Effects of Low-Profile Stud Attachment Configurations on Stress Distribution Characteristics of Implant-Retained Overdentures

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Purpose: Implant-retained mandibular overdentures are a proven treatment modality for edentulous patients. Low-profile stud attachments may allow divergence between the abutments up to 40 degrees. The purpose of this study was to investigate load transfer characteristics of various locations and nylon male configurations of low-profile stud attachment–retained overdentures. Materials and Methods: Three tapered dental implants were placed into three photoelastic mandibular models. The center implants were placed vertically onto the midline, and the distal implants were inclined 20 degrees corresponding to centralized implants. Three different distances (11, 18, and 25 mm) between the centralized and the distal implants were set on the models. Low-profile stud attachment (Locator)–retained mandibular overdentures were fabricated for each photoelastic model. Five different nylon male configurations of this stud attachment were established. The load transfer characteristics of the configurations were tested using a circular polariscope. Results: The observed stress levels for the tested configurations were moderate except for group 25C (photoelastic model with 25-mm interimplant distances and clear nylon male), which illustrated a high stress level. For the 11-mm photoelastic model, little or no discernible stress was noted around the dental implants for group 11R (red nylon male), group 11G (green nylon male), and configurations of clear and red or green nylon males (group 11CR [clear and red nylon males] and group 11CG [clear and green nylon males]). Conclusion: The applied loads were distributed to the supported dental implants and denture-bearing areas for tested designs. Equitable load distribution and less stress may be gathered using nylon males for angulated implants (red and green) when dental implants are placed inclined. Int J Oral Maxillofac Implants 2018;33:754–763. doi: 10.11607/jomi.6207

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Implant-retained mandibular overdentures are frequently recommended to rehabilitate patients with edentulous mandibles.¹ This treatment modality has been proven to improve quality of life compared with conventional mandibular complete dentures.² In addition, function, esthetics, denture design, retention, stability of the denture, quality of supporting tissues, and patient expectations may affect satisfaction of overdenture wearers.³⁻⁵

Mandibular overdentures supported by two to four dental implants have demonstrated successful, viable, and cost-effective rehabilitation in the literature.⁶⁻¹⁴ A mandibular overdenture supported with two implants in the interforaminal or intercanine regions has been suggested to the clinicians as the standard of care owing to a more cost-effective approach, adequate retention, and support for the edentulous mandible.¹⁵⁻¹⁷ However, several studies¹³⁻¹⁵ have reported no differences between mandibular overdentures retained by two vs more than two implants. Two implants are superior in the presence of adequate mandibular alveolar ridge height.¹⁶ Placement of three or more dental implants to attach an overdenture, especially in moderately or severely resorbed mandibles, enhances retention and stability of the denture.¹,¹⁸ Apparently, three dental implants establish an angular relationship between the implants instead of a straight-line relationship. This is more cost-effective than placement of four or more dental implants to provide an angular relationship for overdentures.¹,¹⁹

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Bar, stud, magnetic, and telescopic attachments can be used to attach an overdenture to the dental implants. Desired retention value, morphology of edentulous crests, soft tissue support, high muscle attachments, patient expectations, cost of the treatment, mastication forces, and capability of load distribution play key roles in choosing a retention mechanism and planning the denture design for implant-retained overdentures. Moreover, tilted implants should be considered when deciding on the attachment system because alveolar bone morphologies, interferences of jaw anatomy (e.g., mandibular canal, mental foramen, maxillary sinus), and the interferominal or intercanine distances can cause restrictions for placement of the dental implants in the desired location and angulation into the residual crests.

Bars, studs, or a combination of bar and stud attachments retaining overdentures are recommended when the dental implants are inclined. Bar designs can be used regardless of implant angulations and location of the implants in the arch. However, bars need extra occluso-gingival distance for definitive restoration. The fabrication technique is more sensitive, and they are more expensive than stud attachments. Besides, many studies evaluating stress patterns showed that the studs transmitted less stress around the dental implants compared with bar designs.

Despite some research that has reported that several spherical attachment types can be used safely with inclined implants, most of the stud types have frequently been restricted to tolerate less than 10 degrees of divergence between the implants. However, a low-profile stud attachment (Locator) has been on the market since 2000 and has recently come into extensive usage for the past decade due to allowance of extreme inclination between the implants. The Locator attachment has a self-aligning feature, inner and outer retentions, and low profile height. This low-profile stud attachment does not need to be splinted to other implants. The patented design of the Locator offers the male (the patrix), which is replaceable nylon placed on the intaglio surface of the overdenture. The Locator attachment offers color codes for males in order to ensure a retention value that is easy to define. The female (matrix) part of the Locator attachment has a unique design, and allows pivoting action for the nylon male. The pivoting ability of the Locator attachment males (blue, pink, and clear) enables a fit with up to 20 degrees of divergence between the implants. Extended-range males (gray, red, orange, and green), which are nylon males for inclined dental implants, have a pivoting ability to tolerate insertion of implant-retained overdentures with up to 40 degrees of divergence between the implants.

Well-retained overdentures increase self-confidence and satisfaction of the patient. Several pull-out test studies for implant-retained overdentures have shown that the low-profile stud attachments enhanced retention compared with other types of stud attachments. Similarly, some studies have pointed out that clear Locator males provide greater retention than bar/clip attachments. Masticatory forces and distribution of the loads should be considered in the planning of implant-retained overdentures as well as retention and stabilization of the dentures. Although several studies compared load transfer characteristics of low-profile stud attachments and other types of attachments, no study has been conducted to analyze the effect of different nylon males of low-profile stud attachments on stress distribution features.

When excessive loads are transmitted to dental implants, it could cause bone micro-damage around the implants. Thus, load distribution between the implants and the denture-bearing areas is important to overcome the hazards of excessive loads. Numerous studies have shown that success and longevity of the implant-supported prosthesis can be controlled via accurate biomechanical applications.

The aim of the present study was to evaluate stress distribution characteristics of a low-profile stud attachment–retained mandibular overdenture with three different interimplant distances of centralized and distal implants. Also, the effects of various nylon male configurations of this type of attachment on stress concentration and load distribution were investigated in this study.

**MATERIALS AND METHODS**

Three photoelastic mandibular models with three implants were fabricated using a photoelastic resin (PL-2, Measurements Group). The photoelastic models were generated from a mandibular stone cast of an edentulous patient with moderate residual ridge resorption. An elastomeric impression material (Optosil, Xantopren, Heraeus Kulzer) was used to make an impression of the mandibular stone cast. Three wax models were duplicated using a modelling wax (Modelling Wax, Dentsply) from this impression.

Three screw-type dental implants (diameter: 3.7 mm, length: 13 mm, Tapered Screw-vent, Zimmer Dental) were embedded into the wax models. A surveyor (Ney Surveyor, Dentsply) was used to perform placement of the implants in the wax models. Coronal levels of the implants were aligned on the top of the ridge of the wax models. Central implants were placed at the midline and oriented vertically. Distal implants were located 11-, 18-, and 25-mm distances...
from the midline. The distal implants were set at 20 degrees of inclination corresponding to the centralized implant. Prefabricated 20-degree angled abutments (Tapered Screw-vent) were used to ensure standardization of the divergence between the implants.6,12 Nylon males of low-profile stud attachments may tolerate up to 40-degree angulation between the abutments and obtain sufficient retention for implant-retained overdentures.29 Therefore, the divergence between the distal implants was aligned less than or equal to 40 degrees on the wax models.

A silicone mold (Zetaplus, Zhermack) was generated from each wax model with implants, and final photelastic mandibular models were fabricated pouring photelastic resin (PL-2) into the silicone molds following the instruction manual (Figs 1 and 2).

An implant-retained mandibular overdenture with low-profile stud attachment was fabricated for each model. Abutments with low-profile stud attachments (Locator, Zest Anchors LLC) were screwed onto the implants using an inserting core tool (Zest Anchors LLC), and impression copings (Zest Anchors LLC) were placed on the abutments (Zest Anchors LLC). Impressions of the photelastic models were made with an elastomeric impression material (Optosil, Xantopren) using a single-tray technique with a stock tray (Teknik Dis).6 Abutment analogs (Zest Anchors LLC) were inserted into the impression copings (Zest Anchors LLC). Type IV dental stone (Begostone, Bego Dental) was poured into the impressions, and the master casts were generated. Assemblies for processing (black) nylon males and abutment housings (Zest Anchors LLC) were seated on the abutment analogs. One layer of baseplate wax (Cavex Dental Base Plates, Cavex Holland BV) was adapted to the posterior edentulous ridge of the master casts to imitate the thickness of the soft tissue.10,51 These layers consisted of approximately 3-mm thickness of light body elastomeric impression material (Xantopren) that would be injected into the bilateral posterior intaglio surfaces of the dentures.

Metal frameworks were cast using a base metal alloy (Biosil-F, Degudent). A standardized denture setting was completed on the master cast with 18-mm interimplant distances using bony landmarks that were guided to the occlusal plane.10 Anatomical artificial teeth (Major, Major Prodotti Dentari) were used for denture setting. The master cast with the denture setting was put into the injection flask (SR-Ivocap, Ivoclar Vivadent) in order to duplicate them. The heavy-body elastomeric impression material (Optosil) was used to obtain a negative silicone mold. The denture setting was removed from the mold, the metal framework was placed, and a clear autopolymerizing acrylic resin (Futura Self, Schutz-Dental Group) was injected through the access openings of the injection flask.6 This procedure was applied for the other master casts, and finally, three low-profile stud attachment–retained overdentures were fabricated and polished (Fig 3).
The light-body elastomeric impression material (Xantopren) was injected onto the intaglio surfaces of the overdentures at the posterior edentulous area. Polymerized light-body impression materials had 3-mm thicknesses and mimicked soft tissues on the bilateral distal free ends. Five different male configurations—all clear, all red, all green, clear and red, clear and green—were evaluated on the photoelastic models. Tested groups and configurations of nylon males are illustrated in Table 1.

The photoelastic models were immersed in oil (Mineral oil, Castrol) and brushed with a cotton pellet to facilitate observation of fringes. All of the photoelastic models were inspected to be under negligible stress in the circular polariscope (Measurement Group, Instruments Division) before the force application. Vertical loads of 135 N were applied to the left first molar of the overdentures using a custom loading device (Custom-made, Gazi University, Technical Education Faculty, Mechanical Education Department, Teknik Okullar). Fringe patterns were photographed using a camera (Fujifilm HS10, Fujifilm) in the circular polariscope (Measurements Group, Instruments Division) for each group.

The stress intensity and locations were subjectively compared by a single author. The stress data were defined, and the following terminology was implemented: low stress, one fringe or less; moderate stress, between one and three fringes; and high stress, more than three fringes.

### RESULTS

The stress levels and locations were determined to compare records from before and after occlusal loads on the photoelastic mandibular models.

For the photoelastic mandibular model with 11-mm interimplant distances, moderate stress (1+ fringe orders) was observed on the apex and distal middle third of the loaded side implant for group 11C. Low stress (less than 1 fringe order) was noted on the mesial cervical third of the ipsilateral implant. Moderate stress (~2 fringe orders) was transmitted to the loaded side posterior alveolar crest. Moderate stress (1+ fringe orders) was seen along the mesial surface of the contralateral implant. Any stress pattern was experienced around the central implant (Figs 4a and 5a).

For groups 11R and 11G, moderate stress levels (1.5+ fringe orders) were recorded on the loaded side posterior edentulous area (Figs 4b, 4c, 5b, and 5c). For groups 11CR and 11CG, moderate stress levels (1+ fringe orders) were noted on the loaded side distal free ends (Figs 4d, 4e, 5d, and 5e). Little or no discernible

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Table 1

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<th>Tested Models and Configurations of Locator Male</th>
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<td>Locator</td>
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<td>Model</td>
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<td>11-mm interimplant distance</td>
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<td>18-mm interimplant distance</td>
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stress was observed around the implants for those four groups (Figs 4b to 4e and 5b to 5e).

For the photoelastic mandibular model with 18-mm interimplant distances, moderate stress (1+ fringe orders) was transferred around the apex of the loaded side implant and between the central and left implants for group 18C. Moderate stress (~2 fringe orders) was seen along the distal surface of the ipsilateral implant. Also, the left posterior edentulous area illustrated a moderate stress level (2+ fringe orders) (Figs 4f and 5f).

For group 18R, low stress (less than 1 fringe order) was noted on the distal cervical third of the loaded side implant. Moderate stress (1+ fringe orders) was observed between the central and the left implants. Moderate stress (1.5+ fringe orders) was transmitted to the loaded side posterior alveolar ridge (Figs 4g and 5g).

For group 18G, moderate stress (1+ fringe orders) was recorded on the loaded side implant apically and in the posterior edentulous area. Moderate stress (1.5+ fringe orders) was seen on the distal surface of the loaded side implant (Figs 4h and 5h).

For group 18CR, the apex and distal middle third of the loaded side implant and loaded side posterior alveolar crest showed moderate stress levels (1+ fringe orders). Moderate stress (~2.5 fringe orders) was experienced on the distal cervical third of the loaded side implant (Figs 4i and 5i).

For group 18CG, moderate stress levels (1+ fringe orders) were transferred along the body and the apical area of the loaded side implant and the left posterior edentulous area (Figs 4j and 5j).

Any stress pattern was illustrated around the central and unloaded side implants for the tested designs of the photoelastic mandibular model with 18-mm interimplant distances. Applied occlusal loads were distributed to the loaded side implant and distal free ends (Figs 4f to 4j and 5f to 5j).
At the photoelastic mandibular model with 25-mm interimplant distances, moderate stress (1+ fringe orders) was noted along the left surface of the central implant for group 25C. High stress levels (3+ fringe orders) were seen around the apex and distal apical third of the loaded side implant. Mesial (1.5+ fringe orders) and distal (~2.5 fringe orders) surfaces of the loaded side implant showed moderate stress levels. Little or no discernible stress was observed around the right implant and loaded side posterior edentulous area (Figs 4k and 5k).

For group 25R, moderate stress (1+ fringe orders) was recorded along the left surface of the central implant. Moderate stress (1.5+ fringe orders) was transmitted to the loaded side distal free ends. Any stress pattern was noted around the contralateral implant (Figs 4l and 5l).

For group 25G, moderate stress levels (1+ fringe orders) were transferred around the left apical third of the central implant, mesial cervical third of the left implant, and the loaded side posterior alveolar ridge. Any notable stress pattern was experienced around the right implant (Figs 4m and 5m).

For group 25CR, low stress (less than 1 fringe order) was seen around the apex of the central implant. Moderate stress (1+ fringe orders) was transmitted to the apical area of the ipsilateral implant. Also, moderate stress (1.5+ fringe orders) was observed on the distal surface of the ipsilateral implant. Little or no discernible stress was noted on the loaded side posterior edentulous area and the contralateral implant (Figs 4n and 5n).

For group 25CG, low stress levels (less than 1 fringe order) were transferred around the apex of the central and the loaded side implants. Moderate stress levels (1+ fringe orders) were illustrated on the cervical section of the distal surface of the loaded side implant and left distal free ends. Any notable stress pattern was transmitted to the right implant (Figs 4o and 5o).

Little or no discernible stress was observed on the contralateral implants for the tested designs of the photoelastic mandibular model with 25-mm interimplant distances (Figs 4k to 4o and 5k to 5o).
**DISCUSSION**

Equitable load transmission to the denture-bearing areas and supported implants may enhance durability of the denture, precision attachments, implant components, and preserved underlying mucosa and alveolar bone. Well-designed implant-retained overdenture and balanced load distribution to the dental implants and the edentulous crests can decrease stress and bone microdamage. The present study investigated the effects of various configurations of low-profile stud attachment males for three-implant-retained mandibular overdentures using a photoelastic stress analysis technique on the mandibular models with various interimplant distances between the centralized and distal implants.

The two-implant-retained mandibular overdenture treatment modality has been reported as the standard of care for edentulous mandibles. Although two implants ensure acceptable retention and sufficient support, three or more implants constitute an angular relationship instead of a linear relationship for implant-retained overdentures. Placement of three implants to support a mandibular overdenture obtains better retention than placement of two implants and is also cost-effective compared with using more dental implants. Many studies investigated three-implant-retained mandibular overdentures in terms of load transfer characteristics and retentive forces. Therefore, a three-implant-retained mandibular overdenture is a proven treatment option for edentulous patients. In the present study, three implants were placed in the photoelastic mandibular models.

Biomechanically, the dental implants are different than the nature of the tooth, and this may easily arouse clinical problems. However, dental case scenarios need to be assessed and compared with each other using indirect analyzing methods. Photoelasticity is an indirect stress analysis method, and a major advantage of this method is to facilitate visualization of stress patterns in the complex biologic structures. Although photoelastic stress analysis has some limits, such as requiring similar illustrations of the clinical situation and restrictions of resistance of the material to excessive forces, it is able to demonstrate stress characteristics of the studied scenarios. Whereas cortical and trabecular bones have different features, experimental photoelastic models are fabricated using unique resin similar to the elasticity modulus of the bone. However, observed stress points and behavior in the model are similar to the clinical condition. Many photoelastic studies were carried out to evaluate stress distribution characteristics of dental implant–retained prostheses.

Placement of dental implants into intercanine or interfomral regions is suggested to support mandibular overdentures for edentulous elderly patients in order to meet the patients' expectations. The intercanine and the interfomral distances could vary in different populations. The mean distance between the mental forams was reported to be 47 mm. Aggarwal et al studied mandibular intercanine distances and compared them with different populations. In the Indian population, they found distances of 26 mm in males and 25 mm in females. The mean mandibular intercanine distance was noted to be 26.28 mm in males and 25.03 mm in females in the French population. Bondevik investigated distances in the Norwegian population, and the author calculated mean mandibular intercanine distances of 19.06 mm in males and 18.24 mm in females. In the Saudi Arabian population, the mean mandibular intercanine distance was measured to be 27.36 mm in males and 26.11 mm in females. Also, Anderson and Thompson studied the mean intercanine distances in mandibles in Canada. They found distances of 26.08 mm in males and 25.33 mm in females.

Interferences of bony structures and soft tissues, variations of crucial anatomical structures in the mandible such as the mandibular canal, and mental foramen affect the angulation and location of the dental implants. Thus, some of the implants might be placed into the posterior areas instead of the interfomral region for overdenture support. Michelinakis et al compared retention values of three attachment systems in three different mandibular models. They set interimplant distances between centralized and distal implants at 19, 23, and 29 mm. The same interimplant distances were used to investigate retention characteristics of various attachments by Doukas et al. In this study, the maximum interimplant distance was set at 25 mm, and the other interimplant distances were 11 mm and 18 mm for the photoelastic mandibular models.

Kim et al studied angled and straight placed implant models. The generated stresses were not influenced by implant angulation on the denture-bearing areas and the ipsilateral implants. Celik and Uludag compared stress levels of Locator, ball, bar, and barball attachments in photoelastic models with three inclined and straight implants. The highest observed stress level was moderate, and the loads were distributed to the loaded side and the centralized implants. Also, they reported the same conclusion that divergences between the implants did not affect generated stress patterns. In the present study, the distal implants were placed at 20 degrees of inclination in the models.

Many attachment systems are available to retain implant-retained overdentures, but bar and stud types.
have frequently been chosen by the vast majority of clinicians. The stud attachments represent more vertical room for the denture and easy application procedures. Furthermore, the studs are cheaper than the bars.\(^{20,30}\) The studs are used securely in the presence of angulated implants, and many of them can tolerate divergences up to 10 degrees.\(^ {35–37}\)

Load transfer characteristics of ball and bar attachments were compared using finite element analysis by Menicucci et al.\(^ {31}\) They concluded that the ball attachment transferred less stress around the implants than the bar attachment. Similarly, Meijer et al.\(^ {32}\) suggested to use stud types in order to obtain balanced load transmission between the dental implants and denture-bearing areas for implant-retained overdentures. Manju and Sreelal\(^ {33}\) evaluated different designs of two-implant-retained mandibular overdentures, and ball attachments illustrated the lowest stress compared with bar and magnet attachments.\(^ {33}\) The same attachment designs were investigated by Tokuhisa et al.\(^ {34}\) and the authors reported that the bar and magnet attachment designs experienced higher stress levels than the ball attachment. Celik and Uludag\(^ {7}\) studied the effect of the number of dental implants and different attachments on load distribution characteristics of implant-retained mandibular overdentures. The researchers compared a stud attachment (ERA) and three different bar designs. ERA showed the lowest stress in all mandibular models. In the previous research of Tokar and Uludag,\(^ {12}\) who evaluated stress patterns of three-implant-retained mandibular overdentures with splinted and stud attachments, the Locator attachment–retained overdenture design transferred the lowest stress to the dental implants.

One of the low-profile stud types, the Locator attachment, which has provided males (green, orange, red, and gray) for inclined implants, allowed adequate retention up to 40 degrees of divergence between the dental implants.\(^ {14,29}\) The Locator attachment–retained overdenture has been described well, and the retention characteristics of this stud attachment have been reported in the literature.\(^ {13,14,38–41,43}\)

Cayouette et al.\(^ {41}\) evaluated the retentive forces of the Locator attachment regarding configuration of number and location. Four different scenarios were set up, and retention strengths were compared. All tested designs presented similar retention characteristics during simulations. Uludag et al.\(^ {14}\) studied the effects of implant angulations and various configurations of this low-profile stud attachment on retention values of three-implant-retained mandibular overdentures. The authors concluded that using at least one green nylon male ensured better retention compared with the tested configurations. A combination of different nylon males was suggested to prevent decreases in the retention values. However, the effects of nylon males with different retentive forces on the stress distribution for implant-retained mandibular overdentures have not been documented yet. In this study, Locator attachments were used to retain overdentures, and various configurations of the nylon males were tested.

Lauritano et al.\(^ {43}\) investigated Locator and ball attachment systems under oblique and vertical forces using finite element analysis. The authors reported that the Locator attachment showed better response to applied forces. Also, they concluded that both attachments illustrated good standing if instruction manuals were followed. Elsyad et al.\(^ {44}\) compared the same attachments. Implant-retained mandibular overdentures were tested using strain gauges in a resilient silicone-coated acrylic model. The ball attachment caused significantly higher deformation on the denture base than the Locator attachment. The researchers suggested that denture base reinforcement may increase strength of the base and prevent possible fractures for ball attachment–retained overdentures.

El-Anwar et al.\(^ {45}\) studied Locator and ball attachment–retained overdentures using different magnitude of force applications; 50, 100, and 150 N vertical loads were applied unilaterally to the molar area. The vertical loads were transmitted to soft tissue and alveolar bone rather than the dental implants for the Locator attachment. They concluded that the performance of the Locator attachment was better than the ball attachment and also suggested using this attachment system to increase the life span of overdentures. In the present study, all groups of the 11-mm photoelastic model except for group 11C showed little or no discernible stress around the dental implants. The occlusal loads were withstood only by the denture-bearing areas in those groups.

Heckmann et al.\(^ {8}\) investigated five different attachment types on stereolithographic models. According to the results of this study, they pointed out the importance of denture-bearing areas for implant-retained overdentures. Stress levels of the denture-bearing areas were measured for the tested attachments, and these were correlated to rigidity or resiliency of the attachment system. In the present study, the loaded side denture-bearing areas illustrated moderate stress levels except for groups 25C and 25CR.

The Locator attachment system has offered different retention forces of standard males (blue, pink, and clear) and extended-range males (gray, red, orange, and green).\(^ {14}\) Clear male (5 lbs) as a standard male, and green male (4 lbs) and red male (1 lb) as extended-range males were used for configurations in this study. The applied loads were distributed well-balanced to the denture-bearing areas and the supported implants, when configurations of Locator males were set.
up according to manufacturer recommendations. A high stress level was solely experienced in group 25C, which was a false design in terms of male configuration because the standard nylon males can tolerate up to 20 degrees of divergence.14,29 Inner retention spurs of the clear nylon male may cause an increase in stress levels when inserted into the inclined distal implants.

Angulations between the distal implants in the photoelastic models were at 40 degrees. Therefore, the use of the extended-range nylon males might be suitable with regard to retention. However, generated stresses in the photoelastic models were not linked to retention values of the extended-range males. The groups, which included extended-range males (green and red), transferred moderate stress levels to the loaded side posterior edentulous area and around the dental implants.

CONCLUSIONS

This in vitro stress analysis study demonstrated the following conclusions. No discernible stress pattern was generated around the dental implants for extended-range nylon males (groups 11R and 11G) and configurations of standard (clear) and extended-range nylon males (groups 11CR and 11CG) in the 11-mm photoelastic mandibular model. The applied loads were endured by the posterior edentulous ridge instead of the dental implants when the implants were placed into the most anterior region. All tested male configurations of low-profile stud attachment transmitted stresses to the loaded side posterior edentulous area or the dental implants. The greatest experienced stress level was high and was observed in group 25C. However, the other 14 groups illustrated moderate stress levels. The use of extended-range nylon males (red and green) for inclined implants can provide equitable stress distribution to the supported dental implants and denture-bearing areas. Hence, using this is important when there is more than 20-degree divergence between the dental implants for balanced load distribution as well as retention. Long-term clinical studies are necessary to evaluate Locator and other types of low-profile stud attachments, and configurations of nylon males related to tested designs in the present study, in order to clarify in vivo effects of this type of stud attachment–retained overdenture to the jaws.

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REFERENCES


