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ORIGINAL ARTICLE

Pressure Produced on the Residual Maxillary Alveolar Ridge by Different Impression Materials and Tray Design: An In Vivo Study

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Abstract Increased ridge resorption may occur due to inappropriate pressure applied during final impression making phase of complete denture fabrication. This study was done to evaluate the pressure applied on the residual ridge while making impressions with two tray designs (with and without spacer) using, zinc oxide eugenol and light body polyvinyl siloxane impression material. Five edentulous subjects were randomly selected. For each of the five subjects four maxillary final impressions were made and were labelled as, Group A-Impression made with tray without spacer using zinc oxide eugenol impression, Group B-Impression made with tray with spacer using zinc oxide eugenol impression material, Group C-Impression made with tray without spacer using light body polyvinyl siloxane impression material, Group D-Impression made with tray with spacer using light body polyvinyl siloxane impression material. During the impression procedure a closed hydraulic system was used to remotely measure the pressures produced in three areas. The pressure produced were calibrated according to the micro strain record. Statistical comparisons of readings were done using *t* test and ANOVA. The acquired data revealed that ZOE produced an average pressures value of 26.534 and 72.05 microstrain, while light body PVS produced 11.430 and 37.584 microstrain value with and without spacer respectively. Significantly high values were recorded on the vault of the palate when using trays without spacer. The use of light body polyvinyl siloxane and zinc oxide eugenol impression material showed insignificant difference. Within the limitations of this study, tray design has a significantly effected on the pressures produced, while the impression materials does not have any significant difference.

Keywords Impression pressure · Strain gauge · Impression material · Tray design · Residual alveolar ridge

Introduction

An ideal impression is the one embracing all the denture bearing area, embodying a composite of the tissues at rest without any over compression or displacement. Displacement of soft tissues during impression making may result in residual ridge resorption and loss of retention [1]. Numerous modifications in impression techniques have been suggested in literature for controlling the pressure on the residual alveolar ridge [1–7].

Proponents of selective pressure techniques have recommended certain areas of the residual alveolar ridge to be stressed and certain areas to be relieved. Although various methods have been reported for making selective pressure impressions, a definitive procedure has not been clearly elucidated to control the pressure onto the edentulous ridge. Frank [3, 4] reported that impression pressure could be controlled by tray design and material selection. Komiyama

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et al. [5] suggested escape hole of 1.0 mm, or a spacer of one sheet thickness of base plate wax to selectively reduce pressure. Al-Ahmad [6] evaluated the pressure during edentulous impression making at different locations using a mandibular simulated analog. Rihani [7], measured the pressure using a manometer connected to the custom tray by flexible tubes and reported that the highest pressure recorded was at the centre of the palate.

This in vivo study was done to evaluate the pressure produced on the residual alveolar residual ridge by two tray designs (with and without spacer) using, zinc oxide eugenol and light body polyvinyl siloxane impression material.

Materials and Methods

Five completely edentulous subjects were randomly selected, the study was explained to them and an informed consent was obtained. Maxillary preliminary impressions were made, followed by peripheral sealing and secondary impression, the master casts were poured with type III dental stone. Four special trays were fabricated for each cast using autopolymerising resin [(DPI) RR cold cure India], by dough technique. Of the four trays fabricated two trays were fabricated without the spacer and two trays with spacer of one sheet thickness of modeling wax.

A closed hydraulic system based on Pascal's law was used to remotely measure the pressure produced in the tissue-material interface. The apparatus used to measure the pressure consisted of a tin chamber of length 1 in. and diameter 0.5 in. One end of the chamber was covered with a 49 gauge copper diaphragm and the other side had provision for the attachment of the plastic pneumatic tube of 0.5 mm internal diameter, and 1 m in length. Three transducer units with loading plates were fitted to the special trays, one in the vault of the palate and two units on either side of the alveolar ridge in the premolar area on the crest of the ridge. The special tray with the loading plates and the transducers were connected to the other end of the plastic pneumatic tube. The pneumatic tube was made air tight and filled with distilled water devoid of air bubbles (Figs. 1, 2, 3).

Four secondary impressions of the maxillary arch were made,

Group A: tray without spacer using ZOE impression material (DPI),
Group B: tray with spacer using ZOE impression material (DPI),
Group C: tray without spacer using PVS impression material (Aquasil Ultra LV Dentsply),
Group D: tray with spacer using PVS impression material (Aquasil Ultra LV Dentsply)

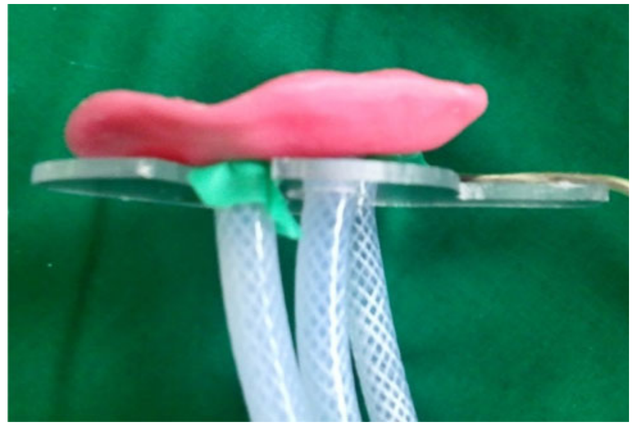

Fig. 1 Impression trays connected to tubes with loading plate

Fig. 2 Impression tray connected to tubes filled with distilled water

Fig. 3 Pressure transducer made of a tin chamber with a copper diaphragm to which a strain gauge is bonded

The impressions were made by the same operator, using finger pressure to seat the tray in position. The pressure was monitored using a strain gauge attached to a plate (Fig. 4). The strain gauge was of 5 mm length, with resistance of 120 Ω and gauge factor of 2.0 ± 0.2 % (Rathna Controls, Chennai. Batch No: SG58635). The transducer deflection gave different microstrain values for the applied unit load.

The pressure was calibrated from the micro strain recorded from the three pressure transducers. After completely loading the tray the first digital reading was recorded and the second reading was recorded after complete placement of tray. The difference in these two readings is the actual microstrain produced during impression making. These digital readings were then subjected to statistical analysis to determine significant differences in the pressures produced.

Statistical Analysis

Comparisons of microstain readings at different reference pressure points, for different impression materials and tray designs were done using *t* test. The pressure between the pressure points was analyzed using ANOVA.

Results

The collected data were analysed using paired sample *t* test and one way ANOVA to test the characteristics of the data. P value <0.01 indicated a significant difference between the variables (Table 1).

The statistical analysis of the acquired data revealed that ZOE produced an average pressures value of 26.534 and 72.05 microstrain, while light body PVS produced 11.430 and 37.584 microstrain value with and without spacer respectively. The use of spacer resulted in significant reduction in the strain values, irrespective of the impression material used with the average values being 26.534 and 11.430 microstrain, Significantly high values of 201 and 295 microstrain values were recorded on the vault of the palate when using trays without spacer The strain recorded did not show any significant correlation between the type of impression material used $P > 0.05$.

Discussion

The study was done to evaluate the pressure applied on the residual ridge while making impression with two tray designs (with and without spacer), using ZOE impression material and light body PVS impression material, both these materials are mucostatic materials causing minimal distortion to the underlying tissues.

The spacer provides space for the impression material and prevents application of pressure by the impression material on the tissue bearing areas. Literature reveals that many authors have advocated the use of spacer, but their design varied based on their understanding of the theories of impression. Advocates of mucostatic impression have clearly demonstrated that mere pressure applied by the impression material causes tissue displacement, residual ridge resorption leading to loss of retention. Evaluation of pressure on the tissue bearing areas has been reported earlier were in vitro studies, so this in vivo study was undertaken with fewer sample.

A closed hydraulic system was used to measure the pressures produced in three areas during the impression procedure and the pressure produced were calibrated using the micro strain recorder. Strain gauges have been used to measure pressure intra orally for more than 60 years [8].The apparatus used in this study was similar to the

Table 1 Pressure exerted by different impression materials and tray design

Combination of material and tray design	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Average	*F* value	*P* value
Group A								
ZOE left	95	75	82	45	71	73.6	72.05	0.001 ($P < 0.01$)
ZOE right	92	82	87	60	56	75.4		
ZOE center	212	230	207	170	190	201		
Group B								
ZOE spacer left	52	64	56	34	51	51.4	26.534	0.001 ($P < 0.01$)
ZOE spacer right	89	47	62	41	40	55.8		
ZOE spacer center	117	165	124	106	127	127.8		
Group C								
Light body PVS left	68	54	64	30	54	54	37.584	0.001 ($P < 0.01$)
Light body PVS right	65	80	85	47	89	73.2		
Light body PVS center	280	190	180	180	195	205		
Group D								
Light body PVS spacer left	68	54	64	30	54	54	11.430	0.001 ($P < 0.01$)
Light body PVS spacer right	35	47	63	37	65	49.4		
Light body PVS spacer center	217	111	107	107	112	130		

Fig. 4 Strain indicator with digital reading

apparatus used by Frank [3, 4], except in this study a bonded strain gauge that gives digital readings were used whereas he had used a un bonded strain gauge as a pressure transducer and an oscillograph for the output mechanism. In 1955 Stromberg [9] used a strain gauge instrument with a gold spring attached to a movable acrylic resin window constructed in the lateral part of the maxillary denture base to measure the force during clenching.

In this study the vault of the palate recorded maximum pressure irrespective of impression materials and tray design used. This study findings were in accordance with earlier studies of, Rihani [7], Masri et al. [1], and Frank [3, 4] and who claimed that the pressure is greatest at the location farthest of its escapement which gradually reduces at the point of escapement. Frank [3, 4] concluded that forces were twice as strong in the vault of the palate than on the crest of the ridge when escape holes were not employed. There was a significant reduction in the pressure produced with spacer while using either of the impression materials. These results are in accordance with earlier studies by Komiyama et al. [5].

Further studies can be conducted by altering the variables like the escape holes for relief, different spacer thickness, different spacer designs and different impression materials.

Conclusion

Within the limitations of this study, it can be concluded that:

- A relief space of one sheet thickness of modeling wax is effectively to reduce pressure exerted on the residual alveolar ridge while making edentulous impressions.
- The pressure applied in the vault of the palate was significantly higher than those produced on the ridge crest which emphasizes the need for vent holes.
- Both ZOE impression paste and light body poly vinyl siloxane produced equivalent pressures during impression making under similar special tray design.

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