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Original Research

Assessment of stress distribution around dental implants in three arch form models for replacing six implants using finite element analysis

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ABSTRACT:
Background: Debris, periodontal disease, diabetes, endodontic procedures, and fractures cause the teeth to be lost. The present study was conducted to assess stress distribution around dental implants in three arch form models for replacing six implants using finite element analysis. **Materials &Methods:** This vitro study investigatedand simulated implants for the repair of six maxillary anterior teeth in three models. Every implant was assessed in three different arch shapes: square, ovoid, and tapered. **Results:** Von mises stress in square type cortical bone in model A, B and C was 190.4 MPa, 120.5 MPa and 84.5 MPa respectively. In ovoid bone was 250.5 MPa, 50.4 MPa and 42.6 MPa respectively. In tapered bone was 246.2 MPa, 46.8 MPa and 34.2 MPa respectively. The difference was significant ($P< 0.05$). Von mises stress in square type cancellous bone in model A, B and C was 190.4 MPa, 120.5 MPa and 84.5 MPa respectively. In ovoid bone was 250.5 MPa, 50.4 MPa and 42.6 MPa respectively. In tapered bone was 246.2 MPa, 46.8 MPa and 34.2 MPa respectively. The difference was significant ($P< 0.05$). **Conclusion:** The shape of the jaw's arch should be taken into consideration as an intervention element once the anterior teeth have been replaced and the fewest number of implants have been inserted. The impact of the jaw arch form diminishes as the number of implants increases. In order to lessen the impact of the arc shape, it is advised that one or two implants be replaced in the incisor region at the anterior of the maxilla.
Keywords: Cancellous, Implant, Stress

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INTRODUCTION

Debris, periodontal disease, diabetes, endodontic procedures, and fractures cause the teeth to be lost. It is crucial to replace these teeth in order to preserve the arch's shape, the appropriate occlusion, and the mandibular joint. The prosthetic restoration type could be chosen based on comfort, appearance, and the quickest possible return to natural condition. One of the least effective dental treatments is a soft tissue-supported removable partial denture, which is also one of the acceptable therapies. Among its unwanted features are the partial denture's low survival rate, the health risk to the neighbouring teeth, and the surrounding tissues.[1]

Another option is fixed prosthodontic treatment, which has fundamental complications that are related to biology and mechanics.[2] On one side, periodontal disorders and bone loss lead to abutment failure and the need for prosthesis replacement, while on the other side, dental decay and endodontic failure cause the abutments to fail. The most reliable method of replacing lost teeth is with dental implants. Improvements in implant therapy, superior long-term outcomes, and the ability to use implants for partial edentulous region repair are the reasons why implants are now the preferred option.[3]

There are benefits and drawbacks to the clinical and laboratory techniques used to measure the stress surrounding the implant.[4] It is frequently possible to use a clinical assessment approach to understand the impact of arch shape and implant count, but it is unethical and its risks are unclear. These days, laboratories are used to replicate therapies and examine their hazards. The modelling of bone tissue and its reactions to applied mechanical forces is the primary challenge in the laboratory simulation of dental implant mechanical behaviour.[5] Although this approach is a suitable and practical tool for forecasting the effects of stress on the implant and the surrounding bone, detailed considerations should be made for the realization of modelling and analysis.[6]The present study was conducted to assess stress distribution around dental implants in three arch form models for replacing six implants using finite element analysis.

MATERIALS & METHODS

This vitro study investigatedand simulated implants for the repair of six maxillary anterior teeth in three models using ABAQUS software. In the A model, two implants were positioned on each side of the canine tooth region; in the B model, two implants were positioned on each side of the canine tooth region and one on the central incisor region; and in the C model, two implants were positioned on each side of the canine tooth region and two in the central incisor area. Every implant was assessed in three different arch shapes: square, ovoid, and tapered. Results thus obtained were subjected to statistical analysis. P value < 0.05 was considered significant.

RESULTS

Table: I Assessment of Von Mises stress distributions in the cortical bone

Arch type	Model A	Model B	Model C	P value
Square	190.4	120.5	84.5	0.02
Ovoid	250.5	50.4	42.6	0.01
Tapered	246.2	46.8	34.2	0.03

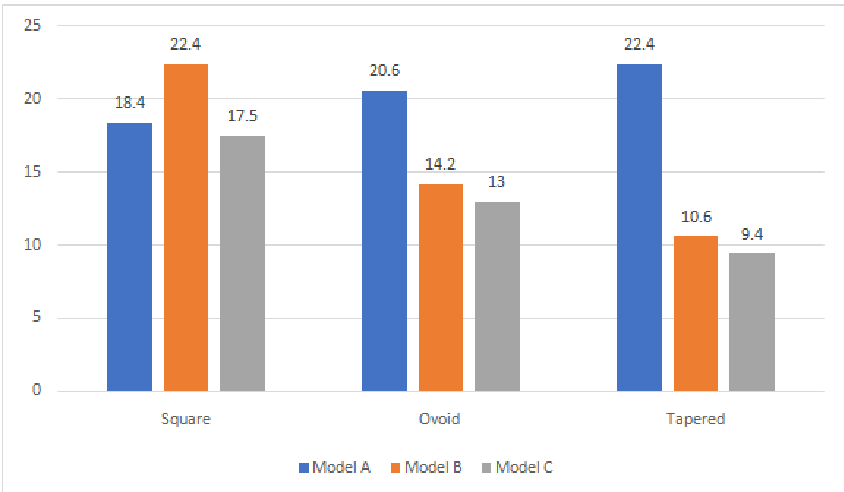
Table I shows that von mises stress in square type cortical bone in model A, B and C was 190.4 MPa, 120.5 MPa and 84.5 MPa respectively. In ovoid bone was 250.5 MPa, 50.4 MPa and 42.6 MPa respectively. In tapered bone was 246.2 MPa, 46.8 MPa and 34.2 MPa respectively. The difference was significant (P< 0.05).

Table: II Assessment of Von Mises stress distributions in the cancellous bone

Arch type	Model A	Model B	Model C	P value
Square	18.4	22.4	17.5	0.05
Ovoid	20.6	14.2	13.0	0.01
Tapered	22.4	10.6	9.4	0.02

Table II, graph I shows that von mises stress in square type cancellous bone in model A, B and C was 190.4 MPa, 120.5 MPa and 84.5 MPa respectively. In ovoid bone was 250.5 MPa, 50.4 MPa and 42.6 MPa respectively. In tapered bone was 246.2 MPa, 46.8 MPa and 34.2 MPa respectively. The difference was significant (P< 0.05).

Graph: I Assessment of Von Mises stress distributions in the cancellous bone



DISCUSSION

In terms of aesthetics and reconstruction, the anterior maxillary teeth have shown to be a crucial and difficult location.[7] The chin gradually protrudes and the lower portion of the face shortens as a result of anterior missing teeth. Following tooth extraction, crestal bone resorption and alveolar bone reduction in height lead to aesthetic issues, particularly in the anterior maxilla (which comprises canine and incisor teeth).[8] Fortunately, the premaxilla arch's ovoid, square, and tapering structure persisted even after the tooth was extracted.[9] A short-span prosthetic had a higher survival rate than a long-span prosthetic during load time, and the canine is a crucial location for implant implantation, according to general criteria. Stress surrounding the implant was caused when it was restored.[10]

We found that Von mises stress in square type cortical bone in model A, B and C was 190.4 MPa, 120.5 MPa and 84.5 MPa respectively. In ovoid bone was 250.5 MPa, 50.4 MPa and 42.6 MPa respectively. In tapered bone was 246.2 MPa, 46.8 MPa and 34.2 MPa respectively. Zarei M et al[11]evaluated stress distribution around replacement of six maxillary anterior teeth implants in three models of maxillary arch.In this in vitro study, using ABAQUS software (Simulia Corporation, Vélizy-Villacoublay, France), implant simulation was performed for reconstruction of six maxillary anterior teeth in three models. Von Mises stress by increasing of implant number was reduced. In a comparison of A model in each maxillary arch, the stress created in the cortical and cancellous bones in the square arch was less than ovoid and tapered arches. The stress created in implants and cortical and cancellous bones in C model was less than A and B models.

We observed that Von mises stress in square type cancellous bone in model A, B and C was 190.4 MPa, 120.5 MPa and 84.5 MPa respectively. In ovoid bone was 250.5 MPa, 50.4 MPa and 42.6 MPa respectively. In tapered bone was 246.2 MPa, 46.8 MPa and 34.2 MPa respectively. Mahshid et al[12]showed that the level of stress in cancellous bone decreases from two-implant model to the four-implant model, but it increases in the five-implant model. Furthermore, stress on cortical bone of the end implants in two-, three-, and four-implant models was similar. While in five-implant model, the amount of stress on the end implants was dramatically higher in the five-implant model.

The shortcoming of the study is small sample size.

CONCLUSION

Authors found that the shape of the jaw's arch should be taken into consideration as an intervention element once the anterior teeth have been replaced and the fewest number of implants have been inserted. The impact of the jaw arch form diminishes as the number of implants increases. In order to lessen the impact of the arc shape, it is advised that one or two implants be replaced in the incisor region at the anterior of the maxilla.

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