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Comparative Evaluation Of Pressure Generated On A Maxillary Arch By Different Impression Materials Through Selective Pressure And Minimal Pressure Impression Techniques: An In Vivo Study

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Abstract:

Introduction: The knowledge of stress bearing and relief areas on the basis of the anatomy and histology led us to presume that placing a spacer and providing escape holes will lead to differential pressure on the surface of maxilla and mandible. Therefore, a study was planned to compare the pressure on mucosa using selective and minimal pressure technique with the incorporation of two impression materials.

Aims and Objectives- The objective of this study was to evaluate the pressure exerted during final impression procedure using two different spacer designs and impression materials on various denture bearing tissues on maxillary arch.

Materials and Methods: 80 impressions were made using two different impression materials on the patient's maxillary arch. Custom trays for selective and minimal pressure technique were designed. Three pressure sensors were placed on the intaglio surface of the special trays, one in the mid palatine area and the other two on the right and left ridge crest. The two impression materials tested were light body polyvinyl siloxane and zinc oxide eugenol. Pressure was recorded as initial pressure and end pressure.

Results: A significant difference in the pressure produced using different impression materials was found ($P < 0.001$). Light body polyvinyl siloxane produced significantly lesser pressure than zinc oxide eugenol impression materials. The presence of relief did affect the magnitude of pressure at various locations.

Conclusion: On the basis of the study the design of spacer, escape holes and the two type of impression materials produced significant pressure during impression making.

Keywords: Impression material, Sensors, Pressure, Spacer designs.

Introduction

According to Boucher's there is no single 'best' impression technique. The variety of impression materials and the range of working characteristics of these materials, make possible the development of impression procedures best suited for the specific condition in each area in a given mouth.

As the impression is a critical step in determining the fit, esthetics, comfort, and efficiency of the denture.[1] An accurate impression will help to ensure the fabrication of stable, retentive, and comfortable complete denture with efficient masticatory ability. This outcome is enhanced by paying enough attention to the pressures produced during the final impression. Hardly any research work has been done to prove or disprove the advantages of the various impression techniques and different impression materials on the compression of the muscoa.

Therefore, a need was felt to evaluate the effect of various impression materials and different tray designs on the pressures exerted on the denture bearing tissues. A study to validate the existing beliefs was planned to compare the pressure on mucosa using selective pressure technique and minimal pressure technique, with the incorporation of two different impression materials utilizing the pressure sensors during secondary impression procedure.

Materials And Methods

The present In Vivo study was conducted in the Postgraduate Department of Prosthodontics Babu Banarasi Das College Of Dental Sciences after ethical clearance and informed consent from subjects. The pressure on different areas of denture bearing mucosa was gauged using the Force sensitive resistor (Model FSR400) diameter (active area of the resistor) of FSR was 0.2” (5.0 mm) and thickness was 0.012” (0.3 mm). A printed circuit board was used to mechanically support and electrically connect electronic components.

Method:-

Twenty completely edentulous subjects were selected. A primary impression was made on the patient’s maxillary arch using impression compound. The impression was trimmed and primary cast (maxillary edentulous cast) was fabricated in type II dental plaster. A special tray was fabricated using selective pressure impression principles. Border molding was done and 0.5mm of the borders recorded were scraped to allow for the final wash impression of the maxilla.

Fabrication Of Special Trays-

1) **Minimal Pressure Technique**: A single modelling wax sheet was softened and adapted over the entire tissue surface of the master cast. The wax sheet is then cut 2 mm short of the sulcus depth of cast. Four tissue stops measuring 2x2mm were made in the spacer, two in canine region and two in molar region bilaterally at crest of ridge. The acrylic resin was manipulated in the dough stage and adapted on the cast with spacer to form a fully extended special tray of uniform thickness. The special tray was finished and polished after setting. The spacer wax removed from special tray and relief holes of uniform diameter of 2mm were made with a round bur throughout the special tray.

2) **Selective Pressure Technique**: Another I shape wax spacer was adapted over the cast and extended antero-posteriorly from incisive papilla to fovea palatine along midpalatine raphe. acrylic resin is mixed as mentioned above and a fully extended special tray is fabricated. The spacer wax was removed from the special tray and relief holes of uniform diameter of 2 mm were made with a round bur in the midpalatal raphe region of the special tray.

NOTE- After removing the spacer from both the special trays and making relief holes three cuts or slits were made on the special tray, two at the crest of the ridge bilaterally and one at the mid palatine raphe region to make space for the sensors, through which the sensors and wires can pass through and which are connected to the circuit board.

RECORDING THE SECONDARY IMPRESSION-

Under controlled conditions of temperature and humidity, the three force sensitive resistors, enveloped in customized very thin plastic, were placed on the special tray - two over the crest of ridge bilaterally in molar region and one at the centre of midpalatine raphe region. Two impression materials namely Zinc oxide eugenol impression paste and light body (polyvinyl siloxane) were used for wash impressions.

The zinc oxide eugenol impression paste was loaded onto the special tray covering the entire border and placed immediately on the patient’s maxillary arch with pressure sensors. Pressure readings were noted in all the three pressure sensors from the time of placement of tray intraorally till final set.

Similarly, light body addition silicone was used for making final impressions with both trays as per manufacturer’s instructions and the pressure readings were noted.

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Selection Criteria:

Inclusion Criteria:

1. Maxillary edentulous patients with well round arch.
2. Patients within the age of 50-70 years irrespective of gender.
3. Patients willing to undergo prosthetic rehabilitation.

Exclusion Criteria:

1. Patients with any known systemic conditions affecting patient's compliance for the study.
2. Patients with allergy to any chemical substance and/or material used in study.
3. Patients with insufficient inter-arch space to accommodate the equipments and instruments required for the study.

Five completely edentulous subjects were randomly selected, the study was explained to them and an informed consent was obtained. A primary impression was made on the patient's

maxillary arch using impression compound. The impression was trimmed and primary cast

(maxillary edentulous cast) was fabricated in type II dental plaster. The cast was retrieved after its final set according to the manufacturer's instructions. The maxillary cast thus obtained was trimmed and finished using a model trimmer. A special tray was fabricated using selective pressure impression principles. Border molding was done and 0.5mm of the borders recorded were scraped to allow for the final wash impression of the maxilla. Master cast was poured using type III stone.

GROUPING OF SAMPLES-

Number of samples- 80

Total of forty samples were made as per following distribution-

Group I consists of impressions made with Zinc oxide eugenol impression paste

Group II consists of impression made with light body addition silicone

10 readings are noted immediately after placement of loaded special tray (initial pressure) and then 10 readings are noted after final set with each of impression materials (end pressure) using the minimal pressure technique.

The same procedure is repeated with selective pressure technique as per manufacturer's

instructions and 10 initial readings are noted till final set for Group I and II each.

Readings were noted immediately after the placement of loaded special tray on maxillary analog denoted as initial pressure and then readings were noted after final set of impression materials denoted as end pressure for each sample of different groups. For each sample, three readings at locations S1, S2, and S3 were recorded.

Results

Out of 80 samples included in this study, 40 were prepared from zinc oxide eugenol and comprised the Group I of present study whereas remaining 40 were prepared from light body and comprised the Group II of study. Out of 40 samples in each group, a total of 20 samples each were subjected to minimal pressure application and comprised the subgroup A of the study while remaining 20 samples each in both the groups were subjected to selective pressure application and comprised the subgroup B of the study.

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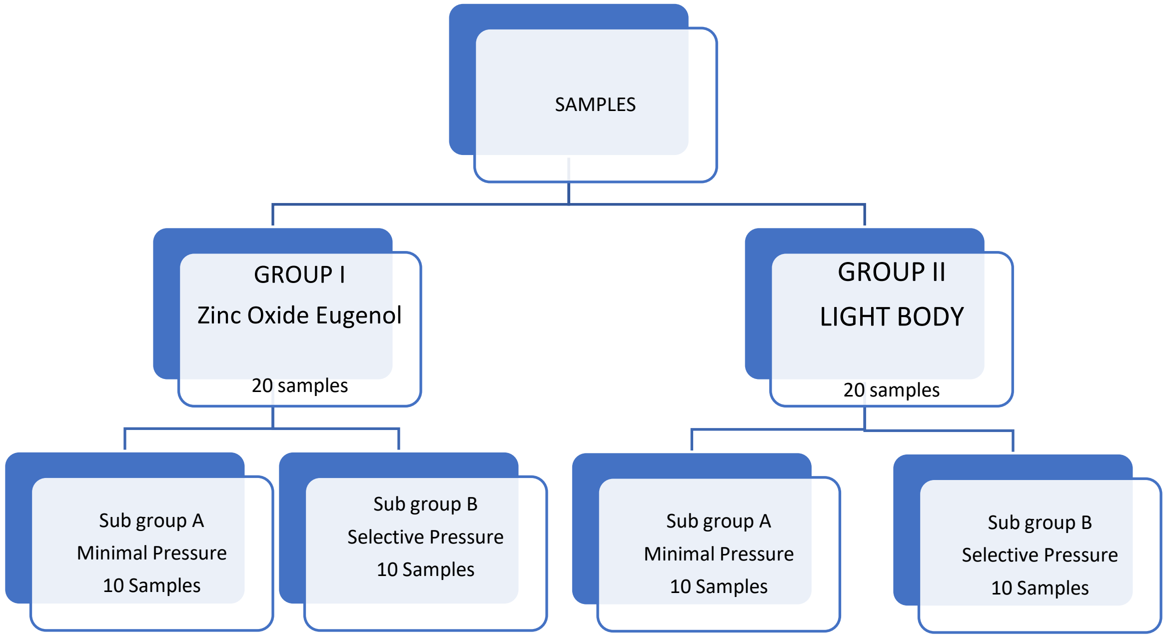

With minimal pressure application on comparison of Group I and II, a significant (p=0.0001) difference in initial pressure between the two groups was observed at S3 location where values in Group 1 were observed to be of higher as compared to Group II. [Graph 1]

With selective pressure application on comparison of Group I and II, a significant (p=0.02) difference in end pressures between the two groups was observed at S3 location. [Graph 2]

On comparison of pressure at different locations between minimal and selective at initial and end pressure in Group 1, a significant difference in initialpressure was observed at S1 (p=0.03) and S3 (p=0.002) location.[Graph 3]

On comparison of pressure at different locations between minimal and selective at initial and end pressure in Group 2, a significant difference in initial pressures was observed at S2 (p=0.01) and S3 (p=0.04) location. [Graph 4]

Discussion

An impression should fulfill M.M. Devans dictum. "It is perpetual preservation of what already exists and not the meticulous replacement of what is missing.[2] Success of complete denture largely depends on accuracy of impression.

The important objective of complete denture impressions as outlined by Boucher seems to be quite adequate; (1) retention, (2) support, (3) stability, (4) esthetics, (5) preservation of the residual ridges.[3] These objectives can be best fulfilled by a thorough understanding of the oral anatomy and histology of the patient and by an impression technique and material that will most accurately record these structures with minimal displacement of tissues.[4] The pressure applied during the impression procedures has its ill effects on the denture bearing tissues too. According to **Page** soft tissues should be registered in rest position as any other position will compel the tissues to regain their rest position leading to dislodgement of denture.[5]

The application of pressure during an impression procedure is partly due to the viscosity of impression material and partly due to the approximation of the tray to the oral tissues. When a tray is loaded with impression material and placed in the mouth against the tissues without pressing against them, the material does not record the tissue details and contours as it does not flow over the tissues. Hence pressure makes the material flow and facilitates intimate tissue contact. This intimate tissue contact aids in fulfilling a very important objective of impression making that is retention.[6]. On the other hand, the application of pressure on the denture bearing areas is not only confined to the soft tissues but has its influence on the underlying bone. On application of pressure there is mucosal displacement after which a strained equilibrium is established, and alveolar bone is subjected to tensile and shear stresses.[7] These stresses cause harmful effects on the alveolar bone even leading to accelerated bone resorption.[8,9]

The amount and location of pressure produced during impression making is pertinent and if controlled, may help to produce a sufficiently stable and retentive prosthesis. Numerous modifications of impression techniques have been suggested for control of impression pressures. These include the mucostatic (nonpressure) technique, the selective pressure technique and the functional (mucocompressive) technique.[10,11,12,13]

No pressure is applied during mucostatic impression technique, thus preserving the underlying tissues but intimate tissue contact is not established.[13] Although most criticized aspects of the mucostatic principle is the lack of flanges that would lead to compromised retention.[11]

In contrast, a mucocompressive impression technique compresses the underlying tissues in a similar manner to the way in which the resultant denture will compress the underlying tissues. In this fashion, the resultant occlusal forces will be more evenly distributed across the denture bearing tissues.[14,15,16] However an impression technique that theoretically places the supporting tissues under constant pressure when the tissues are actually subjected to biting forces for only a few minutes every day is found to be irrational.[17,18]

Hence in practice, “selective pressure” technique could be considered most ideal impression technique for “conventional dentures”.[19]

Also there has been considerable disagreement regarding the placing of pressure, relief, and post dams in maxillary impressions.[20]The important consideration is that relief must be provided selectively to minimize the pressure against the various areas of the palate. All these considerations are required in a selective pressure technique.

Woelfel concluded in his study that the placement of spacers and escape holes in an impression tray are far more important factors in producing an excellent final impression than is the choice of a corrective wash material. He reinforced that they should be modified differently to meet the requirements of the specific type wash material used.[4]

Hence this study was undertaken to evaluate the pressures generated upon the edentulous maxillary residual. The pressures applied on the stress bearing areas that is the crest of ridge and relief area that is the mid palatine raphe were evaluated. This anatomy dictates the placement of our three pressure sensors.

Zinc oxide eugenol impression material was used for wash impression in the study as it has been commonly used impression material with satisfactorily functioning dentures.[4]

The second material used was light body addition silicone which is well known to exert less pressure on the underlying tissues and to record excellent details.[21]

In this In Vivo study it was found that in minimal pressure application, for both impression materials, there was statistically significant pressure difference between S1 and S2 locations (both initial and end pressure) and S2 and S3. Findings also suggest that pressure were slightly higher on S3 than S1. This difference may be due to difference in digital pressure during impression making.

On comparison of Group I and Group II, a significant ($p = 0.0001$) difference in initial pressure between two groups was observed at S3 location where values in Group 1 were observed to be of higher as compared to Group II.

While in selective pressure technique the pressure was measured at S1 and S3 (crest of the ridge) were significantly higher than those measured at S2 (mid palatine raphe). This could be attributed to the placement of relief holes at mid palatine raphe region and absence of relief holes at the crest of the ridge.[22]

On comparison of pressure at different locations between the groups at initial and end pressure (selective pressure application). On comparison of Group I and II, a significant ($p=0.02$) difference in end pressures between the two groups was observed at S3 location.

The pressures recorded with Zinc oxide eugenol impression paste were significantly higher than those recorded with light body addition silicone in both minimal pressure as well as selective pressure. The pseudoplastic property of light body causes its viscosity to decrease with increasing stress rate. Hence when force is applied over the material it tends

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to flow more, this property might be leading to lesser pressures exerted by it than those exerted by zinc oxide eugenol impression paste.[23]

A similar study was conducted by Chopra et al in 2016. The study was In Vitro and performed using a maxillary analog.[24] Our findings of least pressure at mid palatine raphe region are consistent with those given in this study. The lowest pressure readings at S2 region i.e. mid palatal raphe region is mainly due to escape holes made in those regions particularly.

Similarly, our findings were supported by Frank. He had tested the effect of tray modification on pressure production and found that pressure varied with the viscosity of the impression material and the presence or absence of relief and escape holes in the tray. In unrelieved custom trays, pressure was greater over the ridge crest than over the palate.[22]

On comparing all our samples, initial pressures at all the locations were found to be higher than the end pressures and this difference was found to be statistically highly significant ($p = 0.0001$). the reduction of end pressures with the placement of relief holes and variation in spacer designs can be attributed to the fluid nature of impression materials and due to the presence of escape holes and space at the periphery of the tray, the material begins to flow out, hence reducing the pressure with time. As soon as the loaded tray is placed on the tissues and pressure is applied, it exerts maximum pressure due to its highest volume. But as the material is fluid, it begins to flow under the hand pressure owing to its low viscosity ending up in a thin layer of film over the tray and soft tissues consequently the pressure on the underlying tissues begins to reduce until it becomes negligible depending on the flow and viscosity of the material, and the pressure exerted during impression procedure is mainly hydrostatic pressure, once the material sets there is hardly any hydrostatic pressure.

Thus the results show that minimal pressure could be best achieved with the use of light body addition silicone material.[21,25] As per our study the role of varying the spacer designs or placing holes in the special trays as well as the impression material has been shown to be significant on the end pressures which determine the final state of tissues below the denture.

A similar kind of study was done by **Masri** et alusing pressure transducers on a simulated oral analogue.[26].Contrary to our study, Masriet al. believed that the tray design was not clinically important in controlling the pressure produced. However, as per our study, the role of varying the spacer design or placing escape holes in the special tray as well as the choice of impression material has been significant on the pressure which determines the state of tissues below the denture.

Conclusion

On the basis of this in Vivo study, the following conclusions have been drawn:

1. End pressure in both groups with both tray designs are significantly lower than the initial pressures and were of very low value. Therefore, it may be concluded that once material is set, it exerts least pressure on the tissues.
2. In the minimal pressure technique, the difference of pressures at different locations of denture bearing area is practically insignificant.
3. In the selective pressure technique, the pressure is significantly higher at crest of the ridge (stress bearing area) than at the midpalatine raphe region (relief area).
4. The pressures recorded with light body addition silicone are lower than those recorded with zinc oxide eugenol impression paste at all the three locations.
5. These findings in the present study show that the design of spacer and the use of escape holes as well as the type of impression material have a significant influence on the pressure exerted on the denture bearing area during the secondary impression technique.
6. Therefore, light body poly vinyl siloxane impression material may be recommended to achieve minimal pressure on the denture bearing tissues in both selective as well as minimal pressure techniques.

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