±0.034) mm for the indirect technique, 0.116 (±0.046) mm for the direct technique, and 0.080 (±0.025) mm for the direct splinting technique (p=0.120; Tamhane test) [20]. In a systematic review 22 studies were reviewed on this factor, it was concluded that the splinted impression technique yielded better results than the non splinted direct impression technique in both partial as well and completely edentulous patients [21].

Indirect impression technique: The indirect impression technique, or the closed tray technique, uses a tapered impression post that is screwed onto the implant for impressions. After the impression material is polymerised, the tray is removed from the mouth, while the impression post remains fixed to the implant, then the impression post is separated from the implant and combined with the implant analogue. In the next stage, the assembled parts are placed in such a way that they correspond to the negative of the size formed by the impression post when making the impression, care should be taken to place the impression post and analog in exactly the right position [Table/Fig-4] [22,23].

[Table/Fig-4]: Impression post and analog being put in place (indirect impression technique).

In cases where the mouth opening is limited, the implants are in a very backward position in the mouth, and the direct technique is difficult to manipulate because of the length of the impression posts, or in clinical situations such as patients with exaggerated gag reflexes, forcing the clinician to use the indirect technique [9,10]. The biggest advantage of the indirect technique is that, it is easier to apply in the clinic and there is no need for an individual tray. Since prefabricated tray is used, the thickness of the impression materials around the impression post is greater, thus providing more support and a more stable impression [2,9,24,25].

Digital impression: With the application of Computer-Aided Manufacturing/Computer-Aided Design (CAD/CAM) techniques in the field of prosthetics, the concept of intraoral digital impressions was introduced in the early 1980s. This technique attracted the attention of dentists and is used in many cases to construct prosthetic restorations [26].

CAD/CAM systems: There are two techniques of digital impression now-a-days available for dental professionals to use [27]. One type takes the images as digital photographs (Tero™, Lava™ COS and CEREC® Bluecam) that the software 'stitches' together, providing dental professionals with a series of images; the second type takes images as digital video (3shape TRIOS®, 3M True Definition™ Scanner, CEREC® Omnicam and E4D NEVO™ Scanner) [28].

CAD/CAM systems consist of three main parts:

- A data acquisition unit that collects data from the intraoral region and neighboring structures and then converts them into virtual impressions (an optical impression is created, either directly or indirectly).
- Software for designing virtual restorations fixed to virtual dimensions and setting all turning parameters.
- A computerised milling device fabricating the restoration with solid blocks of the selected restorative material [29].

Digital impression is made with scan bodies and recorded with surrounding tissues and a digital model is made with this information. With the aid of scan body implant position can be determined digitally [30,31]. In 2017 study, complete digital full-arch implant impressions mistreatment; True Definition scanner and Omnicam were considerably more correct (trueness) than the conventional impressions with the splinted open tray technique [32]. A systematic review published by Alikhasi M et al., draws attention to conflicted results as five articles included in the synthesis suggested the use of intraoral scanners whereas two in-vivo studies did not recommend the use of scanners [9]. In another systematic review published in 2020 by Papaspyridakos P et al., about digital and conventional impressions showed that 3D accuracy of these techniques differs from complete or partial edentulism and also information is mostly gained from in-vitro studies [33].

Impression Materials

Impression materials can be classified according to their composition, polymerisation reaction and properties, but the commonly used classification is based on the properties after polymerisation of the material [Table/Fig-5] [34].

Conventional	
Elastic	**Non elastic**
Alginate	Wax
Agar Agar	Compound
Polysulfide	Dental stone
Polyether	Metal oxide pastes (Zinc oxide eugenol)
Additional silicone (A-type silicone)	
Condensate silicone (C-type silicone)	
Vinylsiloxanether (VSE)	
Digital	
Direct intraoral	Indirect intraoral

[Table/Fig-5]: Classification of impression materials

It has been stated that a one stage impression technique is used in implant-mounted fixed prosthesis impressions, where generally putty and light body elastomeric impression materials are mixed and applied at the same time [35].

A number of ideal properties can be defined for impression materials. These are accuracy, elastic rebound, dimensional stability, flow, flexibility, workability, hydrophilicity, long shelf life, patient comfort and economy [8,33]. Impression materials vary considerably in properties, and these differences may provide a basis for the selection of particular materials in particular clinical situations. Some impression material properties, such as hardness and dimensional stability, can affect the accuracy of the implant impression. When direct (open tray) implant impression technique is applied, to ensure the positions of impression posts are similar in impression and patients mouth, a tight relationship must be obtained between impression material and impression post in order to have minimum positional distortion, and impression material should be rigid in such a way that it does not cause distortion that may occur in the impression when placement of combined implant analogues and impression posts [36,37].

Although no impression material provides perfect accuracy, four types of elastomeric impression materials are generally used for implant impressions: polysulfide, condensation silicone, additional silicone (polyvinyl siloxane) and polyether. In terms of dimensional stability, the greatest dimensional inconsistency was observed with condensation silicones, with volumetric inconsistency greater than 0.5% [38]. On the other hand, rigidity of polyether is useful for positioning impression posts accurately, also has high resistance to permanent deformation, and sufficient dimensional stability, making it an acceptable impression material for implant-supported prostheses [39]. Furthermore, polyvinyl siloxane impression materials showed a good result in terms of high dimensional stability, elastic recovery ability without permanent deformation, and precision impression of details [2].

Although none of the existing impression materials have 100% elastic recovery, and for all impression materials, the greater the equatorial line depth, the greater the deformation of the impression material. Polyvinyl siloxane impression materials are reported to have the best elastic recovery, with an elastic recovery of over 99% [2,10]. This feature together with excellent dimensional stability makes it the best choice for obtaining a second model [37,38]. Although different results were reported, in most studies, the least amount of dimensional mismatch appears to occur with silicones (0.06%) and polyethers (0.1%), therefore these two materials are the most preferred materials for the multiple implant impression procedure [35,39].

Polyvinyl siloxane: Addition type silicone, also known as polyvinyl siloxane (polysiloxane is the general chemical expression for silicone resins), was introduced as a dental impression material in the 1970's and is similar in structure to condensation silicone in many ways, except that it has better dimensional stability and greater wettability [40-42]. It was also reported that temperature affects the polymerisation time of this material [43]. One of the disadvantages of this material is that the polymerisation reaction is affected by latex particles in gloves used in clinics and it creates a problem when mixed by hand. Silicones are hydrophobic in nature, but surfactants are added to some formulations to provide hydrophilic nature, thus providing polyether like wettability. Although single-phase formulations are also available, additive type silicones are usually measured with a system with two different viscosities. In order to get rid of some by products (ethanol) in the additive type silicones produced previously, the pouring process should be delayed upto four hours. If this situation is not taken into account, a general porosity may occur on the plaster model surface due to the by products of the impression material. Newer products were developed that prevent the formation of gas at the polymer pattern plaster interface, allowing immediate pouring of the impression [37].

Polyether: Polyether impression material was developed in Germany in the 1960's and has a different polymerisation mechanism than other elastomers. The polymerisation process, in which volatile by products are not formed, provides better dimensional stability. Furthermore, it is accepted that polymerisation shrinkage is less than other impression materials that polymerise at room temperature [44]. Also, due to the high dimensional stability of the polyether, accurate models can be obtained even after 24 hours of casting the model plaster after the impression is taken. Another advantage of polyether is that it has a short curing time (approximately five minutes) in the mouth. Moreover, when the tear resistance of impression materials

was compared, it was stated that polyether showed the highest values and this might be more suitable for open tray technique [37]. For these reasons, the usage of polyether is also recommended. On the other hand, polyether has some disadvantages. The high hardness of the polymerised impression material is its biggest disadvantage, so it is very difficult to separate the model plaster from the impression surface without being damaged. In all elastomeric impression materials, shrinkage was observed over time due to loss of by products [37]. Polyether material may become distorted over time due to water absorption. For this reason, in order to obtain the most accurate impression model with polyether material, the material should be stored dry after impression making and if these conditions cannot be met, it should be poured within one hour at the latest after the impression process [36].

Comparison of impression materials (polyether and polyvinyl siloxane): In the literature, there are many studies investigating the effect of impression material type on the accuracy of multiple implant impressions. Holst S et al., investigated the effect of impression materials on the final accuracy of the models prepared with four experimental groups containing four implants, four different materials, medium body viscosity polyether and three different types of polyvinyl siloxane placed on a control model and reported that polyvinyl siloxane materials have similar precision to polyether materials, although polyether materials are considered the gold standard for impression material in multiple implant cases [45]. Aguilar ML et al., prepared a main model with five implants and tested the polyether and polyvinyl siloxane material on the control model in two different groups and reported that there was no significant difference when comparing the produced models of both groups [46]. In a study by Moreira AHJ et al., it was reported that regardless of the technique used, using polyether or polyvinyl siloxane as an impression material could yield more accurate results than other elastomeric impression materials [47]. In addition to all these, when the tear resistance of impression materials is compared, it was reported that polyether shows the highest tear resistance values, therefore it is more suitable for direct non splint technique [40].

Vinyl Siloxanether (Vinyl Polyether Siloxane): A new impression material combining the properties of polyether and polyvinyl siloxane, vinyl siloxanee or vinyl polyether siloxane was introduced to the market in 2009 (Identium, Kettenbach Co, Eschenburg, Germany) [48]. This material was reported to combine the ease of removal of PVS from the mouth with the hydrophilicity of polyether [48], making it a promising material for conditions where moisture control is difficult, such as bleeding, deep gingival sulcus [45,46].

Implant Angles and Number of Implants

When the effect of implant angles on the accuracy of impression of implants was investigated, it was reported that the presence of an angled implant may cause more distortion in implant size [25,49,50]. Choi JH et al., reported using a two implant model, the accuracy of implant-level impressions for internal connection implant restorations was similar for the direct non splinted and splinted techniques in settings with divergence upto 8° [51]. Conrad HJ et al., studied 5°, 10° or 15° angulated implants; and reported that the average angle errors for the closed and open tray impression techniques did not differ significantly. There was no consistently noticeable pattern of average angle errors in terms of implant angulation and implant number. Similar range of distortion was noticed for various combinations of impression technique, implant angulation, and implant number [41]. Wee AG investigated the accuracy of impression techniques in a clinical study, where open and close tray technique was applied to the same 11 implant sites and verification framework was prepared to compare the fit resulting from both techniques with microcomputed tomography scanning and two blind examiners used to assess the framework fit. He reported that no difference was found between close and open impression techniques' accuracy related to implants with less than 10° angulation [36]. However, Assuncao WG et al., compared accuracy of impression technique and material related to four different angulations 90, 80, 75, 65 degrees, metal matrix with four implants was prepared as control model and different techniques and material was used, as a result they concluded that the less angulated the implant was the more accurate was the impression provided, the greatest dispersion occurred in implants at 65° [52]. In a previous study, it was reported that implants positioned at an angle greater than 20° would cause more distortion in the impression material [53]. On the other hand, some researchers stated that there was no significant difference between the effect of angled and perpendicular implants on impression accuracy [21].

In a study, a six implant model with different angles of 0°, 15°, 30° and 12 experimental plaster models with each technique were prepared. As a result of this study, it was reported that there was no difference in accuracy between various angled implants in both groups [21]. In cases where the implants are parallel to each other or the number of implants is less than four, the applicability of both direct and indirect impression methods; and in the presence of many implants, the usage of direct impression technique and splinting of impression posts are recommended. It was observed that the direct technique and splinting process give better results in cases where the angle difference between the implants is evident. However, indirect technique can also be applied in cases where the number of implants is less than four and the angulation between the implants is less than 15°.

Implant Placement and Implant Depth from Tissue Surface

When the implant placement depths were examined, it was seen that the implants may need to be positioned more subgingivally due to reasons such as differences in aesthetics and bone anatomy, and as a result, the impression post may need to be positioned more subgingivally. In this case, the surface of the impression piece remaining on the gingiva is reduced and has less contact surface with the impression material [8]. Martínez-Rus F et al., worked with six tapered Screw-Vent implants were placed in a reference model with different angles (0, 15, and 30 degrees) and subgingival positions (0, 1, and 3 mm) and reported that impression procedure affected the accuracy of definitive casts. The metal-splinted direct technique produced the most accurate casts, followed by acrylic resin-splinted direct, indirect, and unsplinted direct techniques [8]. Lee H et al., used five parallel implants and two types of impression materials (polyether and polyvinyl siloxane) to evaluate the effect of subgingival depth of implant position on the accuracy of multiple implant impressions. One implant was placed 4 mm below the surface of the model and another 2 mm below. As a result of this study, the researchers reported that the implant depth had no effect on the dimensional accuracy of the vertical or horizontal combined putty and light body polyvinyl siloxane impressions, and the impressions taken with the medium body polyether were significantly less accurate in deeper implants[2]. Too few studies were available to draw any conclusions.

DISCUSSION

The accuracy of the model is very important for the compatibility of fixed and removable prosthesis on implants. Due to this situation, more attention should be paid to factors such as impression material, impression technique, tray type and splinting or no splinting [8]. It is possible to make accurate stock tray impressions, although the accuracy is not as consistent compared with custom trays. Provided an accurate impression material and desirable impression protocol are used, a rigid stock tray can be a legitimate opportunity to custom trays for implant fixture-level impressions [54].

With the availability of various techniques and developments, the clinician must select the material and technique best suited to the

particular situation. Intraoral digital impression technique assists the CAD/CAM process. As a relatively new technique, virtual models produced with intraoral digital impressions demonstrated accuracy close to conventional impression accuracy [32].

It has been stated that the technique that gives the most reliable results among the implant impression techniques and provides superiority in accuracy is the direct technique with splinting (open tray technique) [21]. On the other hand, a study over digital full-arch implant impressions mistreatment True Definition scanner and Omnicam delivered more accurate impresssions than the conventional impressions with the splinted open tray technique [32]. Also, the digital acquisition of implant position allows to eliminate several clinical and laboratory phases [55,56], which might introduce distortions [2,51,52]. This is significant, because the ability to simplify the prosthodontic workflow, by removing one or more steps, leads to error reduction, with an enhancement of final accuracy as a consequence [57].

The usage of polyether and polyvinylsiloxane impression material is advantageous in implant restorations due to its dimensional stability, non deformation and rigidity. The number of studies supporting the superiority of these two materials over each other is limited [2,39].

CONCLUSION(S)

The direct impression technique with splinting and digital impression techniques produce more accurate results than indirect impression techniques. If clinician is using traditional techniques, the usage of polyvinyl siloxane or polyether material will cause minimal impression deformations and errors. According to previous studies, custom tray seems more advantageous than stock tray. Further, in-vivo studies are required to confirm digital impression accuracy in a clinical setting.

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