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Major clinical findings on the types of impressions used in implant-supported prostheses: a systematic review

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Abstract

Introduction: The key to obtaining perfect prostheses depends on the passive fit between its connector and the implant itself. The compromised fit between the contact surfaces of implant-supported prostheses creates uncontrolled stresses in the components and peri-implant tissues, evoking biological and mechanical complications. **Objective:** It was to review the scientific literature on the types of impression used in implant prostheses. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from July to August 2024 in the Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 111 articles were found, and 44 articles were evaluated in full, and 23 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 06 studies with a high risk of bias and 31 studies that did not meet GRADE. Minimizing contraction appears to be the most important factor in ensuring an accurate impression for this technique. Digital printing has achieved high patient acceptance, reduces possible impression and master mold errors, reduces time in the chair, provides a three-dimensional image of the preparation, and ease of communication between the clinician and the laboratory. However, there is a dearth of scientific data regarding implant fingerprints and their accuracy. Research on implant fingerprinting has been limited to a few *in vitro* studies and case reports.

Keywords: Implant-supported prostheses. Prostheses. Dental implants.

Introduction

The key to obtaining perfect prostheses depends on the passive fit between its connector and the implant itself. The compromised fit between the contact surfaces of implant-supported prostheses creates uncontrolled stresses in the components and peri-implant tissues, evoking biological and mechanical complications [1-3]. Screw loosening and fracture, implant fracture and occlusal inaccuracy have been reported as mechanical complications resulting from prosthesis misfit. Biologically, the marginal discrepancy of the misfit can cause unfavorable reactions in the soft and/or hard tissues, due to increased plaque accumulation [2]. Although achieving an absolute passive fit is virtually impossible, minimizing misfit to avoid potential complications is a generally accepted goal in implantsupported prosthetic procedures [4].

The technique selected for taking the impression, which simulates the exact position of the implant on the working model, is a crucial step and must be as accurate as possible. An ideal impression records the precise three-dimensional spatial position of the implant, analog, or abutment concerning other structures in the oral cavity [5-7].

The accuracy of the fabrication of the plaster mold for the implant transfer positioning of a prosthesis is influenced by the technique and type of impression material, parallelism or not of the implants, depth of implant position, dimensional stability of the plaster, and repositioning of the transfers in the correct position [8].

The angulation of the implants can increase the likelihood of the impression material dislodging and the consequent distortion of the final plaster. Each procedure step can be influenced by human error or error in the impression material [9,10]. A variety of impression materials have been suggested, and some parameters must be met, such as ease of handling, low toxicity, biological compatibility, resistance to rupture, hydrophilicity, accuracy, elastic recovery, and dimensional stability [5,11]. Hydrocolloids and elastomers are mentioned with four basic types of polysulfides, polyether, condensation silicones, and polyvinylsiloxane, also known as addition silicones [12]. Polyether has been recommended for implant impressions due to its dimensional stability, rigidity, resistance to rupture, and hydrophilicity.

Another frequently used material is polyvinylsiloxane, which presents many desirable properties of polyether concerning the quality of implant impressions, at a lower cost [12]. Since the property of the impression material to avoid distortion of the position between the implant analogs caused by the accidental displacement of the impression copings is a key factor, polyvinylsiloxane and polyether have been suggested as the materials of choice [5].

As for impression techniques, several have been suggested, such as open-tray and closed-tray, and different impression transfers and materials have been investigated for their accuracy [13], and are classified as direct or indirect techniques. Direct (drag) techniques, with or without splinting, are also described as open-tray impression techniques because they have an open window for unscrewing the guide pins of the impression copings [14]; the entire assembly is removed at the same time and the copings are repositioned by fixing this same screw [15]. Indirect techniques are also known as closed-tray techniques. They consist of copings on the implants while the tray is removed from the mouth. The transfer is removed from the implant, fixed to the analog outside the mouth, and repositioned in the impression. The closed tray technique is performed when indications such as limited space between the arches, nausea, or difficulty accessing a posterior implant are present [13]. Transfers are devices that adapt to the implant platform or prosthetic abutment and transfer, through a molding technique, the position and shape of these elements to the plaster model; round ones are used in closed trays, and square ones in open trays [16].

Another recommendation to increase the accuracy of the impression in cases involving multiple implants is to splint the transfers together or in the custom tray before making the impression. The open tray technique is used when the transfers are joined by splinting [4]. Although different materials have been tested for this procedure, such as composite resin, impression plaster, and stainless steel pins, acrylic resin, alone or in combination with dental floss, is the most commonly used material to prevent individual movements of the transfers during the impression procedure [4,17]. Conventional techniques can incorporate many human errors such as tray design, component fixation, impression, and material flow at various levels if not followed meticulously, in addition, dimensional changes in impression materials, laboratory pouring techniques, and plaster expansion are the main technical errors encountered in these techniques [18], as well as patient discomfort due to additional components, necessary tolerance to mouth opening and taste and odor of silicone materials remain a disadvantage [19], the advent of computer-aided design and computer-aided manufacturing (CAD/CAM) technology has improved the fabrication procedures of structures and increased the accuracy of fit of implant-supported prostheses [20]. The creation of a virtual impression can be performed intraorally or by scanning conventional impressions with a scanner. Benchtop scanners have become more frequently used because they combine the advantages of a CAD/CAM prosthesis with the reduction of laboratory costs [15].

Since passive adjustment depends on the accuracy of the impression technique and the resulting master model produced, and because the implant/abutment connection is directly related to the long-term success of the implant-supported prosthesis [3], an accurate impression is extremely important to produce a reliable mold [2].

Given this, the present study aimed to review the literature on the types of impressions used in implant-supported prostheses.

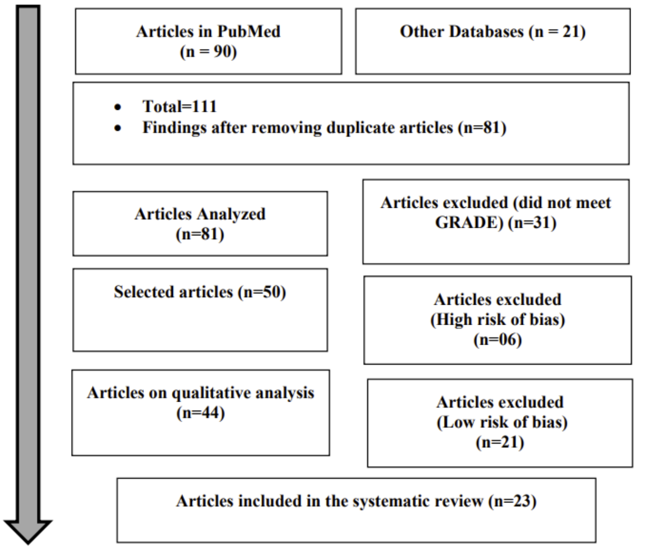
Methods

Research Methods and Results

The systematic review rules of the PRISMA Platform were followed. The search was conducted from August to September 2024 in the Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. A total of 111 articles were found. Initially, duplicate articles were excluded. After this process, the abstracts were evaluated and a new exclusion was performed, removing the articles that did not include the topic of this article, resulting in 81 articles. A total of 44 articles were evaluated in full and 23 were included and developed in the present systematic review study (Figure 1). Considering the

Cochrane tool for risk of bias, the overall assessment resulted in 06 studies with high risk of bias and 31 studies that did not meet GRADE.

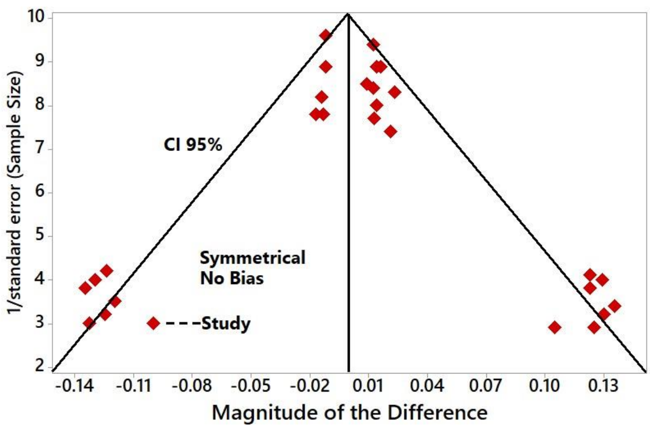
Figure 1. Flowchart showing the article selection process.



Source: Own Authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using Cohen's Test (d). The sample size was determined indirectly by the inverse of the standard error (1/Standard Error). This graph showed symmetrical behavior, not suggesting a significant risk of bias, both among studies with small sample sizes (lower precision) that are shown at the base of the graph and in studies with large sample sizes that are shown in the upper region.

Figure 2. The symmetrical funnel plot does not suggest a risk of bias among the studies with small sample sizes that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (NTotal=23 studies evaluated in full in the systematic review).



Source: Own Authorship.

Major Findings

According to Flügge et al. (2018) [18], the accurate transfer of the implant position in relation to the implants or neighboring teeth is vital for the selection of the appropriate prosthesis design and to ensure a good passive fit, to achieve long-term implant success, without mechanical and biological complications [2,6]. Corroborating these authors, Gayathridevi et al. (2016) [5] postulated that the implant impression is one of the most important steps to obtain a passive fit, accurately relating an implant analog or implant abutment to other structures in the dental arch. In addition, the accuracy of the impression is affected by the selection of the impression tray, the technique and type of impression material, and the number and angulation of the implants. Conventional impressions can be performed using closed-tray (indirect/transfer) or open-tray (direct/drag) impression techniques. A systematic review by Lee et al. (2008) [4] compared the accuracy of open-tray and closed-tray impression techniques and found no significant difference in both when taking impressions for three or fewer implants. The open-tray technique was recommended for situations involving four or more implants. Similarly, in the experimental analysis performed by Osman et al. (2019) [27] no statistically significant difference was found between the open-tray and closed-tray impression techniques.

On the other hand, Martínez-Rus et al. (2013) [16] reported that the open-tray technique was more accurate than the closed-tray technique for edentulous patients. Similarly, in another systematic review, Papaspyridakos et al. (2014) [20] found that opentray impressions were more accurate for completely edentulous arches. No significant difference between the two techniques was found for partially edentulous patients. Kalpana et al. (2019) [21] also stated that the open tray technique was better than the closed tray technique, especially in cases with a greater number of implants and in edentulous patients. The open tray technique was superior and more accurate in the study by Elshenawy et al. (2018) [22]. Moretti et al. (2018) [13] reported that the open tray technique is especially indicated for impressions of more than three implants to reduce the effects caused by angulation, decrease deformation of the impression material, and eliminate the care of repositioning the transfer coping in the respective impression space. They mentioned that its disadvantages are the difficulty and the need for experience to remove the entire impression coping + transfer set from the mouth.

The authors also evaluated the need for splinting of the impression copings [4,5,16,20,21]. According to Lee et al. (2008) [4], the splinting technique for an implant impression was introduced together with the development of a fixed complete implant prosthesis of methacrylic resin for an edentulous mandible. The underlying principle was to connect all impression copings with a rigid material to prevent their movement during the impression procedure. These same authors stated that impressions are more accurate with the splinting technique. Martínez-Rus et al. (2013) [16] reported that the technique with splinting was more accurate than that without. Also, Papaspyridakos et al. (2014) [20] supported the splinting technique of impression coping for completely edentulous patients. In their systematic review, they found that some authors sectioned the splinting material connection, leaving a thin space between them and then rejoining with a minimum amount of the same material to minimize shrinkage, or connected all the impression transfers with splinting material, then waited for the material to complete polymerization.

According to the authors Gayathridevi et al. (2016) [5] and Vinodh et al. 2023 [2], the accuracy of a splinting impression technique depends on its resistance to deformation under the forces of the impression material; therefore, the use of rigid material is essential for an accurate master model. Kalpana et al. (2019) [21] corroborated these authors, recommending the splinting procedure in the case of multiple implants to decrease the amount of distortion and improve impression accuracy and implant stability. Splinting the transfer copings prevents rotational movement of the impression copings in the impression material during analog attachment, which provides better results than not splinting.

Regarding the splinting material, Dashaputra et al. (2021) [7] described that self-curing acrylic resin is the most commonly used because of its desirable properties of low shrinkage and fast setting time. The timeline for splinting with this resin ranges anywhere from immediately before to 24 hours before the impression, according to Lee et al. (2008) [4]. Thus, Dashaputra et al. (2021) [7] recommended sectioning the resin and re-splicing the segments before the impression to compensate for the polymerization shrinkage of the resin, which affects the accuracy of the impression. Splinting can be performed intraorally on a model made from a previous unmodeled impression.

Self-curing acrylic resin was chosen as the splinting material in the study conducted by Elshenawy et al. (2018) [22] because it is easy to apply and does not require a dry environment. The acrylic resin splinting was sectioned and resplined after 17 min to minimize any discrepancies due to polymerization shrinkage. Gayathridevi et al. (2016) [5] added that the splinting of impression copings includes light-cured composite resin, impression plaster, thermoformed material, and acrylic resin. For Kalpana et al. (2019) [21], several splinting methods can be used, each with advantages and disadvantages. The technique that uses dental floss as a scaffold for chemically activated acrylic resin is widely used and requires more clinical time for application. Other forms of splinting are prefabricated bars and metal rods, which use a smaller amount of acrylic resin.

Regarding implant angulation, in the systematic review conducted by Lee et al. (2008) [4], four studies examined the effect of implant angulation on impression accuracy. Two reported less accurate impressions with angled implants than with straight implants, and the other two reported no angulation effect. According to these authors, when multiple implants are inserted at different angles, the distortion of the impression material upon removal may increase. Furthermore, this effect may be potentiated by an increasing number of implants.

To determine the relationship between the angulation effect and implant numbers, further studies are needed. Papaspyridakos et al. (2014) [20] found the majority of in vitro studies that reported accurate results with angled implants. Also, clinical studies that, although not focusing on the details of implant angulation, reported that the splinting technique was clinically better than the non-splinting technique or closed tray with angled implants. Of the six in vitro studies, three reported that the splinting technique was more accurate when taking an impression of angled implants. Hazboun et al (2015) [23] conducted a study to evaluate the distances between angled and straight implants in impressions made with open and closed trays and found no statistically significant differences between the groups or the angles.

Similar to these authors, Moura et al. (2019) [15] found no difference in the measurements of the distances between angled and straight implants for the conventional techniques. The rationale for posterior tilting of a distal implant in the study conducted by Osman et al. (2019) [24] was that anatomical and esthetic considerations do not always allow parallel positioning of the implants. Such placement would be a valid compromise for bone grafting, sinus elevation, or mandibular nerve displacement, with the added benefit of shorter treatment times, lower potential morbidity, and reduced cost. This finding was similar to the study conducted by Hazboun et al. (2015) [23], reporting that impression techniques (open vs. closed tray) and implant angulation (0º, 15º, and 30º) had no significant effect on in vitro impression accuracy. In the study by Elshenawy et al. (2018) [22], increasing the angulation between implants to 30º affected the accuracy of the direct technique without splinting, while it did not significantly affect the accuracy of the direct technique with splinting. This is in agreement with Martínez-Rus et al. (2013) [16]. According to Lee et al. (2008) [4], this may occur because splinting of the impression copings with a rigid material prevented their individual movement during the impression making procedure.

Regarding impression materials, Lee et al. (2008) [4], Gökçen-Rohlig et al. (2014) [25], Papaspyridakos et al. (2014) [20], and Osman et al. (2019) [24] agreed that polyvinylsiloxane and polyether appear to be the materials of choice for making an accurate impression. According to Gökçen-Rohlig et al. (2014) [25], the main purpose of implant impression is to transfer the implant/abutment position from the oral cavity to the master model, and the impression material should be rigid enough to hold the copings and minimize positional distortion during replica positioning. In the study by Osman et al. (2019) [24], polyvinylsiloxane was used as it was reported to have superior strain recovery, higher physical and mechanical properties, lower potential for dimensional changes, accurate reproduction of details, and desirable modulus of elasticity. It is also easier to remove from undercuts, with less deformation, which makes it a popular choice in implant dentistry. To overcome the disadvantages and limitations of conventional impression techniques, digital impression techniques were developed. Intraoral scanners have revolutionized the field of prosthetic and implant dentistry, outlining the possibilities of error at various stages involved in prosthesis fabrication, from impression-taking to cementation [9,19,21,26-29].

According to Dashaputra et al. (2021) [7], digital impression, when taken with the appropriate scanning technique, provides good clinical results. Papaspyridakos et al. (2020) [20] stated that digital impressions are as accurate as conventional ones. Yuzbasioglu et al. (2014) [9], in a clinical trial with 24 individuals who had not experienced conventional and digital impression procedures, after answering a standardized questionnaire to record the attitude, preference, and perception towards digital and conventional impression procedures, reported that the subjects preferred digital impression over conventional impression mainly because of comfort.

Similarly, Joda et al. (2017) [19] demonstrated in their study that digital impressions are time-efficient, as they allow for the reduction of working times and, therefore, costs when compared to conventional impressions. They advocated that with these impressions there is no need to pour stone molds and obtain physical plaster models; it is possible to send by email the virtual 3D models (proprietary files or STL) of the patient directly to the dental laboratory. This allows for the saving of a considerable amount of time and money during the working year. However, Flügge et al. (2018) [18], in a systematic review and meta-analysis to evaluate and compare the accuracy of conventional and digital implant impressions, concluded that most studies were conducted in vitro and, therefore, compromised in their informative value for the clinician. They considered that the main obstacle to conducting in vivo studies could be the lack of an adequate protocol to evaluate the accuracy of intraoral impressions.

Finally, a clinical study carried out by the authors Vinodh et al. (2023) [2] evaluated and compared the development and distribution of deformations of maxillary implant-supported complete fixed dental prostheses (ISCFDP) with computer-aided design and computer-aided manufacturing milled PEEK BIO-HPP superstructure when placed using Allon-4 and All-on-6 situation using an extensometer and finite element analysis (FEA). The stress and strain minimization developed in the implant were compared in premolars and two clinically simulated situations of All-on-4 and All-on-6 ISCFDP. The study involved converting a human skull into .stl format to create 3D-printed stereolithography models with an elastic modulus closer to the bone. Implants were placed in two models (M1 and M2) in the incisor, premolar and pterygoid regions. A fixed dental prosthesis framework was fabricated in both models and strain gauge sensors were attached. The results obtained were tabulated and showed strain around the neck of ISCFDP at 100N setting in strain gauge analysis. Stress was found more in the molar region when compared to the premolar region. This design showed that the highest stress around the neck of ISFDP under 100N load was found more in the premolar region when compared to the molar region due to reduced stresses in the pterygoid region in FEA. Therefore, strain gauge analysis at 100 N for loading in the premolar and molar region shows the reduction in stress in the tilted implants in the All-on-6 situation due to stress dissipation to the terminal pterygoid implant using the strain gauge.

Conclusion

It was concluded that the choice of closed-tray or open-tray impression techniques depends on the number, depth, angulation, and relative parallelism of the implants. The materials of choice for making impressions following the closed-tray and open-tray impression techniques were polyether and polyvinylsiloxane. Most studies reported more accurate impressions with the splinting technique than with the technique without. Acrylic resin was the most frequently used material. Thus, minimizing its shrinkage appears to be the most important factor in ensuring an accurate impression for this technique. Digital impressions have achieved high patient acceptance, reduced potential impression and master impression errors, reduced chair time, provided a three-dimensional image of the preparation, and facilitated communication between the clinician and the laboratory. However, there is a paucity of scientific data on digital implant impressions and their accuracy. Research on digital implant impressions has been limited to a few *in vitro* studies and case reports.

CRediT

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Informed Consent

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No additional data are available.

Conflict of Interest

The authors declare no conflict of interest.

Similarity Check

It was applied by Ithenticate@.

Peer Review Process

It was performed.

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