Original Article

Effect of technique and impression material on the vertical misfit of a screw-retained, three-unit implant bridge: An *in vitro* study

Hamidreza Rajati Haghi, Masoud Shiehzadeh, Mohammadreza Nakhaei, Fatemeh Ahrary, Saeid Sabzevari[1]

Department of Prosthetic, Faculty of Dentistry, Dental Research Center, Mashhad University of Medical Sciences, [1]Department of Prosthetic, Faculty of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran

Abstract

Introduction: A dental impression is a negative imprint of an oral structure that can be used to produce a positive cast of a patient's teeth as a permanent record. The accuracy of the impression affects the accuracy of the cast, and a precise impression is needed in order to create prosthesis with optimal fitting. Minimization of misfit is an important aim in prosthesis science and dental implants. The aim of this study was to evaluate the effects of the materials and techniques used to take an impression on the vertical misfit of implant-supported, screw-retained, three-unit bridges.

Materials and Methods: The principal model used was an acrylic block with two ITI implants. A 1.5-mm abutment was attached to fixtures with torque of 25 N.cm. A base-metal framework was built on the abutment in the acrylic block. The abutments of the acrylic model were unscrewed and fixture-level impressions were made. The impression techniques included open/closed-tray techniques and the impression materials were polyether and polyvinyl siloxane. Forty acrylic custom trays were built for each impression. The marginal gap in the framework at three points (buccal, lingual, and distal) was measured using an optical microscope with ×250.

Results: It is demonstrated that in all 360 evaluated samples, the mean vertical misfit in polyether samples of molar and premolar teeth was significantly lower than in polyvinyl siloxane ($P < 0.001$ and $P = 0.017$, respectively) in all three locations of the molar and lingual premolar examined (buccal, lingual, and distal), the mean vertical misfit of the polyether samples was significantly lower than those of polyvinyl siloxane ($P < 0.01$). On the other hand, although the mean vertical misfit using the open-tray technique in the molar teeth was significantly lower than with the closed-tray method ($P = 0.002$), no statistical difference was seen between the open-tray and closed-tray technique in general ($P = 0.87$).

Conclusion: Within the limitations of this study, the following conclusions can be drawn: The impression method had no effect on marginal discrepancy of 3-unit screw retained fixed partial dentures. A higher marginal accuracy was obtained using polyether impression material compared to polyvinyl siloxane.

Key Words: Dental implant, impression, open/closed-tray technique, vertical misfit

Address for correspondence:
Dr. Saeid Sabzevari, Department of Prosthodontics, School of Dentistry, Vakilabad Blvd, P. O. Box 91735-984, Mashhad, Iran.
E-mail: sabzevaris921@mums.ac.ir

Received: 16th April, 2016, **Accepted:** 16th August, 2016

Access this article online	
Quick Response Code:	Website: www.j-ips.org
	DOI: 10.4103/0972-4052.197937

How to cite this article: Haghi HR, Shiehzadeh M, Nakhaei M, Ahrary F, Sabzevari S. Effect of technique and impression material on the vertical misfit of a screw-retained, three-unit implant bridge: An *in vitro* study. J Indian Prosthodont Soc 2017;17:41-7.

INTRODUCTION

A dental impression is a negative imprint of an oral structure utilized to produce a positive replica of the structure that can be used as a permanent record or in the production process of a dental restoration.[1]

As the accuracy of an impression affects the accuracy of the cast, a precise impression is needed in order to create prosthesis with optimal fitting. A misfit in the prosthesis influences the pattern and magnitude of stress distribution in the prosthesis itself as well as the components of the implant and surrounding bone that may lead to unfavorable complications. Manifestations of these complications may range from fracture of the various components in the implant system, framework fracture, or porcelain fracture, through loosening of the abutment and retaining screws, to pain, marginal bone loss, and even loss of osseointegration. Thus, minimizing the misfit and optimizing the passive fit through variation in impression techniques and impression materials is an important aim in prosthesis science and dental implants.[2-4]

In addition to dimensional stability, the implant impression materials must exhibit appropriate resilience. They must also be sufficiently rigid to prevent the implant components from movement during the impression-making procedure. Polyvinyl siloxane and polyether are the most common implant impression materials and many researchers have found no statistically significant difference in terms of implant impression between the two materials.[5-8]

There are several methods for obtaining impressions from dental implants, of which two of the most common techniques are closed tray and open tray. The open-tray technique (also called pick-up/direct technique) uses a tray with an opening and square impression coping in which the screws are exposed outside the tray. After setting of the impression materials, first, the copings are unscrewed and then the impression is removed. The implant analogs are connected to the copings, which are still in place in the impression. By contrast, the closed-tray technique (also called transfer/indirect technique) uses tapered impression copings with retaining screws that match the height of the copings. Using a closed-tray technique, an impression is made and separated from the mouth while the copings are still connected to the implants. Then, the copings are removed and connected to the implant analogs and reinserted in the impression.

Some implant manufacturers have introduced a modified closed-tray technique, called the snap-on impression technique. This technique uses a closed tray, but does not involve a transfer impression because the plastic impression copings are picked up in the impression. There are few research comparing the snap-on impression coping closed-tray and open-tray impression techniques;[9,10] the present study was designed to compare the accuracy of these two commonly adopted methods using two different impression materials (polyvinyl siloxane and polyether).

MATERIALS AND METHODS

The main model was fabricated by inserting two implants in an acrylic block (ITI regular neck (033.030s), wide neck (033.630s); Straumann). The acrylic block was duplicated from a posterior alveolar ridge and was poured with heat cure acrylic resin (Vertex™ Rapid Simplified, Vertex Dental Inc.). Simulating the distance between the first premolar and first molar, the two implants channels were placed a distance of 17 mm from each other. The two channels were made using a dental survivor in an 8-degree-convergent position, simulating condition that is more clinical. The two implants were fixed into the channels using auto-polymerizing methylmethacrylate and left 24 h, so polymerization could complete. 1.5-mm abutments (AG 048.601, 048.603, synOcta ITI Dental Implant System; Strauman) were attached to fixtures with torque of 25 N cm. The base-metal framework (Duceram, Degussa, Frankfurt, Germany) was built on the abutments in the acrylic block. Minimizing the marginal gap to <10 μm, the framework was inspected using the light microscope. An accurate framework was obtained by cutting through the pontic and soldering the framework. This framework was utilized for assessing the accuracy of the impressions [Figure 1].

The study was conducted comparing the accuracy of 40 casts in four groups; i.e. 20 casts made using the closed-tray impression technique (with snap-on copings) and 20 casts made using the open-tray impression technique. Ten casts in each group were made from polyether and 10 were made from polyvinyl

Figure 1: Framework

siloxane (10 cast closed-tray/polyvinyl siloxane, 10 cast closed-tray/polyether, 10 cast open-tray/polyvinyl siloxane, and 10 cast open-tray/polyether).

The impression trays were made using an acrylic custom tray (Megatray; Megadenta, Radberg, Germany). To homogenize the acrylic custom tray, one-layer base-plate wax (modelling wax; Dentsply, Weybridge, UK) was used over the copings and the acrylic model. All 40 trays were 3 mm in thickness [Figures 2 and 3]. The trays were seated on the stops over the model using finger pressure, and their complete seating was visually confirmed.

In the snap-on technique, the two-part Snap-On impression coping consisted of a white nylon basket (synOcta ITI Dental Implant System; Straumann AG #048.017) that snaps over the shoulder of the implant and a red plastic positioning cylinder (synOcta ITI Dental Implant System; Straumann AG #048.070) that slides inside the nylon basket and engages the internal octagon of the premolar regular implant. For the molar implant, a wide-neck fixture was used. Its copings (synOcta ITI Dental Implant System; Straumann AG #048.013, #048.095) were connected the same way [Figure 4].

The open-tray impressions were conducted using the traditional engaging metal, red-colored impression coping (synOcta ITI Dental Implant System; Straumann AG #048.090) for the regular fixture and the metal direct impression coping (synOcta ITI Dental Implant System; Straumann AG s #048.091) for the wide neck implant [Figure 5].

Ten trays were filled with polyether (Impergum Penta; 3M Espe Dental AG, Seefeld, Germany) and 10 with polyvinyl siloxane (Panasil Monophase Medium VPS; Kettenbach LP, Germany), placed on the main cast. The impression material was allowed to polymerize for 10 min before detachment [Figure 6]. The fixture analogs (048.124, 048.171, synOcta ITI Dental Implant System; Straumann AG (were then connected to the impression copings [Figure 7]. The soft tissue model (Coltene/Whaledent, Mahwah, NJ, USA) is injected around each analog. Material was confined to the coronal third to allow sufficient length of the analog within the model stone. After the completion of set, a die stone (Moldano; Heraeus Kulzer), is then poured into the impression to complete the cast. After setting of the type 4 stone, the soft tissue model was removed [Figure 8].

The 1.5-mm abutments were connected to the fixture analogs on every 40 casts. The accuracy of every cast was assessed by measuring of the marginal gap between the main framework (that was built on the abutments in the acrylic block) and the fixture analogs using a light microscope Sony exwave HAD color CCTV video camera (×250 magnification) [Figures 9 and 10].

Figure 2: Closed costume tray

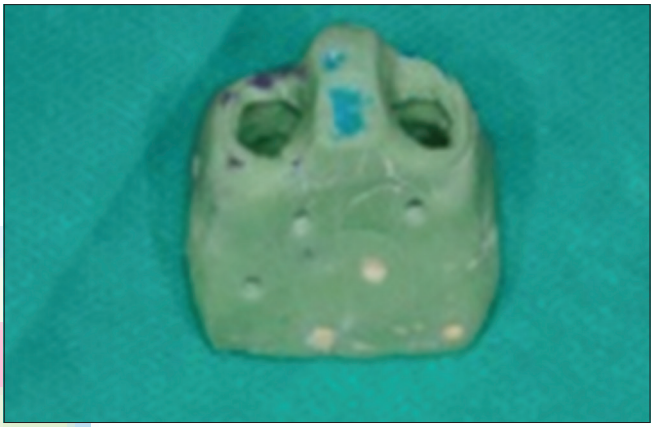

Figure 3: Open costume tray

Figure 4: Snap-on impression copings

The vertical misfit was analyzed in terms of the marginal gap between the framework and the analogs. The mean and the standard deviation of each group were calculated. Since

Figure 5: Pick-up impression copings

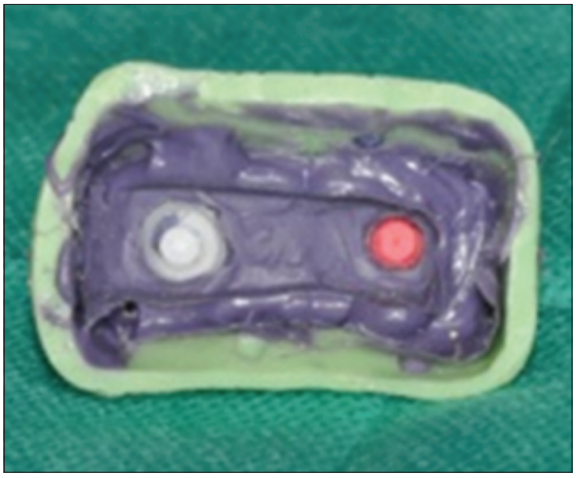

Figure 6: Implant impression copings in impression material

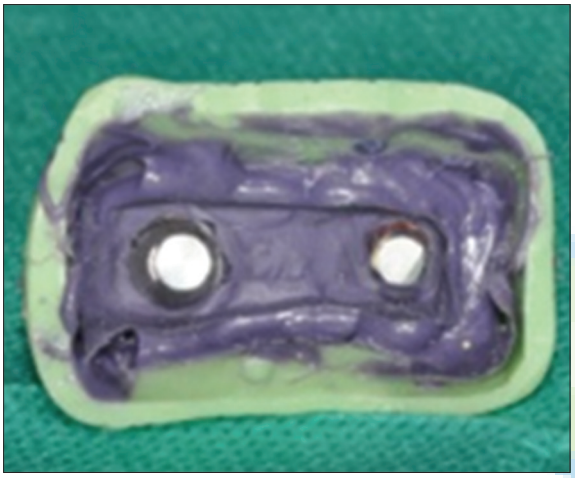

Figure 7: Implant analogs attached to impression copings

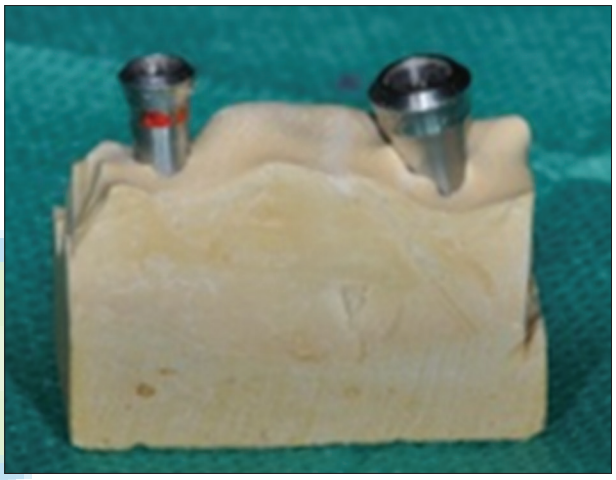

Figure 8: Definitive cast

Figure 9: The marginal gap

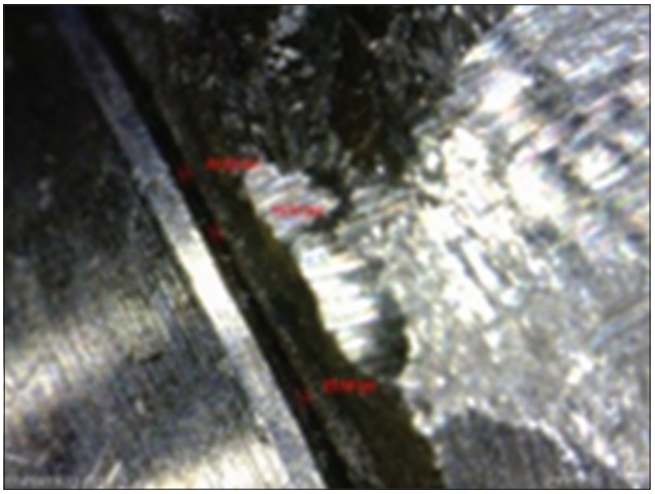

Figure 10: The marginal gap under light microscope

the Kolmogorov–Smirnov test did not confirm a normal distribution, the Mann–Whitney U-test was used to detect significant differences between the open-tray and the closed-tray groups. The significance level was set at $P < 0.01$.

RESULTS

The current study was performed on 40 samples, with 18 test samples in each group. The vertical misfit of every cast was

assessed in the premolar abutment and the molar abutment. In the distal, lingual, and buccal area of every abutment, three points were evaluated using the light microscope. The content of the vertical misfit was reported to be 18.96 ± 4.22 μm for the closed-tray group and 18.12 ± 2.99 μm for the open tray. Mann–Whitney analysis showed that there was no significant difference between the closed-tray technique and the open-tray one ($P = 0.78$). In all three locations (buccal, lingual, and distal) of the molar and lingual of the premolar, the mean vertical misfit of the polyether samples was significantly lower than that of the polyvinyl siloxane. The vertical misfit was reported to be 17.57 ± 2.8 μm for the polyether samples and 19.47 ± 4.28 μm for the polyvinyl siloxane group, and the Mann–Whitney analysis showed that there was a statistically significant difference between the impression materials (two-tailed significance $P < 0.001$) [Table 1].

The vertical misfit data for the molar and premolar areas with respect to impression technique are reported in Table 2. Table 3 also shows the vertical misfit data for the molar and premolar areas with respect to the impression materials.

Table 1: The vertical misfit data for impression technique and impression materials

Group	Number	Mean (μm)	SD	*P*
Closed tray	360	18.96	4.22	0.87
Open tray	360	18.12	2.99	
Poly ether	360	17.57	2.8	<0.001
Polyvinyl siloxane	360	19.47	4.28	

SD: Standard deviation

Table 2: The vertical misfit data for the molar and premolar areas with respect to impression technique

Group	Number	Mean (μm)	SD	*P*
Closed tray/premolar/buccal	60	15.65	3.39	0.143
Open tray/premolar/buccal	60	16.20	3.12	
closed tray/premolar/mesial	60	17.68	2.98	0.349
Open tray/premolar/mesial	60	16.85	2.84	
Closed tray/premolar/lingual	60	18.05	3.59	0.785
Open tray/premolar/lingual	60	17.61	2.72	
Closed tray/molar/buccal	60	19.02	2.24	0.112
Open tray/molar/buccal	60	19.7	2.16	
Closed tray/molar/distal	60	18.29	2.38	0.021
Open tray/molar/distal	60	19.42	2.75	
Closed tray/molar/lingual	60	18.75	1.78	0.16
Open tray/molar/lingual	60	19.55	2.75	

SD: Standard deviation

Table 3: The vertical misfit data for the molar and premolar areas with respect to the impression materials

Group	Number	Mean (μm)	SD	*P*
Polyether/premolar/buccal	60	15.95	3.09	0.852
Polyvinyl siloxane/premolar/buccal	60	15.9	3.43	
Polyether/premolar/mesial	60	16.86	2.14	0.144
Polyvinyl siloxane/premolar/mesial	60	17.67	3.52	
Polyether/premolar/lingual	60	16.79	2.64	0.001
Polyvinyl siloxane/premolar/lingual	60	18.87	3.34	
Polyether/molar/buccal	60	19.02	2.24	<0.0001
Polyvinyl siloxane/molar/buccal	60	21.54	3.57	
Polyether/molar/distal	60	18.29	2.38	<0.0001
Polyvinyl siloxane/molar/distal	60	22.1	4.34	
Polyether/molar/lingual	60	18.75	1.87	0.003
Polyvinyl siloxane/molar/lingual	60	20.73	3.84	

SD: Standard deviation

DISCUSSION

The objective of this study was to compare the accuracy between casts fabricated using the open-tray and closed-tray technique, as well as two different impression materials.

The accuracy of a definitive cast is crucial for implant prosthodontics. With some types of implant components, displacement can occur when making an implant impression. The first is the discrepancy between the impression copings and the mating surface of the implant within the range of machining tolerances, which can be defined as an intrinsic characteristic that exists between machined implant components. This error quantifies the degree of possible misfit between paired components.[11] Ma *et al*. reported the measurement of machining tolerances from 22 to 100 μm.[12] The average misfit demonstrated in this study suggests that most of the errors may occur due to machining tolerance. Braian *et al*. indicated that metallic components show lower tolerance than prefabricated plastic copings.[13] The use of plastic components versus metallic ones might impact the results of the study; however, no statistical difference was observed between the open-tray group (metallic components) and the closed-tray group (plastic components).

The second potential error results from the displacement of each impression coping during the impression process. Many studies have investigated the accuracy of implant impressions. Different impression methods have been introduced as ways to reduce the displacements of impression copings; i.e., a direct/indirect technique and splinting techniques. No consensus has yet been reached regarding the most accurate impression technique (splinted/nonsplinted, pick-up/transfer).[14] The movement of the impression copings inside the pick-up impression materials during the clinical and laboratory phases may cause inaccuracy in transferring the spatial position of implants from the oral cavity to the master cast as well as dislodging during reinsertion of the indirect impression copings. In addition, the number of implants affects the comparison of the pick-up and transfer techniques.[2] There was no statistically significant difference between the closed and open-tray technique in this *in vitro* study, which is consistent with numerous projects.[2,5,14-18] In fact, in this study, the

snap-on technique has been used as the closed-tray technique, which means copings are inserted into the impressions directly, reducing the error associated with manual reinsertion. Since the most common error factor of the closed-tray technique occurs during reinsertion of the coping and analog by clinician,[5] the use of the snap-on technique as well as the parallelism of the two implants in this study might have been the reason for the demonstrated similarity of the two techniques.

The third error factor is caused due to the characteristics of the impression material. Most of the evidence supports polyvinyl siloxane and polyether as the most accurate impression materials for the implant impression.[2,5,6,19,20] Due to the greater viscosity and lower tensile strength of polyether compared with additional silicone materials, this has been recommended for edentulous multiple-implant situations.[21,22] Sorrentino *et al*. demonstrated that in the presence of parallel implants, a polyether impression material performed better than additional silicone material in terms of accuracy.[7] Aguilar *et al*. showed that hydrophilic addition silicone and polyether impression materials had similar distortion effects for implant impressions when using the open-tray technique and machine mixing.[6] In a systematic review, Baig states that approximately eighty percent of *in vitro* investigations published between 1990 and 2012 were statistically equal in terms of the impression accuracy of the polyether and polyvinyl siloxane.[14] Another systematic review between 1980 and 2008 discovered even greater similarity between these two impression materials;[2] however, in this study, impressions that were taken with polyether showed a lower vertical misfit than those with polyvinyl siloxane in both premolar and molar abutments. This may be explained by the greater viscosity of the polyether. In line with this, Moreira *et al*. analyzed implant impression techniques articles published between 2009 and 2013 and observed that the most accurate results were achieved using polyether as the impression material.[23] The impression tray rigidity is another important factor in the accuracy of the impressions. It has been proven that metal trays and rigid custom trays reproduce casts with less distortion in comparison with the plastic stock trays.[24,25] However, Patil *et al*. reported no differences between custom trays and stock trays using polyvinyl siloxane.[26] This factor may not impact on the results of this study as the same custom trays were used for both groups.

Although the present study supports the use of polyether in the implant impression making, further *in vivo* research is necessary to confirm the better accuracy of polyether, while adjacent dentition may interfere with the impression accuracy.

Limitations of study as this are *in vitro* study parameters such as effect of saliva and temperature of oral cavity on polymerization of impressions is not considered.

CONCLUSIONS

Within the limitations of this study, the following conclusions can be drawn:

The impression method had no effect on marginal discrepancy of 3-unit screw retained fixed partial dentures.

A higher marginal accuracy was obtained using polyether impression material Compared to polyvinyl siloxane.

Financial support and sponsorship

This study was supported by a research grant from the Chancellor of Research at Mashhad University of Medical Sciences, Iran.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Kim S, Nicholls JI, Han CH, Lee KW. Displacement of implant components from impressions to definitive casts. Int J Oral Maxillofac Implants 2006;21:747-55.
2. Lee H, So JS, Hochstedler JL, Ercoli C. The accuracy of implant impressions: A systematic review. J Prosthet Dent 2008;100:285-91.
3. Alikhasi M, Siadat H, Fathi B. Accuracy of implant transfer with open-tray and closed-tray impression techniques and surface detail reproduction of the tooth during impression. Dent Med 2012;25:77-84.
4. Kunavisarut C, Lang LA, Stoner BR, Felton DA. Finite element analysis on dental implant-supported prostheses without passive fit. J Prosthodont 2002;11:30-40.
5. Daoudi MF, Setchell DJ, Searson LJ. A laboratory investigation of the accuracy of two impression techniques for single-tooth implants. Int J Prosthodont 2001;14:152-8.
6. Aguilar ML, Elias A, Vizcarrondo CE, Psoter WJ. Analysis of three-dimensional distortion of two impression materials in the transfer of dental implants. J Prosthet Dent 2010;103:202-9.
7. Sorrentino R, Gherlone EF, Calesini G, Zarone F. Effect of implant angulation, connection length, and impression material on the dimensional accuracy of implant impressions: An *in vitro* comparative study. Clin Implant Dent Relat Res 2010;12 Suppl 1:e63-76.
8. Madhan R, Nayar S, Annapoorani H. Comparative evaluation of accuracy of six different implant impression techniques: An *in vitro* study. J Indian Prosthodont Soc 2006;6:185-9.
9. Balamurugan T, Manimaran P. Evaluation of accuracy of direct transfer snapon impression coping closed tray impression technique and direct transfer open tray impression technique: An *in vitro* study. J Indian Prosthodont Soc 2013;13:226-32.
10. Nakhaei M, Madani AS, Moraditalab A, Haghi HR. Three-dimensional accuracy of different impression techniques for dental implants. Dent Res J (Isfahan) 2015;12:431-7.
11. Fernandez MA, Paez de Mendoza CY, Platt JA, Levon JA, Hovijitra ST, Nimmo A. A comparative study of the accuracy between plastic and metal impression transfer copings for implant restorations. J Prosthodont 2013;22:367-76.
12. Ma T, Nicholls JI, Rubenstein JE. Tolerance measurements of various implant components. Int J Oral Maxillofac Implants 1997;12:371-5.
13. Braian M, De Bruyn H, Fransson H, Christersson C, Wennerberg A. Tolerance measurements on internal- and external-hexagon implants. Int J Oral Maxillofac Implants 2014;29:846-52.

14. Baig MR. Accuracy of impressions of multiple implants in the edentulous arch: A systematic review. Int J Oral Maxillofac Implants 2014;29:869-80.
15. Conrad HJ, Pesun IJ, DeLong R, Hodges JS. Accuracy of two impression techniques with angulated implants. J Prosthet Dent 2007;97:349-56.
16. Akça K, Cehreli MC. Accuracy of 2 impression techniques for ITI implants. Int J Oral Maxillofac Implants 2004;19:517-23.
17. Herbst D, Nel JC, Driessen CH, Becker PJ. Evaluation of impression accuracy for osseointegrated implant supported superstructures. J Prosthet Dent 2000;83:555-61.
18. Naconecy MM, Teixeira ER, Shinkai RS, Frasca LC, Cervieri A. Evaluation of the accuracy of 3 transfer techniques for implant-supported prostheses with multiple abutments. Int J Oral Maxillofac Implants 2004;19:192-8.
19. Chee W, Jivraj S. Impression techniques for implant dentistry. Br Dent J 2006;201:429-32.
20. Buzayan MM, Yunus NB. Passive fit in screw retained multi-unit implant prosthesis understanding and achieving: A review of the literature. J Indian Prosthodont Soc 2014;14:16-23.
21. Lu H, Nguyen B, Powers JM. Mechanical properties of 3 hydrophilic addition silicone and polyether elastomeric impression materials. J Prosthet Dent 2004;92:151-4.
22. Arbree NS, Fleck S, Askinas SW. The results of a brief survey of complete denture prosthodontic techniques in predoctoral programs in North American dental schools. J Prosthodont 1996;5:219-25.
23. Moreira AH, Rodrigues NF, Pinho AC, Fonseca JC, Vilaça JL. Accuracy comparison of implant impression techniques: A systematic review. Clin Implant Dent Relat Res 2015;17 Suppl 2:e751-64.
24. de Lima LM, Borges GA, Junior LH, Spohr AM. *In vivo* study of the accuracy of dual-arch impressions. J Int Oral Health 2014;6:50-5.
25. Gordon GE, Johnson GH, Drennon DG. The effect of tray selection on the accuracy of elastomeric impression materials. J Prosthet Dent 1990;63:12-5.
26. Patil PS, Chowdhary R, Mishra S. Comparison of custom trays and stock trays using polyvinylsiloxane to evaluate linear dimensional accuracy: An *in vitro* study. J Indian Prosthodont Soc 2008;8:156-61.