Original Article

Comparison of efficacy of different fitting systems in implant-supported overdentures: An original research

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Abstract

Aim: The present in vitro study compared the load transfer characteristics to the implant and the movement of implants supported overdentures among the three different types of attachments (ball and ring, clips on a bar and magnetic).
Methodology: Stress on the implant surface measured using strain gauge technique and denture displacement by dial gauge.
Results: Least displacement occurred in the bar & clip attachment. At the non-loading site, the bending moment was highly significant between these attachments. In backward-forward direction, the ball attachment had significantly less displacement than the other attachments ($p<0.01$) while, maximum displacement was noted with magnetic attachment. In the upward–downward direction, magnetic attachment had a significantly greater displacement ($p<0.01$). The difference between ball and bar attachments was also significant ($p <0.05$).
Conclusion: Ball/O-ring produces optimal stress on the implant body and promotes denture stability but more resilience was seen in telescopic attachments.

Keywords: Overdenture, ball & ring, bar & clip, magnetic attachment.

INTRODUCTION

Edentulism is defined as “the state of being without any natural permanent teeth. It is an irreversible condition that is evident in age groups of 65 years and older, and was previously considered part of the normal aging process”.1 To make matters worse, edentulousness is often associated by lower quality of life due to negatively affecting general as well as oral health. Elderly patients could be forced to modify their dietary habits in favor of less fibrous foods, due to an important reduction in masticatory function. Because of this behavior the risk of cardiovascular diseases and gastrointestinal disorders may increase.2 Phonetic and speech functions are also affected particularly after the loss of anterior teeth, making edentulous patients less confident and limited to interacting with other people.3,4 Trying to solve these problems, in these cases, dental implants can be invaluable. To overcome the above problems implant-retained and -supported overdentures have been proposed during last decades for restoring completely edentulous patients, as an alternative and more effective treatment modality to the conventional complete removable denture. High long-term success rates and improved patients’ quality of life were reported for implant-retained and -supported overdentures.5-7 Implant-supported overdenture (I-SO) takes the bite force through the implants and into the jawbone, providing the most natural and effective bite for patients. However, treatment is usually more expensive since a greater number of implants are required. With implant retained overdenture (I-RO), the gingiva and the underlining bone absorb the bite force. Fewer dental implants are required, so treatment is more cost-effective and often it may be possible to use mini dental implants. Various attachment systems have been used for years as retentive elements for root overdentures and are now being used almost exclusively to stabilize an overdenture to the installed as implants, including, but not limiting to, balls, magnets, bars, and telescopic attachments.1 Among these, ball attachments are the more simple, commonly used and well-proven attachment systems used for anchorage on both splinted and non-splinted implants, offering high retentive ability, reduced loading forces along the implants, and aid in correcting disparallelism between the implants.8 However, their clinical application requires more vertical and buccolingual spaces, potentially encroaching on the tongue space, particularly in tapered arches. In addition, gingival hyperplasia around the attachment system may complicate the plaque control and the hygiene maintenance. Overdenture stability is a key factor for patient satisfaction and is dependent upon the ability of the implants to withstand occlusal loads. It is hence important to ascertain, whether implants need to be splinted together, or whether freestanding implants alone can withstand the loads.

AIM OF THE PRESENT STUDY

The present in vitro study compared the load transfer characteristics to the implant and the movement of implants supported overdentures among the three different types of attachments (ball and ring, clips on a bar and magnetic).

METHODOLOGY

A castable bar of length 22mm, and clip length 16mm, were used for the bar & clip attachment (BCA). A metallic housing with rubber-O-ring component was used for ball & ring attachment (BRA). Intraoral magnets (Alnico; power-600gms) were used for magnetic attachment (MA). Cylindrical crown telescopic attachment (TA) design was used. The length (14mm) and diameter (4.3mm) of the fixtures used were same in all the three types of attachments. Edentulous mandibular models were made from heat-cure polymethylmethacrylate resin. Implants were placed in the canine region and retained with resin cement. Overdenture was fabricated in the conventional manner. The stress on the implant surface was measured using the strain gauge technique. Stress measured directly on the implant surface using strain gauge technique could be representative of stress that is introduced into the bone. Four strain gauges were attached around each implant mesiodistally and buccolingually, to measure the strain on the implant. The electrical signals from the eight strain gauges were amplified and recorded using switch & balance unit and a strain indicator. In the present study, a total of 24 strain gauges were used for the three attachments evaluated. Loads were applied to the occlusal surface of the right first molar region. A moderate level of biting force on an implant- retained overdenture was simulated. Loads from 0 to 50 N were applied gradually and increased in 10N steps. Three sessions, one for each attachment, were performed at suitable intervals. Five measurements at each load of (0, 10, 20, 30, 40, & 50N) were made under the same conditions, allowing at least 5 minutes for recovery. The digital counter type dial gauges were used for measuring denture displacement. Denture displacement in mediolateral, backward forward, and upward-downward directions can be detected with this technique. The means and standard deviations were calculated, and statistical comparison was made using a one-way analysis of variance (ANOVA) and Duncan's calculation for post hoc comparisons.

RESULTS

Strain Measurements

a) Ball & ring attachment (BRA): At the beginning of the load, the ball and ring transmitted a small strain in each channel. The strain increased linearly as the load was increased. In addition, the strain on the implant at the loading side was greater than at the non-loading–side implant. The maximum compressive strain occurred in channel 1, the buccal site of the loading side implant. The maximum tensile strain was observed in channel 3, the lingual site of the loading side implant.

b) Magnetic attachment (MA): With the magnetic attachment, the strains in the eight channels differed at the initial load, unlike the ball attachment, but beyond 5 N, the strains in each channel were almost constant. The maximum compressive strain was found in channel 2, the distal site of the loading side implant. The maximum tensile strain was found in channel 6, the mesial site of the non-loading side implant.

c) Bar and clip attachment (BCA): With the bar attachment, the strains in the eight channels differed at the beginning of the load, and no clear trend in strain change was noted with load increase.

d) Telescopic attachment (TA)- the resilience was noticed in the different channels, beyond 10N no change was observed.

While some of the channels changed from compressive strain to tensile strain, a few changed from tensile to compressive strain. The maximum compressive strain was found in channel 4, the mesial site of the loading side implant. The maximum tensile strain was detected in channel 6, the mesial site of the non-loading-side implant. In mediolateral direction, the denture displacement with the magnetic attachment was highly significant. The difference in denture displacement between ball and bar attachments was also significant. Least displacement occurred in the bar & clip attachment. At the non-loading site, the bending moment was highly significant between the three attachments. In backward-forward direction, the ball attachment had significantly less displacement than the other attachments ($p<0.01$) while, maximum displacement was noted with magnetic attachment. In the upward–downward direction, magnetic attachment had a significantly greater displacement ($p<0.01$). The difference between ball and bar attachments was also significant ($p <0.05$). Based on Duncan's post hoc analysis for total displacement, the ball & ring, and bar& clip attachments did not show any statistically significant difference. On the contrary, the values obtained for magnetic attachment was highly significant. (Table 1)

Table 1- Mean vertical force (N) in the attachment designs

Attachment design/Force	Mean	Standard deviation	Minimum	Maximum	P value
Ball and ring attachment	38.61	9.63	22.16	52.12	<0.01
Magnetic attachment	22.66	15.41	11.33	54.62	
Ball and clip attachment	27.87	17.75	7.45	49.12	
Telescopic attachment	33.03	12.44	18.11	51.13	

DISCUSSION

In an implant-supported overdenture, two basic factors are to be minimized. One is the stress on the implants, and the other is the movement of the denture. Numerous methods have been followed to achieve this goal. The role of anchorage, which includes ball attachments, clips on a bar connecting the implants9, and magnetic attachments 10 was reported to be quite important. Cost is an important factor that determines the placement of implants. By reducing the number of implants required to support an overdenture, the cost can be considerably reduced. Two instead of four implants in the mandible, can also offer an almost equal amount of stability to the denture. A multicentric study of overdentures supported by two, three and four Branemark implants, advocated the placement of two implants in mandible (canine region), for uniform load distribution and denture stability.11 The assumption that unfavourable loading of implants may lead to bone resorption has been neither confirmed, nor rejected. Therefore, is it necessary to learn more about naturally occurring forces in vivo. In the present study, stress on the implant surface was measured using a strain gauge technique and, denture displacement, by the dial gauge technique. The strain gauge device offers quite reliable measurements as noted by Duyck et al, who performed a methodological study to measure the three-dimensional forces on oral implants using this technique.12 Digital counter type dial gauges on the other hand, are comparatively a newer and reliable method for measuring various linear displacements. When ball and bar attachments were compared using 3-D finite element analysis methods, the peri-implant bone stress was greater with bar & clip attachments. However, these studies 13,14 focused only on minimizing the stress on the implant and peri-implant tissue without considering the stability. We found that with ball and magnetic attachments, the strain was concentrated on the loading side implant. The stress on the loading side implant was small when the load was slight, because of the secondary splinting that occurs with ball attachments. The bar attachment on the contrary, produced higher stress on the non-loading-side implant when compared with ball and magnetic attachment, because of the primary splinting effect even at low pressure. Our result is consistent with a previous study which noted that the axial force on the loading-side implant was minimal with the ball attachment.15 This may be the result of stress absorbing effect of the rubber-O-ring component. Of the three attachments, the ball attachment resulted in the least denture displacement. This is thought to be due to the presence of rubber O-ring, and deformation of the denture. Even though magnetic attachment induced the least bending moment, it resulted in greater denture movement. The main drawback of magnetic attachment however, is its corrosive nature and power deterioration.16 A high correlation exists between patient satisfaction and denture stability, and it was found that magnetic attachment would not significantly improve the patient's satisfaction.

CONCLUSION

Since implant failure can result from excessive load on the implant, the practical goal for clinician is to avoid excessive stress on the implants. We suggest that ball/O-ring attachments might provide an adequate system with respect to reducing the stress on the implant and promoting the denture stability.

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