Numerical Investigations of Edentulous Patients with Complete Denture and Implant-Supported Overdenture

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Introduction

Implant-supported overdentures with ball head retention elements are a good treatment option for edentulous patients, in particular for the lower jaw. The supporting implants are selected according to the available bone volume. Conventional implants (diameter 3.3 to 4.5 mm) are usually used to support overdentures. However, these implants are not indicated for narrow residual ridges without bone augmentations. This could be avoided by using mini dental implants with reduced diameter (diameter 1.8 to 2.4 mm). Bone quality and implant system directly affect the loading of the bone bed.

The aim of this study was to numerically analyse the stability of a denture before and after implant insertion and the loading of the alveolar bone. Moreover, the effect of implant system and number of implants on denture stability and bone loading was analysed as well.

Materials and Methods

Ten individual 3D finite element models were generated for the lower jaw of five edentulous patients. For each patient two models were created: one model with a complete denture and a second model after implant insertion to simulate the implant-supported overdenture. All patients received implants in the interforaminal region. Patient 1 received two conventional implants (3.7 mm x 13 mm, tioLogic, Dentaurum); patients 2 and 3 received four conventional implants (3.7 mm x 13 mm, 3.7 mm x 11 mm, tioLogic); patient 4 received three mini-implants (2.1 mm x 15 mm, MDI, 3M ESPE); patient 5 received five mini-implants (2.1 mm x 15 mm, MDI, 3M ESPE). The geometry of the lower jaw was reconstructed from CT-data (Mimics, Materialise). The CAD/CAM data of the implant systems and their retention elements together with STL-data of the denture (scanned with a 3Shape Scanner) were imported into the finite element program (MSC.Marc/Mentat 2010). The dentures were loaded individually with biting forces measured in a previous clinical study [1] before and after implant insertion.

Results

Mean biting forces increased from 250 N to 400 N after insertion of implants for all patients which consequently caused an increase in denture displacement in comparison with the condition with complete denture. However, maximum denture displacement with two conventional implants was comparable to five mini-implants (100 µm). The stress within the denture with two conventional implants was noticeably higher (1.9 MPa) in comparison with the denture supported by five mini-implants (0.6 MPa). There was a slight increase in stress within the bone around the implants in comparison with the condition with complete denture. There was no difference in stress magnitude between conventional and mini-implants.

Discussion

The application of conventional and mini-implants improve the biting ability of edentulous patients and slower bone resorption process in comparison to complete denture. The maximum stress in bone bed was below the physiological range of bone loading.

References

[1] I. Hasan I, C. Madarlis, L. Keilig, C. Dirk, A. Weber, C. Bourauel, F. Heinemann: Ann. Anat. Vol. 208 (2016) p 116-122.