Effect of using rigid versus nonrigid attachments on stresses induced in peri-implant bone in implant-supported prostheses (finite element analysis): a nonrandomized in-vitro study

Hitham M. Shalaby

Department of Implantology, Faculty of Dentistry, Cairo University, Cairo, Egypt

Correspondence to Hitham M. Shalaby, MSc, 11 El-Saraya Street, El-Manyal, Cairo, Egypt. Tel: +20 106 548 7179; fax: 0020223635413; e-mail: hitham.shalaby@yahoo.com

Received: 23 October 2019
Revised: 4 November 2019
Accepted: 15 November 2019
Published: 4 March 2020

Kasr Al Ainy Medical Journal 2019, 25:74–75

Background
Peri-implant bone stresses can sometimes be detrimental. Efforts are made in order to keep these stresses at the normal level.
Methods
A finite element analysis was carried out in which two models were compared, the rigid attachment used in a fixed prosthesis versus the nonrigid one used in a removable prosthesis. Both of them were completely implant-supported.
Results
Have shown that the rigid type produced higher stresses than the nonrigid one.
Conclusion
Nonrigid attachments are more biocompatible than the rigid attachments.

Keywords:
overdentures versus fixed prostheses, removable versus fixed, rigid versus nonrigid

Kasr Al Ainy Med J 25:74–75

1687-4625

Introduction

The most common treatment modality for completely edentulous patients was the complete dentures. Patients have often complained of some problems such as low chewing efficacy, denture instability, reduced satisfaction, and reduced quality of life [1].

With dental implant prostheses, many of the problems associated with complete dentures have been solved [2]. There are different options of the implant prostheses that vary according to many factors such as the number and distribution of implants. Misch [3] has recommended the use of two to seven implants in the mandible.

With further increase in the number of implants, more benefits and satisfaction can be achieved [4].

Implant prostheses usually cause high stresses on the surrounding tissues; therefore, this should be accounted for during treatment planning, in order to reduce these stresses to the proper level. Attachments can be rigid, which are used in fixed prostheses, or nonrigid, which are used in removable prostheses. Different attachments offer different advantages – for example, rigid types used in fixed prostheses need less maintenance than the nonrigid types used in the removable prostheses [5,6]. Attachments also might have an effect on the fallen stresses, and therefore they should be tried, examined, compared and evaluated.

Many methods have been proposed to measure the stresses falling on peri-implant bone: one of them is the finite element analysis (FEA). FEA is widely used in dentistry for predicting and measuring different responses and stresses under different loading situations. It can be two dimensional (2D) FEA or three dimensional (3D) FEA.

3D FEA has been reported to be more accurate than 2D FEA, because it is more similar and related to the real geometries. Nevertheless, 3D FEA is more complicated and time-consuming [7,8].

In the software workflow, a 3D model of the dental arches can be made just as well as any dental prosthesis, and then different loads can be simulated and applied on the model. Lastly, the results are compared and analyzed to assess the load amount, distribution and transfer through the different components in the whole model.

The question is which type of these attachments used, rigid or nonrigid, will transmit the least amount of stresses into the underlying peri-implant bone?

 DOI: 10.4103/kamj.kamj_27_19

Materials and methods

PICO formulation

P: completely edentulous mandible model.

I: overdenture prosthesis with bar and clips attachment.

C: fixed hybrid denture prosthesis with screw retention attachment.

O: peri-implant bone stress.

S: in-vitro 3D FEA study.

Primary outcome	Measuring tool	Measuring unit
Stress of the peri-implant bone	FEA	MPa

In this experiment, the intervention treatment is the overdenture model representing the nonrigid attachment type, and the control treatment is the fixed hybrid denture model representing the rigid attachment type. Both of them were completely implant-supported.

First the models were drawn and simulated. Thereafter, meshing of the models was performed. The next step was defining the loads and the proper boundary conditions. After this, simulation analysis was carried out, and thereafter the results were obtained. Lastly, interpretation and comparing of the two models' results was carried out. In both models, the implants had the same dimensions and positions, which were according to the Misch and Bidez treatment planning [9,10].

Results

From all the stress results obtained, we can see that the fixed denture suffered much higher stresses than the overdenture model. Moreover, the stresses are more concentrated on the peri-implant bone area and more specifically on the compact bone compared with the spongy bone.

Conclusion

On the basis of this 3D FEA, in which we compared the stresses placed on the peri-implant bone using rigid attachments represented in the hybrid model compared with the nonrigid attachments represented by the bar and clips overdenture model, the following conclusions are deduced:

(1) Rigid attachments suffer much higher stresses than the nonrigid types; hence, nonrigid attachments are more biocompatible..
(2) Compact bone receives higher and most of the stresses compared with the spongy bone, as it is the first to receive the loads, and also because of its higher modulus of elasticity.
(3) Further studies and experiments are needed in order to verify these results.

Acknowledgements

This study was funded by the author's private funding.

Special thanks and appreciation to professor Dr Hamdi Abo-Elftooh, Department of Prosthodontics, Cairo University, for his valuable inspiration, general writing assistance, and knowledge provision.

Special and deep thanks, acknowledgment and appreciation for the great, humble, smart, honest, courageous Dr Amal Kaddah, for the effort, encouragement, inspiration and general contribution she provided.

Special thanks and appreciation to the assistant professor Dr Nouran Abd-Elnaby, Department of Prosthodontics, Cairo University, for her valuable encouragement, and general contribution.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Hildebrandt G, Dominguez B, Schork M, Loesche W. Functional units, chewing, swallowing, and food avoidance among the elderly. J Prosthet Dent 1997; 77:588–595.

2 Kroll P, Hou L, Radaideh H, Sharifi N, Han PP, Mulligan R, Enciso R. Oral health-related outcomes in edentulous patients treated with mandibular implant-retained dentures versus complete dentures: systematic review with meta-analyses. J Oral Implantol 2018; 44:313–324.

3 Misch CE. Dental implant proshtetics 2nd ed. Missouri: Mosby, an imprint of Elsevier Inc; 2015.

4 Elsyad MA, Hegazy SA, Hammouda NI, Al-Tonbary GY, Habib AA. Chewing efficiency and electromyographic activity of masseter muscle with three designs of implant-supported mandibular overdentures. A cross-over study. Clin Oral Implants Res 2014; 25:742–748.

5 Hemmings K, Schmitt A. Complications and maintenance requirements for fixed prostheses and overdentures in the edentulous mandible: a 5-year report. Int J Oral Maxillofac Implants 1994; 9:191–196.

6 Walton J, MacEntee M. Problems with prostheses on implants: a retrospective study. Int J Prosthet Dent 1994; 71:283–288.

7 Buchanan GR. Schaum's outline of theory and problems of finite element analysis. New York: McGraw-Hill 1994. 264.

8 Sertgöz A. Finite element analysis study of the effect of superstructure material on stress distribution in an implant-supported fixed prosthesis. Int J Prosthodont 1997; 10:19–27.

9 Adell R, Lekholm U, Rockler B, Brånemark P. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw?. Int J Oral Surg 1981; 387:416-1.

10 Snauwaert K, Duyck J, van Steenberghe D. Time dependent failure rate and marginal bone loss of implant supported prostheses: a 15-year follow-up study. Clin Oral Investig 2000; 4:13–20.