International Journal of Applied Dental Sciences 2020; 6(3): 467-473

ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2020; 6(3): 467-473
© 2020 IJADS
www.oraljournal.com
Received: 12-04-2020
Accepted: 14-05-2020

Mohit Kheur
M.D.S, Ph.D., Professor, Department of Prosthodontics and Implantology, M.A. Rangoonwala College of Dental Sciences and Research Centre, Pune, Maharashtra, India

Tabrez Lakha
M.D.S, Senior Lecturer, Department of Prosthodontics and Implantology, M.A. Rangoonwala College of Dental Sciences and Research Centre, Pune, Maharashtra, India

Ramandeep Sandhu
M.D.S, Lecturer, Department of Prosthodontics and Implantology, M.A. Rangoonwala College of Dental Sciences and Research Centre, Pune, Maharashtra. India

Supriya Kheur
M.D.S, PhD, Head of the Department, D. Y. Patil Dental College, Pune, Maharashtra. India

Maknojia Amin
M.D.S, Consultant, Perfect Dental Care, Mumbai. Maharashtra. India

Mohsin Shaikh
Post-Graduate Student, Department of Prosthodontics and Implantology, M.A. Rangoonwala College of Dental Sciences and Research Centre, Pune, Maharashtra, India

Corresponding Author:
Mohsin Shaikh
Post-Graduate Student, Department of Prosthodontics and Implantology, M.A. Rangoonwala College of Dental Sciences and Research Centre, Pune, Maharashtra, India

Accuracy of different impression techniques for multiple implants angulated to each other: An *in vitro* study

Mohit Kheur, Tabrez Lakha, Ramandeep Sandhu, Supriya Kheur, Maknojia Amin and Mohsin Shaikh

DOI: https://doi.org/10.22271/oral.2020.v6.i3g.994

Abstract
Aim and objective: To evaluate the accuracy of different impression techniques - namely the closed tray impression technique, the open tray non-splinted impression technique, the open tray splinted technique and an experimental technique for multiple implants placed at an angulation with each other.
Materials and Methods: A master model was made of die stone which incorporated four implants having an internal hexagonal connection. The two terminal implants were placed at an angle of 20 degrees (lingually) whereas the two central implants were placed perpendicular to the cast. The samples were divided into four groups (Group I: Closed tray impression technique, Group II: Open tray impression technique non-splinted, Group III: Open tray impression technique splinted and Group IV: Experimental technique) based on the impression technique used. P-values were obtained using one-way analysis of variance (ANOVA) with Tukey's correction for multiple group comparisons.
Results: The P-value was greater than 0.05 (0.869) for Group III. Therefore, open tray splinted technique (Group III) was the most accurate impression technique when compared to the other techniques. On Inter - group comparisons it was noted that the values obtained by experimental technique were within close range of the values obtained by open tray splinted impression technique. Whereas, a comparison of Group I with Group III revealed 2 points of statistical significance (2 points of inaccuracy). Comparison of the Group II with Group III showed that all the points were statistically significant (all points were inaccurate).
Conclusion: The open tray splinted impression technique provides best results for multiple implants placed at varying angulations. The experimental technique can be beneficial in areas of limited access, reduced mouth opening and exaggerated gag reflex.

Keywords: Impression technique, accuracy, multiple implants, non-splinted, splinted

Introduction
Over the years, clinical experience in implantology has optimized treatment protocols and procedures leading to restorations being more predictable and successful [1]. Success in rehabilitation with dental implants is dependent on many factors, one of which is an accurate registration of the structures that are required for the superstructure support. Natural teeth have periodontal ligaments to compensate for minor inaccuracies in recording positioning of the abutments. However since, integrated implants are not mobile, it is important to ensure an accurate three dimensional transfer of their positioning in the mouth to the master cast [2].
An inaccurate impression may result in prosthesis misfit, which can lead to future problems such as abutment screw loosening, screw fracture and implant fracture [3, 4]. Authors have questioned whether an "absolute" passive fit is a pre requisite for success in implant restorations [5]. Although obtaining an absolute passive fit is practically impossible, preventing complications due to misfit is one of the goals of prosthodontic implant procedures [6]. Literature has reported that the accuracy of the implant cast depends on many factors: the type of impression material, implant impression technique, implant angulation, die material accuracy and master cast fabrication technique [7].

It has been documented that improper reproduction of the intra oral implant position to the master cast is very common with available impression techniques [9]. Some authors emphasize the importance of impression posts splinted with dental floss covered with autopolymerizing acrylic resin for transfer impressions [10]. Minimizing the shrinkage of acrylic resin is the most important factor to ensure an accurate impression using this splinting technique [11].

Traditionally, there are two different implant impression techniques. The open tray technique which involves picking up within the impression an impression post which was attached to the implant and the transfer technique or closed tray technique which uses tapered posts and a closed tray to make an impression [8].

The literature has reported studies which have focused on the effect of implant angulation on impression accuracy [12-14]. Filho *et al*. evaluated the accuracy of different impression techniques for implants placed at an angulation to each other and concluded that splinted and transfer type impression technique is superior to pick up type impression technique [15]. The limitation of their study was that it was restricted to only two implants placed at an angulation to each other. Tsagkalidis *et al*. reported that the open tray splinted impression technique is more accurate compared to the open tray non-splinted and snap-fit technique. They concluded that open tray splinted impression technique presented with least amount of distortion for implants placed at an angulation upto 25 degrees [16].

The anatomy of the jaws and morphology of the residual ridges determines the orientation and angulation in which the implants have to be placed. This difference in angulation of multiple implants may create an undesirable path of placement and subsequently an inaccurate impression [12, 17]. Studies have shown open tray splinted impression technique to be more accurate [15, 18]. Regardless of the accuracy, the open tray is technique sensitive and has its limitations. In certain clinical conditions such as limited mouth opening and in the posterior regions with limited access it can be a clinical challenge [19, 20]. Thus, the researchers of the present study designed an experimental impression technique to overcome these clinical limitations of the open tray splinted impression technique. This experimental technique involves customising copings using autopolymerising resin (Pattern Resin LS, GC America Inc. Alsip, IL, U.S.A.). These copings can be attached to abutments that are placed on the implants and are picked up following a conventional impression technique. The abutments placed on angulated implants are milled to achieve desired parallelism as compared to the parallel abutments. This technique avoids distortion of the impression material by eliminating undercuts in relation to the implants that are malaligned.

The present study evaluated the accuracy of different impression techniques- namely the closed tray impression technique, the open tray non-splinted impression technique, the open tray splinted technique and an experimental technique for multiple implants placed at an angulation with each other.

The null hypothesis tested was that no significant difference would be found in the accuracy of different impression techniques for multiple implants that have an internal connection, placed at varying angles to each other.

Material & Methodology

A master model was made of die stone (Ultra Rock, Kalabhai, Mumbai, India) which incorporated four implants (3.7mm x 10mm, Uniti, Equinox Medical Technologies, Amersfoort, Netherlands) having an internal hexagonal connection. The two terminal implants were placed at an angle of 20 degrees (lingually) whereas the two central implants were placed perpendicular to the cast (Figure 1). The smooth collar (0.5mm) of the implant was left exposed to enable verification of fit of the impression post. The cast had notches on its edges for proper orientation of custom trays during the impression procedures. Custom trays with a thickness of 2mm were fabricated using light cure tray material (Poly tray, Delta, India). The trays were designed so as to ensure standardized positioning on the master models, providing consistent space for the impression material. The impression material used for all impressions was Addition Silicone Monophase (Implasil, Equinox, Medical Technologies, The Netherlands) and was loaded in the tray using an auto dispensing mixer (3M Espe Pentamix, Seefeld, Germany). Each tray was coated with adhesive (Zhermack, Elite Iperlink LCT, Italy) prior impression. The samples were divided into four groups based on the impression technique and forty impressions were made.

Group I: (Closed tray impression technique): In this technique, closed tray impression posts (Uniti, Equinox Medical Technologies, Amersfoort, Netherlands) were placed on the master cast and an impression was made. The closed tray impression posts remained on the cast when the impression material had polymerized and the tray was removed (Figure 2). These impression posts were removed one at a time from the master cast and attached to an implant analog. The combined impression post analog unit was inserted into the impression by firmly pushing it into place to full depth and the model was poured using type IV dental stone (Ultra Rock, Kalabhai, Mumbai, India).

Group II: (Open tray impression technique non-splinted): Impression protocol followed was similar to that mentioned above. For the open tray technique, warm modelling wax was adapted over the openings of the tray before loading the tray with impression material. After the tray was seated, the wax was used to prevent venting of the impression material through the openings and to identify the location of the impression posts. After the impression was made, an implant analog was connected to the post and the screws were hand tightened (Figure 3). The impressions were poured in type IV dental stone (Ultra Rock, Kalabhai, Mumbai, India).

Group III: (Open tray impression technique splinted): Open tray impression posts (Uniti, Equinox Medical Technologies, Amersfoort, Netherlands) were placed on the model. The posts were splinted using dental floss. Each post was attached with the floss in a figure of eight manner and autopolymerising resin (Pattern Resin LS, GC America Inc. Alsip, IL, U.S.A.) was applied using brush bead technique over the floss. The posts were splinted to each other with the resin (Figure 4). A vertical slit was made in the centre of each segment using a diamond disk. The resultant section was re-aligned using same resin. This was done to compensate the polymerization shrinkage of resin.

Group IV: (Experimental technique): In this technique, two 17 degree angulated abutments (Uniti, Equinox Medical Technologies, Amersfoort, Netherlands) and two straight abutments (Uniti, Equinox Medical Technologies, Amersfoort, Netherlands) were used. The angulated

abutments were attached to the distal implants. The straight abutments were attached to central implants. The angulated abutments were milled (AF 350, Amann Girbach North America, Charlotte, NC, USA), so that they were parallel to the straight abutments and all abutments were parallel to each other (Figure 5). A pick up cap was fabricated in autopolymerising resin (Pattern Resin LS, GC America Inc. Alsip, IL, U.S.A.) to fit on each abutment (Figure 6). After the impression was made, the abutments were unscrewed from the model, lab analogs were attached and they were reoriented into the impression to their respective pattern resin pick up caps. The model was poured as described earlier. (Figure 7)

A computerized coordinate measuring machine using a probe with diameter of 2mm (Reinshaw TP2) (Figure 8) was used for measurement of the models. Before scanning the model, implant carriers were attached on each implant. Since the carrier was cylindrical in shape, measurements were standardized throughout the scan.

The centre of one implant carrier was selected along with four points in different directions at the same level with the probe. Using these points, the 3-Dimensional virtual image of the implant carrier and the implant inside the master cast was processed using the software (Spectra series 5.6.4 Accurate TP2, Renishaw Plc, United Kindom) (Figure 9). Similarly, the procedure was repeated for all four implants and the angles between the carriers and the surface of the cast were measured in 3D planes (X-Y-Z axis).

The master cast was first scanned using the protocol mentioned above and the results were treated as master readings. For easy calculation the implants were named Point A, Point B, Point C, and Point D. Similar principle was used to get the measurements of the casts retrieved from the impressions poured using all techniques.

Ten impressions were made for each group, the resultant casts were scanned and measurements were recorded. Forty such scans were made.

Results

The results were tabulated and subjected to statistical analysis. (Table 1 and Table 2)

Mean values were obtained. P-values were obtained by one sample 't' test with reference values to master model. P-value less than 0.05 was considered to be statistically significant with respect to master model (Table 1). P-value greater than 0.05 was considered to have better accuracy with respect to master model. In the present study it was observed that the open tray splinted impression technique (Group III) had values in agreement with those of the master model. The p-value was greater than 0.05 (0.869) for Group III. Therefore, open tray splinted technique (Group III) was the most accurate impression technique when compared to the other techniques.

P-values were obtained using one-way analysis of variance (ANOVA) with Tukey's correction for multiple group comparisons. P-value less than 0.05 were statistically significant. An inter-group comparison was made between the open tray splinted impression technique (Group III) and the remaining Test Groups (Table 2). This was done to determine which of the remaining test groups showed maximum agreement with the open tray impression technique splinted (Group III). A comparison of Group I with Group III revealed 2 points of statistical significance (2 points of inaccuracy). Comparison of the Group II with Group III showed that all the points were statistically significant (all points were inaccurate). However the experimental technique (Group IV) when compared with open tray impression technique splinted (Group III) had only one statistically significant point. Hence the values obtained by experimental technique were within close range of the values obtained by open tray splinted impression technique. The reported results are for measurements in XY plane only.

Discussion

A passive restoration is critical for long term prosthetic and biological success in implantology. Passivity is a concern with multiple implants placed at varying angulations to each other because of documented inaccuracies in implant impressions and in restoration manufacturing procedures [5].

The accuracy of an implant cast depends on many factors: the impression material, impression technique, angulation at which the implant is placed, accuracy of dental stone and master cast technique [15, 16, 21]. With the use of implants having an internal connection there is a reported decrease in the accuracy of impressions with an increase in the angulation of implants [22]. Researchers in the past have reported a less accurate impression made in presence of multiple implants placed at an angulation to each other as compared to the parallel ones [12, 22, 17].

Various studies have been conducted on impression techniques in implantology however none of them are conclusive about which technique is ideal and should be used for implant impressions [19, 23, 24]. The present study measured the accuracy of various implant impressions using open tray, closed tray and an experimental technique for implants placed at angulation to each other.

Distortion can be measured as absolute or relative. For absolute distortion analysis, an external point was taken as reference point and for relative distortion the inner surface of the model which was covered in impression was taken up by the probe unit. Since the prosthesis connects all implants together, the amount of strain on the implant is related to the relative position of implant to one another and therefore a relative distortion analysis was done [25, 26].

Errors can be easily introduced during the steps required for fabrication of master cast. There could be errors due to inaccurately repositioned impression post, improper connection of components, dimensional changes of the impression material used and variable dental stone expansion to fabricate the master cast [27]. In this study, all procedures involved with all impression techniques were conducted by the same operator.

In this study Monophase Addition silicone impression material was used. This material exhibits high resistance to deformation as compared to other elastomeric impression materials. The Monophase impression material also eliminates the drawbacks of dual phase impressions and the dual impression technique [28].

In terms of the reproduction of position and angulation of the implants, the maximum deviation from the master cast was shown by the closed tray impression technique (Group I, Table 1). The most accurate technique was the open tray splinted impression technique (Group III, Table 1) followed by the experimental technique (Group IV, Table 1).

The impression posts placed on terminal implants were tilted lingually by 20 degree in angle to the X-Y plane simulating a clinical situation. While removing the closed tray impression from the master model, the path of removal did not match with the alignment of these impression posts. This resulted in stress concentration between the impression material and

impression post. These stresses are released while reorienting the posts with the laboratory analog causing distortion of the impression and inaccuracy in the final cast [8, 16, 18].

A possible explanation for the significantly high error noticed in the horizontal plane for the open tray non splinted group could be due to movements induced in the impression posts while unscrewing the screw from the impression posts when the tray is removed or tightening the matching lab analogs into the impression. [16, 20] Such inaccuracy can be overcome by splinting the posts with autopolymerising resin (Pattern Resin LS, GC America Inc. Alsip, IL, U.S.A.) [29] All resins show polymerization shrinkage and the effect of the same can be minimised using brush bead technique and sectioning of set resin followed with re-splinting.

The open tray splinted (Group III) showed most accurate results in Z-X plane, X-Y plane and Y-Z plane. The splinting of posts to each other does not permit any movements of the posts while making or retrieving the impression. It also avoids micro movement of the posts during attachment of the lab analogs to the posts before pouring the cast [8, 9, 16, 20, 30, 31].

These results of this study are in agreement to the study conducted by Tsagkalidis *et al*. They studied the accuracy of different impression techniques at varying implant angulations and concluded that the direct splinting technique was the most accurate when implants were placed at an angulation upto 25 degrees [18]. Similar results were noted in several studies that reported accuracy and excellence of open tray splinting impression technique for internal connection implants [16, 25, 32-36]. However, Conrad *et al*. studied the accuracy of impression techniques for three implants placed at varying angulations and reported that angulation did not affect the accuracy of implant impressions. [14] Several other studies have shown no difference between splinted and non-splinted implant impression techniques. [11, 36-39] These contrasting results could be explained by the varying selection of study designs and implant systems used, different impression and splinting materials used, different angulations of the implants and variable expansions of dental stone.

Regardless of the accuracy, the open tray splinted technique may not be suitable in patients with limited mouth opening, areas of limited access like the posterior dentition and in patients with an exaggerated gag reflex. [19, 20, 40] This procedure requires fabrication of custom tray and is technique sensitive. [41] Acrylic resin splinting can be time-consuming. [21] It has also been reported that the fabrication of the splint to connect the impression components be done one day prior the procedure to minimise the distortion. [12, 23]

An experimental technique was introduced in an attempt to overcome inaccuracy of closed tray impression technique, to avoid splinting of the impression posts, as well as to avoid problems of simultaneous pick up of impression posts in the open tray technique. Instead of using closed tray copings, two angulated abutments and two straight abutments were used. The angulated abutments were placed on the terminal implants and were milled so that they were parallel to the straight abutments placed on to the central implants. All the abutments remained parallel to each other. A pick up cap was fabricated in autopolymerising resin (Pattern Resin LS, GC America Inc. Alsip, IL, U.S.A.) to fit on each abutment. Retentive elements were attached on the surface of the pick-up caps so that it would be picked in the impression and helped in re-orienting the respective abutment and lab analog in place. As the impression material was not stressed upon removal, this technique showed superior results as compared to closed tray impression technique and open tray non splinted technique. Thus, this experimental technique can be easily used to make impressions which are as accurate as open tray splinted impression technique.

Some of the advantages of experimental technique are as follows:

a. It avoids need for splinting of copings, required for open tray splinted impressions technique.
b. It is less technique sensitive than open tray impressions.
c. The open tray impression technique needs a greater mouth opening than this technique.
d. The same abutments used for impressions can be used for final prosthesis.

The null hypothesis was rejected as results of the present study showed significant difference in the accuracy of various impression techniques for the internal connection implants placed at varying angles from each other.

The limitations of the current study were that it did not simulate the oral environment and an exact reproduction of implant position was not accomplished in this study. It is impossible to duplicate exact implant position, which implies that clinically a precise fit may not be possible. Advances in technologies such as digital impressions and a CAD/CAM system that produces implant components with minimum machining tolerance may solve this problem.

Table 1: Comparison of angular measurements across various groups with the respective master model.

Angle (Degrees)		Group I (n=10) Close tray		Group II (n=10) Open tray non-splinted		Group III (n=10) Open tray splinted		Group IV (n=10) Abutment with close tray	
X-Y Plane	Master Model	Mean (SD)	p	Mean (SD)	p	Mean (SD)	p	Mean (SD)	p
A	76.833333	79.04 (1.6)	0.001	78.94 (1.1)	0.001	75.77 (0.9)	0.010	74.41 (1.2)	0.001
B	87.263565	87.52 (0.4)	0.081	84.66 (1.2)	0.001	86.56 (0.5)	0.003	85.06 (1.8)	0.004
C	88.426259	85.31 (1.1)	0.001	84.80 (1.1)	0.001	87.71 (0.8)	0.025	86.73 (1.4)	0.004
D	74.030353	75.25 (0.8)	0.001	72.17 (1.1)	0.001	74.07 (0.81)	0.869	75.03 (1.8)	0.112

Table 2: Inter-group statistical comparison of angular measurements.

Angle (Degrees)	Group I vs. Group III	Group II vs. Group III	Group III vs. Group IV
A	0.001 (Significant)	0.001 (Significant)	0.079
B	0.257	0.004 (Significant)	0.031 (Significant)
C	0.001 (Significant)	0.001 (Significant)	0.229
D	0.143	0.006 (Significant)	0.303

Fig 1: Master model with implants and implant carriers.

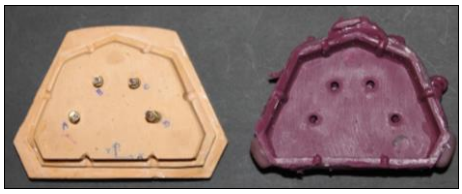

Fig 2: Impression retrieved from master model.

Fig 3: Laboratory analogs attached to open tray copings.

Fig 4: Impression copings splinted with pattern resin.

Fig 5: Angulated abutments attached to the terminal implants.

Fig 6: Pick up caps for the indigenous technique.

Fig 7: Pattern resin coping caps picked-up in impression.

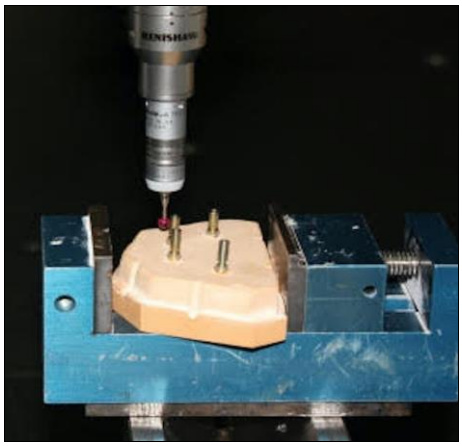

Fig 8: Scanning of the cast.

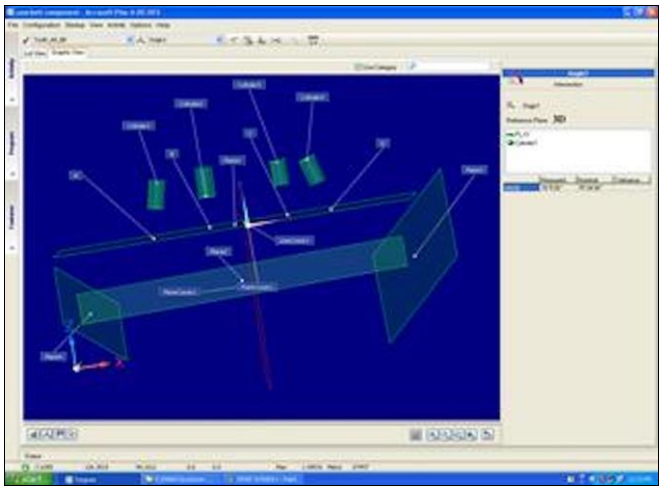

Fig 9: Virtual image and measurement procedure

Conclusion

The open tray splinted impression technique provides best results for multiple internal connection implants placed at varying angulations. The experimental technique can be beneficial in areas of limited access, reduced mouth opening and exaggerated gag reflex.

References

1. Steigenga JT, Al-Shammari KF, Nociti FH, Misch CE, Wang HL. Dental implant design and its relationship to long-term success. Implant Dent. 2003; 12:306-317.
2. Pesun IJ. Intrusion of teeth in combination implant-to-natural-tooth fixed partial denture: a review of the theories. J Prosthodont. 1997; 6:268-277.
3. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. J Prosthet Dent; 2003; 90:121-132.
4. Holst S, Blatz MB, Bergler M, Goellner M, Wichmann M. Influence of impression material and time on the 3-dimensional accuracy of implant impressions.

Quintessence Int. 2007; 38:67-73.
5. Karl M, Wichmann MG, Winter M, Graef F, Taylor TD, Heckmann SM. Influence of fixation mode and superstructure span upon strain development of implant fixed partial dentures. J Prosthodont. 2008; 17:3-8.
6. Lindhe J, Berglundh T, Ericcson I, Liljenberg B, Marinello C. Experimental breakdown of peri-implant and periodontal tissues. A study in the beagle dog. Clin Oral Implants Res. 1992; 3:9-16.
7. Kan JY, Rungcharassaeng K, Bohsali K, Goodacre CJ, Lang BR. Clinical methods for evaluating implant framework fit. J Prosthet Dent. 1999; 81:7-13.
8. Carr AB. Comparison of impression techniques for a five-implant mandibular model. Int J Oral Maxillofac Implants. 1991; 6:448-455.
9. Spector MR, Donovan TE, Nicholis JI. An evaluation of impression techniques for osseointegrated implants. J Prosthet Dent. 1990; 63:444-447.
10. Branemark PI, Zarb GA, Albrektson T. Tissue-integrated prostheses: Osseointegration in clinical dentistry. Chicago: Quintessence. 1985; 11(2)253-257.
11. Lee YJ, Heo SJ, Koak JY, Kim SK. Accuracy of different impression techniques for internal-connection implants. Int J Oral Maxillofac Implants. 2009; 24:823-30.
12. Assuncao WG, Filho HG, Zaniquelli O. Evaluation of transfer impression for Osseo integrated implants at various angulations. Implant Dent. 2004; 13:358-366.
13. Assuncao WG, Tabata LF. Prosthetic transfer impression for osseointegrated implants at various angulations. Implant Dent. 2008; 17:248-56.
14. Conrad HJ, Pesun IJ, Delong R, Hodges JS. Accuracy of two impression techniques with angulated implants. J Prosthet Dent. 2007; 97:349-356.
15. Filho HG, Mazaro JV, Vedovatto E, Assunção WG, dos Santos PH. Accuracy of impression techniques for implants. Part 2 - comparison of splinting techniques. J Prosthodont. 2009; 18(2):172-6.
16. Tsagkalidis G, Tortopidis D, Mpikos P, Kaisarlis G, Koidis P. Accuracy of 3 different impression techniques for internal connection angulated implants. J Prosthet Dent. 2015; 114:517-23.
17. Ebadian B, Rismanchian M, Dastgheib B, Bajoghli F. Effect of different impression materials and techniques on the dimensional accuracy of implant definitive casts. Dent Res J (Isfahan). 2015; 12:136-143.
18. Del'Acqua MA, Arioli-Filho JN, Compagnoni MA, Mollo Fde A Jr. Accuracy of impression and pouring techniques for an implant supported prosthesis. Int J Oral Maxillofac Implants. 2008; 23:226-236.
19. Mpikos P, Kafantaris N, Tortopidis D, Galanis C, Kaisarlis G, Koidis P. The effect of impression technique and implant angulation on the impression accuracy of external- and internal connection implants. Int J Oral Maxillofac Implants. 2012; 27:1422-8.
20. Wenz HJ, Reuter HU, Katrin H. Accuracy of impression and casts using different impression techniques in a multi-implant system with an internal hex connection. Int J Oral Maxillofac Implants. 2008; 23:39-47.
21. Teo JW, Tan KB, Nicholls JI, Wong KM, Uy J. Three-dimensional accuracy of plastic transfer impression copings for three implant systems. Int J Oral Maxillofac Implants. 2014; 29:577-84.
22. Vigolo P, Fonzi F, Majzoub Z, Cardioli G. An evaluation of impression techniques for multiple internal connection implant prosthesis. J Prosthet Dent. 2004; 92:470-6.
23. 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):63-76.
24. Herbst D, Nel JC, Driessen CH, Becker PJ. Evaluation of impression accuracy for osseointegrated implant supported superstructures. J Prosthet Dent. 2000; 83:555-561.
25. Jo SH, Kim KI, Seo JM, Song KY, Park JM, Ahn SG. Effect of impression coping and implant angulation on the accuracy of implant impressions: an *in vitro* study. J Adv Prosthodont. 2010; 2:128-33.
26. De Avila ED, Barros LA, Del'Acqua MA, Castanharo SM, Mollo Fde A Jr. Comparison of the accuracy for three dental impression techniques and index: An *in vitro* study. J Prosthodont Res. 2013; 57(4):268-74.
27. Hariharan R, Shankar C, Rajan M, Baig MR, Azhagarasan NS. Evaluation of accuracy multiple dental implant impressions using various splinting method. Int J Oral Maxillofac Implants. 2010; 25:38-44.
28. Prithviraj DR, Pujari ML, Garg P, Shruthi DP. Accuracy of the implant impression obtained from different impression materials and techniques: review. Clin Exp Dent. 2011; 3:106-11.
29. Vigolo P, Majzoub Z, Cardioli G. Evaluation of the accuracy of three techniques used for multiple implant abutment impressions. J Prosthet Dent. 2003; 89:186-92.
30. Taylor PA. Incorporating retrievability in fixed implant-supported prostheses by transverse fixation in the ITI Abutment System. J Can Dent Assoc. 2004; 70:459-63.
31. Kim S, Nicholls J, Han CH. Displacement of implant components from impressions of definitive casts. Int J Oral Maxillofac Implants. 2006; 21:747-755.
32. Stimmelmayr M, Güth JF, Erdelt K, Happe A, Schlee M, Beuer F. Clinical study evaluating the discrepancy of two different impression techniques of four implants in an edentulous jaw. Clin Oral Investig. 2013; 17:1929-35.
33. Papaspyridakos P, Chen CJ, Gallucci GO, Doukoudakis A, Weber HP, Chronopoulos V. Accuracy of implant impressions for partially and completely edentulous patients: a systematic Review. Int J Oral Maxillofac Implants. 2014; 29:836-45.
34. Naconecy MM, Teixeira ER, Shinkai RS, Frasca LC, Cervieri A. Evaluation of the accuracy of 3 tranfer techniques for implant-supported prostheses with multiple abutments. Int J Oral Maxillofac Implants. 2004; 19:192-8.
35. Vigolo P, Mutinelli S, Fonzi F, Stellini E. An *in vitro* evaluation of impression techniques for multiple internal- and external-connection implant prostheses. Int J Oral Maxillofac Implants. 2014; 29:807-18.
36. Martinez-Rus F, Garcia C, Santamaria A, Özcan M, Pradies G. Accuracy of definitive casts using 4 implant-level impression techniques in a scenario of multi-implant system with different implant angulations and subgingival alignment levels. Implant Dent. 2013; 22:268-76.
37. Pujari M, Garg P, Prithviraj DR. Evaluation of accuracy of casts of multiple internal connection implant prosthesis obtained from different impression materials and techniques: an *in vitro* study. J Oral Implantol. 2014; 40:137-45.
38. Chang WG, Vahidi F, Bae KH, Lim BS. Accuracy of three implant impression techniques with different

impression materials and stones. Int J Prosthodont. 2012; 25:44-7.
39. Choi JH, Lim YJ, Yim SH, Kim CW. Evaluation of the accuracy of implant-level impression techniques for internal-connection implant prostheses in parallel and divergent models. Int J Oral Maxillofac Implants. 2007; 22:761-8.
40. Buzayan M, Baig M, Yunus N. Evaluation of accuracy of complete-arch multiple-unit abutment- level dental implant impressions using different impression and splinting materials. Int J Oral Maxillofac Implants. 2013; 28:1512-20.
41. Bhakta S, Vere J, Calder I, Patel R. Impressions in implant dentistry. Br Dent J. 2011; 211:361-367.