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Stress Analysis on Equator Attachment with Palatal and Palatless Maxillary Implant Overdenture designs

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تحليل الإجهاد على وصلة الربط الإكويتور في تصميمات أطقم الأسنان العلوية المدعومة بزرعات، سواءً كانت حنكية أو غير حنكية

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Abstract:
This study aimed to compare the amount of stress generated on two versus four implants with equator attachments in maxillary implant overdentures with palatal coverage and palateless designs. Four standardized educational edentulous maxillary models simulating bone type II were used. The models were divided into two main groups according to palatal design (palatal coverage and palateless), and each group was further subdivided based on the number of implants (two or four implants). In the two-implant subgroup, implants were placed bilaterally in the canine regions perpendicular to the residual ridge using a surgical stent, whereas in the four-implant subgroup, implants were installed bilaterally in the canine and second premolar regions. Equator attachments with appropriate cuff heights were selected, and framework patterns were constructed. Four strain gauges were cemented to each fixture using strain gauge cement. A LLOYD digital loading device was used to apply compressive loads to measure the resulting stresses around the implants for each attachment configuration. The results demonstrated a statistically significant difference between stresses on two implants with equator attachments (74.53 ± 35.9 N/m × 10^2) and four implants with equator attachments (10.85 ± 10.81 N/m × 10^2) within the same palatal coverage design. Similarly, a statistically significant difference was found between stresses on two implants with equator attachments (123.75 ± 44.60 N/m × 10^2) and four implants with equator attachments (14.51 ± 14.60 N/m × 10^2) within the same palateless design. It was concluded that stress on two implants with equator attachments was markedly greater in the palateless design compared with the palatal coverage design, whereas stress on four implants with equator attachments was slightly greater in the palateless design than in the palatal coverage design, with no statistically significant difference.

Keywords: Stress, Equator, Maxilla.

الملخص:
هدفت هذه الدراسة إلى مقارنة مقدار الإجهاد المتولد على زرعتين مقابل أربع زرعات مع وصلات الربط الإكويتور في أطقم الأسنان العلوية المدعومة بالزرعات، سواءً ذات تغطية حنكية أو بدونها. استُخدمت أربعة نماذج تعليمية موحدة للفك العلوي عديم الأسنان، تحاكي نوع العظم الثاني. قُسّمت النماذج إلى مجموعتين رئيسيتين وفقًا لتصميم الحنك (تغطية حنكية وبدونها)، وقُسّمت كل مجموعة فرعية بناءً على عدد الزرعات (زرعتان أو أربع زرعات). في المجموعة الفرعية ذات الزرعتين، وُضعت الزرعات بشكل ثنائي في منطقة الأنياب بشكل عمودي على الحافة المتبقية باستخدام دعامة جراحية،

بينما في المجموعة الفرعية ذات الأربع زرعات، وُضعت الزرعات بشكل ثنائي في منطقة الأنياب والضاحك الثاني. تم اختيار وصلات الربط الإكويتور ذات ارتفاعات مناسبة، وصُممت نماذج الهيكل. تم تثبيت أربعة مقاييس إجهاد على كل زرعة باستخدام أسمنت خاص بمقاييس الإجهاد. استُخدم جهاز تحميل رقمي من نوع LLOYD لتطبيق أحمال ضغط لقياس الإجهادات الناتجة حول الزرعات لكل تكوين من تكوينات الوصلات. أظهرت النتائج فرقًا ذا دلالة إحصائية بين الإجهادات الواقعة على زرعتين مزودتين بوصلات الربط الإكويتور (74.53 ± 35.9 نيوتن/متر × 10²) وأربع زرعات مزودة بوصلات الربط الإكويتور (10.58 ± 10.81 نيوتن/متر × 10²) ضمن نفس تصميم تغطية الحنك. وبالمثل، وُجد فرق ذو دلالة إحصائية بين الإجهادات الواقعة على زرعتين مزودتين بوصلات الربط الإكويتور (123.75 ± 44.60 نيوتن/متر × 10²) وأربع زرعات مزودة بوصلات الربط الإكويتور (14.51 ± 14.60 نيوتن/متر × 10²) ضمن نفس التصميم الخالي من الحنك. وخلصت الدراسة إلى أن الضغط على زرعتين وصلات الربط الإكويتور كان أكبر بشكل ملحوظ في التصميم الخالي من الحنك مقارنة بتصميم تغطية الحنك، في حين أن الضغط على أربع زرعات مع وصلات الربط الإكويتور كان أكبر قليلاً في التصميم الخالي من الحنك مقارنة بتصميم تغطية الحنك، دون وجود فرق ذي دلالة إحصائية.

الكلمات المفتاحية: الإجهاد، وصلات الإكويتور (المتوازية)، الفك العلوي.

Introduction:

Removable complete dentures (RCDs) were the primary, cost-effective solution for edentulous patients, restoring function, esthetics, and speech, but they often faced issues like instability and discomfort, leading to the development of more advanced options like implant-supported dentures to improve quality of life. (1)

Implant-supported overdentures (IODs) significantly improve stability, comfort, and chewing ability, leading to greater patient satisfaction and a better oral health-related quality of life compared to conventional dentures, (2) with many studies recommending them as a minimum standard of care, especially for the lower jaw. Patients experience enhanced confidence, better speech, improved diet, and preservation of jawbone, although the initial cost can be a factor. (3)

In maxillary implant overdentures, there are many biomechanical challenges than mandibular implant overdentures, which bone resorption often forces implants to be angled forward and downward, creating leverage (forces) that stress implants and bone more significantly than in the mandible, where implants are typically more vertical. (4) (5)

Palatal coverage on a maxillary implant overdenture is often indicated, especially with fewer implants or compromised support, to provide crucial denture stability, reduce implant/attachment stress, prevent base fracture, and improve overall rigidity, even though palateless designs offer better sensory feedback. (6)

Different attachment types are available to connect implants with overdentures. The Equator attachment system is a low-profile, compact dental implant attachment known for its minimal vertical height (around 2.1mm) and small diameter, making it excellent for limited space in implant overdentures, offering superior esthetics and function with adjustable retention via color-coded nylon caps and compatibility with most implant platforms. (7) (8)

So, this study aimed to compare amount of stress on two and four implants with equator attachments in maxillary implant over dentures with palatal coverage and palatless designs.

Materials and Methods:

This in vitro study was performed on a total of four standard educational edentulous maxillary models resemble bone type II* for each model, different distribution of a custom made resilient two-dimensional resilient attachment over two and four dental implants was done.

The models were covered by polyvinylsiloxane impression material (Speedex coltene/Whale dent .inc Cuyahoga Falls, oh, USA.) to simulate the oral mucosa covering the ridge.(9)

The models were classified into two groups according to the palate designs and each group was classified into two subgroups according of the number of implants installed as follows:

- **Models I:** where the maxillary implant overdentures were designed with palatal coverage.
- **Model I (A):** where two implants were installed at canine's region.
- **Model I (B):** where four implants were installed; where two implants were installed at canine's region, while another two implants at the second premolar region.
- **Models II:** where the maxillary implant overdentures were designed without palatal coverage (palatless).
- **Model II (A):** where two implants were installed at canine's region.

- **Model II (B*)***: where four implants were installed; where two implants were installed at canine's region, while another two implants at the second premolar region.

Two implants were placed bilaterally in the canine's region perpendicular to the residual ridge guided by surgical stent, while four implants were installed bilaterally at the canine's region and at the second premolar region.

The equator was selected with the appropriate cuff height. OT Equator was placed into implant using Equator square screwdriver. Torque range is 22 - 25 newton centimes.

Frameworks patterns were constructed so that meshwork minor connectors were over ridge crest area, and metal base was made extended from the crest area of the ridge to the vibrating line in palatal designs.

An external palatal finishing line was placed on the anterior palatal and lateral palatal slopes for palatless designs, then after investing and casting procedures, the polishing was done.

Stress analysis procedures:

Four strain gauges around each implant installed by making tunnels which were made in the epoxy model to facilitate strain gauge instillation measurements. One strain gauge was installed at the cervical one third, opposing to the buccal, palatal, mesial and distal aspects of each implant.

Central loading was done by using a standardized 5 mm diameter and 6 cm length stainless steel hexagonal bar, the mid-point of the bar was marked on the loading point.

LLOYD Digital loading device was used in this the study to apply compressive loads to measure the resulting stress around the implants for each type of attachment. Loading device consists of 2 columns with capacity of 5 kilo Newton (KN) A load cell is attached to move either a compressive mode.

Statistical analysis:

The descriptive statistics implant stress values including, minimum, maximum, mean, standard deviation, and median range. Mann-Whitney test was used to diagnose the normal distribution of data. The data was parametric and normally distributed.

Repeated measures ANOVA was used to compare recorded implant stress between different palatal designs (Palatal, Palatless) with number and distribution of implants (two, four).

One way ANOVA was used to compare different position of strain gauges of (Mesial, distal, buccal, and palatal). The data was analyzed using SPSS (statistical package for social science). P value is significant if it was less than o.5.

Results:

Comparison between stresses in models of palatal maxillary overdentures design with two implants installed at canine's region (group I-A) and four implants, two implants at the canine's region and another two implants at the second premolar region (group I-B) with equator attachment were presented in table 1.

Statistically there was a significant difference between stresses on two implants with equator attachments (**74.53 ± 35.9**) **N/M × 10^2** and stresses on four implants with equator attachments (**10.85 ± 10.81**) **N/M × 10^2** in the same palatal coverage designs figure 1.

Table (1): Comparison between stresses in palatal maxillary overdentures models with two and four implants and equator attachments.

Palatal maxillary overdentures design N/M × 10^2				
Equator attachment	**Min.**	**Max.**	**Mean ± SD.**	**Median**
Two implants	30.3	110.2	74.53 ± 35.9	90.5
Four Implants	1.1	35.4	10.85 ± 10.81	17.5

Comparison between stresses in models of palatless maxillary overdentures design with two implants installed at canine's region (group II-A) and four implants; two implants at the canine's region and another two implants at the second premolar region (group II-B) with equator attachment were presented in table 2.

Statistically there was a significant difference between stresses on two implants with equator attachments (123.75 ± 44.60) N/M × 10^2 and stresses on four implants with equator attachments (14.51 ± 14.60) N/M × 10^2 in the same palataless designs Figure 1.

Table 2: Comparison between stresses in palatless maxillary overdentures models with two and four implants and equator attachments.

Palatless maxillary overdentures design N/M × 10^2				
Equator attachment	**Min.**	**Max.**	**Mean ± SD.**	**Median**
Two implants	70.20	187.30	123.75 ± 44.60	135.5
Four Implants	3.4	55.3	14.51 ± 14.60	20.5

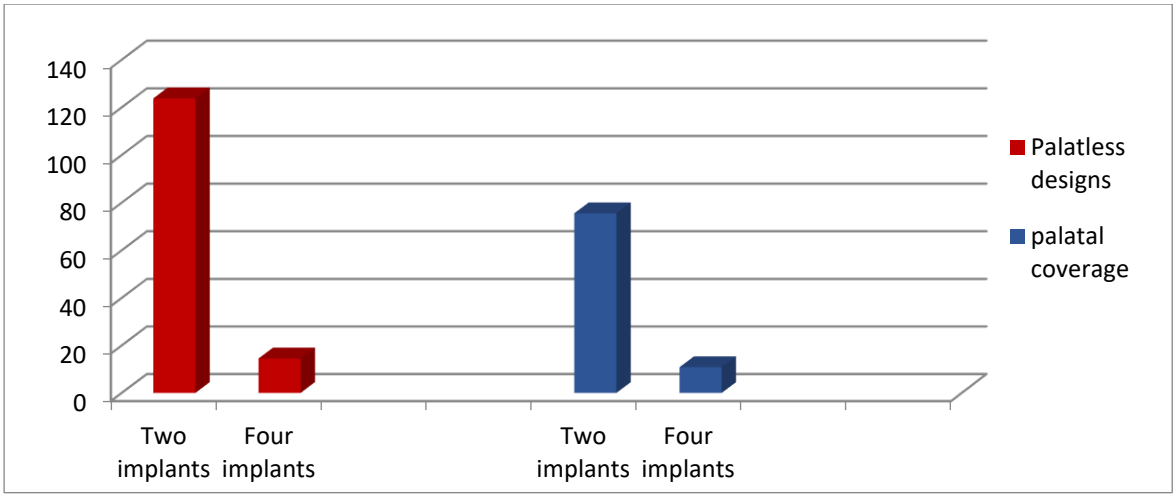

Figure (1): A column chart comparing stresses in models with two and four implants and equator attachments in palatal and palatless designs. N/M × 10^2.

Discussion:

In vitro models are essential in dental research for simulating complex, hard-to-reach oral environments, enabling the comparative design analysis of materials and techniques while eliminating human biological variables. These controlled, cost-effective, and fast-acting models provide high, reproducible accuracy for testing, though they often require subsequent in vivo confirmation. (10)

At the maxillary edentulous ridges, the thickness of the masticatory mucosa ranges from 1.92 mm to 2.38 mm according to in vivo measurements, and from 1.45 to 1.58 mm at the mandibular edentulous ridge. (11) Therefore, 2 mm silicone soft lining material was used to ensure that the thickness of the silicone was similar to the average thickness of the masticatory mucosa in vivo. (12)

As a technique to record the stresses from all surfaces of the implant abutments, four strain gauges were bonded axially parallel to long axis on each implant (palatal, buccal, distal and mesial). Strain gauge is the most common technique used to evaluate strain at the certain point in experimental mechanics. (13)

Four-implant supported overdentures are a highly successful, long-term treatment option with 10-year survival rates frequently exceeding 90-95%. Studies indicate superior outcomes in the mandible and high success in the maxilla, (14) (15) So in this study there was agreement with that, which the stresses on two implants with equator attachment in different palatal designs were more than those with four implants.

The stress on the two implants with equator attachments in palataless design (123.75 ± 44.60) N/M × 10^2 was much greater than two implants with equator attachments in palatal coverage design (74.53 ± 35.9) N/M × 10^2, also the stress on the four implants with equator attachments in palatless design (14.51 ± 14.60) N/M × 10^2 was little greater than four implants with equator attachments in palatal coverage design (10.85 ± 10.81) N/M × 10^2.

These results are consistent with the previous study using un-splinted attachments (16) found that the implant strain under palateless coverage dentures was much greater than that under dentures with palatal dentures; this tendency has also been reported in other experimental models. (17)

During posterior load application, several reports in the literature have described greater stress concentrations on posterior area and lower stress concentrations on the anterior region. (18) This is identical to the results of this study, which shows decreased stress at anterior implants with equator attachments in both palatal designs in compared with stress at posterior implants in both palatal designs.

Conclusion:

1. The stress of two implants with equator attachments was much greater in palatless design than palatal design, so the maxillary two implants retained overdenture with equator attachments must be with palatal coverage if possible.
2. The stress of four implants with equator attachments was little greater in palatless design than palatal design with no significant, so the maxillary four implants retained overdenture with equator attachments can be with both palatless or palatal coverage, in relation to other significant factors.
3. The distribution of stress depends on the number of implants, which are greater in two implants than four implants with the same equator attachments and same palatal designs.

References:

1. Emami, E. R. F. de Souza, M. Kabawat, and J. S. Feine, “The impact of edentulism on oral and general health,” International Journal of Dentistry. 2013; Article ID 498305, 7 pages.
2. Cardoso, R.G.; De Melo, L.A.; Barbosa, G.A.S.; Calderon, P.D.S.; Germano, A.R.; Junior, W.M.; Carreiro, A. Impact of mandibular conventional denture and overdenture on quality of life and masticatory efficiency. Braz. Oral Res. 2016, 30, e102.
3. Slot, W, G. M. Raghoebar, A. Vissink, and Meijer, J. A. “Maxillary overdentures supported by four or six implants in the anterior region; 1-year results from a randomized controlled trial,” Journal of Clinical Periodontology. 2013; 40 (3): 303–310.
4. Razavi R, Zena R, Khan Z Gould A. Anatomic site evaluation of edentulous maxillae for dental implant placement. J Prosthodont 1995; 4:90-94.
5. Rodriguez A, Orenstein I. Morris H, Ochi S. Survival of various implant-supported prosthesis desiggns following 36 months of clinical function. Ann Periodontal 2000; 5:101-108.
6. Conny D, Tedesco L. The gagging problem in prosthodontic treatment, description and causes. J Prosthodont Dent 1983; 49:601- 606.
7. Hobrick J. A., and Watson R.M: Color atlas and text of dental Maxillofacial Tmplantology Mosby-Wolf, London. 1992; 13.
8. Dariusz Rolski, Elzbieta Mierzwinska-Nastalska, Jerzy Gladkowski. The application of precision attachments of Equator in prosthetic rehabilitation of patient following surgery of the mouth neoplasm. Protet stomatol. 2011; 61; 130-137.
9. El Charkawi, Wagdy M, Radi, Wahab I. Effect Of Dislodging Forces On Mandibular Implant Attachment-Retained Overdenture. Implant Dentistry 1996; 20: 246-254.
10. Shohet H: Relative magnitudes of stress on abutment tooth with different retainers. J. Prosthet .Dent.1969; 21:267.
11. Uchida H, Kobayashi K, Nagao M. Measurement in vitro of masticatory mucosal thickness with 20 MHz B-mode ultrasonic diagnostic equipment. J Dent Res. 1989;68: 95-100.
12. Ichikawa T. Horiuchi M, Wigianto R, Matsumoto N. In study of mandibular implant-retained overdentre:the influence of stud attachments on load transfer to the implant and soft tissue. Int J Prosthodont. 2004;9:394-399.
13. Walton J, Huizinga S, Peck C. Implant angulation: a measurement technique, implant overderiture maintenance, and the influence of surgical experience. Int Prosthodon 2001; 14:523-530.
14. Nishimura, Y.; Takahashi, T.; Gonda, T.; Ikebe, K. Influence of implant distribution and palatal coverage on the strain of splinted implants and overdenture in maxillary implant overdentures. Int. J. Oral Maxillofac. Implants 2021, 36, 281–288.
15. Hatakeyama, W.; Takafuji, K.; Kihara, H.; Sugawara, S.; Fukazawa, S.; Nojiri, T.; Oyamada, Y.; Tanabe, N.; Kondo, H. A review of the recent literature on maxillary overdentures with dental implants. J. Oral Sci. 2021, 63, 301–305.
16. Cepa S, Koller B, Spies BC, Stampf S, Kohal RJ. Implant-retained prostheses: Ball vs. conus attachments—A randomized controlled clinical trial. Clin Oral Implants Res 2017;28:177–185.
17. ELsyad MA, Ghoneem NE, El-Sharkawy H. Marginal bone loss around unsplinted mini-implants supporting maxillary overdentures: A preliminary comparative study between partial and full palatal coverage. Quintessence Int 2013;44:45–52.
18. Machado AC, Cardoso L, Brandt WC, Henriques GE, de, Arrudo Nobilo MA. Photoelastic analysis of the distribution of stress in different systems of overdenture on osseous-integrated implant. The Journal of craniofacial surgery. 2011; 22(6): 2332-2336.