Research Article

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Finite Element Analysis to determine and compare the stress distribution in Conventional and Mini Implant Supported Distal Extension Removable Partial Denture: An In-vitro study

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ABSTRACT

Background: A common clinical problem confronting Prosthodontists is the design and maintenance of bilateral distal extension removable partial denture [RPD], as support is required from the teeth, the mucosa and underlying residual alveolar ridges. Distal extension removable partial denture (RPD) can cause stress on supporting hard tissues and abutment teeth, which may lead to harmful effects. There has been concern over the control of these destructive forces.1 The direction of the force on an abutment should be along the long axis of the teeth, so that the potential for tilting and torqueing of the abutment teeth would be minimized.2, 3 In the bilateral distal extension RPD, the functional force applied to the denture base creates an axis of rotation around the most distal abutment teeth and causes lateral and torqueing forces on these teeth. This problem occurs mainly in the mandible since it has less supporting tissue.4 There are three types of stresses that are induced on the abutment teeth by a bilateral distal extension RPD as vertical, horizontal and oblique stresses. In all types of stresses, abutment becomes a fulcrum. Therefore, mechanical and biomechanical aspects are generally agreed to be significant, particularly during the planning of restorative treatments and design of prosthetic appliance.4 This is an invitro study which uses Finite Element Analysis to determine and compare the stress distribution in Conventional and Mini Implant Supported Distal Extension Removable Partial Denture.

Keywords: Fenite element, stress distribution, implants.

INTRODUCTION

Rehabilitation of large edentulous areas like Kennedy's Class I, II and IV are a major challenge to the restorative dentist. The decision on the type of restoration may depend on various factors like the state of the oral cavity, the degree of oral hygiene, the periodontal status of the remaining teeth and the degree of residual ridge resorption. Implants are an expensive option and therefore many patients cannot afford them, particularly those with large edentulous areas. For reconstruction among these patients, fixed-type prosthesis usually requires more implants for support than removable prosthesis. In addition, these patients may require several surgeries to increase bone mass, thus making the entire treatment extraordinarily expensive and complicated. However, if a traditional removable partial denture (RPD) is used, insufficient retention may induce problems. The disparity of support between the teeth and soft tissues could create movements, which are harmful to the supporting structures. In order to offer these patients a more affordable prosthesis with better

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retention and stability, removable partial dentures supported by few mini implants are a viable option. There have been studies accounting for the stress distribution in removable partial dentures but very few documented evidence are available for the analysis of stress generated in mini implant supported removable partial dentures. Hence this study was carried out to determine and compare the stress distribution seen in a conventional and mini implant supported removable partial denture frameworks in Kennedy's Class I situations using finite element analysis. This study aimed to determine and compare the stress distribution in conventional and mini implant supported distal extension removable partial denture. Two finite element models of Kennedy's class I situation were created one with mini implant in 36 and 46 position and one without mini implant. The model were meshed with finite elements , assigned appropriate material properties , boundary conditions and the vertical 20N and oblique 50N load applied. The result was statistically analysed.

Aims & Objectives

Aim of this study was to know the effectiveness of removable partial denture with its load distribution between the supporting tissue and abutment teeth. The study aimed to evaluated the load distribution on periodontium, mucosa of edentulous ridge, alveolar bone surrounding the abutment teeth and mini implant in case of conventional and mini implant supported removal partial denture.

Objectives of this in-vitro study were to use finite element analysis;

To determine the stresses induced on abutment teeth and the supporting residual ridge in conventional removable partial denture in Kennedy's Class I situation.

To determine the stresses induced on abutment teeth, mini implant and the supporting residual ridge in implant supported removable partial denture in Kennedy's Class I situation.

To determine and compare the stress distribution seen in conventional removable partial denture with stress distribution seen with mini implant supported distal extension removable partial denture.

To determine and compare the stress distribution after vertical and oblique loading in conventional and mini implant supported distal extension removable partial denture.

MATERIAL & METHOD

This in- vitro study was carried out at "Tejvi Techno Solutions" using following computer characteristics.

- Ansys level 12.0 Version.
- Software Pentium IV
- Memory 8GB
- RAM 256 MB

The Study was divided under following steps

1. Construction of geometric model.
2. Preparation of finite element mesh.
3. Material properties.
4. Application of boundary conditions
5. Application of loads.
6. Analysis of stress pattern.

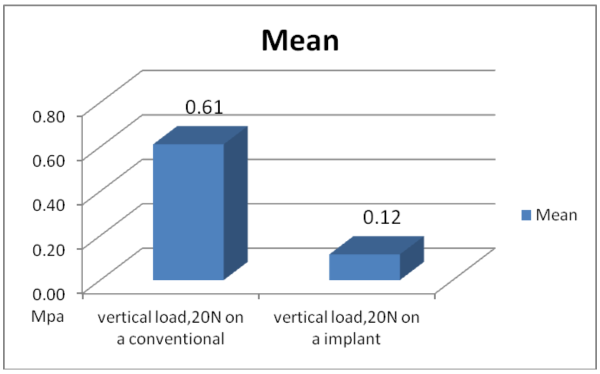
RESULTS & DISCUSSION

This study was designed to determine and compare the stress distribution seen in a conventional and mini implant supported removable partial denture frameworks. Two different loads of 20N in a vertical direction and 50 N in an oblique direction were applied. Using the finite- element method, the calculations were performed with the planned load. Following results were observed.

Under the vertical load application of 20 N in a conventional removable partial denture, the maximum stress was found to be concentrated at the alveolar bone around the abutment tooth 0.8000000 followed by periodontium of the abutment tooth 0.6050000 and at the abutment tooth 0.5750000. The least stress was seen in the mucosa of the edentulous region which was 0.4650000. Under the vertical load application of 20 N in a mini implant supported removable partial denture, the maximum stress was found to be concentrated at the alveolar bone surrounding the implant 0.1620000. The stress around abutment tooth and periodontium of the abutment teeth was respectively 0.1508000 and 0.1507000. The least stress was seen in mucosa of edentulous area

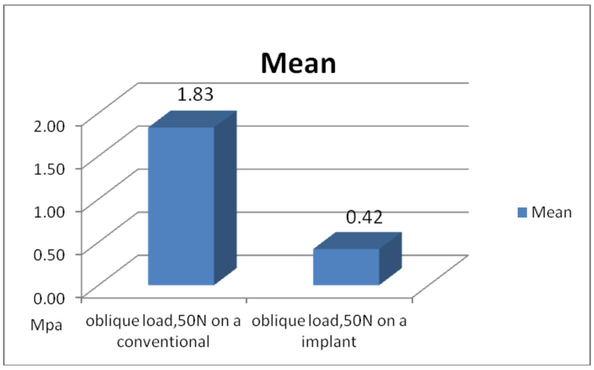
0.0000900. In the implant, the major part of the stress concentration was located at the neck of the implant 2.719.When an oblique load of 50N was applied on a conventional removable partial denture, the maximum stress was found to be concentrated at the alveolar bone 3.1000000 followed by, periodontium of the abutment tooth 1.8100000 and at the abutment tooth it was 0.7200000. The least stress was seen on the mucosa of the edentulous region 0.6900000. When an oblique load of 50N was applied on an implant supported removable partial denture , the maximum stress was found to be concentrated at the perimplant region 1.2860000 followed by periodontium of the abutment tooth 0.2500000 and at the abutment tooth it was 0.1400000.The least stress was noted in the mucosa of the edentulous ridge 0.0000970. In the implant, the major part of the stress concentration was located at the neck of the implant 4.237.

The difference in stresses induced due to vertical load of 20N by a conventional removable partial denture and implant supported removable partial denture is 0.61 and 0.12 respectively. The mean difference when analyzed by person Chi square and Fischer's exact test was found to be statistically highly significant (p<0.001). The difference in stresses induced due to oblique load of 50N by a conventional removable partial denture and implant supported removable partial denture is 1.83 and 0.41 respectively. The mean difference when analyzed by person Chi square and Fischer's exact test was found to be statistically highly significant (p<0.001).The difference in stresses induced due to vertical load of 20N and oblique load of 50N by a conventional removable partial denture is 0.33 and 1.18 respectively. The mean difference is found to be statistically significant P(<0.05).The difference in stresses induced due to vertical load of 20N and oblique load of 50N by an mini implant supported removable partial denture is 0.39 and 0.72 respectively. The mean difference is found to be statistically non-significant P (>0.05). The difference in stresses induced by a combination load of 20N vertical and 50N oblique, on the mucosa of edentulous ridge by conventional removable partial denture and mini implant supported removable partial denture is 1.07 and 0.0000935 respectively. The mean difference is found to be statistically significant P (<0.05).



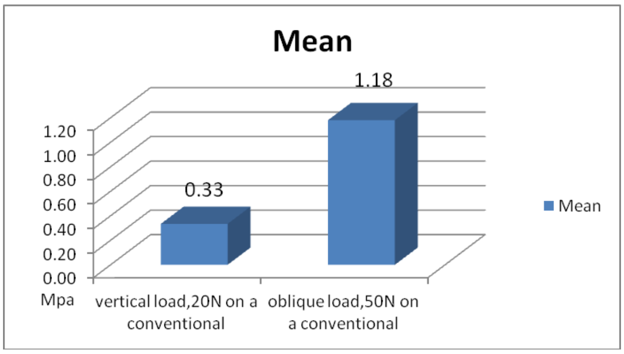
P (<0.001)**

Fig 1: Comparison of stresses induced on application of vertical load of 20 N between Conventional removable partial denture and Mini Implant supported removable partial denture.



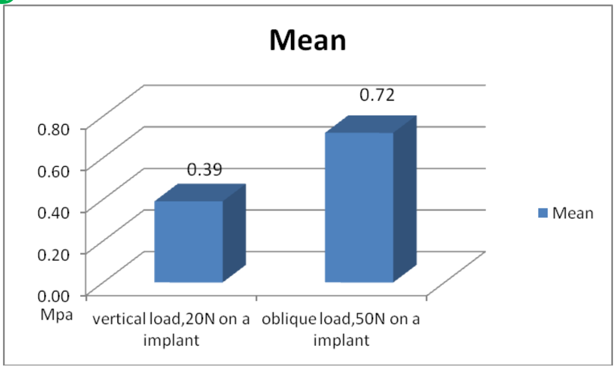
P (<0.001)**

Fig 2: Comparison of stresses induced on application of oblique load of 50 N between Conventional removable partial denture and Mini Implant supported removable partial denture.



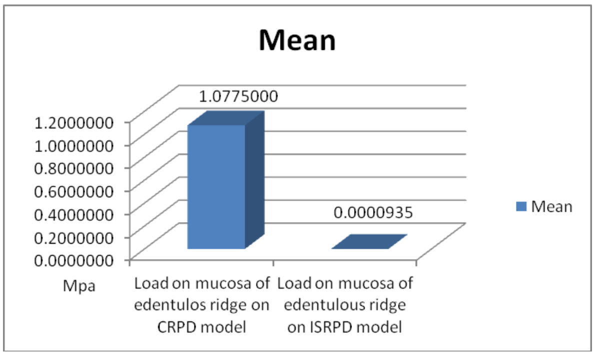
P (<0.05)*

Fig 3: Comparison of stresses induced on application of vertical load of 20 N and oblique load of 50 N on Conventional removable partial denture.



P (>0.05)

Fig 4: Comparison of stresses induced on application of vertical load of 20 N and oblique load of 50 N on mini implant supported removable partial denture.



P (<0.05)*

Fig 5: Comparison of stresses induced by a combination load of 20N vertical and 50N oblique, on the mucosa of edentulous ridge by conventional removable partial denture and mini implant supported removable partial denture.

CONCLUSION

The conclusions drawn from this study were:

On application of a vertical load of 20 N and oblique load of 50N the Conventional removable partial denture transmitted more occlusal force to the periodontium of abutment teeth and the alveolar bone surrounding the abutment teeth and mucosa of edentulous ridge than an mini implant supported removable partial denture. In case of mini implant supported partial denture stress transmission on the supporting structure was considerably less.

In conventional removable partial denture, more stresses are observed on application of oblique load of 50N then vertical load of 20N.

In mini implant supported removable partial denture, stresses transferred by on application of oblique load of 50N and vertical load of 20N were similar, hence the direction of force applied does not greatly affect the transmission of stress to underlying mucosa, bone and abutment teeth.

Therefore we can conclude that under vertical loading, the stress on the abutment teeth, mucosa of edentulous region and alveolar bone of mini implant supported removable partial denture was lower than conventional removable partial denture. Under oblique loading the stress on each part of the conventional removable partial denture increase significantly than the mini implant supported removable partial denture. Hence, within the limitations of this study we can conclude that distal extension supported by mini implants works well to protect the abutment teeth and supporting tissues.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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