Süleyman Demirel Üniversitesi
Mühendislik Bilimleri ve Tasarım Dergisi
2(3),ÖS:BiyoMekanik2014, 267-271, 2014
ISSN: 1308-6693

Suleyman Demirel University
Journal of Engineering Sciences and Design
2(3),SI:BioMechanics2014, 267-271, 2014
ISSN: 1308-6693

THE EFFECTS OF DIFFERENT ATTACHMENT SYSTEMS ON STRESS IN 2-IMPLANT-RETAINED OVERDENTURES

Serdar POLAT*[1], Bulent ULUDAG[2]
[1] Gazi University, Department of Prosthodontics, 06510 Ankara, Turkey

Keywords
Attachment systems
Galvanoformed bar
Implant
Overdentures
Stress analysis

Abstract
Osseointegrated implants have been used to improve denture support, stability and retention. Currently, the placement of 2 implants and the fabrication of an implant-retained overdenture is considered by some to be the standard of care. The influence of various types of attachments on stress distribution of 2-implant-retained mandibular overdenture designs has not been sufficiently assessed. The purpose of this study was to compare the load transfer characteristics of 5 attachment systems for 2-implant-retained mandibular overdenture designs. One photoelastic model was fabricated having 2 screw-type implants (3.75 X 13 mm) embedded in the interforaminal region and implants were parallel to each other and vertically oriented. Five retention mechanisms were studied on model; a bar with yellow-colored clips, a milled galvanoformed bar, a bar with two clear distal locator attachments, a bar with two distal ceka attachments, clear locator attachments. For measurements of stress a vertical load 135 N was applied unilaterally to the central fossa of the right first molar. The resultant stresses that developed in the supporting structure were monitored photoelastically and recorded photographically. A bar with two clear distal locator attachments and,clear locator attachments showed higher stress than other attachments.

FARKLI TUTUCU SİSTEMLERİN 2-IMPLANT TUTUCULU OVERDENTURE UYGULAMALARINDA STRESLER ÜZERİNE ETKİSİ

Anahtar Kelimeler
Tutucu Sistemler
Galvano Bar
Implant, Overdenture
Stres Analizi

Özet
Osseointegre implantlar protezin destek, stabilite ve tutuculuğunu geliştirmek için kullanılmışlardır. Günümüzde 2 implant ve üzerine yapılan implant tutuculu overdenture uygulamaları standart tedavi olarak kabul edilir. Farklı tip tutucuların, 2-implant tutuculu mandibular overdenture tasarımları üzerindeki stres dağılımına etkisi yeterince değerlendirilmemiştir. Bu çalışmanın amacı; 5 tutucu sistemin, 2 implant tutuculu mandibular overdenture tasarımlarında yük transferini kıyaslamaktır. 2 adet vida tipi implantın (3.75 X 13 mm) interforaminal bölgeye, vertikal düzleme ve birbirine paralel olarak yerleştirildiği 1 fotoelastik model üretilmiştir. Modelde 5 tutucu mekanizma değerlendirilmiştir; Bar-sarı klips, bar-galvano, bar-distal locator (şeffaf), bar-distal ceka, locator (şeffaf). Stres ölçümü için, tek teraflı olarak sağ birinci molar dişin santral fossasına 135 N vertikal yük uygulanmıştır. Destek yapıda gelişen stresler fotoelastik olarak izlenmiş ve fotoğraf olarak kaydedilmiştir. Bar-distal locator (şeffaf) ve locator (şeffaf) tutucu diğer tutuculardan daha yüksek stres göstermişlerdir.

* Corresponding author: drserdarpolat@gmail.com

1. Introduction

Elderly patients often have difficulty adapting to new complete dentures and have problems attaining comfortable and efficient denture function (Van Waas et al., 1993; Cune et al., 2005). Edentulous patient with severely resorbed mandibles may experience problems with conventional dentures because of impaired load bearing capacity, and this result related to comfort and patient satisfaction (Burns et al., 1995; Al-Ghafli et al., 2009). Osseointegrated implants have been used to improve denture support, stability and retention (Ichikawa et al., 1996; Bergendal and Engquist, 1998). Currently, the placement of 2 implants and the fabrication of an implant-retained overdenture is considered by some to be the standard of care (Feine et al., 2002).

The level of clinical comfort achieved is dependent upon many factors, including degree of retention, proper location and orientation of implants, restorative component fit, type of attachment elements used and proper denture fabrication (Williams et al., 2001).

There are many different attachments produced by a large number of manufacturers around the world. Most of these are compatible with the majority of implant systems currently available. In general, attachments are divided into 2 major categories: bar attachments and stud attachments (Trakas et al., 2006).

Locators are a newly introduced type of connector designed to provide accurate seating and secure adequate retention of implant-supported overdentures (Alsiyabi et al., 2005). Locator attachments do not require splinting, are self-aligning and possess dual (inner and outer) retention characteristics (Evtimovska et al., 2009). In contrast to locators, bar attachment systems splint implants, with the amount of movement tissuewards dependant upon the specific cross-sectional shape of the attachment (Al-Ghafli et al., 2009). Bar attachments can be cantilevered, galvano (electroformed), milled or cemented (Williams et al., 2001; Uludag et al., 2007; Bueno-Samper et al., 2010) and can use either metal or plastic clips (Walton and Ruse, 1995).

2. Materials and Methods

A model of an edentulous mandible was fabricated from photo-elastic resin (PL-2; Vishay Intertechnology, Malvern, PA) (Figure 1) using an arch configuration adapted from a mandibular cast of an edentulous patient. A silicone mold (Speedex; Coltane/Whaledent, Alstatten, Switzerland) was used to duplicate the cast in wax (Poliwax; Bilkim Kimya, Izmir, Turkey), and 2 parallel, vertically oriented, tapered screw-vent implants (3.75 mm-13 mm, Zimmer Denta, Carlsbad, CA) were placed in the wax model using a surveyor (Ney Surveyor; Dentsply Intl, York, PA). (Ney Surveyor; Dentsply Intl, York, Pa).

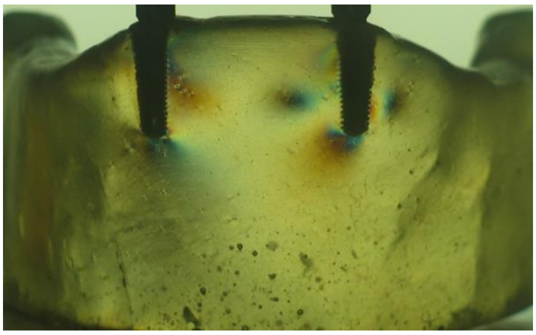

Figure 1. Photoelastic model with implants

Five attachment systems were tested: a bar with yellow-colored clips (Bredent, Senden, Germany), a milled galvanoformed bar (Gramm Technik GmbH,Muehlhausen,Germany), a bar with two clear distal locator attachments (Attachments Intl Inc, San Mateo, CA), a bar with two distal ceka attachments (Ceka/Preci-Line, Alphadent NV), clear locator attachments (ZEST Anchors LLC, Escondido, USA). In total, 5 dentures were fabricated.

2.1. Measurement of Stress

All dentures were sequentially placed on the models with the attachments engaged, and examined photoelastically. Mineral oil (Castrol, Istanbul,Turkey) was applied to the models using a cotton pellet (Boz Tekstil, Usak, Turkey) to facilitate photoelastic observation. Photoelastic model was photographed and again evaluated to ensure that they were stress-free with no inherent stresses in a circular polariscope before force application7,18,21. Loads were applied with a loading device (Custom-made; Gazi University, Technical Education Faculty, Mechanical Education Department, Teknikokullar-Ankara, Turkey). A vertical load of 135 N was applied unilaterally to the central fossa of the right first molar. The resulting stresses of the models were observed and recorded photographically (Canon Powershot G3; Canon Inc, Tokyo, Japan) in the field of a circular polariscope (Measurements Group). All photographs were evaluated visually for stress-induced fringes. The stress intensity and their locations were subjectively compared.

In the evaluation of these stress data, the following terminology was adopte: Low stress – 1 fringe or less; moderate stress – between 1 and 3 fringes, and high stress – more than 3 fringes (Figure 2).

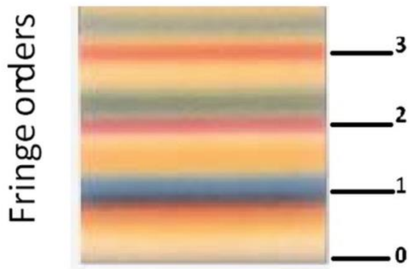

Figure 2. Relation between stress level and fringe order used to describe results.

3.Results

Loading on the right and left side produced similar fringe patterns. Therefore, only results from the right side are presented. On the model for the overdenture prosthesis with bar clips attachments, along the mesial of the right implant low stress (1 fringe order) was seen. On the left implant, moderate stress (2 fringe order) was seen apically (Figure 3).

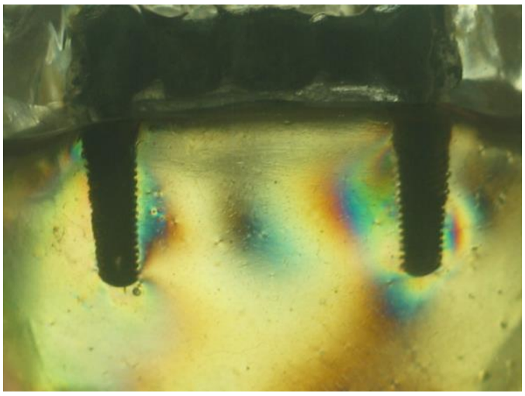

Figure 3. Stresses produced by bar clips attachment-retained prosthesis

For the overdenture prosthesis with galvano bar attachments; Little or no discernible stress was noted on the left implant and on the right implant (Figure 4).

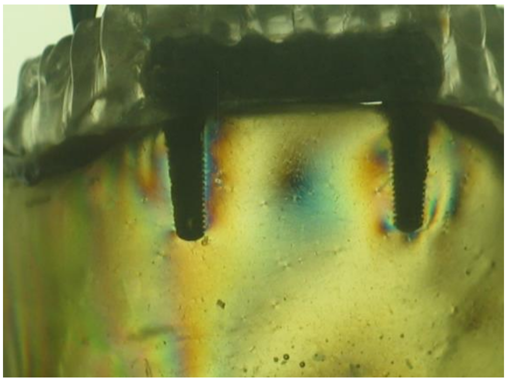

Figure 4. Stresses produced by galvano bar attachment-retained prosthesis

For the overdenture prosthesis with Bar-ceka attachments; Middle and apical area of the right implant, little or no discernible stress was noted. On the left implant, low stress (less than 1 fringe order) was seen distal apical area (Figure 5).

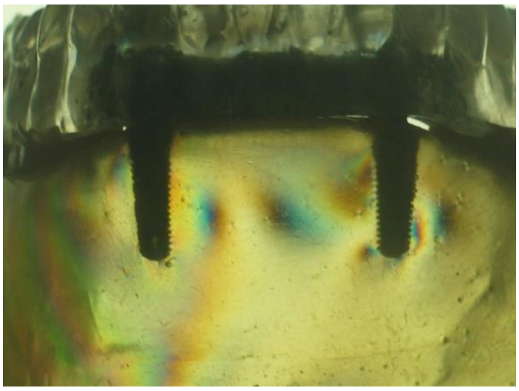

Figure 5. Stresses produced by bar-ceka attachment-retained prosthesis

For the overdenture prosthesis with Bar-locator attachments; High stress (more than 3 fringe order) was seen on right implant. Little or no discernible stress was noted on the left implant (Figure 6).

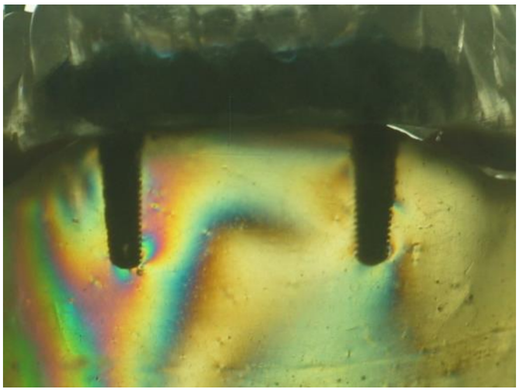

Figure 6. Stresses produced by bar-locator attachment-retained prosthesis

For the overdenture prosthesis with Locator attachments; apical area of the right implant, moderate stress (2 fringe order) was observed. Moderate stress (2.5 fringe order) was noted on the left implant (Figure 7).

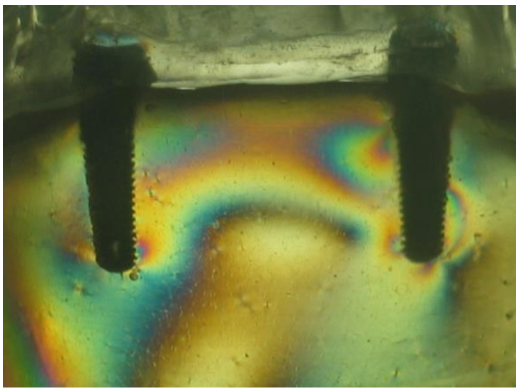

Figure 7. Stresses produced by locator attachment-retained prosthesis

4. Discussion and Conclusion

Load transfer may be dependent on clinical factors such as durability of prosthetic attachments, implant structures, and the supporting osseous and soft tissue structures (Ochiai et al., 2004). Various types of attachments are available, including bars and studs to connect a denture to the implants. (Trakas et al., 2006). In the current study different attachments were compared. The photoelastic model used in this study consists of impression material to represent the periodontium and complete integration of implants. Although there was no differentiation between cortical and medullary bone and the magnitude of stress concentrations might have been different if our model had also differentiated between cortical and medullary bone the locations of the stress concentrations would not have changed substantially (Sadowsky and Caputo, 2000).

An earlier study with a photoelastic model found that when compared to bar/clips attachments, ball/O-ring attachments transferred less stress to implants subjected to a posterior vertical load (Kenney and Richards, 1998). Similarly, another study using 3-D finite element analysis showed peri-implant bone stress to be greater with bar-clips attachments than with ball attachments (Menicucci et al., 1998). Both these studies focused on minimizing stress on implant and peri-implant tissue only, which can be achieved if there is no retentive mechanism or support from the implant; However, in clinical practice, not only is it important to minimize stress on implants, it is also necessary to minimize denture movement (Tokuhisa et al., 2003).

Stress-transfer characteristics of various overdenture attachments have been well-documented by in vitro studies in the literature (Ichikawa et al., 1996; Sadowsky and Caputo, 2000; Porter et al., 2002; Tokuhisa et al., 2003; Sadowsky and Caputo, 2004; Kenney and Richards, 1998; Fanuscu and Caputo, 2004). The authors suggested that differences in stress levels may be due to the structural characteristics of the locator, whose matrix-patrix relationship may affect the transfer of stress to implants. The authors found that the use of solitary anchors resulted in a tendency towards greater forces on implants, whereas rigid bars had a positive effect on load distribution. In contrast, Kenney and Richards (1998) found that ball/O-ring attachments transferred less stress to implants than bar-clips attachments when a photoelastic model with 2-implant-supported overdentures was subjected to a posterior vertical load. Ochiai et al. (2004) compared a Hader bar with distal ERA, Zaag and locator attachments and observed the highest stress when the splinted bar was used, followed by the locator and Zaag attachments. Porter et al. (2002) compared various stud attachments and bar-clip by means of load distribution, and concluded that ERA attachments exhibited lowest stress values around implants. Celik and Uludag (2014) compared a bar with distal ball attachments, bar with distally placed extracoronal rigid attachments, bar attachments and ERA attachments and observed the highest stress when the bar with distally placed extracoronal rigid attachment (Easy Slot) design was used, followed by bar-ball, bar, and the single anchor attachment (ERA).

In the current study, the locator attachment resulted in higher stresses in vertically oriented implants, followed by the bar-locator, the bar/clips, bar-ceka, galvanoformed bar design

Within the limitations of this study, the following conclusions were drawn:

1-Of all the prosthodontic designs tested, the galvanoformed bar attachment resulted in the lowest amount of stress transference to implants.
2- Of all the prosthodontic designs tested, the locator attachment resulted in the highest amount of stress transference to implants.
3-Both splinted designs produced lower stresses than the unsplinted design.

Conflict of Interest

No conflict of interest was declared by the authors.

5. References

Al-Ghafli, S.A., Michalakis, K.X., Hirayama, H., Kang, K., 2009. The in vitro effect of different implant angulations and cyclic dislodgement on the retentive properties of an overdenture attachment system. J Prosthet Dent, 102, 140-147.

Alsiyabi, A.S., Feiton, D.A., Cooper, L.F., 2005. The role of abutment-attachment selection in resolving inadequate interarch distance: A clinical report. J Prosthodont, 14, 184-190.

Bergendal, T., Engquist, B., 1998. Implant-supported overdentures: A longitudinal prospective study. Int J Oral Maxillofac Implants, 13, 253-262.

Bueno-Samper, A., Hernandez-Aliaga, M., Calvo-Guirado, J.L., 2010. The implant-supported milled bar overdenture: A literature review. Med Oral Patol Oral Cir Bucal, 15, 375-378.

Burns, D.R., Unger, J.W., Elswick, R.K., Beck, D.A., 1995. Prospective clinical evaluation of mandibular implant overdentures: Part I. Retention, stability and tissue response. J Prosthet Dent, 73, 364-9.

Celik, G,, Uludag, B., 2014. Effect of the number of supporting implants on mandibular photoelastic models with different implant-retained overdenture designs. J Prosthodont, 23, 374-80.

Cune, M., van Kampen, F., van der Blit, A., Bosman, F., 2005. Patient satisfaction and preference with magnet, bar-clip and ball socket retained mandibular implant overdentures: A cross-over clinical trial. Int J Prosthodont, 18, 99-105.

Fanuscu, M.I., Caputo, A.A., 2004. Influence of attachment systems on load transfer of an implant-assisted maxillary overdenture. J Prosthodont, 13, 214-20.

Feine, J.S., Carlsson, G.E., Awad, M.A., Chelade, A., Duncan, W.J., Gizani, S., et al. 2002. The McGill consensus statement on overdentures. Mandibular two-implant overdentures as the first choice standart of care for edentulous patients. Gerodontology, 19, 3-4.

Evtimovska, E., Masri, R., Driscoll, C.F., Romberg, E., 2009 The changes in retentive values of locator attachments and hader clips over time. J Prosthodont, 18, 479-483.

Ichikawa, T., Horiuchi, M., Wigianto, R., Matsumoto, N., 1996. In vitro study of mandibular implant-retained overdentures: The influence of stud attachments on load transfer to the implant and soft tissue. Int J Prosthodont, 9, 394-399.

Kenney, R., Richards, M.W., 1998. Photoelastic stress patterns produced by implant- retained overdentures. J Prosthet Dent, 80, 559-64.

Menicucci, G., Lorenzetti, M., Pera, P., Preti, G., 1998. Mandibular implant-retained overdenture: Finite element analysis of two anchorage systems. Int J Oral Maxillofac Implants, 13, 369-376.

Ochiai, K.T., Williams, B.H., Hojo, S., Nishimura, R., Caputo, A.A., 2004. Photoelastic analysis of the effect of palatal support on various implant-supported overdenture designs. J Prosthet Dent, 91, 421-7.

Porter, J.A., Petropoluos, V.C., Brunski, J.B., 2002. Comparison of load distribution for implant overdenture attachments. Int J Oral Max Imp, 17, 651-662.

Sadowsky, S.D., Caputo, A.A., 2000. Effect of anchorage systems and extension base contact on load transfer with mandibular implant-retained overdentures. J Prosthet Dent, 84, 327-334.

Tokuhisa, M., Matsushita, Y., Koyano, K., 2003. In vitro study of a mandibular implant retained with Ball, Magnet, or Bar Attachments: Comparison of load Transfer and Denture Stability. Int J Prosthot, 16, 128-134.

Trakas, T., Michalakis, K., Kang, K., Hirayama, H., 2006. Attachment systems for implant retained overdentures: A literature review. Implant Dent, 15, 24-34.

Uludag, B., Sahin, V., Celik, G., 2007. Fabrication of a maxillary implant-supported overdenture retained by two cemented bars: A cilinical report. J Prosthet Dent, 97, 249-251.

Van Waas, M.A., Jonkman, R.E., Kalk, W., et al. 1993. Differences two years after tooth extraction in mandibular bone reduction in patient treated with immediate overdentures as with immediate complete dentures. J Dent Res, 72,1001-1004.

Walton, J.N., Ruse, N.D., 1995. In vitro changes in clips and bars used to retain implant overdentures. J Prosthet Dent, 74, 482-486.

Williams, B.H., Ochiai, K.T., Hojo, S., Nishimura, R., Caputo, A.A., 2001. Retention of maxillary implant overdenture bars of different designs. J Prosthet Dent, 86, 603-7.