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# Original Research

## 3D Finite Element Analysis to Assess the Stress Distribution Pattern in Mandibular Implant-supported Overdenture with Different Bar Heights

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***ABSTRACT:***
**Background:** To assess the stress distribution pattern in mandibular implant- supported overdenture with different bar heights. **Materials & methods:** A total of eight 3D finite element models (FEMs) were developed from mandibular overdentures with two implants in the canine region separated by a distance of 20 mm. In these models, four different bar heights from the mucosa (0.5, 1, 1.5, and 2 mm) with 12 mm occlusal plane height were analyzed. **Results:** In unilateral loading models, the maximum stress was found in a model with a 2 mm bar height (0.43 MPa) on the distal side of the ipsilateral implant, and in bilateral loading cases, the maximum stress was also found in a model with a 2 mm bar height (0.427 MPa). **Conclusion:** The reduction of bar height in implant-supported overdentures result in less stress in periimplantcrestal bone.
**Keywords:** overdenture, implants, stress analysis.

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## INTRODUCTION

Implant-retained mandibular overdentures have been proven to be an effective treatment modality for restoration of missing teeth and nowadays are frequently used as a standard treatment for edentulous patients. [1] Retention and stability problems of conventional complete dentures have been solved using implants-attachments-retained overdentures. Overdenture supported by 1–6 implants has become a common and effective procedure in the last decades. [2,3]

Most edentulous patients who use complete dentures suffer from functional, aesthetic, and psychosocial problems. Implant-retained overdentures are utilized to overcome those issues. [4,5] However, the placement of implants may be challenging in severely resorbed edentulous arches and is a common problem with the long-term use of complete dentures. [6] Implant treatment modalities may vary as the stress distribution associated with the mechanical behavior of the implant-bone complex changes. [6,7] Finite element analyses have been used in implant dentistry to predict the effects of clinical situations on the success rates of the implants. [8] Prior studies on the stress distribution of implant-supported overdentures have evaluated various contributing factors. [9] Accordingly, the factors contributing to the distribution of stress can be considered, such as the thickness and resiliency of the mucosa, the attachments of the overdentures, alveolar bone height, and functional loads. [9,10] The distribution of forces is affected by the number of implants, the shapes and sizes of the individual components of the implant-prosthetic structure, and the quality and quantity of the surrounding bone. [11] It has been reported that the stress values in the cortical bone around the implant platforms were higher than those in other locations. [12] Hence, this study was conducted to assess the stress distribution pattern in mandibular implant- supported overdenture with different bar heights.

## MATERIALS & METHODS

A total of eight3D finite element models (FEMs) were developed from mandibular overdentures with two implants in the canine region separated by a distance of 20 mm. In these models, four different bar heights from the mucosa (0.5, 1, 1.5, and 2 mm) with 12 mm occlusal plane height were analyzed. A unilateral and a bilateral vertical load of 150 N were applied to the central occlusal fossa of the first molar and the stress of bone around the implant was analyzed by finite element analysis (FEA). Data was collected and analysed by FEA. The result was done using SPSS software.

## RESULTS

A total of eight 3D finite element models (FEMs) were developed from mandibular overdentures with two implants in the canine region separated by a distance of 20 mm. Four different bar heights from the mucosa (0.5,1,1.5 and 2 mm) were included. In unilateral loading models, the maximum stress was found in a model with a 2 mm bar height (0.43 MPa) on the distal side of the ipsilateral implant, and in bilateral loading cases, the maximum stress was also found in a model with a 2 mm bar height (0.427 MPa). In unilateral, the minimum stress was found in 0.5mm bar height in mesial side was 0.265 and in bilateral loading, the minimum stress at 0.5mm bar height was 0.265 MPa.

**Table 1: Evaluation and comparison of stresses on the crestal bone due to unilateral force on different bar height**

| Maximum stress (MPa) | | | | |
|---|---|---|---|---|
| Bar height (mm) | Ipsilateral side | | Contralateral side | |
| | Mesial | Distal | Mesial | Distal |
| 0.5 | 0.265 | 0.349 | 0.1 | 0.05 |
| 1 | 0.312 | 0.378 | 0.17 | 0.091 |
| 1.5 | 0.385 | 0.410 | 0.264 | 0.15 |
| 2 | 0.412 | 0.43 | 0.272 | 0.193 |

**Table 2: Evaluation and comparison of stresses on the crestal bone due to bilateral force on different bar height**

| Maximum stress (MPa) | | | | |
|---|---|---|---|---|
| Bar height (mm) | Right side | | Left side | |
| | Mesial | Distal | Mesial | Distal |
| 0.5 | 0.265 | 0.302 | 0.162 | 0.202 |
| 1 | 0.308 | 0.319 | 0.210 | 0.310 |
| 1.5 | 0.368 | 0.401 | 0.332 | 0.342 |
| 2 | 0.401 | 0.427 | 0.348 | 0.358 |

## DISCUSSION

Currently, implant-retained overdentures have become one of the most preferred options for the treatment of completely edentulous patients. [13] Implant-retained overdentures have various attachment systems including bar-clip, ball, bar ball, O-ring, and magnet. The forces resulted from mastication are transferred to implants and produce stress in peri-implant bone. Two to four implants are used in the interforaminal region to support mandibular overdentures. [14] Increasing the crown height and degree of nonaxial (eccentric) load over an implant-supported prosthesis increases the risk of excessive occlusal overload because of an increased moment arm. [15] An alternative term is crown height space (CHS), defined as the distance measured from the crest of the alveolar bone to the plane of occlusion. The biomechanics of CHS is related to the mechanics of lever arm. [16] Non-axial loading creates a significant lateral moment, which proportionally increases with the increase of CHS, resulting in stress concentration at the bone surrounding the implant neck [17] and will result more crestal bone loss which is a major criterion for implant success. [18]Hence, this study was conducted to assess the stress distribution pattern in mandibular implant-supported overdenture with different bar heights.

In the present study, A total of eight 3D finite element models (FEMs) were developed from mandibular overdentures with two implants in the canine region separated by a distance of 20 mm. Four different bar heights from the mucosa (0.5,1,1.5 and 2 mm) were included. In unilateral loading models, the maximum stress was found in a model with a 2 mm bar height (0.43 MPa) on the distal side of the ipsilateral implant, and in bilateral loading cases, the maximum stress was also found in a model with a 2 mm bar height (0.427 MPa). A study by Joshi S et al, studied eight 3D FEMs were developed from mandibular overdentures with two implants in the canine region separated by a distance of 20 mm. By increasing the bar height, the maximum stress values around implants on the crestal bone were found to be increased in unilateral and bilateral loading models. In unilateral loading models, the maximum stress was found in a model with a 2 mm bar height (0.46 MPa) on the distal side of the ipsilateral implant, and in bilateral loading cases, the maximum stress was also found in a model with a 2 mm bar height (0.456 MPa). As the vertical cantilever increases (here the bar height), the maximum stress on the crestal bone increases. A minimum of 0.5 mm of space is sufficient between the mucosa and the inferior border of the bar to maintain oral hygiene.[19]

In the present study, in unilateral, the minimum stress was found in 0.5mm bar height in mesial side was 0.265 and in bilateral loading, the minimum stress at 0.5mm bar height was 0.265 MPa. Another study by Ebadian B et al, studied 3D finite element models were developed from mandibular overdentures with two implants in the interforaminal region. By increasing vertical restorative space, the maximum stress values around implants were found to be decreased in unilateral loading models but slightly increased in bilateral loading cases. By increasing bar height from gingival crest, the maximum stress values around implants were found to be increased in unilateral loading models but slightly decreased in bilateral loading cases. In unilateral loading models, maximum stress was found in a model with 9 mm occlusal plane height and 1.5 mm bar height (6.254 MPa), but in bilateral loading cases, maximum stress was found in a model with 15 mm occlusal plane height and 0.5 mm bar height (3.482 MPa). [20] FEA is a mathematical method; cannot fully represents the complexity of the biological field. It assumes that the structures are homogenous, linear, elastic, and isotropic. The dental structures as bone and periodontal ligaments are nonhomogenous, viscoelastic, and anisotropic which make the calculated values relative rather than absolute. FEA lacks the knowledge of the amount of stresses at which biological changes such as resorption or deposition of bony structures occurs, which makes it difficult to obtain a definite conclusions. Most FEA models assume a state of optimal osseointegration that both cortical and cancellousbone are perfectly bonded to the implant and that does not actually happen in the clinical conditions. [21]

## CONCLUSION

The reduction of bar height in implant-supported overdentures result in less stress in periimplant bone**.**

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