THE EFFECT OF ALVEOLAR BONE CREST SHAPE ON STRAIN DISTRIBUTION IN PERI-IMPLANT BONE TISSUE

Barbora Thomková[1], Tomáš Zikmund[2], Jozef Kaiser[2], Marek Joukal[3], Petr Marcián[1]

[1] *Faculty of Mechanical Engineering, Brno University of Technology, Czech Republic*

[2] *CEITEC – Central European Institute of Technology, Brno University of Technology, Czech Republic*

[3] *Department of Anatomy, Faculty of Medicine, Masaryk University, Czech Republic*

Introduction

With the increasing average life expectancy of the population, dental implants are used more often. In some cases, it is necessary to widen the alveolar crest area where the dental implant is inserted. This reduction should be from 1 to 3 mm and the alveolar bone's total height must be considered [1].

The aim of this study is to analyse the mechanical influence of the alveolar crest reduction and strain distribution in the peri-implant bone tissue during chewing.

Materials and methods

The mandibular bone segment (20 x 15 x 15 mm) was scanned by micro-computed tomography (GE phoenix v|tome|x L240, GE Sensing & Inspection Technologies GmbH, Wunstorf, Germany) with voxel size of 30 μm. The sample of the human mandible was acquired from the Department of Anatomy, Faculty of Medicine, Masaryk University Brno, Czech Republic in full accordance with relevant institutional and legislative requirements. The geometry model of bone tissue with trabecular structure was created in the software RETOMO using thresholding (see Figure 1a)). The geometry model with alveolar crest reduction was created by cutting 1 mm of alveolar crest bone (see Figure 1b)). For analysis of peri-implant bone tissue, the cylinder with an 8 mm diameter around the dental implant was created. Geometry model of dental implant (Brånemark® System Mk III Groovy (NP Ø 3.3 mm, 11.5 mm)) was created in SolidWorks 2012 (Dassault Systèmes, France).

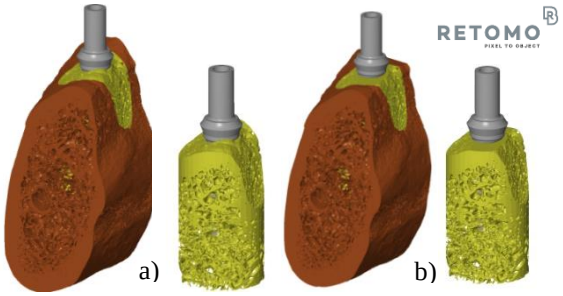

Figure 1: Geometry model of bone tissue a) without alveolar crest reduction b) with alveolar crest reduction

Material model of bone tissue and dental implant was assumed as homogeneous, linear and isotropic. Three variants of the material model of bone tissue (simulation of differently mineralized bones [2]) with different Young's modulus E= 5 GPa, 10 GPa and 15 GPa and Poisson's ratio μ=0.3 were created. The mechanical properties of the titanium alloy dental implants used in this study were E=110 GPa and μ=0.34.

The dental implant was loaded with axial loading of magnitude 200 N and the segment was fixed.

FE mesh was created by using SOLID 187 elements with around 9 million elements in all variants. The implant and bone were assumed as fully osseointegrated and for their interaction were elements CONTA174 and TARGE170 used. Contact was set as “always bonded”.

Results and discussion

The analysis of strain intensity values in peri-implant bone based on mechanostat hypothesis by Frost [3] was performed for all variants. The isolines of strain intensity are more consistent for the variant with alveolar crest reduction (see Figure 2). Also with the increasing Young's modulus, the strain intensity values in bone tissue are decreasing.

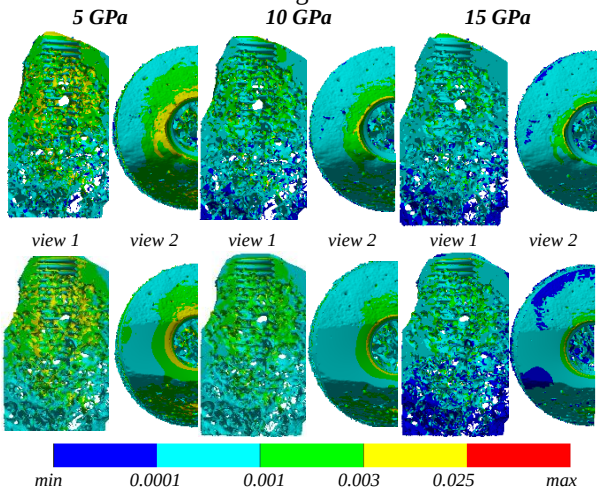

Figure 2: Isolines of strain intensity for all variants

Conclusion

This study shows changes of strain intensity distribution in the peri-implant bone with and without alveolar crest reduction.

References

1. Juodzbalys et al, Journal of Oral and Maxillofacial Research, 4(2), 2013.
2. Shefelbine et al, Bone, 36(3), 2005.
3. Frost, Harold, The angle orthodontist,74(1), 2004.

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