University J Dent Scie 2023; Vol. 9, Issue 1

Evaluation of the accuracy of light polymerizing tray material for splinting in open tray implant impressions: An In-vitro 3D Spatial Analysis.

Abstract:

Aims and objective: Precise reproduction of the intra-oral spatial relationship of implants with an impression becomes the first step in achieving an accurate, passively fitting prosthesis. Thisin vitro study aims to compare the dimensional accuracy of dental implants in casts obtained from open tray splinted implant impression techniques using two different splinting materials.

Methods and Material: A mandibular acrylic model with four implant analogues was used as a reference model. Open tray impression copings were attached to the implant analogues and were splinted using two different materials. Group I-splinted with pattern resin, sectioned and re-joined and Group II- splinted with light cure tray material. Eight polyether impressions were made for each group and poured in type IV dental stone. The casts retrieved from each group were three-dimensionally analysed using coordinate measuring machine with 0.001 mm accuracy.A one-way ANOVA and post hoc test was done to calculate the statistically significant difference between the groups.

Results: The present study revealed no significant difference in the inter-implant distances obtained from pattern resin splinted group, whereas, significant difference in z-axis was found in light polymerising tray resin splinted group when compared to the values obtained from the reference model.

Conclusions: Casts obtained from splinting the impression copings using pattern resin before making implant impression were found to be moreaccurate than splinting with light cure tray material.

Key-words: dental implants, accuracy, impressions, splinting

Introduction:

Dentistry has encountered phenomenal advancements in dental restorative materials, sciences and techniques. Moreover, with the advent of osseointegrated dental implants, the long term management of edentulism has transformed exceptionally[1]. Dental implants, however, lacks periodontal ligament around the implant, thus small procedural errors could lead to misfit of the superstructure exerting additional stress to the surrounding bone that could cause problems ranging from screw loosening to loss of osseointegration[2].

The first step to ensure a passive fit of implant framework is the transfer of the spatial relationships of implants from the

Access this article online

Website: www.ujds.in

Quick Response Code

DOI: https://doi.org/10.21276//ujds.2023.9.1.3

[1]MANISHA SHARMA, [2]NITASHA GANDHI, [3]NIRMAL KURIAN, [4]KEVIN G VARGHESE, [5]NISHANTH A SUSHARSON, [6]NITIKA GUPTA

[1]Deptt. of Prosthodontics, Sri Aurobindo College of Dentistry, Indore

[2-6]Deptt. of Prosthodontics, Christian Dental College, Ludhiana, Punjab.

Address for Correspondence: Dr. Manisha Sharma, Assistant Professor, Deptt. of Prosthodontics, Sri Aurobindo College of Dentistry, Indore, M.P.

Postal Address: Flat no. 202, Surya apartment, M.G. Road, South Tukoganj, Indore, M.P, Pincode- 452001.

Email : manishasharma6993@gmail.com

Received : 2 Nov., 2022, **Published :** 31 March, 2023

How to cite this article: Sharma, M., Gandhi, Nitasha, Kurian, Nirmal, George Varghese, Kevin, A Sudharson, Nishanth, & Gupta, Nitika. (2022). Evaluation of the accuracy of light polymerizing tray material for splinting in open tray implant impressions: An In-vitro 3D Spatial Analysis. UNIVERSITY JOURNAL OF DENTAL SCIENCES, 9(1). 16-22

mouth to the master cast with an accurate impression. Various factors that influence the accuracy of implant impressions are direct or indirect impression techniques, splinting of impression copings, surface treatment of impression copings and type of impression materials used[3]. Previously, literature indicated both polyether and polyvinylsiloxane to produce accurate impressions as compared to other available impression materials. However, polyether has been found to produce improved results in terms of implant cast accuracy and lower abutment-framework interface gaps than polyvinyl siloxane and hence, preferred for implant impressions because of its dimensional stability, rigidity, tear-resistance and hydrophilicity[4,5]. Direct/open tray transfer technique was also found to produce less distortion and therefore recommended as the standard technique in case of two or more implants and with multiple angulated implants[2].

To ensure maximum accuracy, Branemark et al emphasized on the importance of splinting impression copings together intraorally before making multiple implant impression[6]. Various splinting materials have been recommended such as dental floss, orthodontic wire, auto polymerizing resin, impression plaster and bite registration silicones[7]. Recently, the use of light polymerizing tray material has been suggested as a reliable mode of splinting for implant impressions due to its ease of use, better operator-controlled working time, evasion of intra-oral spillage of resin monomer, improved patient compliance and uniform thickness of the material[8,9].

However, the studies evaluating the accuracy of different types of splinting materials have yielded conflicting result in the previous literature[7,10-12]. Therefore, this study aims to compare the positional accuracy of casts obtained from direct splinted implant impression using two different splinting material- conventionally used auto-polymerizing pattern resin with light-polymerizing tray material. The null hypothesis of this study was that there is no difference in the positional accuracy of casts between the two splinting materials.

Methods:

An edentulous mandibular reference model was fabricated using heat cure clear acrylic resin (DPI Heat cure, DPI Union House Mumbai) to obtain an acrylic reference model. Three notches with one in the anterior and two in the posterior region were made in the land area of the acrylic model to ensure proper orientation of the impression tray placement. Four parallel holes were drilled on the reference model in the intraforaminal region, where four implant analogues (TS OSSTEM IMPLANT, Osstem Implant India Pvt Ltd) regular, 4mm in diameter numbered as 1, 3, 4, 2 from left to right, were placed to mimic a mandibular implant-supported overdenture situation [fig 1(a)].

Open tray impression copings (Osstem Implant India Pvt Ltd)) were then secured with guide pins onto the implant analogues on the model. Two layers of modelling wax were then adapted uniformly over the acrylic master model and the impression copings [fig 1 (b)]. An irreversible hydrocolloid impression was made to obtain a spaced primary cast [fig 1(c)]. Over this preliminary cast, sixteen uniformly spaced custom trays of 2mm thickness were made using light cure resin (Plaque Photo R, Premier Dent Int. Khanna). [Fig 1(d)] Four windows corresponding to the positions of implant analogues were created on the special tray for an open tray impression technique.

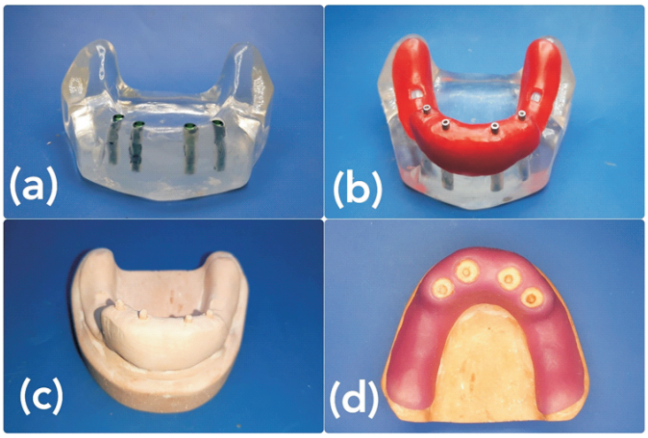

Figure 1: (a) Reference model made in heat cure acrylic resin (b) Wax spacer adapted (c) Spaced primary cast (d) Custom tray fabricated with four windows.

Two study groups are made according to the type of splinting material used.

Group I - Dental floss (Oral B Waxed dental floss, India) was tightly looped around the open tray impression copings. Pattern resin (GC Pattern Resin, GC India Dental Pvt Ltd, Telengana) was then mixed according to the manufacturer's instruction and packed around onto the dental floss and the impression copings and allowed to polymerize for 4 minutes. The splint was sectioned in between the impression copings using 0.2mm disk to relieve the stresses caused by polymerization shrinkage. [Fig 2(a) and (b)] The cut sections were re-joined by applying the pattern resin in brush bead manner. Once the splint became rigid, the impression copings, custom tray and the splint were all coated with polyether tray adhesive and allowed to dry for 15 minutes.

Group II- Splinting was achieved using visible light polymerizing resin tray material (Plaque Photo R, Premier Dent Int. Khanna). Two wide strips of the material were wrapped around the impression copings with a spatula ensuring proper adaptation of the material. The splint was then light-cured using visible light curing unit for 60 sec on each side[8]. [Fig 2(c)] The impression copings, custom tray and the splint were coated with tray adhesive before proceeding to impression making.

Polyether impression material (3M ESPE Impregnum Soft, Bengaluru) was then hand-mixed. Part of the material was meticulously syringed around the impression copings and the remaining impression material was loaded onto the impression tray. It was ensured that the tray seated completely on the three stops that were made on the acrylic model to verify the orientation of the impression tray. The impression was maintained in position with hand pressure during the recommended setting time of 6 min [Fig 2(d)]. Sixteen impressions were made, eight for each group by the same operator.

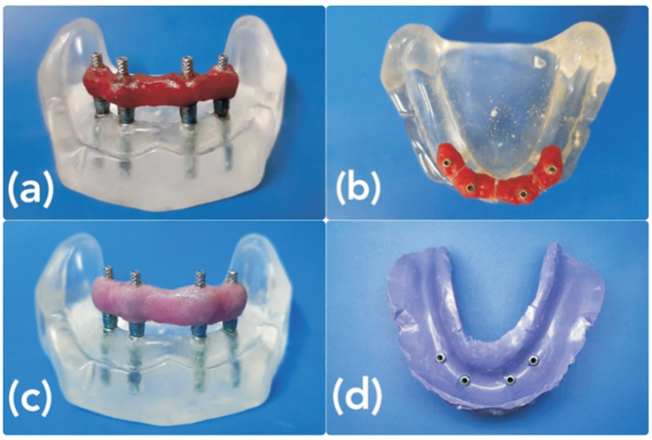

Figure 2: (a) Impression copings splinted with pattern resin (b) Pattern resin splint sectioned with 0.2mm disk (c) Impression copings splinted with light cure tray material (d) Impression made with polyethertransfer copings and each impression was poured with ADA type IV dental stone (Kalrock, Kalabhai Karson Pvt td. Mumbai). [Fig 3]

Figure 3: Definitive cast obtained

Measurement protocol:

All the casts obtained along with the reference model were measured for three-dimensional accuracy using a coordinate measuring machine of 0.001mm accuracy (Mitutoyo BHN710, Tokyo, Japan). [Fig 4 (a) and (b)].

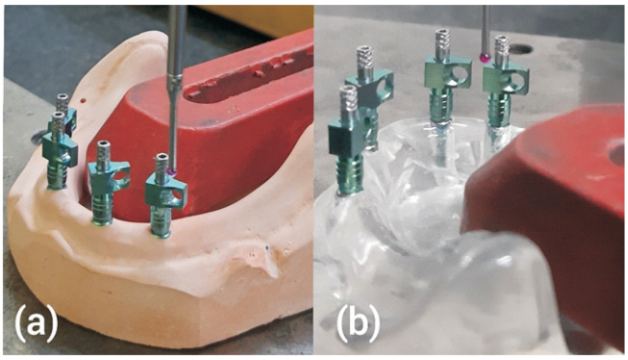

Figure 4: (a) Definitive cast obtained, (b) Evaluation of the cast and the master model using coordinate measuring machine.

Three measurements were recorded for every inter implant distance in the *x*-, *y*-, and *z*-axes for each cast, and then the mean values were calculated. Impression copings were then screwed onto the implant analogues and sequentially numbered as 1, 3, 4, and 2 from left to right. The centroid of coping 1 located with the CMM probe of diameter 2mm (Renishaw TP2) was considered as the reference point (0, 0, 0) for all measurements with the *y*-axis passing through the centres of the copings 1 and 2. The distances between the centroids of 1 and 2 (Dx12, Dy12), 1 and 3 (Dx13, Dy13), 1 and 4 (Dx14, Dy14), 2 and 3 (Dx23, Dy23), 2 and 4 (Dx24, Dy24), and 3 and 4 (Dx34, Dy34) were measured in the *x*- and *y*-axes, respectively. The vertical distances between the planes formed by the platform of the impression copings 1 and 2, 1 and 3, 1 and 4, 2 and 3, 2 and 4 and 3 and 4 were then measured to analyse the inter implant distances in the *z*-axis (Dz12, Dz13, Dz23, Dz24, and Dz34).

The inter implant distances in all the three axes were measured for the reference model and the sixteen casts. The mean values obtained from the casts were compared with the standard values derived from the reference model and the differences were calculated.

Results:

The measurements obtained were tabulated and statistically analysed. A one-way analysis of variance (ANOVA) was used to obtain the mean and standard deviation for each group and further post hoc test- Tukey's HSD was utilised to calculate the statistically significant difference (p-value $\leq$ 0.05) in between the groups.

The mean and standard deviations with the statistical differences in the inter implant distances in the x-, y-, and z-axes were tabulated.

On comparing the inter-implant distance between the implant analogue 1 and 2, a significant difference was found in both x and z-axis among the groups (Dx12= 0.026*, Dz12= 0.005*). Post hoc analysis indicated a significant difference in the values of group II when compared to the master model and group I. [Table 1]

Table 1: Group comparison of the positional accuracy between implant analogues 1 and 2 when compared with master model.

Axis	Groups	Mean	Mean difference	Std. deviation	p value	M vs I	M vs II	I vs II
Dx12	Master	30.771	0	0				
	I	30.741	0.03	0.099				
	II	30.564	0.207	0.203	0.026*	0.925	0.047*	0.054
Dy12	Master	0	0	0				
	I	0	0	0	0	0	0	0
	II	0	0	0				
Dz12	Master	0.514	0	0	0.005*	0.928	0.013*	0.013*
	I	0.653	0.139	0.488				
	II	1.715	1.201	0.942				

*Indicates statistically significant difference ($P \leq 0.05$)

Between implant analogues 1 and 3, a significant difference was found among the groups in the z-axis (Dz13= 0.001*). Paired comparison with post hoc analysis further revealed a significant difference between group II when compared to the master model and group I. [Table 2]

Table 2: Group comparison of the positional accuracy between implant analogues 1 and 3 when compared with master model

Axis	Groups	Mean	Mean difference	Std. deviation	p value	M vs I	M vs II	I vs II
Dx13	M	8.168	0	0	0.056	0.65	0.057	0.194
	I	8.101	0.067	0.056				
	II	7.982	0.186	0.202				
Dy13	M	7.198	0	0	0.131	0.43	0.836	0.118
	I	7.231	0.033	0.056				
	II	7.183	0.015	0.049				
Dz13	M	1.676	0	0	0.001*	0.79	0.001*	0.001*
	I	1.791	0.115	0.141				
	II	2.575	0.899	0.47				

*Indicates statistically significant difference ($P \leq 0.05$)

Group comparison between the implant analogues 1 and 4 showed significant differences in the z-axis (Dz14= 0.001*). Post hoc test indicated a significant difference in the values of group I and group II when compared to the master model and also with each other.[Table 3]

Table 3: Group comparison of the positional accuracy between implant analogues 1 and 4 when compared with master model.

Axis	Groups	Mean	Mean difference	Std. deviation	p value	M vs I	M vs II	I vs II
Dx14	M	23.259	0	0	0.353	0.961	0.594	0.347
	I	23.226	0.033	0.115				
	II	23.38	0.121	0.326				
Dy14	M	6.558	0	0	0.714	0.692	0.843	0.951
	I	6.521	0.037	0.112				
	II	6.533	0.025	0.054				
Dz14	M	0.514	0	0	0.001*	0.021*	0.001*	0.046*
	I	1.377	0.863	0.301				
	II	2.036	1.522	0.757				

*Indicates statistically significant difference ($P \leq 0.05$)

The inter-implant distances between the implant analogues 3 and 4 varied significantly in y- and z-axis (Dy34=0.009*, Dz34=0.001*) Further comparison within the groups showed significant differences between group I and group II in the y-axis. The highest deviation was found to be in z-axis where both group I and II significantly differed from the master model. [Table 4]

Table 4: Group comparison of the positional accuracy between implant analogues 3 and 4 when compared with master model.

Axis	Groups	Mean	Mean difference	Std. deviation	p value	M vs I	M vs II	I vs II
Dx34	M	15.091	0	0	0.244	0.792	0.663	0.217
	I	15.122	0.031	0.104				
	II	15.049	0.042	0.086				
Dy34	M	-0.64	0	0	0.009*	0.08*	0.797	0.009*
	I	-0.741	0.101	0.103				
	II	-0.612	0.028	0.067				
Dz34	M	-1.162	0	0	0.01*	0.074	0.007*	0.43
	I	-0.432	0.73	0.223				
	II	-0.087	1.075	0.843				

*Indicates statistically significant difference ($P \leq 0.05$)

The group comparison between the implant analogues 2 and 3 and 2 and 4 showed similar results in which the values obtained from the group I and group II. No significant difference was found in x-, y- and z-axis. [Table 5,6]

Table 5: Group comparison of the positional accuracy between implant analogues 2 and 3 when compared with master model.

Axis	Group	Mean	Mean difference	Std. deviation	p value	M vs I	M vs II	I vs II
Dx23	M	22.603	0	0	0.001*	0.001*	0.001*	0.266
	I	-22.631	0.028	0.081				
	II	-22.529	0.074	0.186				
Dy23	M	-7.198	0	0	0.001*	0.001*	0.001*	0.666
	I	7.211	0.013	0.091				
	II	7.183	0.015	0.049				
Dz23	M	0.497	0	0	0.132	0.125	0.24	0.898
	I	1.246	0.749	0.441				
	II	1.106	0.663	0.441				

*Indicates statistically significant difference ($P \leq 0.05$

Table 6: Group comparison of the positional accuracy between implant analogues 2 and 4 when compared with master model.

Axis	Groups	Mean	Mean difference	Std. deviation	p value	M vs I	M vs II	I vs II
Dx24	M	7.511	0	0	0.001*	0.001*	0.001*	0.921
	I	-7.529	0.018	0.083				
	II	-7.512	0.001	0.112				
Dy24	M	-6.558	0	0	0.001*	0.001*	0.001*	0.996
	I	6.536	0.022	0.094				
	II	6.533	0.025	0.054				
Dz24	M	1.659	0	0	0.001*	0.001*	0.001*	0.1
	I	0.869	0.79	0.224				
	II	1.188	0.471	0.21				

*Indicates statistically significant difference ($P \leq 0.05$

Discussion:

A passively fitted prosthesis is a prerequisite for the success of the osseointegrated implants. Misfit of superstructure generates stress on the implants which further leads to mechanical complications such as the fracture of prosthetic framework or veneering material, abutment screw loosening or fracture[13]. Therefore, various techniques and materials have been introduced and compared to improve the accuracy of the impression procedure.

Polyether impression material was used in this study as it has properties ideally suited for the transfer of impression copings such as excellent resistance to permanent deformation, low strain under compressions, and high tear resistance. It provides sufficient rigidity to prevent rotation of the squared transfer coping during analogue fastening and cast formation[14]. Direct impression technique was used in this study as it displays lesser distortion because the impression copings stay within the impression when compared to the indirect technique where distortion may take place while transferring the copings back to the impression[15].

Splinting is a standard practice of joining the open tray impression copings with a rigid material as an attempt to prevent the rotation of copings during implant or abutment analogue fastening, stabilizing the relationship between implants in a rigid fashion[15]. Splinting of two or more copings has been suggested to improve the dimensional accuracy of the impression compared to the non-splinted technique[16-18].

The inaccuracy in the splinting materials can be measured on the casts obtained from the impressions in both horizontal and vertical directions. Horizontal displacements (x and y-axis) may lead to binding of the screws and bending stresses in implant system whereas vertical misfits (z-axis) can increase the preload making the screw vulnerable to fatigue fractures and loosening[6]. Also, as the prosthesis connects all the implants and the amount of strain on the implants is related to the relative positions of the implants to one another, a three-dimensional relative distortion analysis was performed for the evaluation of the inter-implant distances with reference to implant analogue[13].

This study attempted to evaluate the reliability of– light polymerizing tray material as a splinting material by comparing it to conventionally used pattern resin material. On the basis of the results of the study, the null hypothesis was rejected as the casts obtained from pattern resin splinted group was found to be significantly more accurate than light cure tray material splinted group. This may be attributed to the technique used for pattern resin splinting. Since, the polymerisation shrinkage of pattern resin (5.72%) is more as compared to light cure tray material (<2%)[19], the pattern resin splint was sectioned and then re-joined just before making the impression[7]. Therefore, the large amount of resin used for making the initial splint did not influence the positional accuracy between the implant analogues and the small amount of resin added just before making the impression resulted in minimal overall shrinkage[16].

The values obtained from the analysis of casts fabricated with light cure tray material as the splinting material exhibited significant difference in the inter-implant distances when compared with group I and the master model. This may be caused due to incomplete polymerisation of the material and can be further attributed to the intensity and direction of the light source. The other disadvantages of using light polymerizing tray material intra-orally can be improper access for the light curing unit especially in the posterior region and probable interference with the impression tray because of the thicker tray material adapted over the impression copings[8].

Comparison of the current results with the past studies was found inconclusive, as to best of author's knowledge, none of them compared the accuracy of light polymerizing tray material with pattern resin as splinting material. However, a study conducted by Papaspyridakos et al. compared the accuracy of light polymerising tray material splinted implant impression technique with non-splinted impression technique and conceded that the light polymerising tray material splinted technique splinted technique generated more accurate master casts than the non-splinted technique[9].

In this study, as no compensation technique to reduce acrylic shrinkage for tray material splint was employed, therefore further studies incorporating techniques of sectioning and rejoining the light cure tray material splint before impression making can be performed. Moreover, the study was carried out in purely in-vitro conditions, therefore, further in-vivo studies are required to include more clinically relevant factors.

Conclusion:

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

I. Splinting impression copings with pattern resin with adequate compensation procedure of sectioning and re-joining was found to be the most accurate method of splinting.

II. Splinting with visible light polymerising tray material showed statistically significant distortion in inter-implant distances when compared with the master model and pattern resin group.

Hence, the accuracy of visible light polymerising tray material as a splinting material was found to be inferior to the conventionally used pattern resin and requires further research to improve its properties to be effectively used as a regular splinting material in implant impressions.

References:

1. Adell R, Lekholm U, Rockler BR, Brånemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J **Oral** Surg 1981;10(6):387-41
2. Tarib NA, Seong TW, Chuen KM, Kun MS, Ahmad M, Kamarudin KH. Evaluation of splinting implant impression techniques: two dimensional analyses.Eur J Prosthodont Restor Dent. 2012;20(1):35.
3. Buzayan M, Baig MR, 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(6).
4. 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 Den. 2010;103(4):202-9
5. Reddy S, Prasad K, Vakil H, Jain A, Chowdhary R. Accuracy of impressions with different impression materials in angulated implants. Niger J Clin Pract 2013;16(3):279-84.
6. Lee SJ, Cho SB. Accuracy of five implant impression technique: effect of splinting materials and methods. J Adv Prosthodont. 2011;3(4):177-85.
7. Cabral LM, Guedes CG. Comparative analysis of 4 impression techniques for implants. **Implant** Dent 2007;16(2):187-94.

8. Rutkunas V, Ignatovic J. A technique to splint and verify the accuracy of implant impression copings with light-polymerizing acrylic resin. J Prosthet Den. 2014;111(3):254-6.
9. Papaspyridakos P, Benic GI, Hogsett VL, White GS, Lal K, Gallucci GO. Accuracy of implant casts generated with splinted and non-splinted impression techniques for edentulous patients: an optical scanning study. Clin Oral Implants Res. 2012;23(6):676-81.
10. Buzayan M, Baig MR, Yunus N. Evaluation of accuracy of complete-arch multiple-unit abutment-level dental implant impressions using different impression and splinting materials. International Journal of Oral & Maxillofacial Implants. 2013;28(6).
11. Selvaraj S, Dorairaj J, Mohan J, Simon P. Comparison of implant cast accuracy of multiple implant impression technique with different splinting materials: An in vitro study. The Journal of the Indian Prosthodontic Society. 2016;16(2):167.
12. Walker MP, Ries D, Borello B. Implant Cast Accuracy as a Function of Impression Techniques and Impression Material Viscosity. International Journal of Oral & Maxillofacial Implants. 2008;23(4).
13. Hariharan R, Shankar C, Rajan M, Baig MR, Azhagarasan NS. Evaluation of accuracy of multiple dental implant impressions using various splinting materials. Int J Oral Maxillofac Implants 2010;25(1)
14. Hsu CC, Millstein PL, Stein RS. A comparative analysis of the accuracy of implant transfer techniques. J Prosthet Den. 1993;69(6):588-93.
15. Selvaraj S, Dorairaj J, Mohan J, Simon P. Comparison of implant cast accuracy of multiple implant impression technique with different splinting materials: An in vitro study. J Indian Prosthodont Soc. 2016;16(2):167.
16. Joseph TM, Ravichandran R, Lylajam S, Viswabharan P, Janardhanan K, Rajeev S. Evaluation of positional accuracy in multiple implants using four different splinting materials: An in vitro study. J Indian Prosthodont Soc 2018;18(3):239.
17. Assif D, Nissan J, Varsano I, Singer A. Accuracy of implant impression splinted techniques: effect of splinting material. Int J Oral Maxillofac Implants 1999;14(6).
18. Kurtulmus-Yilmaz S, Ozan O, Ozcelik TB, Yagiz A. Digital evaluation of the accuracy of impression techniques and materials in angulated implants. J Dent. 2014;42(12):1551-9.
19. Gibbs SB, Versluis A, Tantbirojn D, Ahuja S. Comparison of polymerization shrinkage of pattern resins. J Prosthet Den. 2014;112(2):293-8.