International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

The Influence of Implants Number and Distribution on the Load Transmitted to the Palate for Implant Assisted Maxillary Overdentures

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Abstract: ***Statement of problem:** There is little information as to how the number and distribution of implants affect the amount of load transmitted to the palate in implant-assisted maxillary overdentures. Purpose: Evaluate the difference in the load transmitted to the palate at different implants number and distribution. **Materials and Methods:** six overdenture bases were fabricated to fit an average sized edentulous maxillary replica with different implants number and distribution using positioner attachments. A force-measuring sensor was used to measure the force transmitted to the palate when static force of 110 and 220 N were applied on the denture bases. Data were statistically analyzed. **Results:** The mean (SD) of force transmitted to the palate was in its highest value when no implants (control group) were used (38.28 ± 2.47), (80.68 ± 2.62) N and lowest value when overdenture bases assisted by 8 implants (12.33 ± 2.52), (26.60 ± 2.55) N when static load were 110 and 220 N respectively. The amount of force transmitted to the palate from implant assisted maxillary overdenture bases significantly declined with increasing the number and the distance between the implants. **Conclusion:** implant numbers and distributions had a significant effect on the load transmitted from implant assisted maxillary overdenture to the palate.*

Keywords: Maxillary overdenture, implant number, implant distribution, load transfer, the palate

1. Introduction

Implant-supported and implant-retained prostheses have quickly become more widely available and are used as an alternative therapy to complete conventional dentures. Patients report positive outcomes in satisfaction, masticatory function and quality of life after receiving implant-retained prostheses [1]. It improves distribution of occlusal forces to the supporting tissues from opposing natural dentition or fixed implant supported prosthesis even if compared to satisfactory conventional complete denture [2].

This treatment option for the edentulous maxillae is perhaps the most predictably satisfying restorations because esthetics and hygiene access can be easily achieved in most patients, and may allow to reduce the prosthesis flanges and palatal coverage, which is a great benefit for new denture wearers, gaggers and patients with tori or exostosis [3]. This type of restoration could be without palatal coverage when four or more implants are present [4].

Esposito et al. [5] reported that quality and volume of remaining bone, number and position of implant are factors influence success of implants and prosthesis in the maxillary arch.

There are no specific guidelines for the number of implants necessary to support a maxillary overdenture [6] Based on survival rate, four implants is the minimum number needed for implant assistant maxillary overdentures [7]. Slot W et al, [8] concluded that, the best anchorage design for the maxillary overdenture is four equidistances implant, and recommended six implants in case of compromised bone.

Although clinical success had been reported as determined by survival of prosthesis and implants in treating patients with a palate-less implant retained overdenture with 4 supporting implants but, it had been recommended that use of palatal coverage when 4 or less implants are used [9]. While Eckert and Carr recommended six implants In order to avoid dramatic changes in prosthetic design should an implant fail to integrate [10].

It has also been reported that the design of 6 implants used with bar attachments had the highest success rate [11]. While Cavallaro and Tarnow [12] reported long-term success in treating patients with 4-6 non- splinted implants and reduced palatal coverage. Moreover, a difference between the treatment outcome of splinted and non-splinted implants could not be detected [13].

Many authors favor a minimum of four implants for design without palatal coverage [4,14]. Despite of different recommendation on the number of implants used in implant assisted maxillary overdentures, other complicating factors in the maxilla can affect the decision about the sufficient number of implants in a palateless implant assistant overdenture. These factors include the lower quality of bone in the maxilla, the muscles of mastication, the type of dentition of the opposing arch and resulting occlusal forces, the type of attachments, the inter-arch distance, the relationship between the shape of the residual ridge and the dental arch form; and implants angulation [9,15]

The total length of supporting implants has not been related to implant loss during overdenture function, [16] although the length of individual implants has been related to implant failure [17].

The distribution of the supporting implants over the arch is related to size, curvature and shape of the ridges which may influence their survival due to forces acting on the prosthesis in the maxilla [18]. Benzing et al, [19] demonstrated from a biomechanical perspective that a spread-out arrangement of implants in the maxilla results in a better load distribution to the implants, than a concentrated arrangement. However, whether a less favorable load distribution will cause crestal bone resorption around the implants has neither been established nor rejected by any author. Bars with distal cantilevers tend to increase the loads on the terminal implants by more than three-times in the maxilla [20].

Mericske [21] stated that the minimal number of implants is preferably four and that implants should be evenly distributed throughout the arch and the overdenture may have a horseshoe design, and thus be more acceptable to the patient.

The benefit of splinting implants is potential distribution of the forces to more osseointegrated surfaces to share the loads. Many studies found a tendency for higher forces with a solitary anchors and a positive effect of rigid bars for load distribution and sharing the occlusal load between the implants [22]. Whether the overdenture abutments are to be left separate or are to be connected to a bar depends primarily on the number, distribution, and angulations of the abutments [23].

Patients with conventional maxillary complete dentures may seek dental implant treatment to obtain increased retention, necessary prosthesis support, and improved comfort by removal of palatal coverage that is customary with conventional complete dentures [24].

The reduction or elimination of palatal coverage with maxillary implant-supported overdentures may be perceived as advantageous to patients by providing greater comfort through reduction of tissue coverage for complete denture wearers. Palatal coverage provides support to reduce load on supporting implants. The support differences provided by palatal coverage were greater than the effect of load support differences shown with the various attachment designs evaluated [25].

A patient may be advised that palatal coverage may be beneficial to load transfer and reduction of stress to the supporting implants in many situation such as implants of reduced width or length, reduced implant number, reduced implant support due to quality of integration, unfavorable implant positions and location, immediate or progressive implant loading protocols and implants of questionable or guarded prognosis due to clinical findings. However, palatal coverage may not be possible or considered appropriate for patients with a hyperactive gag reflex, psychological or emotional problems and the presence of maxillary tori [26].

There is a great controversy about the minimum number used for implant assisted maxillary overdenture as a primary support and if it enough to reduce or eliminate the palatal coverage and if the implant distribution or /and the attachments used may affect the load distribution to the implants and the supporting tissues which certainly may affect on the survival of the implants and the prosthesis.

This study was designed to measure the loads transmitted to the hard palate in implant assisted maxillary overdentures. The research hypothesis states; if there is a significant reduction in the amount of load transmitted to the palate in a 4-implant assisted maxillary overdenture when the distance between the anterior and posterior implants increases from 8 to 16 and 24 mm.

2. Material and Methods

This study had been done in the Removable Prosthodontic and dental biomaterial Departments, Faculty of Dentistry, Alexandria University.

Stone cast of an average-sized square shaped edentulous maxilla with moderate resorption was made using silicon based cast-former (Nissin model products inc. Kyoto. Japan). A hard acrylic thermoplastic clear sheet 2mm in thickness had been adapted to the stone cast using a vacuum former machine. The acrylic sheet was seated into the cast former and well adapted to the base of the former from the polished side and painted homogenously with a very thin layer of tin foil substitute which acted as separating medium. Special Pouring type of Autopolymerized acrylic resin (Castavaria, Vertex-Dental B.V. The Netherlands) with enough amounts was poured into the cast former. After the acrylic resin had been set, the acrylic cast was removed from the cast former and separated from the sheet. The space created between the produced cast and the cast former replaced later with a layer of mucosal tissues mimic material with nearly the same thickness. The produced model was called maxillary replica or replica of the maxilla.

The intended places of implants locations have been marked Using graduated ruler and Ink pin. Eight points was marked in the canines, premolars and molars areas. The implants in the canines areas were 30mm apart (distance from one canine to another), and 15mm posterior to the most anterior part of the edentulous ridge, the distance between the center of implants in the canine areas and the other in the premolar areas were 8mm antroposteriorly, center to center. The same distance (8mm) has been maintained between the centers of the remaining implant on each side. The implant fixtures were internal hex, 3.8 ×10mm, regular platform 4.0. (Dentium superline. Seoul, Korea)

Dental milling machine and a standard surgical drill tools were used to make parallel drill holes in the intended places of implants locations in the maxillary cast corresponding to implant fixture dimensions (platform: 4.0/body:3.8)×10 mm length. The implants were placed in their sites using ratchet and ratchet adapter as the platforms of fixtures were placed flashed or 0.5mm below the surface of simulated maxillary ridge. (Figure1)

Figure 1: all implants in its places and platform placed flashed with the simulated ridge surface

To imitate the resiliency of soft mucosal tissue of the edentulous maxilla, the surface of the cast replica was covered by uniform layer of additional silicone (A-silicone) based soft lining material (Mollosil, Detax Co. Ettlingen/Germany). A tapered carbide bur was used to create v-shape grooves on the sides of the replica to provide space for excess silicone material to flow and escape out between the maxillary replica and the cast former. The surface of the cast former was lightly lubricated with petroleum jelly. The cast replica was lightly painted with an adhesive of the A-silicon material and let to dry. Uniform layer of soft lining material (gingival mask) was applied on the surface of the replica and then seated back inside the cast former which seated on completely flat bench while caution was exercised to make sure that the base of the replica was with the level of the surface of the cast former.

After complete setting of the silicon material, the replica of the maxilla was removed from the cast former and excess silicone material produced was removed using a scalpel. The thickness of the simulated mucosa was 2.5-3mm.The gingival mucosa mimic material covering the implant at the crest of simulated ridge was removed with caution equally to the internal hex diameter using a scalpel. The matrices of the stud attachments (positioner attachments) were attached to the implants in the replica using the abutment hex driver and were torqued to 30N/cm with a torque wrench. (Figure2).

Figure 2: The matrices of positioner attachment were attached to the implants fixtures

Two layers of baseplate wax were softened, placed and adapted on the replica acted as a spacer. One sheet of light polymerized custom tray material was adapted to the replica and polymerized for five minutes in visible light curing unit according to manufacturer's recommendations. The custom made trays were made 2 mm short of the vestibule, but to ensure a controlled pressure during impression making, they were extended in three spots (stops) to contact the acrylic resin of the vestibule of the cast replica. The positions of the stops were: 1 in the anterior and the other 2 in the areas of the hamular notches to provide a tripod effect, and small escape holes centered on the palatal area were made. Another 5 custom made trays were made by the same manner.

The custom made trays were lightly coated with vinyl polysiloxane (VPS) adhesive and let to dry. The surface of the cast replica was lubricated lightly with petroleum jelly. Enough regular amounts of automixed regular body VPS impression material were added to the custom made trays one by one and six final impressions were made to the cast replica. These impressions were boxed and poured in vacuum mixed Type III dental stone and the master casts were produced. Two layers of baseplate wax were adapted over each master cast reinforced with horseshoe shaped 0.9mm gauge stainless steel wire which had been adapted to palatal area of the cast. A wax rim was adapted and secured over the wax base; the wax rim divided into two separate pieces over each side of the ridge, the dimensions of the rim were corresponded to the sum of canines, premolars and molars (34mm in length, 8mm in width and (8&10) mm in height). A putty index of this occlusal rim was made and used to fabricate similar occlusal rims to the remaining 5 denture bases.

The overdenture bases were processed in heat polymerized polymethylmethacrylate resin according to manufacturer’s instructions and packed in the doughy stage at 1500 psi for 2 trial packs in Press Unit using 4 × 4 clear separating sheets (.001”thick), and at 3000 psi for one final pack to avoid deficiency in the produced bases. The overdenture bases were finished and polished.

Relief holes corresponding to each Positioner attachment were made on denture bases using a carbide rotary cutting instrument to make sufficient room for the metal housing/patrix part of the attachment. The Positioner metal housings with white plastic processing sockets (replacement male) were placed over each Positioner abutment, leaving the white block-out spacer beneath it around the matrix to prevent the autopolymerized resin from locking in. Enough amounts of autopolymerized acrylic resin were mixed according to manufacturing instructions, and small amounts were added to the relief spaces and the overdenture base seated back on the replica with light even pressure until complete seating of the overdenture base on the replica and was left to enough time until setting of the pickup material. The overdenture was removed and the patrices or housings were picked up in it. The block out spacer was removed.

The white processing replacement male were replaced by final plastic positioner replacement male (extra-light patrix without center stalks) giving desired degree of retention 300 gram force (gf) using the positioner core tool containing a male removal tool, male seating tool (white colored). The pickup steps were made with the remaining 5 overdenture bases.

A force-measuring sensor (Flexiforce B201; Tekscan, South

Boston, USA) with medium force range (0-150 Ib), 14 mm in diameter ,thickness of 0.127 mm and the active sensing area of the sensor has a diameter of 10 mm had been used to measure force generated on the palate. The sensor was connected to the sensor handle of the Tekscan's Economical Load & Force (ELF Flexiforce; Tekscan, South Boston, USA) and connected to a laptop computer and was calibrated using different known values of perpendicular forces against a universal testing machine (Lloyd Lr5k USA) according to manufacturing instructions.

The Positioner abutments (matrices) were removed from the cast replica and the flexiforce sensor was placed in the middle of the palatal area of the replica then secured in place by applying a small amount of adhesive to the shaft area of the sensor. Caution was exercised not to apply adhesive to the sensor area. The outline of the sensor was marked with a marker on the maxillary replica to mark the exact location in case the sensor moved and allow repeatable position of the sensor during all tests. (Figure 3)

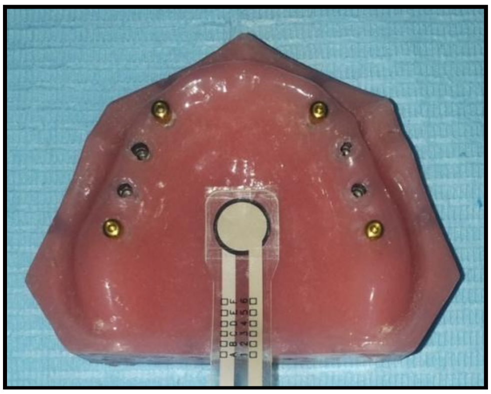

Figure 3: Location of the sensor at maxillary replica.

Overdenture base was seated over the replica of the maxilla with no positioner abutments attached. A custom made aluminum plate with dimensions (3×8cm and 3mm thickness) seated on the both sides of occlusal rim of the overdenture base simultaneously centered on the premolar molars area. The maxillary cast and overlying overdenture base were carefully positioned in the center of the platform of a universal testing machine so that the upper member of the universal testing machine was near the center of the aluminum plate. A perpendicular static load of (110 &220) N was applied respectively bilaterally to the surface of occlusal rim of the overdenture base through the aluminum plate, using a universal testing machine for 60 seconds to ensure that the applied force reached a stable continuous level that can be recorded accurately. (Figure 4)

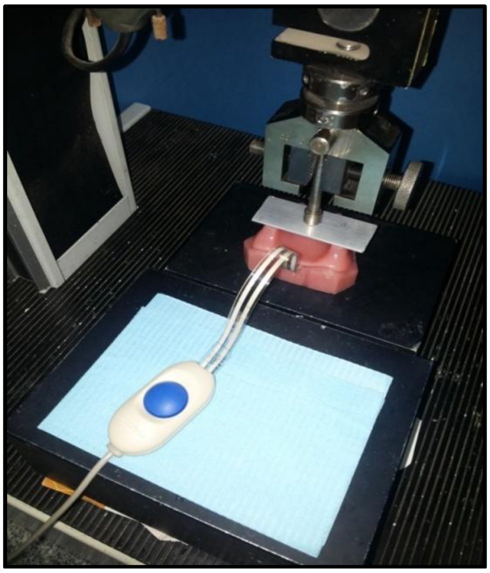

Figure 4: A perpendicular static load applied to the overdenture using universal testing machine.

The peak force measured on the palate was recorded. Data from the force-measuring sensor were collected using a laptop computer and ELF system software.

The matrices of positioner attachments were attached to the implant fixtures in different locations. Various numbers and distributions of implant were introduced due to interchanging between of positioner attachments positions which were the study experimental groups including control group (no attachments or no implants) and five other groups. (table1)

Table 4: Experimental groups

Group number	*Experimental groups*	*Number and distribution of implants*
Group I	(control group) No implants (0)	No implant
Group II	2	2implant in the canine area
Group III	4/8mm	4implants with 8mm anteroposterior distance
Group IV	4/16mm	4implants with 16mm anteroposterior distance
Group V	4/24mm	4implants with 24mm anteroposterior distance
Group VI	8/8mm	8implants with 8mm anteroposterior distance apart

Each overdenture base was tested with all the six variations described and the peak forces measured on the palate were recorded and collected.

Enough" time (fifteen minutes) was given between each force applications as the sensor reset to zero balance and to allow complete rebound of the resilient structures before application of the next load.

The resulting data were fed to the computer and analyzed using IBM SPSS software package version 20.0 .Quantitative data were described in Newton as range (minimum and maximum) mean, standard deviation and median. The distributions of quantitative variables were tested for normality using Kolmogorov-Smirnov test, Shapiro-Wilk test and D'Agstino test and revealed a normally distributed data. Accordingly, Comparison between two independent data was done using independent t-test; Comparison between multiple data was done using ANOVA with repeated measures and Post Hoc test was assessed using Tukey LSD. Significance test results were quoted as two-tailed probabilities. Significance of the obtained results was judged at the 5% level. A p-value of less than 0.05 was considered statistically significant.

3. Results

The load transmitted to the palate was in its highest value when no implants were used (38.28 ± 2.47) & (80.68 ± 2.62) N and lowest value when overdenture bases assisted by 8 implants (12.33 ± 2.52) & (26.77 ± 2.51) N when the total static load were 110 and 220 N respectively. (Table 2)

The force measured on the palate when total original loads were 110 and 220N, with no implant (control group) and when overdenture bases assisted by 2 implants in the canine areas, were significantly higher than all other groups.

The amount of force measured on the palate when the overdenture bases were assisted by 4 implants with 8mm distance was significantly lower than when either no or 2 implants were used. The values of force in the group of 4 implants with 16 and 24 mm distances were significantly lower than that of 4 implants with 8mm distance. Moreover, when implants with 16& 24mm anteroposterior distances were used the amounts of forces were not significantly different.

When the overdenture bases were assisted by 8 implants, the force transmitted to the palate was significantly lower than that assisted by 4 implants when the distance between the anterior and posterior implants was 8mm. Moreover there is no significant difference between that group and groups of 4implants with 16& 24mm distance when the original load was110, whereas with 220N total load the force transmitted to the palate from 8 implants assisted overdenture bases, was significantly lower than that of 4 implants with 8,16 and 24 mm distances.

Table 2: Comparison between loads transmitted to the palate upon different implant numbers and distributions when the total load of 110N and 220N were applied

Total load		No implant (0)	2	4 / 8 mm	4 /16 mm	4 / 24 mm	8 / 8 mm	^{F}p
110 (N)	Min. – Max.	35.70 – 42.70	29.30 – 35.0	19.70 – 24.90	11.90 – 18.60	9.90 – 16.0	8.0 – 15.0	<0.001*
	Mean ± SD (N)	38.28 ± 2.47	32.13 ± 2.13	22.02 ± 1.92	14.30 ± 2.39	13.45 ± 2.24	12.33 ± 2.52	
	Median	37.85	31.75	22.0	13.85	13.95	13.30	
220 (N)	Min. – Max.	77.90 – 84.40	67.10 – 73.90	46.50 – 53.10	29.50 – 36.40	27.80 – 36.40	23.20 – 29.80	<0.001*
	Mean ± SD (N)	80.68 ± 2.62	70.38 ± 2.58	49.44 ± 2.58	32.98 ± 2.71	31.35 ± 3.05	26.77 ± 2.51	
	Median	79.85	70.05	48.85	33.10	30.90	27.25	

^{F}p: value for F test (ANOVA) with repeated measures.
Statistically significant at $p \leq 0.05$

The least value of force reduction was from no implants (control group) to 2 implants groups (16.07%) & (12.77%) and the highest value was that from no implants to 8 implants groups (67.79%) & (66.82%) when the total static load were 110 and 220 N respectively. (Table 3)

Table 3: Percentage of load reduction between the study groups when total applied load were 110N and 220N

Total load		No implant (0)	2	4 / 8 mm	4 /16 mm	4 / 24 mm	8 / 8 mm
110 (N)	Mean ± SD	38.28 ± 2.47	32.13 ± 2.13	22.02 ± 1.92	14.30 ± 2.39	13.45 ± 2.24	12.33 ± 2.52
	% of change from Control group		↓16.07	↓42.48	↓62.64	↓64.86	↓67.79
220 (N)	Mean ± SD	80.68 ± 2.62	70.38 ± 2.58	49.44 ± 2.58	32.98 ± 2.71	31.35 ± 3.05	26.77 ± 2.51
	% of change from control group		↓ 12.77	↓ 38.72	↓59.12	↓61.14	↓66.82

There was a significant difference in the percentage of load reduction when overdenture bases assisted by 2 implants instead of no implants with different original loads which was higher with the total load of 110N than occurred with load of 220N. There was no significant difference in percentages load reduction when overdenture bases assisted by 4 implants (4/8mm, 4/16mm, 4/24mm) or when 8implants (8/8mm) were used instead of 4implants with different distributions (4/16mm, 4/24mm) when comparison done between percentages of force reduction between these groups using 220N total load and another's using load of 110N .

4. Discussion

In vitro study was carried out as it seemed beneficial in providing valid comparative data excluding the effect of variation among individuals. In addition, variation of oral hygiene, strength of masticatory muscles, age and sex are factors representing further difficulties to reach definite result in the clinical evaluation. Accordingly, this study was carried out in-vitro to omit human variation and to produce more realistic results.

The maxillary inter-canine distance of thirty mm was used which agreed with the clinical mean value obtained in previous human literatures [27,28] which claimed a range from twenty five to thirty five mm. The distance from Canine to first and second premolar and canine first molar were respectively 8-16-24mm which were within the values range of precisely measuring regime recommended by Michelinakis et al [29].

The models used for this study were fabricated as much as possible simulating the viscoelastic behavior of the mucosa covering the residual ridges. In order to provide a stable non movable model surface simulating the mucosa; an adhesive was used for bonding to the underlying acrylic model.

According to previous studies, the thickness of the palatal mucosa is variable depending on age, gender and location of the measurement on the palate. In general the mean reported thickness of the palatal masticatory mucosa in those studies, ranged between 2.4±0.7 to 5.11±1.07 mm [30,31]. The thickness of simulated mucosa (2.5-3mm) which used was within the range reported in human literature which had been used previously in in-vitro studies conducted by Al-Ahmad et al [32] and Masri et al [33].

Load cells, strain gauges, piezoelectric and piezoresistive elements are devices used to measure force but have limitations when predicting the response of biologic systems to applied loads, as do all modeling systems involving finite element analysis [34], mathematic models, photoelastic modeling techniques [35]. However, such modeling systems can indicate, under carefully controlled conditions, where potential stress-related differences may occur.

Strain gauges commonly used to obtain force measurements, but yield measurements that are a result of indirect force measurement drawn by correlating the strain of an assembly with a load. This technology also requires expensive electronics to obtain accurate force readings. So special type of force measuring sensor (flexiforce (resistive-based technology) was used for this study [36].

Previous in-vitro investigations on maxillary overdentures, used a static force of 100-110 N to simulate occlusal force [25,37]. The 100N magnitude, equivalent to approximately 10 Kg, seemed to be the closest to the maximum functional biting force in real life situations of a denture wearer [38]. In these studies the amount of occlusal force applied was determined arbitrarily. The maximum occlusal force in patients with overdentures has wide range between 60- 375 N [39,40]. In this study, the force used 110&220 were well within these values [41,42]. Loads were applied vertically to evaluate the effect of the study variables on resulting forces transmitted to the palate.

Vertical Loads were applied at the premolars/ molars region [43] of the overdenture. Such a loading location was selected as it seemed to be the center of the overdenture around which chewing center will be located as suggested by Zarb [38].

The same implant size and geometry with a symmetrical distribution were designed and placed parallel to each other using a dental milling machine to exclude the effect of different angulations on the force analysis and distribution.

Six implant assisted maxillary overdenture bases were tested with different implant numbers and distributions and changes in the load transmitted to the palate were measured and recorded by force measuring sensor. In this study, a control group that used no implants and 5 other groups with different locations and distributions of implants were used. Three of these designs with 0, 2 and 8 implants were used to compare with the other three designs of 4 implants with different distributions of under two different original loads of (220 and 110)N.

When no implants were used (control group), approximately 36.6% and 34.8% of the load was transmitted to the palate with total loads 220N and 110N respectively When only 2 implants were used, the amount of load on the palate, were 31.9% and 29.1%with the same order although the load there is slightly declined but this reduction of load on the palate was significant. Indicate that even 2 independent implants may provide reduction to the load transmitted to the palate and also may provide a successful maxillary implant-retained overdenture. This suggestion supported by reports published by Simon et al [44].

When 4 implants, with minimum distance in between (8 mm), were used, the load transmitted to the palate significantly dropped from 36.6% and 34.8% with no implants and 31.9% and 29.1% with 2 implants to 22.47% and 20.21% with 220N and 110N original applied loads respectively which demonstrating an evidence that support for the 4-implant assistant overdenture may be provided primarily by the implants and to a lesser degree by the palate. This result is in line with results of Sadowsky [13].

When the distance between the 4 implants increased from 8mm to 16 and 24 mm, the mean load transmitted to the palate, significantly declined to (14.9% and 13%) and (14.2%and 12.2%) of 220N and 110N original applied loads respectively. Although the loads transmitted to the palate when the distance between the implants was 24 mm distance were slightly less than that of 16 mm distance, the difference was not statistically significant. These results support the research hypothesis; there was a significant difference in the amount of load transmitted to the palate in a 4-implant-assisted maxillary overdenture when the linear distance between the anterior and posterior implants increases from 8 to 16 and 24 mm. The distance between and distribution of implants had significant effects on the load transmitted to the palate in an overdenture assisted by 4 independent implants. This result was approved by Weingart and ten Bruggenkate [45].

When 8 implants were used, only about 12.7% and 11.2% of the load (220N and 110N) was transmitted to the palate, this load was found to be significantly lower than when 4 implants with a distance of 16 or 24mm were used with the higher load (220N) and had no significant difference with the same groups at a lower load (110). Using more implants should be considered to reduce or eliminate the palatal coverage when parafunctional occlusal contacts or excessive occlusal forces present such as the opposing arch is natural teeth [46].

Moreover, there was no significant difference in percentages of load reduction when using of 8implants (8/8mm) instead of 4implants (4/16mm, 4/24mm) or when using 4 implants with different distributions (4/8mm, 4/16mm, 4/24mm) when comparison done between percentages of force reduction between these groups using 220N total load and another's using load of 110N. This indicate that the palatal portion of overdentures does not contribute significantly to load distribution when 4 implants, with a minimum distance of 16 mm, or more implants are used and the support for the overdenture is primarily provided by the implants rather than the palate. This conclusion is based on the assumption that force measured on the palate is transferred solely to the supporting tissues and that remaining forces are transmitted to the implants.

This study gave evidence in exploring the feasibility of eliminating the palate when only 4 unsplinted implants are used. That is agree with Mericske [21] and Cavallaro and Tarnow [12] and not recommended with Jivraj and Chee et al, [9] and Rodriguez et al, [11].

The results of this in-vitro study demonstrate that; for implant assisted maxillary overdenture, the number and distribution of implants affect the forces measured on the palatal area of a replica of an average sized edentulous maxilla.

5. Conclusion

- There was a direct correlation between the amount of load reduction transmitted from implant assisted maxillary overdenture to the palatal portion of the maxillary arch and the implant numbers and distributions.
- Properly distributed four independent implants assisted maxillary overdentures associated with great amount of load reduction in comparison to others assisted by only two independent implants.
- Eight independent assisted maxillary overdenture associated with the greatest amount of load reduction.
- Increasing the magnitude of the occlusal force did not affect the amount of load reduction.
- The palatal coverage may be reduced or eliminated when only properly distributed four independent implants or more are used.

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