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MAGNET VERSUS OLS ATTACHMENTS FOR IMPLANT OVERDENTURES: A STRESS ANALYSIS STUDY

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ABSTRACT

Objectives: to compare between the microstrains transmitted to the implants with magnetic and OLS attachments in 2-implant overdentures.

Methodology: two dummy implants 3.7 mm in diameter and 12mm in length were placed in an acrylic resin model resembling a completely edentulous mandible. Attachment pick up was done for the magnetic attachment followed by loading and measurement. Four Strain gauges were used to measure microstrains around the implants during unilateral and bilateral loading using a universal testing machine and a multi-channel strain meter. The procedure was repeated for the OLS attachment. Measurements were tabulated and statistically analyzed.

Results: loading sides demonstrated significantly higher microstrains around the implants with the two attachments than non-loading sides**.** OLS attachment showed significantly higher microstrains than magnetic attachment for both loading and non-loading sides during unilateral loading. During bilateral loading, there was no significant difference between the two attachments.

Conclusion: implant overdentures retained by magnetic attachments transmit less stresses to the implants than OLS attachments with PEEK retentive matrices during unilateral loading. During bilateral loading, the stresses transmitted by the two attachments were comparable.

INTRODUCTION

The placement of dental implants has become a reliable and successful treatment modality in completely edentulous cases. Implant placement has a positive effect on patient satisfaction, masticatory performance, health of remaining supporting structures and overall quality of life for edentulous patients[1–3]. Implant overdentures retained by two interforaminal implants have been documented as a standard of care for completely edentulous patients since 2002[4] for being simple, less invasive, cost-effective and successful[5,6]. The connection between implants and the denture is done through the incorporation of attachments. There are several attachments in the market nowadays with a variety of designs that make them applicable in different

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cases. These attachments include bars, rigid and resilient telescopes, magnets and stud attachments[8,9].

Magnetic attachments are well-known for their self-aligning properties as well as their low vertical profile rendering them particularly useful in patients with physical disabilities[10] or where inter-occlusal space is problematic[11]. Their early drawbacks regarding corrosion have been overcome by the introduction of new encapsulated rare earth magnets which come in smaller sizes and have higher retentive as well as corrosion resistance properties[12,13]. Magnetic attachments have low resistance to lateral forces due to their ability to immediately disengage, which reduces the lateral forces transmitted to the implants when compared with other attachments[14]. A number of studies reported that the retentive forces of magnetic attachments were less than other attachments[14,15]. However, this reduced retention was found to generate the least stresses in peri-implant bone during overdenture dislodgement[16]. They also exhibited fewer strains under occlusal loading when compared to ball and bar attachments[15,17]. Theoretically speaking, the lifespan of a magnetic field is never-ending, which indicates that magnets should retain their retentive properties for a much longer time than stud attachments which are subjected to component wear due to friction[14].

Stud attachments are known to be the simplest, least technically complicated and most economic attachments for implant overdentures. Their ease of use and maintenance make them a popular choice for several practitioners as well as patients[18]. Stud attachments differ in their designs, vertical heights, nature of retentive mechanisms, and materials of retentive components. Materials for retentive matrices for stud attachments include rubber, polyethylene and nylon[8,19,20]. Poly Ether Ether Ketone (PEEK) is a well-known material in the field of orthopedics due to its bone-like elasticity and high wear resistance[21,22]. In addition, PEEK has high tensile, flexural and fatigue strengths that have recently promoted its various applications in the fields of implant and prosthetic dentistry[23,24]. It has recently been used as a retentive clip for a few attachments. Bayer et al[23] concluded that PEEK and polymer clips had comparable levels of retention for bar-retained implant overdentures. Aziz[25] reported that PEEK retentive matrices showed higher retentive characteristics after 12 months of function when compared to nylon matrices.

When implants support a prosthesis, they become subjected to various forces during occlusal loading. One of the factors that affect the amount of stresses transmitted to the implants is the type of attachment[16]. The design of the attachment should provide favorable stress distribution around the supporting implants to allow loading of the peri-implant bone within its physiological limits, as overloading can be detrimental to the osseointegrated implants[9,26]. This study was conducted to compare the strains generated around the implants with magnetic attachment and OLS attachment with PEEK retentive matrix.

Methodology

This in vitro study was done to compare between the strains transmitted to the implants via two different types of attachments for implant overdentures retained by two implants. The two investigated attachments were magnets and OLS[*] attachments with a PEEK retentive matrix.

Model fabrication and implant installation

An acrylic resin[**] model was fabricated by duplicating an educational edentulous mandibular cast using a silicon[***] mold. Two dummy implants[****] 3.7mm in diameter and 12mm in length were placed in the canine areas, one on each side. A waxed-up

* Osteoseal dental implants, California, USA
** Clear heat cured acrylic resin, Acrostone, Egypt.
*** Replisil 22n, Dentaurum, Germany.
**** Dentaurum Germany.

trial denture was used to guide the placement of the implants in the correct position. Implant parallelism was achieved through the use of a milling machine*. Drilling sequence was commenced until the implants were flushed with the crest of the ridge of the acrylic resin model. Self-cured acrylic resin was used to attach the implants to the models in a manner resembling osseointegration. An acrylic resin denture was fabricated on the model in the usual manner, and then it was duplicated into another denture using a silicon mold.

Strain gauge installation

The next step was the preparation of the models to receive the strain gauges. The acrylic resin around each implant was reduced using a fissure bur to a thickness of 1mm on all four surfaces (labial, lingual, mesial and distal). The preparations were made to resemble a box shape and were flat and parallel to the long axis of the implants. They were smoothened with sand paper before fixation of the strain gauges to avoid incremental strains. The strain gauges** had a gauge length of 5 mm, a resistance of 120.4±0.4 Ω and a gauge factor of 2.09 ± 1 %. They were bonded to the four surfaces of the acrylic resin surrounding the implants using Cyanoacrylate based adhesive***. No dummy gauge was used in this study as the gauges were temperature-compensated for plastics. The adhesive was left to completely cure for 24 hours. Each wire was labeled according to the surface to which it was attached to. The wires were secured at the base of the model by placing them in specially prepared channels and covering them with self-cured acrylic resin to avoid their dislodgement during measurements.

Pick-up of the attachments

The dentures were prepared for pick-up by reducing the acrylic resin in the fitting surface opposite the attachments. Pick up procedures were commenced for the magnetic attachment followed by loading and measurements. The magnetic attachment was placed first onto the implant and tightened to a torque of 35 NCm (fig 1). The magnetic keeper was placed over the attachment. The denture was checked to ensure complete seating without interference with the attachments. Rubberdam pieces were placed over the ridge area in the model and beneath the attachments to prevent the acrylic resin used during the pick-up procedure from flowing on to the strain gauges. Pick-up was done using self-cure acrylic resin.

After loading and measurements, the magnetic attachment was replaced with the OLS attachment which was also tightened to a torque of 35Ncm (fig 2). Then, the black processing cap and housing were placed on the OLS attachment. Pick up was carried on in the same manner. Afterwards, the processing caps were replaced with the PEEK retentive caps of the OLS attachment (fig 3). Loading and measurements were then done for the OLS attachment in the same manner.

Loading and measurements

A universal testing machine**** was used to apply unilateral and bilateral vertical static loads of 100N for 15 seconds at a cross head speed of 0.5mm/minute to resemble occlusal forces in implant overdentures as recommended by porter et al 2002[27]. A notch was prepared in the central fossa of the first molars on both sides to act as a repeatable point of load application and to avoid slippage of the loading pin. Unilateral loading was done using the I-shaped load applicator on the left side only – the loading side – while the right side was considered as the non-loading side[28] (fig.4). Bilateral loading was applied on both sides of the arch using the T-shaped load applicator (fig.5). A

* Bego Bremer Goldschagerei Wihl. Herbst, Bremen, Germany
** Kyowa strain gauges, KFG-3-120-c1-11L1M2R, Japan
*** CC-33 strain gauge cement, Kyowa electronic instruments co., Japan.
**** Lloyd LR5K instrument, Fareham, Hampshire, UK

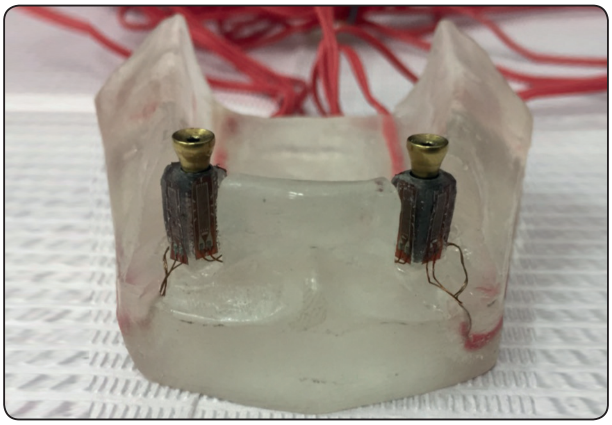

Fig. (1) Prepared model with magnetic attachment after strain gauge installation

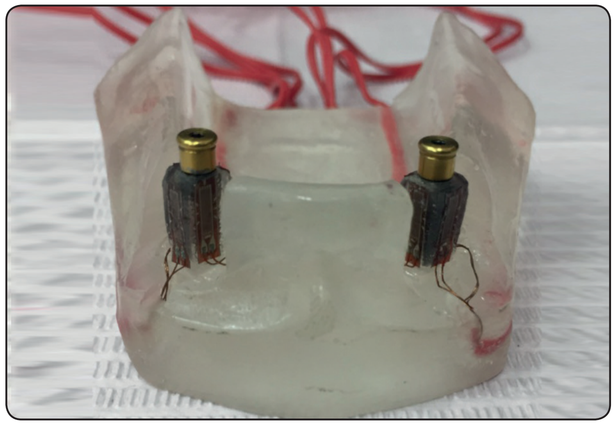

Fig. (2) Prepared model with OLS attachment after strain gauge installation

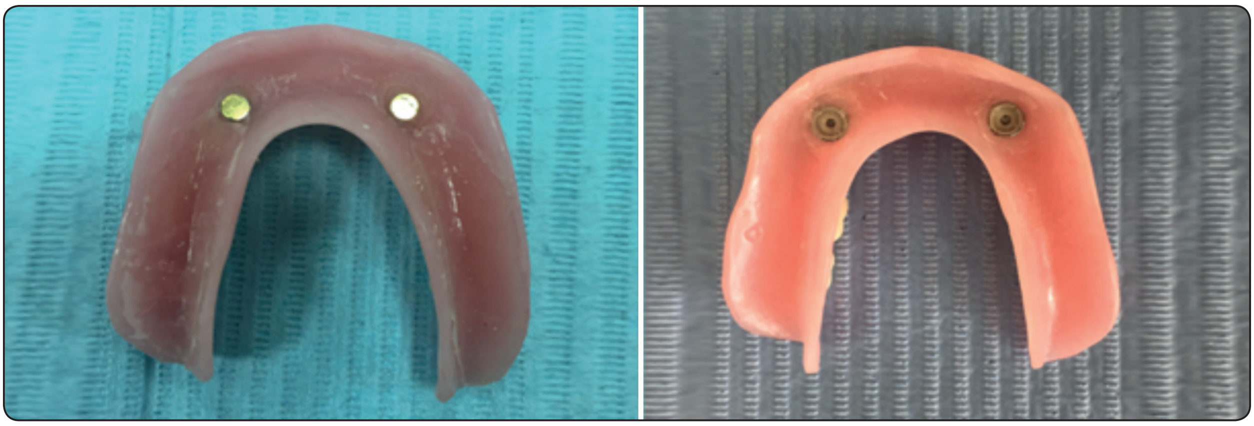

Fig (3) Fitting surface of denture with magnetic keeper (left) and PEEK matrix of OLS attachment (right)

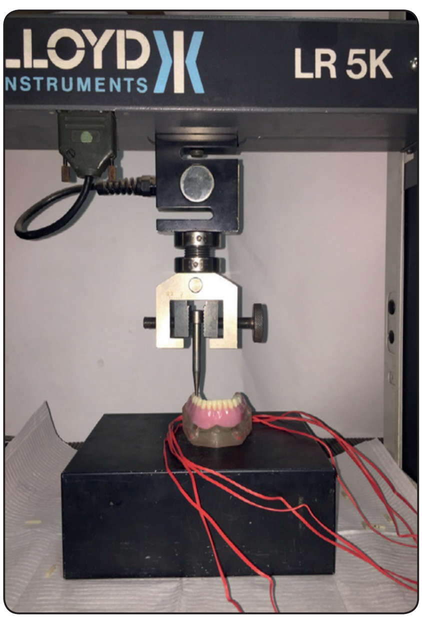

Fig. (4) unilateral loading using the universal testing machine

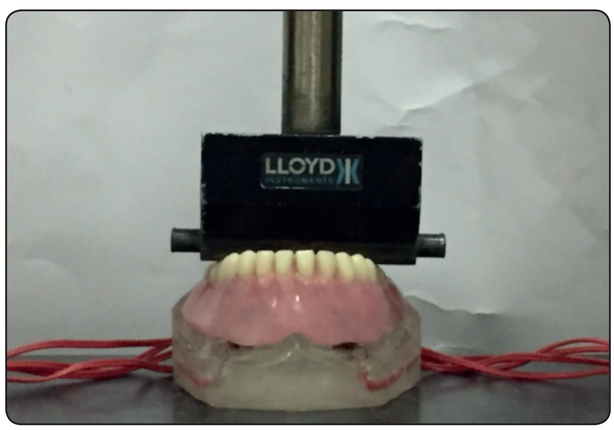

Fig. (5) bilateral loading using the universal testing machine multichannel strain meter*, to which the terminal ends of the strain gauge wires were connected, was used to measure the microstrains transmitted through each of the four strain gauges using special software**. For each attachment, 5 measurements were taken allowing at least 5 minutes between each measurement for heat dissipation. The results were tabulated and statistically analyzed.

Statistical Analysis

The mean and standard deviation values were calculated for each implant and attachment. With bilateral loading, mean values of the two implants were calculated for each attachment. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests and showed parametric (normal) distribution. Independent sample-t test was used to compare between independent samples. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

RESULTS

Unilateral Loading

The mean microstrains recorded for loading and non-loading sides for the two attachments are shown in Table 1. For both attachments, the loading side showed significantly higher microstrains than the non-loading side. For the OLS attachment, the highest mean microstrain occurred on the loading side (410.00 ± 29.15) while the lowest was found on the non-loading side (342.50 ± 18.48). For the magnetic attachment, the highest microstrains were found on the loading side (131.25 ± 17.02) and the lowest were found on the non-loading side (103.75 ± 12.50). On comparing the two attachments, the OLS attachment had significantly higher microstrains on the loading side than the magnetic attachment, while on the non-loading side the magnetic attachment showed significantly lower strains than the OLS attachment (fig. 6).

Bilateral Loading

The highest mean value of microstrains occurred with the OLS attachment (141.13 ± 12.62) while the lowest mean value was found in the magnetic attachment (136.50 ± 14.03). The difference between the two attachments was not statistically significant (p=0.500) (table 2, fig. 7).

TABLE (1) The mean, standard deviation (SD) values of micro strain of unilateral loading with the two attachments

Variables	Unilateral loading				
	Loading side		Non-loading side		*P-value*
	Mean	SD	Mean	SD	
Magnet	131.25 [aA]	17.02	103.75 [aB]	12.50	**0.004***
OLS	410.00 [bA]	29.15	342.50 [bB]	18.48	**0.008***
P-value	**≤0.001***		**≤0.001***		

Means with different small letters in the same column indicate statistically significance difference, means with different capital letters in the same row indicate statistically significance difference. *; significant (p<0.05) ns; non-significant (p>0.05)

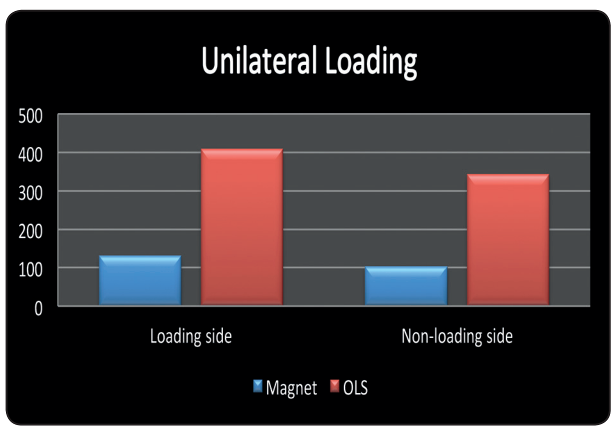

Fig. (6) Bar chart representing means of micro strain of unilateral loading in both attachments

* Model 8692, Tinsely precision instruments, Surrey, UK
** Kyowa PCD 300 A.

TABLE (2) The mean, standard deviation (SD) values of microstrain of bilateral loading in the two attachments

Variables	Bilateral loading	
	Mean	**SD**
Magnet	136.50 [a]	14.03
OLS	141.13 [a]	12.62
P-value	**0.500ns**	

Means with different small letters in the same column indicate statistically significance difference. *; significant (p<0.05) ns; non-significant (p>0.05)

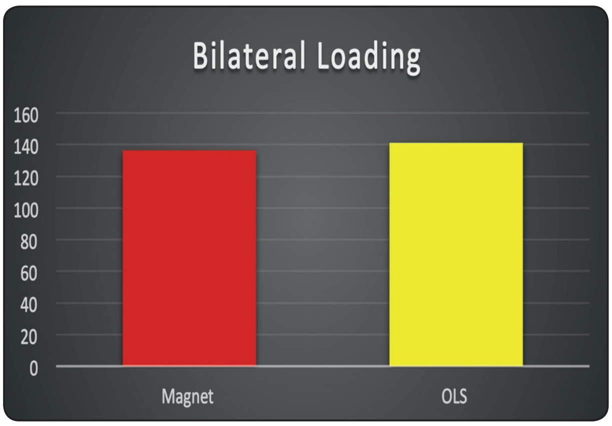

Fig. (7) Bar chart representing means of micro strain with bilateral loading in both attachments

DISCUSSION

A relationship between the type of attachment and the amount of strains transmitted to the peri-implant bone has been previously demonstrated[14,17,27]. Attachments differ in the design of their patrices as well as the material of their retentive matrices. This in turn has an effect on the strain transmitted from the overdenture to the supporting implants during function. From a clinical point of view, an attachment is required to provide a favorable force distribution pattern to the implants to achieve bone preservation and longevity of the prosthesis[26].

Unilateral loading was done to simulate the presence of a preferred chewing side for the patient, while bilateral loading was done to simulate bilateral chewing. Loading on the first molar was done as this is reported to be the area where maximum occlusal forces and maximum contraction of elevator muscles occur[29]. The results of this study showed that the loading side in the two attachments demonstrated higher strains than the non-loading side. This is expected since axial load application on non-splinted attachments results in higher strains on the side on which the load is applied as reported by previous studies[14,29].

On comparing the two attachments, the magnetic attachment demonstrated less microstrains than the OLS attachment on the loading and non-loading sides. This is explained through the findings of Yoda et al[30], who demonstrated that loading causes settling down of the denture base on the loading side resulting in a lateral and posterior direction of load. The direction of load on the non-loading side, on the other hand, was upwards resulting in a rotational movement of the denture. This offers a viable explanation to the strain distribution patterns in the two attachments. When loads were applied at the first molar area of the magnetic attachment, sinking of the denture base resulted in the disengagement of the magnet from its keeper, especially on the non-loading side. The OLS attachment, on the other hand, offered some form of secondary splinting as the retentive caps on the non-loading side continued to engage the retentive undercuts of the attachment, resulting in higher strains on the non-loading side than the magnetic attachment.

During bilateral loading, there was no significant difference between the strains around the two implants with both attachments, suggesting equalized load distribution between the two implants. Therefore, the mean value of the strains for the right and left implants was calculated for each attachment. The results showed no significant difference between magnetic and OLS attachments. One explanation could be that during bilateral loading, the flat surfaces of the magnets remained in contact with their keepers and no forces were dissipated due to disengagement. Since there is a sustained metal-to-metal contact with no vertical resiliency involved, the stresses were transmitted directly to the implants with the magnetic attachment. On the other hand, the resilient nature of the PEEK retentive matrix of the OLS attachment acted as a shock absorber and offered some freedom of movement, resulting in fewer stress transmission to the implants on both sides[15].

Even though magnetic attachments transmit less stresses to implants as proven by this study and other studies, this usually happens at the expense of retention and stability of the denture[14,15,17]. Studies have shown that retentive forces of magnetic attachments are less than other stud attachments which might have an effect on patient satisfaction with the final denture[14,31]. Yet, magnets were found to be satisfactory and comfortable for older patients or those with dexterity issues[12,32,33]. On the other hand, attachments like the OLS, which offer a more stable denture and retentive denture[25], seem to transmit higher loads to the peri-implant bone. However, long-term clinical studies on several stud attachments have shown that these stresses seem to fall within the physiological limits of the supporting bone[32,34,35]. Thus, the choice of attachment for implant overdentures should be based on the clinical situation itself; whether there is a greater need for a denture with high retention and stability or if more importance is given to the comfort and ease of use. Finally, studies on stud attachments with PEEK retentive matrices are scarce. Therefore, more studies are needed to better evaluate their clinical and mechanical performance over long periods of time.

Even though in vitro studies are a reliable means to study the stresses and strains related to implants, teeth and superstructures as accurate measurements are more difficult to attain intra-orally, the results of this study remain essentially descriptive as the physical properties of acrylic resin do not accurately simulate the complex nature of bone and osseointegration. Another limitation of this study is that only vertical loading was applied, which does not resemble the complex directions of forces that occur during mastication.

CONCLUSIONS

Within the limitations of this in vitro study, it can be concluded that implant overdentures retained by magnetic attachments transmit less stresses to the implants than OLS attachments with PEEK retentive matrices during unilateral loading. During bilateral loading, the stresses transmitted by the two attachments were comparable.

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