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Digital evaluation of the accuracy of impression techniques and materials in angulated implants

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ABSTRACT

Objectives: The aim of this study was to investigate the accuracy of 2 different impression techniques and 3 different impression materials in models simulating parallel and angulated implants.

Methods: Three master models simulating partial edentulous mandible with 2 implants at the sites of second premolars (parallel) and second molars with different angulations (parallel, 10° or 20° angulated) were fabricated. Two different impression techniques [splinted direct (D), indirect (I)] and 3 different monophase impression materials [polyether (PE), vinyl polysiloxane (VPS), vinyl polyether silicone (VPES)] were used for each master model and a total of 180 impressions were made ($n = 10$). Master model and casts were scanned by a modified laser scanner and data were transferred to VRMesh software. Master model and duplicate cast scans were digitally aligned observing the superposition of anatomic markers. Angular and coronal deviations between master and duplicated copings were calculated and data were statistically analyzed.

Results: Mean angular and coronal deviations were in a range of 0.205–0.359° and 22.56-33.33 μm, respectively. Statistical analysis revealed that the angulation of implant affected both coronal and angular deviations of the impression copings ($P < 0.05$). According to statistical analyses, for parallel implants, the accuracy of impression materials and techniques were ranging as VPS-D = PE-D > VPS-I = PE-I > VPES-D > VPES-I from most accurate to the least. For 10° and 20° angulated implants the most accurate material and technique was VPS-D whereas the least accurate combination was VPES-I ($P < 0.05$).

Conclusion: Angulation, impression technique and material were found to be effective on the accuracy of implant impressions.

Clinical significance: Clinicians may prefer VPS impression material and splinted direct technique for impressions of both parallel and up to 20° angulated implants.

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1. Introduction

The passive fit of implant-supported prosthesis is critical for long term clinical success.[1] Any misfit between the prosthesis and implant may lead to complications, such as screw loosening, screw fracture, occlusal discrepancies, increased plaque accumulation caused by misfit components and even loss of osseointegration and implant fracture.[1–4] Impression is one of the most important steps for a passive fit and transfer of the precise position of implant to definitive cast with an accurate impression is essential.[5] Impression technique, type of impression material,[6] splinting or non-splinting impression copings, type of splinting material, number and angulation of implants[7] are the factors that affect the accuracy of impression.

To date, several implant impression techniques have been introduced and evaluated for accuracy. Two basic impression techniques are commonly used in implant dentistry: the indirect (transfer, closed tray) and the direct (pick-up, open tray) technique. In indirect technique, the copings are connected to the implant and after the removal of the impression they are retained on the implants. The copings are then removed from implant, attached to the implant analogues and reinserted in the impression. In direct technique, an open tray that exposes coronal ends of the impression coping screws is used. Screws of the copings are loosened when the impression material is set and impression is removed from the mouth with impression copings retained in the impression. The implant analogues are connected to the copings using the same screw.[5,8]

The accuracy of direct and indirect techniques were compared in many studies.[9–24] However the results are still contradictory. In a systematic review, Lee et al.[5] investigated the published researches regarding the accuracy of implant impressions and concluded that there was no difference between direct and indirect techniques if there were 3 or fewer implants.

Accuracy of various implant impression materials were investigated in numerous studies and more accurate impressions were obtained with polyether (PE) and vinyl polysiloxane (VPS) in comparison to condensation silicone, polysulfide, reversible hydrocolloid, irreversible hydrocolloid and plaster.[6,13,25–27] Wetting behaviour is an important physiochemical property of elastomeric impression materials that affects the accuracy of the material. Hydrophilicity provides detailed reproduction of wet oral surfaces and increased wettability with gypsum slurry.[28] Hydrophobic or hydrophilic character of materials can be attributed to their chemical structure. VPS has hydrophobic aliphatic hydrocarbon groups which surround the siloxane bond. However, PE contains functional groups that attract and interact with water molecules, making this material hydrophilic.[29] To improve the wettability of VPS, manufacturers added extrinsic surfactants and labelled these as hydrophilic VPS materials. Recent studies reported that hydrophilized VPS has similar hydrophilicity to PE.[28,30] Many studies showed that there was no difference in the accuracy of PE and VPS[6,13,25,26,31–36] and both of the materials are recommended for implant impressions. Vinyl polyether silicone (VPES) (EXA'lence, GC America Inc., Alsip, IL, USA), a combination of VPS and PE was introduced a few years ago. According to the manufacturer, VPES has intrinsic hydrophilicity and high dimensional stability. However, the data regarding the accuracy of VPES is very limited.[37–39] In a recent study, Schaefer et al.[39] evaluated the accuracy and reproducibility of VPES, VPS and PE impression materials by a 3-D analysis. They reported that there was no significant difference among the materials in terms of spatial deviation and all of the materials demonstrated high accuracy and reproducibility.[39]

Parallel placement of implants is not always possible due to the anatomical limitations and angulations may occur in implant positions. The effect of angulation of implants on the accuracy of impression has been evaluated in previous studies and researches reported that angulated implants caused less accurate impressions in comparison to parallel implants when there were 4–6 implants.[8,25,40,41] However, the studies that used 2 or 3 implants did not report any difference between angulated and parallel implants in terms of impression accuracy.[42–44] There is limited data regarding the accuracy of impression materials in case of implant angulation. The results of previous studies[40,41,45] investigating the accuracy of impression materials for angulated implants showed inconsistency. Sorrentino et al.[41] found VPS more accurate than PE whereas Akalın et al.[40] obtained more accurate impressions with PE. On the other hand, Reddy et al.[45] reported that there was no significant difference in accuracy of VPS and PE for angulated implants. To the best of authors' knowledge, the accuracy of VPES impression material with angulated implants has not been investigated.

The aim of the present study was to investigate the accuracy of 2 different impression techniques (splinted direct and indirect) and 3 different impression materials (PE, VPS, VPES) in models simulating parallel and angulated (10°, 20°) implants.

2. Materials and methods

2.1. *Fabrication of master models*

Three autopolymerizing transparent acrylic resin (Pegasus Plus Repair Acrylic, Davis Schottlander & Davis Ltd., Hertfordshire, England) master models simulating partial edentulous mandible were fabricated. Two implants (T4 3810, NucleOSS, Sanlilar Tibbi Cihazlar Medikal Kimya San Tic Ltd. Sti, İzmir, Turkey) were placed at the sites of the right second premolar (implant 1) and right second molar (implant 2) of each model with different angulations (parallel, 10° or 20° angulated) (Fig. 1).

Model 1: Implant 1 and implant 2 were positioned parallel to each other and long axes of neighbouring teeth; perpendicular to the horizontal plane.

Model 2: Implant 1 was positioned parallel to the long axis of neighbouring tooth and perpendicular to the horizontal plane; implant 2 was placed with 10° mesial angulation with respect to the long axis of implant 1.

Model 3: Implant 1 was positioned parallel to the long axis of neighbouring tooth and perpendicular to the horizontal plane;