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MANDIBULAR FLEXURE – A REASON FOR CHRONIC PAIN SYNDROME IN EDENTULOUS PATIENT RESTORED WITH FIXED ZRO_2 CONSTRUCTION OVER IMPLANTS, INSERTED IN NATURAL BONE AND BONE GRAFT AREA. CASE REPORT

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ABSTRACT

Introduction: The experience of more than fifty years of implantology practice has led to several conclusions or suggestions that led to scientific investigations. It is known that as every other matter the bone has a certain elasticity (Young's modulus). The human mandible has its Young modulus and flexes during masticatory action. This flexure is limited when the entire natural dentition is splinted with metal-ceramic or ZrO_2 prosthetic construction because the elasticity of metal and ZrO_2 is very low. What happens with the mandible flexure strain when there is edentulous jaw rehabilitated with eight implants that does not have periodontium and they are splinted together with rigid prosthetic construction is still not exactly clear. Even far uncertain if implants are inserted in different hard tissues – partially natural bone and partially in guided bone regeneration area with unresorbable xenograft material. This is the reason for this case report in a patient with rigid construction over implants and occurrence of unilateral chronic pain syndrome.

Aim: The purpose of this case report is to inform for a chronic unilateral pain syndrome in patient rehabilitated with fixed prosthetic construction made by zirconium dioxide over eight dental implants (TS III SA Fixture Osstem Implants) distributed over the entire mandible (4 implants in the frontal region and one on each side in the premolar region and one on each side in molar region).

Methods and Materials: Analysis of the literature for studies of the distribution of stress on the mandible during masticatory function as well as Young's modulus in different parts of the mandible. Experimental study by using Cone beam computer tomography analysis of mandible and mathematical analysis made on the finite element method.

Conclusion: Clinical data, x-rays and CT, mathematical analysis made on the finite element method, show mandibular elasticity could be cause of pain syndrome in case of edentulous mandible case with rigid fixed prosthetic construction over dental implants inserted in different kind of bone structure.

Keywords: mandibular flexure, Young's modulus, finite element analysis, rigid prosthetic construction, Cone beam computer tomography analysis,

INTRODUCTION:

The human lower jaw has been shown to deform instantaneously and concurrently with jaw movement [1, 2] during articulation and masticatory action. Four patterns of mandibular deformation have been proposed by Hylander: symphyseal bending associated with medial convergence or corporal approximation; dorso-ventral shear; corporal rotation; and antero-posterior shear. [3]

Mandibular flexure is a phenomenon that occurs due to many different factors such as bone density and quantity, implant location and number, and prosthesis design and material. But the unknowns are getting more and more by adding different materials for fixed prosthetic construction and procedures for bone augmentation. In implant prosthodontics, the implant framework design aims to evenly distribute strain among implants that are splinted together. Skalak [4] investigated the relationship between framework material and strain, with the conclusion that framework material rigidity was not significant, especially if each implant were able to carry the full load applied to it. On the contrary, other researchers have argued that a rigid material can minimize the bending moment of the framework, thus reducing the strain transmitted through the prosthetic screw.[5, 6, 7, 8] These studies have shown that cobalt-chromium frameworks generate the least amount of strain on the implants as a result of the accuracy of fit of the framework. [5, 6, 7, 8] Various studies investigated the effect of different framework fabrication processes on passive fit. [9, 10] These studies found no significant difference among different laboratory techniques and no significant difference between digital technique and the conventional laboratory technique.[9,10]But there are still missing scientific literature of the zirconium dioxide framework and its rigidity. But as we know that the Young's modulus is much lower of the ZrO_2 compared to that of the cobalt-chromium we could conclude that such a framework is limiting the bending moment of the lower jaw.

Another unknown is the elastic modulus of bone graft after procedures for guided bone regeneration using the

Kablan-Khury technique.

The human mandible has its Young modulus and flexes during masticatory action and articulation. This flexure is limited with the entire natural dentition is splinted with metal-ceramic or ZrO_2 prosthetic construction because the elastic module of metal and ZrO_2 is very low. What happens with the mandible flexure strain when there is edentulous jaw rehabilitated with eight implants that does not have periodontium and they are splinted together with rigid prosthetic construction is still uninvestigated. This is the reason for this case report in a patient with rigid construction over implants and occurrence of chronic pain syndrome.

AIM:

The purpose of this case report is to inform for a chronic pain syndrome in patient rehabilitated with fixed prosthetic construction made by zirconium dioxide over eight dental implants (TS III SA Fixture Osstem® Implants) distributed over the entire mandible (4 implants in the frontal region and one on each side in the premolar region and one on each side in molar region) after GBR using the Kablan-Khury technique.

METHODS AND MATERIALS:

One-side Kablan-Khury augmentation technique, Bio-Oss® bovine bone (0.25 – 1.0mm particles), Bio guide collagen resorbable membrane, PRGF, TS III Osstem® Implants, inserted in the mandible 9 mounts after GBR with two stage surgical procedure. Uncovering of the implants with partial thickness apically positioned flap, open tray impression technique, ZnO_2 monolithic prosthetic bridge with 14 press ceramic crowns E-Max.

Analysis of the literature for studies of the distribution of stress on the mandible during masticatory function as well as Young's modulus in different parts of the mandible. Experimental study by using Cone beam computer tomography analysis of mandible and mathematical analysis made on the finite element method.

CLINICAL DESCRIPTION OF THE CASE:

Fifty-eight years old male patient enters the clinic with edentulous mandible and desire for fixed prosthetic construction over implants. On the CT it was observed bone deficiency in height in the distal areas. Kablan-Khury augmentation technique was applied and after 9 months a surgery for implantation of 8 implants toke place. Bio-Oss® bovine bone 0.25-1.0mm particles Bio-Guide® collagen membrane, PRGF, TS III Osstem® Implants, inserted 9 months after GBR with two stage surgical procedure, uncovering with partial thickness apically positioned flap, open tray impression technique, ZnO_2 monolithic bridge with 14 press ceramic crown made from E-Max. The prosthetic construction was fixed with long-term temporary composite cement and the crowns with double polymerized composite cement to the ZrO_2 construction.

Six months after cementation the patient has complained of discomfort and pain in the right distal area. Clinical exam does not show peri mucositis or peri implantitis or bone resorption. X-ray data also did not show lack of bone around implants.

The prosthetic construction was removed and changed with temporary plastic construction. In the next clinical exam lack of pain was reported.

Fig. 1. X-Ray prior treatment

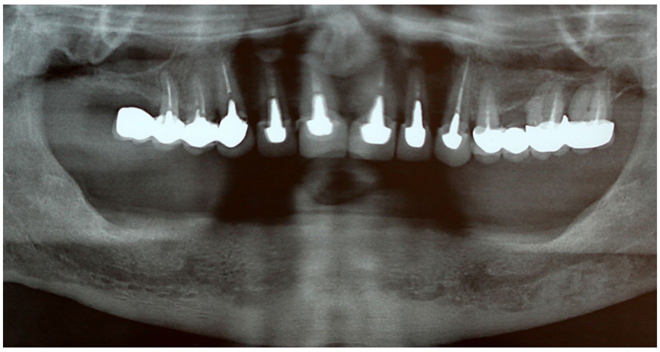


Fig. 2. CT in distal area prior treatment

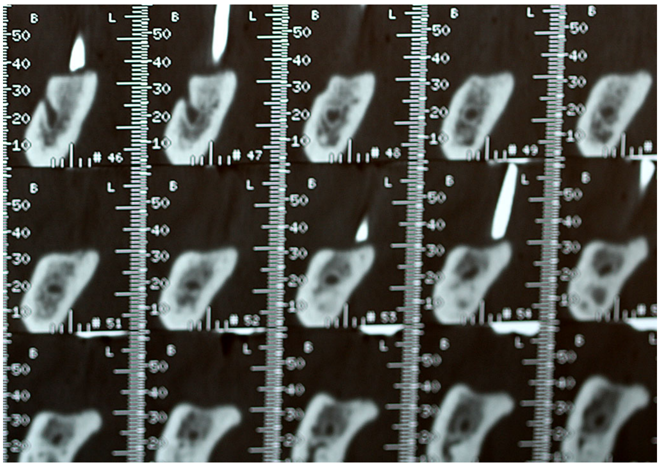


Fig: 3, 4, 5, 6. Stages from Khuri-Kablan technique for vertical ridge augmentation

Fig. 3.

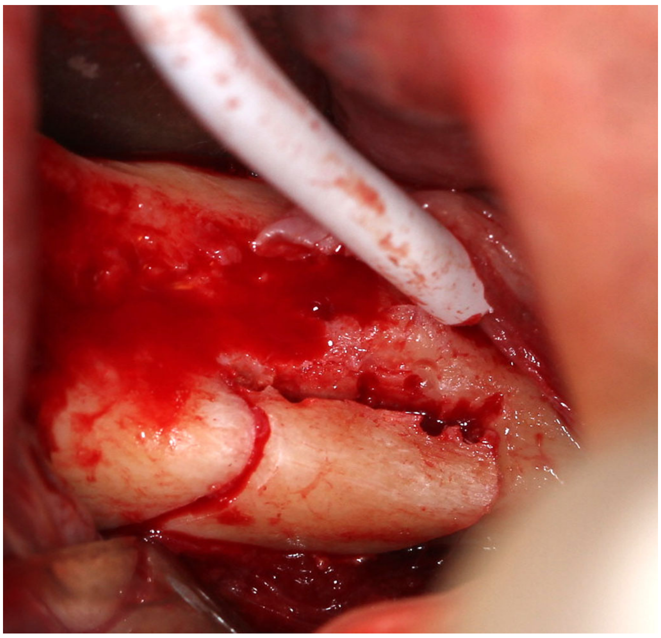


Fig. 4.

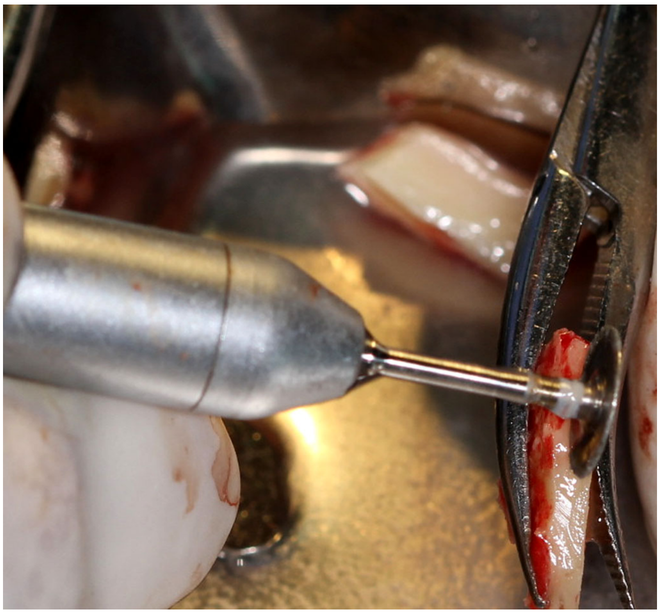


Fig. 5.

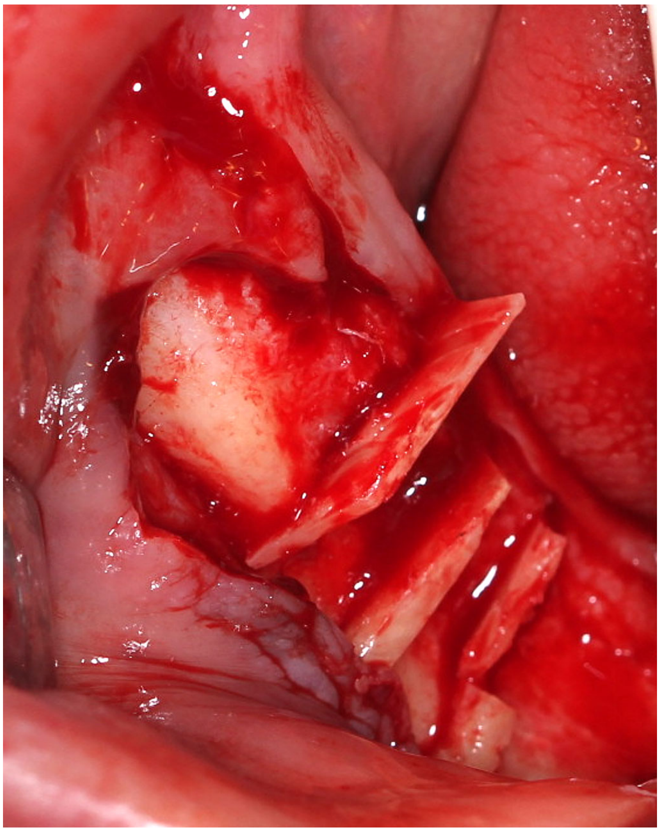


Fig. 6.

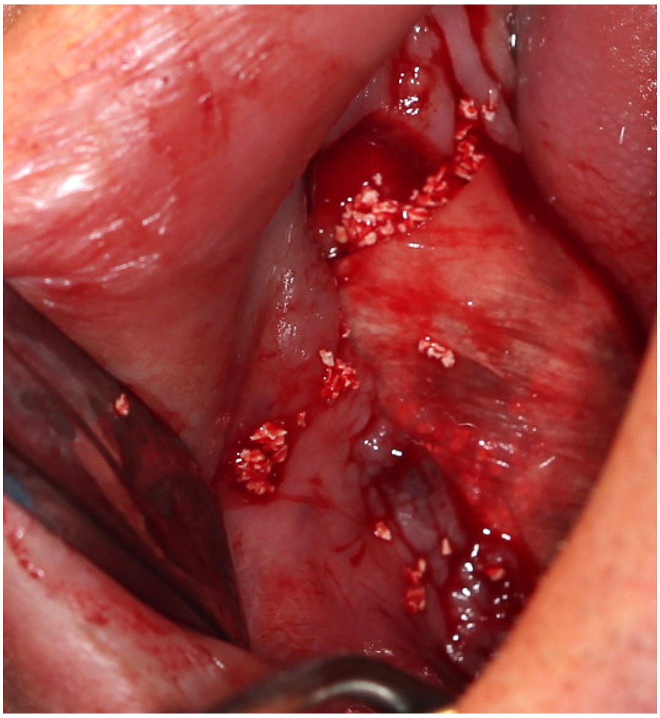


Fig. 7, 8, 9. Open tray impression with transfers
Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10. Technique for laboratory model check up before scan

Fig. 11. Milled and sintered ZrO_2

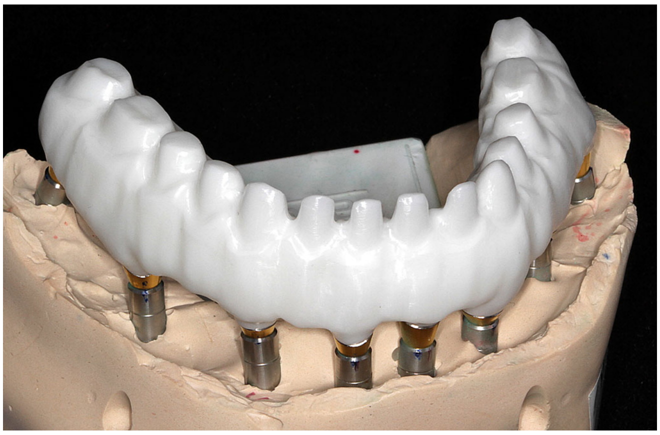


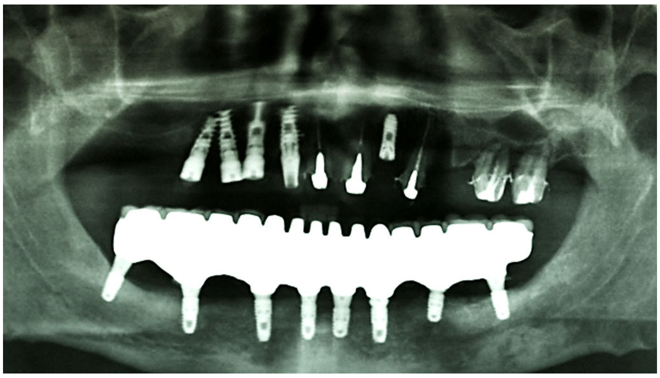
Fig. 12. Single press ceramic crowns

Fig. 13, 14: ZnO prosthetic construction

Fig. 13.

Fig.14.

Fig. 15. OPG with ZnO construction



DISCUSSION:

In treatment of edentulous mandible is of significant importance to have in mind that in cases demanding vertical guided bone regeneration of large area, three different elasticity "matters" are present: natural bone, augmented area and fixed rigid prosthetic construction. In order to avoid pain syndrome it is recommended to select implant sites so that an opportunity for dividing prosthetic construction in to two or three parts to be available. Finite element analysis (FEA) is applied in engineering and other fields as a computational tool for performing engineering (stress/deflection) analysis. It includes the use of mesh generation techniques for dividing a complex problem into small elements, as well as the use of software program coded with FEM algorithm. In applying FEA, the complex problem is usually a physical system with the underlying physics such as the Euler-Bernoulli beam equation, the heat equation, or the Navier-Stokes equations expressed in either PDE or integral equations, while the divided small elements of the complex problem represent different areas in the physical system.

FEM allows detailed visualization of where structures bend or twist, and indicates the distribution of stresses and displacements. FEM software provides a wide range of simulation options for controlling the complexity of both modeling and analysis of a system. Similarly, the desired level of accuracy required and associated computational time requirements can be managed simultaneously to address most engineering applications. FEM allows entire designs to be constructed, refined, and optimized before the design is manufactured. Real validation of simulated results can be done only by physical test.

Several simulations are performed using engineering analysis to evaluate influence of prosthetic construction elasticity over bone stress. The model is combination of reverse engineered mandible (model based on tomography data) and simplified representations of prosthetic construction. These parts are as follows: mandible (represented as monolith body), simplified representations of 6 implants (TS III Osstem type), monolite bridge with 10 press ceramic crowns (decreased as number for simplification). Mesh model, used in engineering analyses, is shown on Fig.10.

Fig. 16. Mesh model.

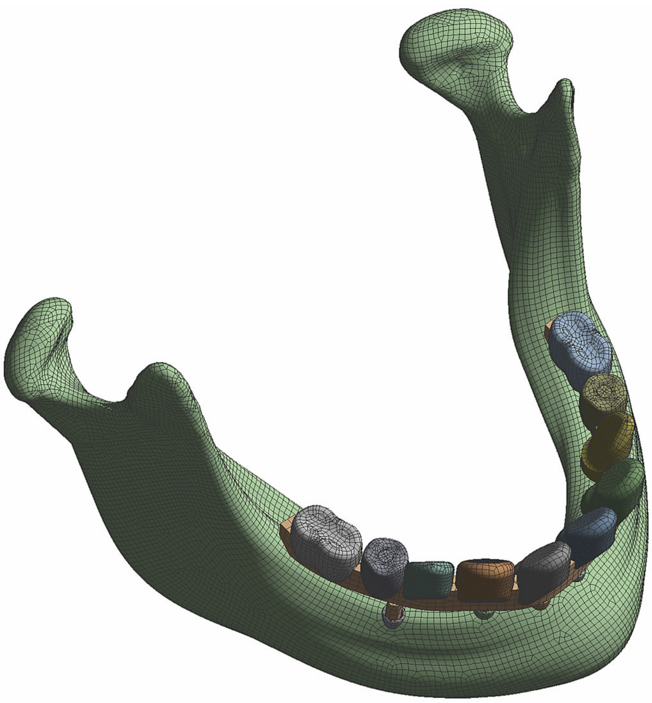


Fig. 17. Applied BCs for LC1.

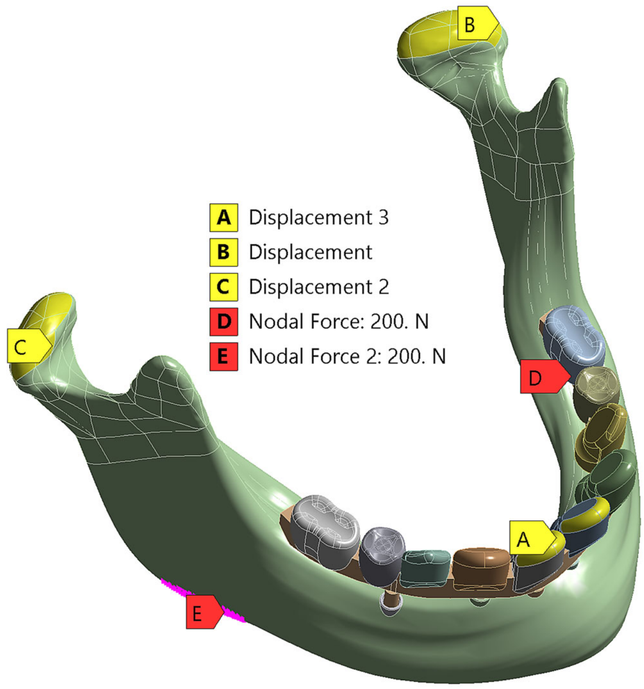
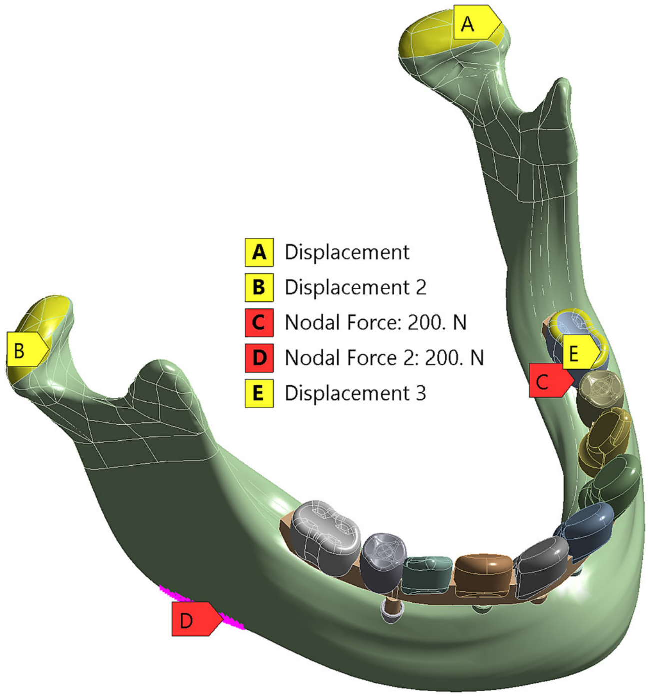


Fig. 18. Applied BCs for LC2



Two load cases are examined:

· LC1 – centric support (over incisors);

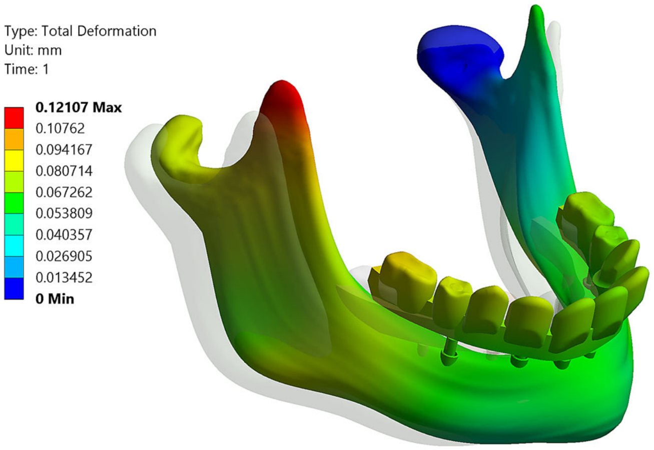
· LC2 – eccentric support (over single endmost molar).

Both load cases uses supports at temporomandibular joints (B and C marks on Fig.11) and applied load on masticatory muscles connections. [11] Sample load of 200N each side is used as representative for masticatory muscles forces. Load cases difference is in teeth support placement (centric – marked as A on Fig.11, or eccentric – marked as E on Fig. 12).

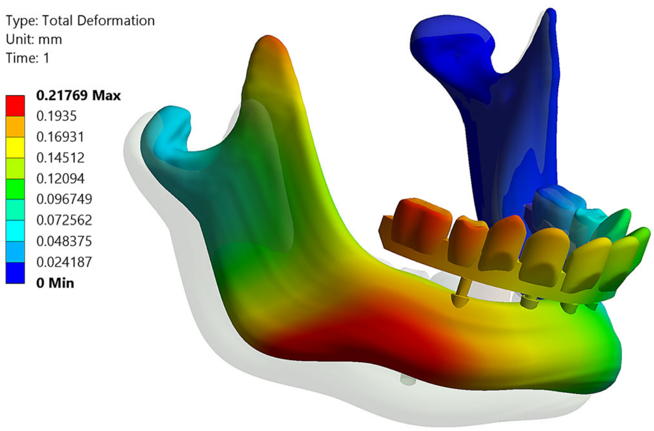
The initial simulations concerns original ZrO_2 construction. Results for both examined load cases are compared by total deformation distribution fields on the figure below. Eccentric case (LC2) shows higher deformations and is more representative.

Fig. 19. Total deformation distribution fields, mm.

19a) LC1: Centric support (incisors)



19b) LC2: Eccentric support (molar)



Further examinations are based on variations in prosthetic construction material. Next design variants are examined:

• DV1_LC1: Original materials (monolithic bridge with 10 press ceramic crowns, using materials properties for ZrO2 and porcelain); centric support (incisors);

• DV1_LC2: Original materials (monolithic bridge with 10 press ceramic crowns, using materials properties for ZrO2 and porcelain); eccentric support (molar);

• DV2_LC1: Plastic prosthetic construction (epoxy resin); centric support (incisors);

• DV2_LC2: Plastic prosthetic construction (epoxy resin); eccentric support (molar);

• DV3_LC2: Modified plastic parameters for prosthetic construction; eccentric support (molar);

• DV4_LC2: Additional variant of modified plastic parameters for prosthetic construction; eccentric support (molar).

Used material properties are listed in the table below.

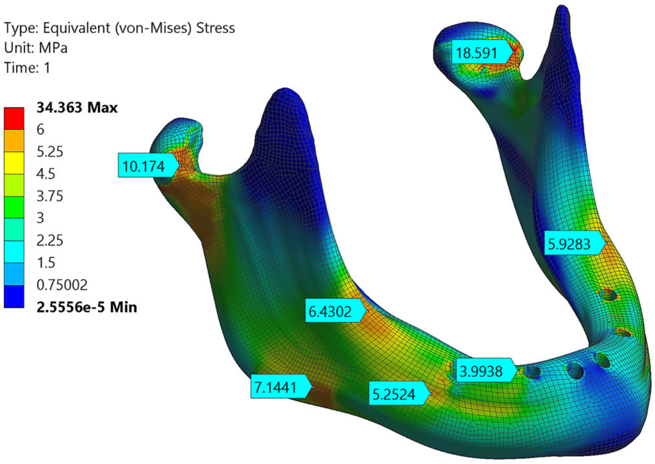
Table 1. Material properties of different components [12, 13]

Material	Elastic modulus, E, GPa	Poisson's ratio, μ	Used for component:
Cortical bone and lamina dura	13	0.3	Mandible averaged material of E = 10GPa
Cancellous bone	5.5	0.3	
Porcelain	67.2	0.3	Press ceramic crowns
Titanium alloy	102	0.33	Implants
ZrO_2	200	0.31	Monolite bridge
Epoxy resin	2.7	0.35	Plastic bridge
Epoxy resin MP1	1.6	0.35	Plastic bridge, modified properties for DV3
Epoxy resin MP2	0.8	0.35	Plastic bridge, modified properties for DV4

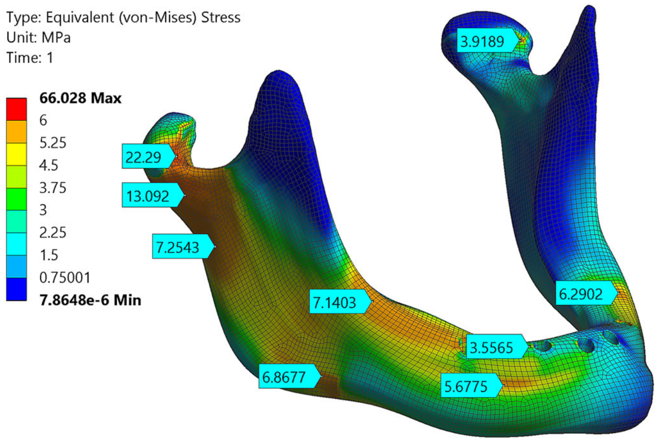
Engineering analyses results are presented as equivalent (von Mises) stress distribution fields on the figures below.

Fig. 20. Equivalent (von Mises) distribution fields, MPa

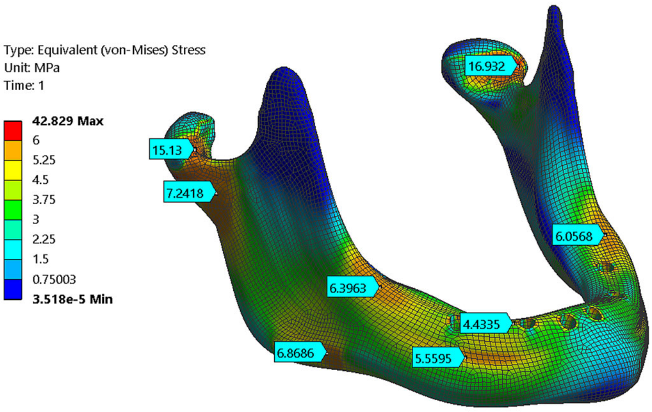
20a) DV1_LC1



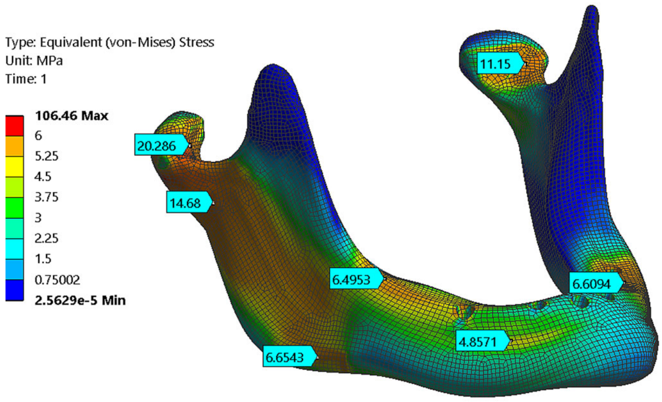
20b/ DV1_LC2



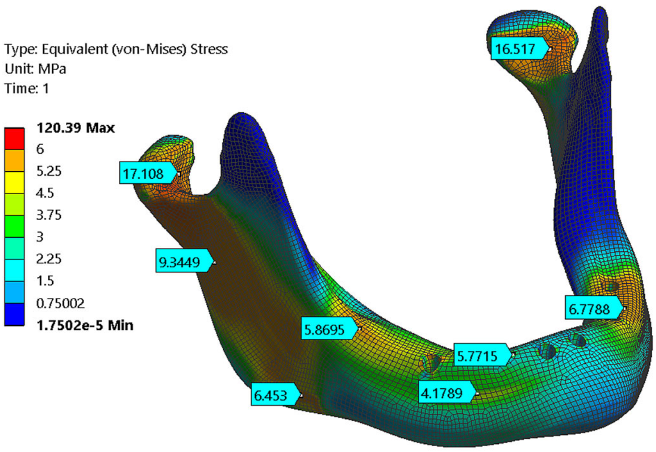
20c/ DV2_LC1



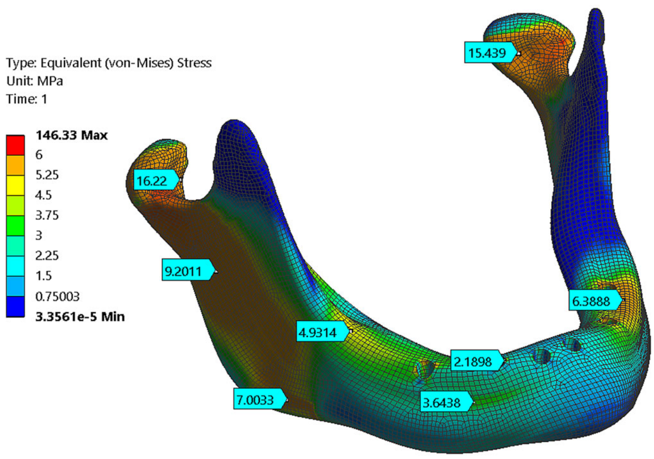
20d/ DV2_LC2



20e/ DV3_LC2



20f/ DV4_LC2

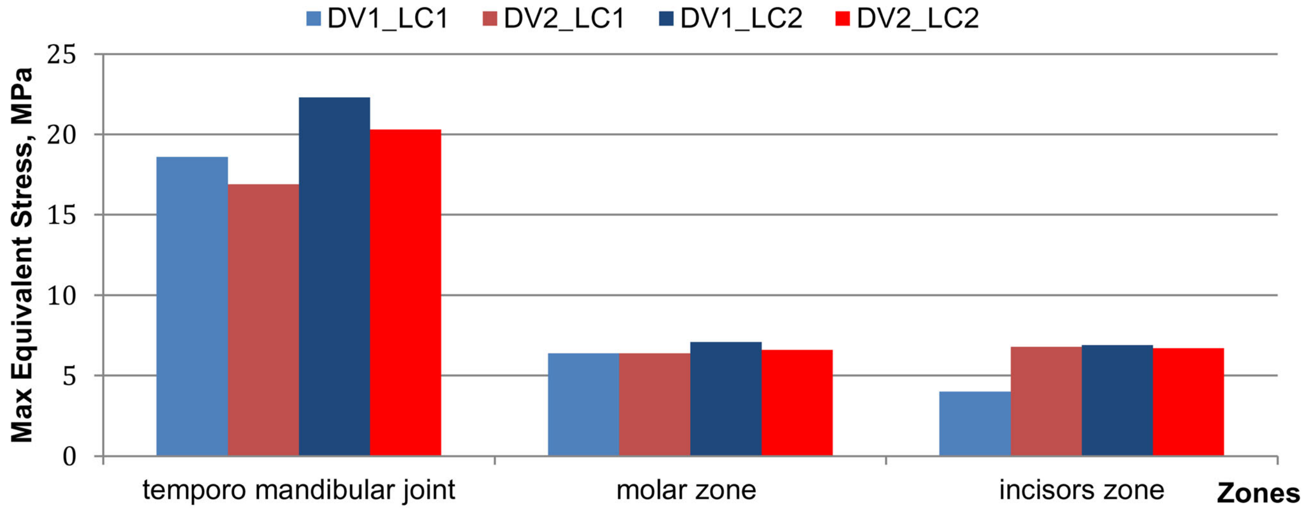


Analyses results are reviewed in two consecutive directions:

• Comparison I: Original construction (ZrO2 bridge) vs. plastic bridge

Results are extracted as maximal stress values in three zones: temporomandibular joint; molar zone and incisors zone. The comparison is presented on the graphics below.

Fig. 21. Comparison by zones and their max equivalent stresses between original and plastic prosthetic

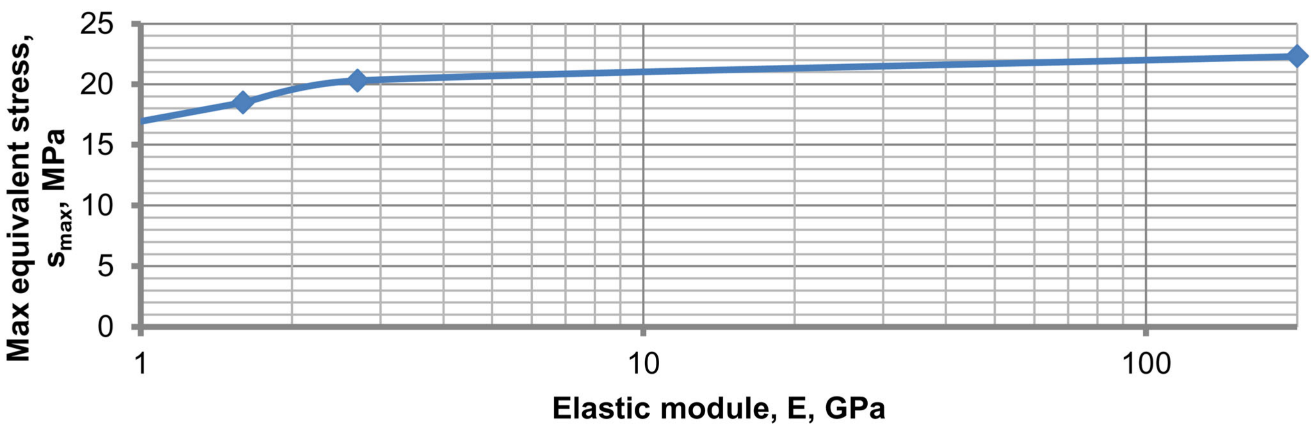


Maximal values of equivalent stress are for the temporomandibular joint area. There is decrease of stresses when prosthetic construction is replaced by plastic. Molar and incisors zone has close values among all variants. In fact, stresses are more evenly distributed in plastic prosthetic construction. Load case 2 (eccentric) shows higher stresses and is examined in detail further.

• Comparison II: Bridge elasticity influence

Similar to above performed comparison, examined variants are graphically compared by change of bridge elasticity (Young's modulus of proper material). This is shown on the figure below.

Fig. 22. Comparison by max equivalent stresses of bridges with different elasticity



The change of elasticity module shows change in maximal stress values mainly in means of stress redistribution.

CONCLUSION:

Clinical and x-ray data and mathematical analysis on the finite element method show that mandibular elasticity could be a reason for chronic pain syndrome in cases of edentulous patients treated with fixed rigid construction over implants. Unification of elasticity of construction and bone is of great importance for avoidance stress in peri-implant area around distally situated implants. The stress in the bone could be diagnosed with discomfort, pain and even with bone resorption.

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