Original Article

Pressure Characteristics of Maxillary and Mandibular Edentulous Impressions: An In-vitro Study

Haby Mathew Somson[1], Pradeep Kumar C[2], Alex Mathew M[3], Sherin Sara George[4], Rajeev Soangra[5], Jitendra Acharya[6]

[1]Senior Lecturer, Department of Prosthodontics, Puphagiri College of Dental Sciences, Tiruvalla; [2]Private Practitioner, Calicut; [3]Professor, Department of Prosthodontics, Azeezia College of Dental Sciences, Kollam; [4]Senior Lecturer, Department of Pedodontics, Puphagiri College of Dental Sciences, Tiruvalla; [5]Senior Demonstrator, Department of Periodontics,RUHS College of Dental Sciences, Jaipur; [6]Senior Demonstrator, Department of Dentistry, SP Medical College and Associated Group of Hospitals, Bikaner, Rajasthan, India

DOI:10.37821/ruhsjhs.5.1.2020.39-45

ABSTRACT

Introduction: One major factor that determines the stability and retention of prosthesis is the amount of pressure produced during final impression. The aim of the present study was to assess the pressure changes created during impression process by relief space, escape holes, and different seating velocity on a simulated maxillary and mandibular edentulous arch using light body polyvinyl siloxane impression material.

Methodology: The present study was done on a total of 54 trays: 27 maxillary and 27 mandibular. Each tray had a specific combination of escape hole, relief space, and seating velocity. Impression was taken with Aquasil (light body polyvinyl siloxane). The variables assessed were relief space, escape holes, and seating velocity. Area chosen for the maxillary arch was midpalatine raphe and the area chosen for the mandibular arch was anterior ridge.

Results: We found that greater the amount of relief space given, lesser was the pressure generated. Similarly, greater the dimension of escape holes, lesser was the pressure generated; in case of seating velocity, greater the seating velocity, more pressure was generated.

Conclusion: All three factors i.e. relief space, escape holes, and seating velocity had an effect on the pressures exerted on denture supporting tissues.

Keywords: Escape holes, polyvinyl siloxane, pressure generation, relief space, ridge resorption, seating velocity.

INTRODUCTION

The basic requisites of an impression are preservation of alveolar ridges, support, retention, stability, and esthetics. One major factor determining the stability and retention of a prosthesis is the amount and spot of pressure produced during final impression. Several concepts proposed to control this factor include: mucostatic (non-pressure or pressureless) concept, mucocompressive concept, functional impression concept, and the selective pressure concept. When evaluated we can see that most of the existing impression techniques are very similar, all of them based on sound principles of anatomy, physiology, and physics.[1,2]

Out of these methods, mucostatic technique records the oral tissues at rest, so that a very minimum amount of pressure is applied to the oral tissues during the whole process of impression taking; whereas the functional impression technique results in a complete denture which is relieved on its internal aspects. The selective pressure technique uses custom trays that are made with less relief in the primary denture stress bearing areas and more relief in the non stress bearing areas. This technique results in a denture base that has property of selective loading pressure on oral tissues during function.[3,4,5]

Different concepts of impression making depend on varying the extent and location of escape holes and relief space in the custom tray made up for the final impression. The other factors that have a role are tray design, viscosity of the material, velocity with which the tray is approximated to the oral tissues etc.[4,5]

This study was carried out to find out whether the relief space and escape holes, when given, actually translate as a reduction in pressure applied at those areas on the edentulous ridge and whether the seating velocity has any effect on the pressure produced.

METHODS

A total of 54 edentulous casts were made, 27 upper and 27 lower casts (Figure 1). On these edentulous casts, special trays were fabricated with autopolymerizing acrylic resin (pink) with different combinations of escape holes and relief spaces (Figure 2). Thus a total of 54 special trays were made (27 upper and 27 lower). Out of the upper and lower 27 special trays, 9 were made without spacer, 9 with 1 mm spacer (1 layer of modeling wax), and 9 with 2 mm spacer (2 layer of modeling wax). For the trays with no spacer, separating medium was applied on the casts and by sprinkle on technique; special trays were fabricated with autopolymerizing acrylic resin extending till the depth of the sulcus. Whereas for trays with single spacer, a single layer of modeling wax adapted on the edentulous casts. Then separating medium was applied on the casts and special trays were fabricated with autopolymerizing acrylic resin extending till the depth of the sulcus. The same procedure was followed for trays with double spacer.

After the special tray fabrication, escape holes were incorporated into the special trays. The selected micro-motor bur and airotor bur were assessed for their thickness or diameter with vernier caliper and it was found to be 2 mm diameter and 1 mm diameter respectively. With the help of micromotor bur (which is 2 mm thick) and airotor bur (which is 1 mm thick), escape holes were incorporated into the special trays. In each of the above sets, 3 trays were given no escape holes (0H), 3 trays were given 1 mm escape hole (1H), and 3 trays were given 2 mm escape holes (2H). So the special trays had a specific combination of relief space and escape holes.

The methodology aims at determining the pressure generated during impression making at 3 different seating velocities 60 mm/min (60V), 120 mm/min (120V), and 180 mm/min (180V). With the specially designed instrument, special trays were approximated to the edentulous acrylic model with the pre determined velocities with the help of motors. So each special tray will have a specific combination of relief space, escape holes, and seating velocity. For example: Tray NS 0H 60V means a special tray with a combination of no relief space, no escape hole, and seating velocity of 60 mm/min.

Preparation of the pressure sensing model: The pressure sensing model was prepared in auto-polymerizing acrylic resin (clear). An impression of the upper and lower edentulous cast was made in irreversible hydrocolloid (Zelgan Plus, Dentsply). A mix of polymer and monomer of autopolymerizing acrylic resin (DPI, Clear) was poured into the impression made in alginate. After it had cured, the acrylic model was retrieved from the impression and checked for irregularities. Finally it was finished and polished (Figure 3).

Evaluation of pressure generated: A specially designed instrument was used which had a provision for determining the pressure which was generated during impression making in vitro (Figure 4). It included a load cell (10 kg capacity) which was attached to edentulous upper and lower model made of clear autopolymerizing acrylic resin. The equipment utilized a motor mechanism to approximate the special trays to the edentulous oral analogue (maxillary and mandibular). The acrylic model was trimmed with a bur to create space for the extension of the load cell to be at level with the surface of the model.

The midpalatine raphe was the selected point of interest for

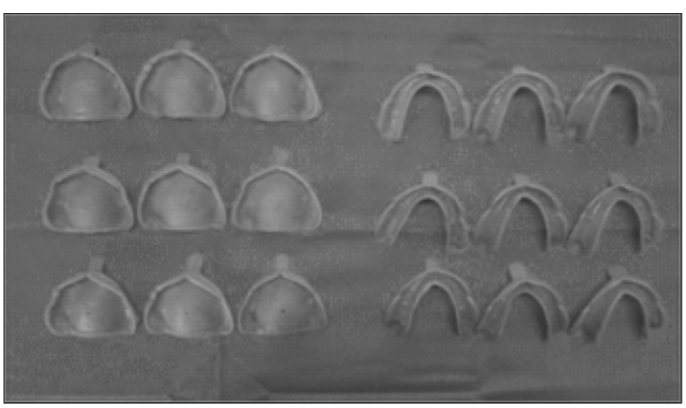

Figure 1 : Special trays with 1mm spacer (maxillary and mandibular).

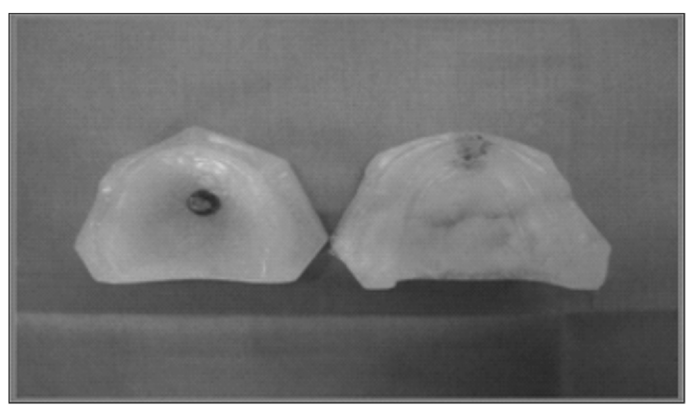

Figure 2: Special trays in position on maxillary and mandibular acrylic models.

the upper model where the pressure sensor was inserted into so that the top of the sensor was at level with the surface of the model. The crest of the alveolar ridge in the center of the mandibular arch was the selected point of interest for the lower model where the pressure sensor was inserted into so that the top of the sensor was at level with the surface of the model.

Thus, the pressure sensing apparatus was ready with the assembled parts for digital recording of the pressure and the motor mechanism for holding the special trays and approximating them towards the model with the impression material (Aquasil Ultra LV, Dentsply) loaded onto the special trays. Thus the special trays and the apparatus were made ready for evaluating the pressure

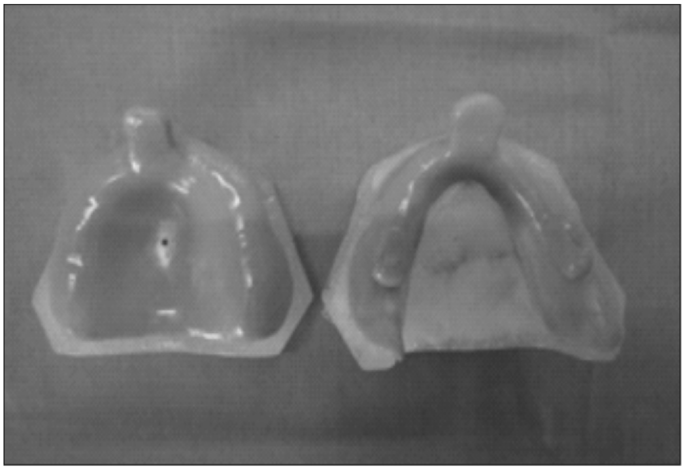

Figure 3: Maxillary and mandibular acrylic models.

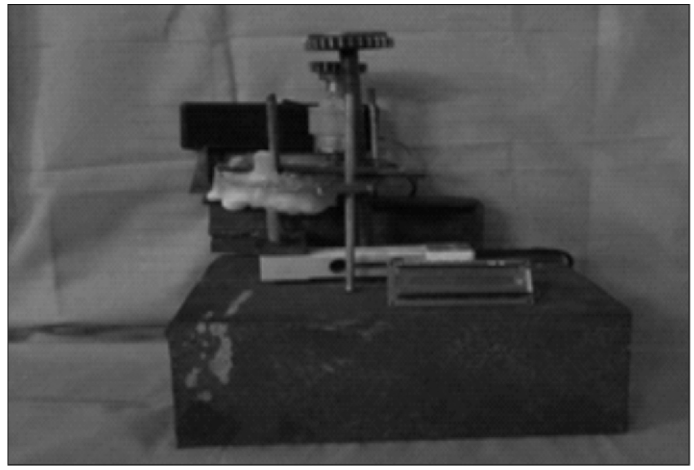

Figure 4: Device measuring the pressure on model.

Table 1. Pressure values (in KPa) for different combinations of relief space, escape holes, and seating velocity (maxillary arch)

Pressure values						Mean
NS 0H 60V	31.3	29.4	30.4	31.2	30.6	30.58
NS 0H 120V	36.6	36.2	37.5	36.8	36.1	36.64
NS 0H 180V	42.5	42	41.7	42.8	42.2	42.24
NS 1H 60V	22.3	21.7	21.9	22.6	22.4	22.18
NS 1H 120V	24.7	25.4	25.4	24.9	25.8	25.24
NS IH 180V	28.3	28.5	27.7	27.9	28.7	28.22
NS 2H 60V	19.4	18.7	18.4	19.2	18.8	18.90
NS 2H 120V	21.8	22.8	22.1	21.3	22.3	22.06
NS 2H 180V	23.7	23.9	24.6	24.8	23.9	24.18
SS 0H 60V	28.4	27.3	28.7	29.0	27.6	28.20
SS 0H 120V	30.6	29.7	28.7	31.5	30.1	30.12
SS 0H 180V	33.3	32.4	32.8	31.8	33.8	32.82
SS 1H 60V	18.4	19.6	20.2	18.1	19.3	19.12
SS 1H 120V	21.5	22.2	21.3	23.0	21.8	21.96
SS 1H 180V	23.3	25.6	24.5	23.8	24.0	24.24
SS 2H 60V	17.3	17.8	16.5	18.4	18.8	17.76
SS 2H 120V	18.7	19.6	19.4	17.7	19.8	19.04
SS 2H 180V	20.7	19.3	21.5	21.8	22.0	21.06
DS 0H 60V	20.6	22.6	20.9	21.7	21.1	21.38
DS 0H 120V	22.8	22.3	23.5	21.6	23.9	22.82
DS 0H 180V	24.3	23.8	24.7	22.9	24.0	23.94
DS 1H 60V	18.9	17.7	18.4	19.3	18.6	18.58
DS 1H 120V	20.4	21.0	19.3	19.7	20.6	20.20
DS 1H 180V	22.8	21.3	23.1	22.6	21.0	22.16
DS 2H 60V	16.0	14.6	16.7	16.4	15.8	15.90
DS 2H 120V	18.0	17.7	17.4	18.6	18.1	17.96
DS 2H 180V	19.8	18.6	20.5	19.7	18.3	19.38

generated during impression making. Each of the trays were predetermined to have a specific combination of relief spaces, escape holes, and seating velocity and each of these special trays were loaded with the selected impression material (Aquasil Ultra LV, Dentsply) manually with the help of dispensing gun and cartridge with the spiral mixing tip attached.

After loading the tray with the impression material, it was approximated to the edentulous model and the pressure generated for that specific combination of variables was recorded on the digital display. Once the impression material has set, it was removed from the tray and reloaded with the impression material again to determine the pressure generated. This procedure was repeated five times for each tray so that the mean value and the statistical significance can be determined.

Statistical Analysis: The data were entered using the software Excel and it was analyzed using the software SPSS (Statistical Package for Social Sciences). For calculating the significance of the pressure changes with respect to relief space, escape holes, and seating velocity, we used univariate and multivariate methods. In univariate analysis, mean and standard deviations of pressure for each of the combinations of relief space, escape holes, and seating velocity were calculated and presented (27 in number). In multivariate analysis, we used 3-way analysis of variance with 3 way interactions and post hoc comparisons using Bonferroni method. All significances were assessed using p value < 0.05 and the analysis of variance was done using F test which is the variance ratio test.

RESULTS

The pressure values (in KPa) for different combinations of relief space, escape holes, and seating velocity for maxillary arch and mandibular arches are tabulated in table 1 and 2, respectively. The comparison of the average pressure values were made after adjusting the relief space (NS) and escape hole (0H) with respect to different values of seating velocity.

Table 2. Pressure values (in KPa) for different combinations of relief space, escape holes, and seating velocity (mandibular arch)

Pressure values						Mean
NS 0H 60V	33.6	32.1	33.9	34.3	33.4	33.46
NS 0H 120V	36.5	38.4	36.3	37.0	35.8	36.80
NS 0H 180V	43.7	42.9	42.4	43.0	44.5	43.30
NS 1H 60V	27.4	25.2	27.6	24.3	26.6	26.22
NS 1H 120V	28.9	26.3	29.8	29.9	27.7	28.52
NS IH 180V	31.4	30.6	29.8	30.5	31.0	30.66
NS 2H 60V	24.3	25.6	24.0	22.9	23.7	24.10
NS 2H 120V	27.7	27.6	25.8	29.3	28.5	27.78
NS 2H 180V	31.7	30.5	33.4	31.4	32.3	31.86
SS 0H 60V	30.7	29.4	31.8	29.1	30.4	30.28
SS 0H 120V	33.4	32.0	32.7	33.6	34.2	33.18
SS 0H 180V	35.7	37.5	38.3	36.0	35.2	36.54
SS 1H 60V	22.4	26.4	23.6	24.0	23.0	23.88
SS 1H 120V	28.4	27.0	27.9	26.5	26.3	27.22
SS 1H 180V	28.7	30.1	29.8	29.4	28.5	29.30
SS 2H 60V	22.6	22.0	20.4	21.1	21.7	21.56
SS 2H 120V	24.0	25.8	23.2	24.5	23.7	24.24
SS 2H 180V	29.1	27.3	28.5	29.6	27.9	28.48
DS 0H 60V	26.8	27.6	27.2	29.0	28.4	27.80
DS 0H 120V	28.5	29.1	28.3	30.3	29.8	29.20
DS 0H 180V	30.6	31.1	28.4	32.9	32.3	31.06
DS 1H 60V	22.1	22.5	24.0	23.7	22.0	22.86
DS 1H 120V	25.3	24.0	24.7	23.5	24.9	24.48
DS 1H 180V	28.2	29.4	27.6	28.7	27.1	28.20
DS 2H 60V	18.5	17.7	19.0	19.8	16.7	18.34
DS 2H 120V	20.7	22.8	20.0	21.6	22.4	21.50
DS 2H 180V	24.6	26.4	25.1	23.8	25.3	25.04

Table 3: Multivariate analysis (maxillary arch) tests of between-subjects effects dependent variable: PRESS

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
Corrected model	5000.916	26	192.343	356.606	0.00	0.99	9271.766	1.000
Intercept	77491.432	1	77491.432	143670.169	0.00	0.99	143670.169	1.000
Space	1282.847	2	641.423	1189.208	0.00	0.96	2378.415	1.000
Holes	2533.754	2	1266.877	2348.807	0.00	0.98	4697.614	1.000
Velocity space	578.756	2	289.378	536.511	0.00	0.91	1073.022	1.000
Holes space	455.872	4	113.968	211.298	0.00	0.89	845.193	1.000
Velocity holes	81.189	4	20.297	37.631	0.00	0.58	150.525	1.000
Velocity space	19.562	4	4.890	9.067	0.00	0.25	36.268	0.99
Holes velocity	48.936	8	6.117	11.341	0.00	0.46	90.728	1.000
Error	58.252	108	0.54					
Total	82550.600	135						
Corrected Total	5059.168	134						

The main effect as well as the effect of relief space, escape holes, seating velocity, 2 way interactions and finally 3 way interactions was assessed in multivariate analysis and all these are presented in tables 3 and 4. All these were significant and all the p values were less than 0.0001. Post hoc comparisons were also made with respect to relief space, escape holes, and seating velocity. When we considered the differences between the spaces, it was not adjusted for escape holes as well as velocities. Therefore the significance comes mainly from relief space, escape holes as well as seating velocity. That is why we have done 3-way analysis of variance with 3 way interactions.

The 3-way interactions of pressure with respect to relief space, escape holes and seating velocity in both maxillary and mandibular arches were significant showing that for the treatment of the patients, for getting the optimal pressure (i.e.; the minimum pressure), one has to consider all the 3 factors namely relief space, escape holes and seating velocity.

DISCUSSION

Different concepts in impression making are based on differential pressure application like mucodisplasive, mucostatic, functional, and differential pressure techniques. The concept of minimal pressure impression technique is in between mucostatic and mucocompressive techniques. According to this method, there should be minimum pressure applied, slightly more than the weight of free flowing material. The concept of selective pressure is the most commonly accepted theory, wherein varying of the pressure over the denture seat is carried out based on the displaceability of the supporting tissues; thereby the load is transferred over to the selected areas of the seat, like buccal shelf area. This is accomplished by varying the thickness of spacer.[4-7]

El Khodary[8] stated that residual ridges palate and areas of easily displaced gingiva are the areas of the edentulous mouth that require little pressure, whereas the border seal area of the denture, retromylohyoid fossa and buccal shelf area require more pressure. Frank used a pressure gauge to examine the difference in pressure produced by different impression materials like irreversible hydrocolloid, polysulfide impression material, and zinc oxide eugenol impression material and also studied the effect of tray modifications. They found that zinc oxide eugenol was the choice of material and tray border molded with modeling paste, with relief space and escape holes resulted in selective pressure application.[9]

The aim of selective pressure impression technique is the long term support for denture thereby safeguarding the residual alveolar ridge. This is achieved by directing the forces of occlusion or mastication on to those areas that are resistant to remodeling changes and relieving those areas that are vulnerable to resorption. Nevertheless, there is a

Table 4: Multivariate analysis (mandibular arch) tests of between-subjects effects dependent variable: PRESS

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power
Corrected model	3762.554	26	144.714	125.502	0.00	0.97	3263.064	1.000
Intercept	108618.804	1	108618.804	94199.329	0.00	0.99	94199.329	1.000
space	816.920	2	408.460	354.236	0.00	0.87	708.472	1.000
Holes	1883.435	2	941.718	816.702	0.00	0.94	1633.404	1.000
Velocity space	873.913	2	436.957	378.949	0.00	0.87	757.898	1.000
Holes space	103.123	4	25.781	22.358	0.00	0.45	89.433	1.000
Velocity holes	20.036	4	5.009	4.344	0.00	0.14	17.376	0.92
Velocity space	18.155	4	4.539	3.936	0.00	0.13	15.745	0.89
Holes velocity	46.972	8	5.871	5.092	0.00	0.27	40.736	0.99
Error	124.532	108	1.153					
Total	112505.890	135						
Corrected Total	3887.086	134						

scarcity of data that states about the precise and sufficient amount of pressure to be applied, amount of relief space and escape hole that must be incorporated in order to reduce the hydrostatic pressure caused by the impression material. Hence, this study was designed to throw some light on the issue regarding the selective pressure impression technique with specific combinations of escape holes, relief space, and seating velocity.

Masri investigated pressure changes produced during maxillary edentulous impression procedures over different areas using current impression materials, with various tray modifications on an oral analog by means of a pressure gauge system. He found medium body vinyl polysiloxane and irreversible hydrocolloid produced the highest pressures, while light body vinyl polysiloxane and light body polysulfide impression materials produced the lowest pressures. He did not find any significant changes in pressure produced withtray modifications and hence did not consider it as a significant factor.[10]

The biologic considerations for mandibular impressions are usually dissimilar than those for maxillary impressions. The reasons are, the basal seat being different in size and form than in maxilla, the nature of the supporting bone on the crest of the residual ridge, and the submucosa of the mandibular basal seat contains different anatomic structures than those seen in the maxilla. Hence, it is important to modify the impression procedures in case of mandibular impressions.[8,9,10]

Komiyama et al[11] found that an escape hole 1.0 mm or larger, a spacer with thickness of base plate wax sheet, can be used to selectively reduce palatal impression pressure while making an edentulous maxillary impression. They suggested that application of a spacer thickness varying from single spacer to double spacer, considerably lessens the amount of pressure exerted on the denture supporting area.

Similarly Frank et al[9] in their in vitro study demonstrated that the introduction of spacing and perforations reduces pressure under impressions. Masri R et al[10] and Al-Ahmad et al[12] in their studies on impression pressures in vitro in the maxilla and mandible, respectively by using oral analogue models and manual recording of the pressures, established the role of relief space, escape holes, and seating velocity in reducing the pressures exerted on denture supporting areas and most of the studies have suggested that spacer design has a more significant role than escape holes.

In respect to each group containing variables of spacer and holes, statistical analysis reveals that the minimal pressure is always attained with 60 mm/min seating velocity (60V). A close inspection of the results also show that a double spacer (DS) with 2 mm escape hole (2H) even at 180 mm/min velocity (180V) shows significantly lesser values than a single spacer (SS), with same dimension of escape hole (2H) even at 180 mm/min velocity (180V).

The same applies when even with single spacer (SS) with 2 mm escape hole (2H) at 180 mm/min seating velocity (180V) exerts a significantly lesser pressure as compared to single spacer (SS) with no hole (0H) at 180 mm/min velocity (180V).

Further extrapolation of the results consistently show that when no holes (0H) are present, irrespective of spacer design, the pressures exerted were significantly in the highest ranges, whereas when 2 mm relief holes (2H) are applied, there is a reduction of pressures exerted. However, this parameter seems to be, from the results obtained, not as significant in reducing pressure on denture bearing areas as much as spacer design. Applying a spacer thickness varying from single spacer (SS) to double spacer (DS), significantly reduces pressures exerted on the denture supporting area and is found to be a critical and paramount factor in reducing pressures under denture bearing area.

CONCLUSION

All the three factors relief space, escape holes, and seating velocity has a significant influence on the amount of pressure exerted on denture supporting areas. Among which spacer design parameter has more vital role than escape holes..

REFERENCES

1. Inoue S, Kawara M, Iida T, Iwasaki M, Komiyama O. Influences of differences in tray design and impression material on impression pressure at edentulous mandible. *J of Oral Science*. 2017;59(4):505-10.
2. Jain AR, Dhanraj M. A clinical review of spacer design for conventional complete denture. *Biol Med.* 2016,8:5.
3. Gupta A, Singhal P, Negi P. Selective pressure impression technique: An overview. *J Evol Med Dent Sci*. 2014;3: 8110-4.
4. ImaniFouladi T, FallahTafti A, Kamran L, Hoseain M, Mostafapour R, Sadegh Pourshahab M, et al. In Vitro effect of vent size and spacer thickness on pressure produced during maxillary edentulous impression making by different impression materials. *Journal of Islamic Dental Association of Iran*. 2016;28(1): 40-7.
5. Rameez M, Razi S, Farhan F, Kumar B, Rashid H. Clinical implications of elastomeric impression materials used for complete denture construction. *Dent Med Res*. 2018;6:19-23.
6. Tripathi A, Saumyendra V. Singh, Aggarwal H, Gupta A. Effect of mucostatic and selective pressure impression techniques on residual ridge resorption in individuals with different bone mineral densities: A prospective clinical pilot study. *The Journal of Prosthetic Dentistry.* 2019;121(1): 90-4.
7. Daniel S, Daniel AY, Kurian N. A modified physiologic impression technique for atrophic mandibular ridges. *Chrismed J Health Res.* 2017;4:204-8.
8. El- Khodary NM, Shaaban NA, Abdel-Hakim AM. Effect of complete denture impression technique on the oral mucosa. *J Prosthet Dent.* 1985;53(4):543- 9.
9. Frank RP. Analysis of pressure produced during maxillary edentulous impression procedures. *J Prosthet Den*t. 1969; 22:400-13.
10. Masri R, Driscoll CF, Burkhardt J, vonFraunhofer A, Romberg E. Pressure generated on a simulated analog by impression materials in custom trays of different designs. *J Prosthodont*. 2002;11:155-60.
11. Osamu Komiyama, Hiroyuki Saeki, MisaoKawara, Kihei Kobayashi, Shigeo Otaki. Effect of relief space and escape holes on the pressure characteristics of maxillary edentulous impressions. *J Prosthet Dent.* 2004;91(6):570-6.
12. Al-Ahmad A, Masri R, Driscoll CF, von Fraunhofer J, Romberg E. Pressure generated on a simulated mandibular oral analog by impression materials in custom trays of different design. *J Prosthodont.* 2006;15:95-101.

Corresponding Author

Haby Mathew Somson, Senior Lecturer, Department of Prosthodontics, Puphagiri College of Dental Sciences, Tiravalla.

email: marvelviks@gmail.com