Effect of Relief Space and Vent Holes on the Pressure Patterns in a Simulated Oral Analogue using Custom Trays of Various Designs. - An In Vitro Study.

A dissertation submitted to the

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CERTIFICATE.

This is to certify that this dissertation titled

"EFFECT OF RELIEF SPACE AND VENT HOLES ON THE PRESSURE PATTERNS IN A SIMULATED ORAL ANALOGUE USING CUSTOM TRAYS OF VARIOUS DESIGNS. – AN IN VITRO STUDY."

is a bonafide work done by ***Dr. Mohamed Behanam P.A.*** *in partial fulfillment of the award of the degree of Master of Dental Surgery in* ***Prosthetic Dentistry****,Branch VI, of* ***The Tamil Nadu Dr. M.G.R. Medical University, February 2005****, under our guidance and supervision in the Department of Prosthodontics, Saveetha Dental College & Hospitals, Chennai 77.*

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INTRODUCTION

The amount and location of the pressure produced during the making of a final impression for a complete denture is an important factor to be considered, and if controlled, may help in producing a more retentive and stable prosthesis.[1,2]. Various concepts have been proposed for making them which include; *the mucostatic* (non pressure or pressureless) *concept*[3,4,5], *the mucocompressive concept*[6,7], *the selective pressure concept*[8,9,10] and *the functional impression concept*[11-15]. All of these concepts focus on the pressure exerted on the oral mucosa, to improve support, stability and retention and to preserve the integrity of the remaining structures. But yet, a widespread consensus still eludes us as to the application of the same in varying clinical situations for achieving optimum results.

The rationale for controlling the pressures generated on the oral mucosa, is due to the variables in the bone and soft tissue morphology in different areas. The cortical bone at the palatine plate can take functional loads, while the residual alveolar ridge, which is susceptible to resorption[16,17] cannot. Similarly, in the soft tissues, while the firmly bound keratinised masticatory mucosa can withstand the pressure generated during normal function, the non-keratinised alveolar mucosa cannot. The presence of a layer of fatty and glandular submucosa (*Lamina Propria*) of variable consistency and thickness, permits moderate compressibility, while areas such as the *Incisive Papilla* and the *Midpalatine Raphe* have to be relieved to preclude any impingement of the structures underlying the denture base during occlusal loading, thereby minimizing trauma and reducing pressure induced bony remodeling as well as secures proper initial denture support.[18,19,20].

Considering these anatomical factors, the different concepts of impression making have been provided for by modifying the extent and location of relief space and vent holes in the custom fabricated tray for the final impression. To advocate a certain concept based on these anatomical variations alone, however would be inappropriate. Other controlling factors, such as the material used for making the impression and the patient multitude should be considered. This study aims to determine whether the relief space and vent holes, when given, actually translate as a reduction in pressure applied at those areas during the making of an impression, and to compare and qualify among the given tray designs.

An important aspect to be considered is the material used for making the final impression. The viscosity of the material used was found to be more significant than the tray designs in reducing the pressures produced during impression making[21,23]. Hence, in this study, the different tray designs were compared by keeping the viscosity of the material constant, i.e. Using a single impression material, namely zinc oxide eugenol, that being the material of choice for the final impression for decades[24,25]. The study was performed using an analogue of a maxillary edentulous arch and the four areas chosen were i.) Incisive papilla, ii.) Residual ridge, iii.) Median palatine raphe and iv.) Palatine plate, and the stress variations were studied using strain gauge technology.

REVIEW OF LITERATURE

Black GV, 1908.[26]

Classic investigations using a gnathodynamometer to study the maximum biting force and a phagodynamometer to study forces required in the mastication of food, which are one of the earliest studies conducted to measure intra-oral forces.

Stansbury CJ, 1925.[27].

He described a negative pressure method of impression making. He stated that the pressure is greatest at the location farthest from its escapement, gradually lessening until the point of escapement is reached. This was proved by compressing a piece of softened modeling compound, between a flat surface and a slab of artificial stone with a series of holes of equal diameter, placed equidistant from each other. More compound extrudes through the central hole. This demonstrates the aforesaid principle. An impression tray is considered a semi confined chamber, and the pressure exerted by the impression material is dependent upon its distance from its path of escapement, i.e. the borders of the tray. Hence, he claimed that higher pressures would be found in the region of the palatal vault than elsewhere when a maxillary impression is made.

Howell AH, Manley RS, Brudevold F, 1948-51.[28,29,30]

Pioneers in using strain gauges to measure intra-oral forces.

Stromberg WR, 1955 [31].

Devised a new method of measuring forces of the denture bases against the supporting tissues. A strain gauge instrumented gold spring attached to a movable acrylic resin window is constructed in the lateral part of the maxillary denture base and forces measures as the subject clenches.

Frechette AR, 1955 [32].

He studied the masticatory forces associated with the use of various types of artificial teeth using strain gauges upon cantilever beams. Interchangeable posterior teeth segments are fabricated on cast metal denture bases, which are made with carefully located islands acting as cantilever beams. Strain gauges were located at the junction of the islands and metal bases.

Tilton GE, 1956 [33].

A method for making the final impression using minimum pressure has been described. The impression is made in two sections, of the mucofibrous tissue (fixed) – major stress bearing area first and then the mucobuccal and mucolabial (yielding) tissues. The initial modeling plastic impression is made in a suitable tray, and the known excess removed at the borders, notch and the distal extensions. A deep recess is made in the middle in relation to the incisive papilla and the mid palate, the impression heated, reinserted and moulded in the mouth. Relief is made over unyielding tissue at the median line, posterior palatal seal, tuberosity, margin of the malar process and large escape holes are made at the median line and closed with wax. A wash impression is made with zinc oxide eugenol. The paste covering the relief area is uncovered, and filled with very soft plaster, inserted back into the mouth and held under extreme pressure. Functional impression waxes are painted onto the borders in excess, including the PPS and left in the mouth to set for eight minutes. The procedure is similar for the mandible.

Lowson WAL, 1960. [34].

He questioned the validity of the methods used by Stromberg[63] and Frechette[64] and demonstrated through controlled laboratory tests that they were inaccurate. He showed that any cantilever arrangement will allow the test point to move away from the supporting tissue.

Lytle RB,1962 [35].

He studied the soft tissue displacement between removable partial and complete dentures, and stated that, if the resilient palatal tissues are displaced and recorded while making the final impression, it creates unseating forces upon the prosthesis.

Douglas et al,1964 [36].

They studied the pressures occurring while making impressions with various kinds of zinc oxide eugenol pastes upon insertion and removal.The equipment used was a capacitance pressure transducer, which consisted of a sturdy steel body of 0.5 inch dia., a 0.004 inch thick brass diaphragm forming one plate of the condenser and a steel center electrode which was held in position by an acrylic plate. They noticed that the insertion pressure was greater in the patient when the pressure transducer was located in the center of the palate. They found that the impression material was subjected to pressure between 1.4 Ppsi on insertion and 1.6 Ppsi on removal. (Pounds per square inch). Comparison could not be made between pressures at the center of the palate with other areas, as the gauge was mounted at the center for some patients and at the periphery for some others.Due to different vault shapes of the patients, it was impossible to compare the two values.

Avci M, Aslan Y, 1965. [37].

They devised a new hydraulic pressure measuring system to measure pressures under a maxillary complete denture at various occlusal vertical dimensions. The hydraulic system, as the name suggests is a closed system, consisting of a flexible membrane, stimulating the transducers via polyethylene tubes filled with water. They convert hydraulic pressure coming from receptors to electric signals.

Frank RP, 1969.[21]

Frank RP analysed the pressures produced during maxillary edentulous impression procedures with several impression materials – regular mix of irreversible hydrocolloid (IH), thin mix of IH, polysulfide impression material and zinc oxide eugenol (ZOE) impression material using strain gauges. The pressure gauge consisted of a brass tubing with one end covered by a thin flexible membrane, and the other end connected by a polyethylene tube to the unbonded strain gauge. The polyethylene tubing is filled with water, and the free end conveys the change in pressures produced onto the strain gauge. A manual and mechanical method of recording pressures was done. He found major differences in the pressures produced with different materials, the more the viscosity, the higher the pressures produced. Thick mix of IH produced the highest pressure, polysulfide and thin mix of IH were essentially similar, and ZOE produced the least pressure. The initial and end pressures, both showed an increases value at the ridge crest as compared to the palate when no relief was used. Similar findings were got with manual method as well.

Frank RP, 1970. [22]

Frank RP tested the effect of tray modification on the pressure production and found that pressure varied with the viscosity of the impression material and the presence or absence of relief or escape holes in the tray. He measured the impression pressure using trays with five escape holes placed equidistant from each other and provided relief using a base plate wax spacer. This design produced 15-16 Kpa, in comparison to 29 Kpa for trays without holes and relief. In unrelieved custom trays, the pressure was the greatest over the crest of the ridge than over the palate. This was in contrast to the findings of Stansbury[33] and Douglas et al[26].

Collett HA, 1970[2]

He described the factors responsible for retention of a complete denture, and described methods for making the final impression according to the various concepts. The primary forces of retention (adhesion, cohesion, surface tension and capillarity) require close contact to the tissues. Both primary and secondary factors are proportionate to the area covered. The non pressure concept focuses upon recording the tissues at rest, hence does not displace the soft tissues at the borders, hence border seal and secondary factors of retention (atmospheric pressure) are compromised. This impression can be modified to record the borders by using a high fusing modeling compound tray, in which the entire basal seat area is relieved to the desired thickness of the impression material, and a large hole is placed in the center of the palate. Another method would be to use a border moulded acrylic tray, if the amount of space required for the material is small. Pressure and selective pressure impressions are made with low fusing compound, relieved only in the areas requiring relief, with loading done at selected areas. The borders are formed by the final impression material.

Atwood DA, 1971 [17].

The residual ridge resorption(RRR) has been described as a major oral disease entity. The RRR curves in one subject studied over a 19 year period illustrates various principles of variation within a given subject. The anterior vertical RRR in the maxilla was 3 mm during the first 3 years, and immeasurable thereafter, while the mandible, after a dramatic early bone loss, continues to show a steady reduction rate (0.4 mm / yr) to a total of 14.5 mm in 19 years.

Walter J D, 1973 [67].

Described an impression procedure for an edentulous fibrous ridge. The technique follows making a mucosa displaced impression of healthy denture bearing tissues using zinc oxide eugenol in a custom tray without spacer and then recording the fibrous part of the ridge with impression plaster, the custom tray being in two parts.

Kidd et al, 1974 [38].

They studied the variations in the response to mechanical stresses of human soft tissues as related to age. The viscoelastic character of the denture supporting tissue has been described as a) Initial elastic compression, occurring instantly on application of a load. b) Delayed elastic compression, c) Instantaneous elastic decompression upon removal of pressure and d) Continuing delayed elastic recovery. Human tissues may take upto 4 hours to completely recover from a moderate load of approximately 50 kpa for 10 minutes. A change in tissue displace ability can also be demonstrated as being a function of age. A longer period is needed for the recovery of displaced mucosa in elderly people (68-70 yrs) than in younger people (21-27 yrs.). Pressures as small as 0.13 g/mm^2 will displace human soft tissues to 95 % of their resting thickness.

Kelsey CC et al, 1976 [39].

They devised a new method of measuring the pressures exerted against the tissues supporting functioning complete dentures. They used a specially designed diaphragm pressure transducer. Half hard Beryllium-Copper rod is machined to a cup-like case with a diaphragm 0.102 mm thick at one end and a small strain gauge attached to the center with leads taken from it , and the top of the case is sealed with Be-Cu disc with epoxy cement. Instrumented cast metal denture bases with interchangeable posterior segments of different designs were constructed, and the pressure transducers attached to the mandibular denture base gives the signal outputs which were recorded on a direct writing oscilloscope and magnetic tape.

Roedema WH, 1976 [40].

He studied the relationship between the width of the occlusal table and the pressures under the dentures during function using diaphragm pressure transducers. Experimental gold base maxillary and mandibular dentures with four interchangeable occlusal tables were constructed with th emandibular denture containing six diaphragm transducers as used by Kelsey[35]. Carrots and raisins are chewed and the pressures noted on two separate days, five months apart. Calibration of the transducers was done hydrostatically. He concluded that the mean pressure developed at the crest of the ridge (mandible) decreased with a reduction in the width of the occlusal table.

Cutright et al, 1976 [41].

They studied the pressures exerted on the mucosa under a complete denture, using a digital recorder (Sanborn 350). The dentures studied were stable.The pressure exerted varied areawise, and every cycle caused an effective double loading, a large positive pressure was recorded upon loading followed by a large negative pressure upon removal of the load. Non-masticatory pressure values were found to be equal to or greater than the masticatory pressure values. The also varied while chewing foods of different consistency.

Rihani A, 1981.[42]

Rihani A measured the pressures under maxillary edentulous impressions using manometers connected with flexible tubes to the custom tray. Impressions were made of three patients, each with a different palatal vault shapes, namely low, moderately shaped and high. Heat cured clear acrylic resin trays were constructed and grooved to a depth of 0.5 mm at the center line, between the center and the ridge crest, at the ridge crest and at the borders. Flexible polyethylene tubes, of 1.5 mm diameter are adhered to these grooves, filled with water which is coloured by a mouth wash and connected to upright calibrated glass tubes forming simple manometers. Spirit levels attached to the face bow frame are used to keep the position upright. No attempt was made to measure the force per unit area, but simply to compare the relative pressures in different areas. Using zinc oxide eugenol, Rihani found the pressures to be uneven, the highest being at the center of the palate, and these diminished towards the borders, during both open and closed mouth techniques. This agrees with Stansbury[27] and Douglas et al[36], but is in contrast to the findings of Frank[21]. Rihani also stated that the pressures at the border were negligible and the shape of the palate did not affect the distribution of pressures.

Watson, McDonald, 1983. [43].

Regional variations in the palatal mucosa of the edentulous mouth have been described using cadaver studies. The submucosa is very thin at the median palatal suture and should not be loaded. The epithelium is the thickest (251.6 μm) and the rete pegs longest at the crest of the ridge. The epithelium is the thinnest (163.5 μm) at the paramedian sites. The connective tissue thickness is the greatest at the region halfway between the crest of the ridge and the midline.

Klien IE, Goldstein BM, 1984 [44].

They enumerated the physiological determinants of primary impressions for complete dentures. A technique has been described whereby a physiologic registration of the attached and unattached tissues of the denture bearing areas can be made. A low fusing impression wax in conjunction with modeling compound has been used.

Klien IE, Broner AS, 1985 [25].

They put forth a secondary impression technique to minimize the distortion of the ridge and border tissues. They enumerated the inadequacies of the mucostatic concept and the tissue loading concept. The primary impression is made with modeling compound and a clear acrylic resin tray is fabricated. This tray is tried in the mouth to check for blanching, and if found, the tray is relieved at those areas. Vent holes are placed at the anterior palate, labial and buccal flanges and the posterior lingual flange on the mandible. They also stated that the impression material of choice was Zinc oxide eugenol.

El Khodary NM et al, 1985 [45]

They studied the effect of complete denture impression technique on the oral mucosa. Thirty edentulous patients (Age 40-63), divided into three groups, received a complete denture made with Minimal Pressure impression, Maximum Pressure (Biting) impression and a Functional impression. Periodical clinical exam was done every 3 weeks for 6 months. A biopsy was done at the premolar area, before insertion of the denture and after 6 months of use, and subjected to histopathological and histochemical analysis. No definite clinical changes were observed. Disturbed keratinisation, increased mononuclear inflammatory cells, decreased activity of succinic dehydrogenase and alkaline phosphatase enzymes , with increased activity of acid phosphatase and increased deposition of PAS, were found in the Maximum pressure technique, all due to displacement of the supporting mucosa resulting in circulatory disturbances. The functional impression technique showed increased alkaline phosphatase activity, due to the stimulating effect of the atraumatic denture base movement within physiological limits. They concluded that dentures made with functional impression were most protective, those with minimum pressure were satisfactory and those fabricated with biting pressure technique affect the mucosa unfavourably.

Fehling et al. 1986.[46].

They studied the dimensional stability of autopolymerising acrylic resin custom impression trays. 20 mandibular arch shaped trays were evaluated for dimensional changes. Linear dimensional changes occurred through out 6 hours, suggesting any impressions made in a PMMA custom tray should be poured as soon as possible. Significant linear dimensional changes were observed for only 40 minutes from the initiation of tray fabrication. While an aged tray is preferred, it is acceptable to make impressions in custom trays after 40 minutes from its fabrication.

Watson CJ, Hugget R, 1987 [47].

They recorded the pressure at the denture base – mucosa interface in complete denture wearers. Four regions were studied, namely the midpalate region in the upper, labial to the midline, left and right first molar region in the lower. Different values for pressure were obtained for different foods, and the younger subjects with short chewing cycles gave the nost reproducible values.

Dubrul EL, 1988. [48].

The palate is covered by firmly bound, keratinised or parakeratinised masticatory mucosa, capable of withstanding functional loading. It is of variable consistency and thickness. The submucosa is resilient, and anterolaterally has adipose tissue, while posterolaterally, it has glandular tissue.

Age often shows narrowing of the arch in the edentulous maxilla. This shrinkage is negligible in the molar region, and may be pronounced in the incisor, canine and premolar region.

Kamano F et al, 1990. [49].

They studied the effect of visco-elastic deformation of soft tissue on the stresses in the structures under a complete denture. The three dimensional model of the supporting structures was constructed and the study performed using the Finite Element Method. The time dependency of stress distribution in the supporting structures were simulated under three loading conditions. The results indicate that the viscous flow of the soft tissues and the loading position determine stress intensity in supporting structures under the denture.

Michael CG et al,1990.[50].

They compared the occlusal forces during chewing in denture wearers using two interchangeable occlusal schemes of posterior teeth, one with a 0 degree cuspal inclination, and the other with 30 degrees. Also, a comparison of chewing forces and the maximum biting strength between complete denture wearers and natural dentition subjects was done. The forces were measured using 4 strain gauge diaphragm pressure transducers (as described by Kelsey[39]), placed in the maxillary denture at the crest of the ridge. The maximum bite strength was measured using a strain gauged gnathodynamometer. The bite strength of natural dentition subjects was found to be 4.5 times greater than that of complete denture wearers. No statistical difference was found in chewing forces between non-anatomic and anatomic teeth.

Zarb et al, 1992 [18,19,20].

Denture supporting tissues include the soft tissues and the underlying cortical and cancellous bone. The denture bearing area in the maxilla, covered by the masticatory mucosa is keratinised and this firmly bound mucosa can withstand the pressure generated during normal function, which the non-keratinised alveolar mucosa can not tolerate. Excessive trauma to the mucosa beneath the denture can lead to abnormal changes such as development of localized hyperkeratoses, epithelial ulceration and necrosis. The presence of a layer of fatty and glandular resilient sub-mucosa (lamina propria) of variable consistency and thickness, permits moderate compressibility without mechanical impingement of the mucosa between the denture base and the underlying bone. However, some areas like the median palatal suture and the incisive papilla should be relieved during function to minimize trauma and reducing pressure induced bony remodeling, as well as secures proper initial denture support.

Ishizuka I, Mizokami T, 1993 [51].

They studied the relationship between the pressure supportability of the prosthesis with the impression method employed to record the mucosa. They found that the pressure supportability generally increased with increasing impression pressure. The maximum pressure supportability, calculated based upon the area projected from the occlusal plane, required impression with 1.24-2.44 kg/cm^2 [0.12 – 0.24 Mpa].

Robert JS et al, 1993. [52].

They studied the cytotoxicity of 6 impression materials namely, polyether, polysulfide, vinyl polysiloxane(PVS), zinc oxide eugenol (ZOE) and two types of irreversible hydrocolloids(IH). The cytotoxicity was studied using the African green monkey kidney cell culture. Three methods of testing the toxicity have been described, and the results indicate the cytotoxicity of the given materials in the following descending order ; Polyether, ZOE, PVS, IH, Polysulfide.

Breeding et al., 1994 [53]

They studied the mechanical properties and stress distribution patterns in acrylic custom trays. The measurement of the mechanical properties allows comparison between various tray materials and is useful in interpreting data on stresses incurred during the removal of the completed impression. They stated that the dimensional stability is an important factor in determining the accuracy achieved – they must remain stable over a period time, and must not exhibit permanent deformation when a completed impression is removed from the oral cavity. Thermoplastic resins showed lower values for strength and modulus of elasticity, than visible light cured (VLC) and autopolymerised poly methyl methacrylate (APMMA) resins.

Breeding et al., 1994 [54].

Studying the removal forces of the completed impression, they stated that it was easier to remove a completed impression made with a custom tray, by a single point of application of force anteriorly (224 N), than by even an force all around the tray (514 N).

Breeding et al., 1994 [55].

Stress distribution during tray removal was predicted by constructing a simple mathematical model. This was coincident with the results found in the analysis, that the stresses produced would be considerably lower than the yield stresses for VLC and APMMA resins. The stresses were sufficiently low for thermoplastic resins as well, but closer to their yield stress.

Abdel Hakim et al, 1994 [56].

They studied the displacement of border tissues during the final impression procedures. Two different impression procedures were used, border moulding with modeling plastic and final with medium body polysulfide, and border moulding with tissue conditioners and final wash with light body polysulfide. Each impression was made thrice for the same patient and in all five patients were studied. The comparison of the profiles of the casts at the premolar and molar coronal sections showed that I) there was not much to compare between the two II) the peripheral tissues were readily displaced by even the least manipulation in both the techniques.III) the second procedure is recommended over the first, because of the convenience to the patient and time efficiency.

Watson CJ, Wahab AMD, 1994 [57].

They showed the development of an inexpensive pressure transducer for use at the denture base – mucosal surface interface. The load transfer is through the use of a diaphragm and the transducer has a wide array of applications for pressure studies in the mouth.

Weng & Khlevnoy, 1995 [24].

They studied the effect of pressure on the different areas in the mouth, and reported that the areas requiring little pressure are the palate, the residual alveolar ridge and easily displaceable gingiva. The areas that require more are the border seal areas, buccal shelf, against the retromylohyoid fossa. The material of choice for the final impression in most instances is Zinc oxide eugenol.

Felton DA et al,1996. [58].

They enumerated a predictable impression procedure for complete dentures. The three basic philosophies of impression making, namely the low pressure technique, the functional technique and the selective pressure technique has been explained. They stated that the fabrication of the custom tray is critical to the final outcome, the three M's of a successful denture impression, Mold – tray, Method – technique used and Material used. Foe making the final impression, the selective pressure impression, advocated by Boucher selective pressure technique advocated by Halperin et al have been described. The Boucher technique uses a 1 mm baseplate wax relief over the entire basal seat area with the custom tray contacting the mucosa 2-3 mm short of the periphery, which is border moulded and the impression made. The Halperin technique, provides 1 mm thick relief over the peripheral extension and the buccal slope extensions of the tray including the posterior palatal seal region, and the custom tray remain in intimate contact with the basal seat areas.

Inoue et al, 1996. [59].

They did an in vitro study on the influence of the occlusal scheme used in the complete denture on the pressure distribution in the supporting tissues. Lingualised occlusal scheme was compared with balanced occlusion, using 16 impedance pressure transducers (5 X 5 X 1 mm). The complete dentures fabricated with lingualised occlusion were found better in transmission of uniform loads onto the supporting tissues.

Mori S et al, 1997. [60].

They studied the effect of continuous pressure on the histopathological changes in denture supporting tissues. They showed that continuous pressure caused irreversible bone resorption, while intermittent pressure allowed recovery partly. The epithelium and lamina propria recovered after removal of the pressure.

Ten Cate AR, 1998 [61].

Histologically, the oral mucosa is of three types, the masticatory mucosa (covering the gingival and hard palate), the lining mucosa and the specialized mucosa. The masticatory mucosa is tightly bound by the lamina propria (corium), and heavily keratinised to withstand constant pounding by the food bolus. The submucosa contains fat and minor salivary glands. The crest of the residual alveolar ridge in the maxilla is composed of compact bone. It is traversed by numerous nutrient canals of the haversian system. The crest is histologically suitable to take functional loads.

The age changes in the mucosa can be attributed to systemic disease, drug therapy, senility or all of the above. Thinning of the epithelium, decreased cellularity, increase in collagen in the lamina propria, dryness of mouth, burning sensations, abnormal taste etc. are some of the changes associated with age.

Kikuchi M et al, 1999 [62].

This study examined the effect of the texture of the fitting surface of the denture base on retention . A specially designed strain gauge force transducer and pen-chart recorder were used were used to record forces required to dislodge mucosa supported palatal denture bases, first without and then with air abrasion of the tissue surface. They concluded that while good adaptation of the denture base is important in retention, additional improvement can be accomplished by air abrading the fitting surface.

Ohguri T et al, 1999 [63].

They studied the influence of different occlusal schemes on the pressure distribution under a complete denture. Simulated maxillary and mandibular complete dentures with three different posterior occlusal schemes, fully balanced, lingualised and monoplane occlusion were compared for pressure distribution using eight diaphragm pressure transducers, 6 mm in dia., 0.6 mm height, placed in the mandibular denture. Food of three consistencies, soft, peanuts and carrots were chewed and the forces measured. They concluded that with fully balanced and lingualised occlusion, a large occlusal force is not needed for crushing hard food and the stress to the supporting tissues is smaller than with monoplane occlusion.

Kawasaki et al, 2001. [64].

They studied the relationship between the stress distribution and the shape of the residual alveolar ridge, the three dimensional behaviour of a lower complete denture. The maximum stresses were distributed on the residual alveolar ridges, and with distal loads, the stresses increased on the inclined planes of the posterior ridge.

Masri R, Driscoll CT et al, 2002.[23]

They studied the pressure generated on a simulated oral analogue by three different impression materials in custom trays of different designs using indirect transmission of the load through tubes filled with water onto pressure transducers. They tested four impression materials namely irreversible hydrocolloid, light body and medium body polyvinyl siloxane and polysulfide, in custom trays with/ without relief space and vent holes. They concluded that during all impression making procedures, the pressure exerted depends more on the viscosity of the material used. The tray modification was not important in changing the amount of pressure exerted.

Rignon et al, 2002 [65]**.**

They compared the displacement seen in oral tissues while making two types of reline impressions using a three dimensional measurement system. The reline techniques were using occlusal pressure (closed mouth) and digital pressure (open mouth). 10 subjects were studied, and the reference cast was made from the existing denture base. They found that the displacement seen was essentially equal, with the greatest difference being seen at the retromolar pad and the lingual flange region.

Osamu Komiyama et al,2004 [66]**.**

They evaluated changes in impression pressures produced by different types of relief space and escape holes in the custom impression tray using a simulated analogue of a maxillary edentulous arch, with a miniature pressure sensor at two points, namely the left 1st molar area and the midpalatal suture. Polyvinyl Siloxane impression material was used. The initial pressure obtained was significantly higher when no hole and no spacer, or a hole less than 1 mm was used. But with the presence of a spacer more than 1.4 mm, lower values were obtained. They concluded that, for impressions of the edentulous maxilla, a tray with escape holes of 1 mm or larger or a spacer of 1.4 mm should be used.

CONCLUSION

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

- A relief space of 1 mm and vent holes of diameter 2 mm in the custom tray can be used effectively to reduce pressure exerted while making edentulous impressions.
- Vent holes are more efficient to control pressure, but relief space can be used to selectively load given areas.
- The usage of relief space or vent holes or both should be based upon sound clinical experience and judgement.

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