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Analysis of load distribution in tooth-implant supported fixed partial dentures by the use of resilient abutment

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SUMMARY

Introduction Differences between the tooth and implant response to load can lead to many biological and technical implications in the conditions of occlusal forces.

Objective The objective of this study was to analyze load distribution in tooth/implant-supported fixed partial dentures with the use of resilient TSA (Titan Shock Absorber, BoneCare GmbH, Augsburg, Germany) abutment and conventional non-resilient abutment using finite element method.

Methods This study presents two basic 3D models. For one model a standard non-resilient abutment is used, and on the implant of the second model a resilient TSA abutment is applied. The virtual model contains drawn contours of tooth, mucous membranes, implant, cortical bones and spongiosa, abutment and suprastructure. The experiment used 500 N of vertical force, applied in three different cases of axial load. Calculations of von Mises equivalent stresses of the tooth root and periodontium, implants and peri-implant tissue were made.

Results For the model to which a non-resilient abutment is applied, maximum stress values in all three cases are observed in the cortical part of the bone (maximum stress value of 49.7 MPa). Measurements of stress and deformation in the bone tissue in the model with application of the resilient TSA abutment demonstrated similar distribution; however, these values are many times lower than in the model with non-resilient TSA abutment (maximum stress value of 28.9 MPa).

Conclusion Application of the resilient TSA abutment results in more equal distribution of stress and deformations in the bone tissue under vertical forces. These values are many times lower than in the model with the non-resilient abutment.

Keywords: dental implant-abutment design; fixed partial denture; stress distribution

INTRODUCTION

The indication field for use of implants in patient treatment is very large. Shortened dental arch is especially challenging for this type of therapy.

A reliable and clinically verified therapy includes production of free-standing implant-supported fixed partial dentures (i-FPD). However, anatomic restrictions and economic reasons often necessitate connecting tooth and implant. Many experimental investigations, followed by clinical studies, dealt with this problem because of the difference between biomechanical response of a tooth and of an implant to loading. The reason for this is different method these supports are connected to the surrounding bone. A natural tooth is attached to the alveolar bone indirectly via periodontal ligament (PDL), which gives it certain mobility under pressure. This mobility is designated as the physiological tooth mobility that can reach even 150 μm. The movement is particularly intensive in the initial phase of loading. Opposite to that, osseointegrated implants have ankylotic connection with the surrounding bone and their mobility under loading is linear. It ranges from 17 μm to 66 μm, and is related to bone tissue elasticity, applied material and position of implant inside the dental arch [1, 2]. Values are lower if an implant is in the anterior segment of the mandible due to its specific bone structure. With the initially larger tooth movement, even when the exerting forces are of low intensity (<20 N), the tooth intrusion of approximately 30 μm will occur. With an implant, these values are much lower – approximately 2 μm [1]. Apart from this, titanium has significantly higher elastic modulus values compared to a natural tooth, which has influence on the differences in bridge support mobility and force distribution to the bone [2]. Finally, not only the intensity of force but also the time of force action is important, since the periodontal ligament shows high elastic properties under load, which is not the case with the ankylotic connection of the implant and the bone tissue [1, 3]. Specifics of the PDL response to loading include the occurrence of biomechanical hysteresis in the case of frequent loading and creep, i.e. slow deformation when load time is long [4].

Event today, after more than three decades of debate on this issue, the controversy in regard

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to the tooth and implant connection is still present [5]. Differences between the tooth response and implant response to load can lead to many biological and technical implications in the conditions of occlusal forces [6, 7]. According to the results of certain experimental and clinical testing, the tooth intrusion results in higher loading on the implant rigidly connected to the bone [8, 9]. This reduces their supporting effect, causes implant overloading and increases marginal bone resorption. Larger tooth mobility and FPD span result in more serious consequences [10, 11]. Data from the literature also imply that the tooth-implant fixed partial dentures (m-FPD) often show cracking in cement film of abutment teeth, occurrence of caries, atrophy of PDL due to inactivity, occurrence of periapical processes, and even tooth root fracture [5, 11, 12]. In addition to that, some technical problems are observed in connection with the loss of occlusal screw, abutment screw, ceramics cracking, as well as the implant fracture [13].

Contrary to these results, many conducted clinical trials showed much lower percentage of biological and technical complications. Gunne et al. [14], followed by Lindh et al. [15] and Brägger et al. [16], published in their studies the results of monitoring after three to five years, in which they have had not observed any statistically significant differences regarding occurrence of complications between free-standing implants and tooth-implant supported prosthesis. However, study results of observation periods longer than ten years, and of the one conducted by Brägger et al. [17], indicate that more problems still occur with mixed fixed partial dentures.

For the purpose of achieving more uniform load distribution, some researchers used various precise connecting elements in order to provide physiological movement of teeth independent of implants. Despite some encouraging results, biological and technical complications could not be disregarded [18, 19]. This problem has not even been fully resolved with telescopic crowns, with various and insufficient explanations of the problem [9].

OBJECTIVE

The effort to achieve balance of different biomechanical responses of an abutment tooth and of an implant to loading has resulted with the application of resilient abutment (Titan Shock Absorber [TSA], BoneCare GmbH, Augsburg, Germany).

The objective of this study was to analyze load distribution in tooth-implant supported fixed partial dentures with the use of the resilient TSA abutment and conventional non-resilient abutment using the finite element method. Stresses and deformations are analyzed in the bone tissue around the tooth and implant. The obtained results could become genuine basis for implementation of resilient abutments in clinical practice with the patients receiving this kind of prosthetic therapy.

METHOD

The finite element method is a widely applied mathematical method in dentistry for calculations in connection with the stress distribution and deformation in the bone tissue around an implant and in the bone around a natural tooth.

This study presents two basic 3D models for interaction analysis of implants, teeth, bone, and PDL under the influence of occlusal loads in the mandible. It is assumed that first and second molars are missing in both cases (Kennedy class I), i.e. that the most distal tooth is the lower second premolar. Then, in both models, an implant (Straumann Standard Plus, 4.1 × 10 mm; Straumann, Basel, Switzerland), was mounted in the place of the second molar. For one implant and model a standard non-resilient abutment is used, and on the implant of the second model a resilient TSA abutment is used. Modelling of the implant and abutment was carried out in accordance with the factory dimensions and recommendation of the TSA abutment producer (Figure 1).

The conventional technique was used for preparation of the abutment tooth and creation of porcelain-fused-to-metal (PFM) crown. For fabrication of the metal substructure Co-Cr alloy of known physical and mechanical properties was used. In this way, in both cases, models were made of PFM fixed partial dentures having three units, with adequate occlusal morphology. The virtual model contains drawn contours of tooth, PDL, mucous membranes, implant, cortical bones and spongiosa, abutment and suprastructure (analogical real model) (Figure 2).

For all used materials it has been assumed that they are homogenous, linear elastic isotropic materials, except for the periodontal ligament. It is modelled as a 0.25 mm thick layer around the tooth. Periodontal ligament is represented with 1,200 3D non-linear highly elastic spring elements, in order to enable tooth movement of about 60 µm under a force of 5–10 N, and its return to the initial position after two seconds. Coordinates for each boundary point are loaded into the program in order to create surfaces of the modelled objects. Input parameters for all modelled

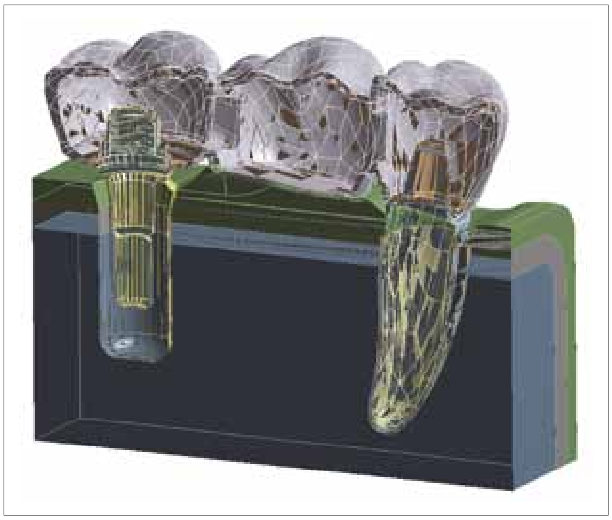

Figure 1. Model of tooth-implant supported FPD

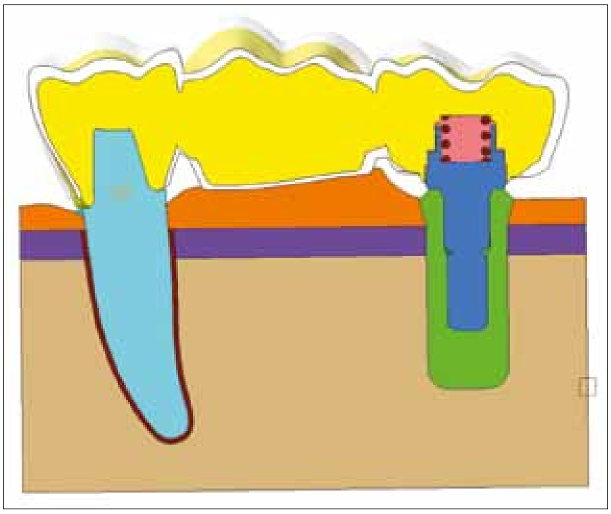

Figure 2. Schematic drawing of model with surface boundary contours

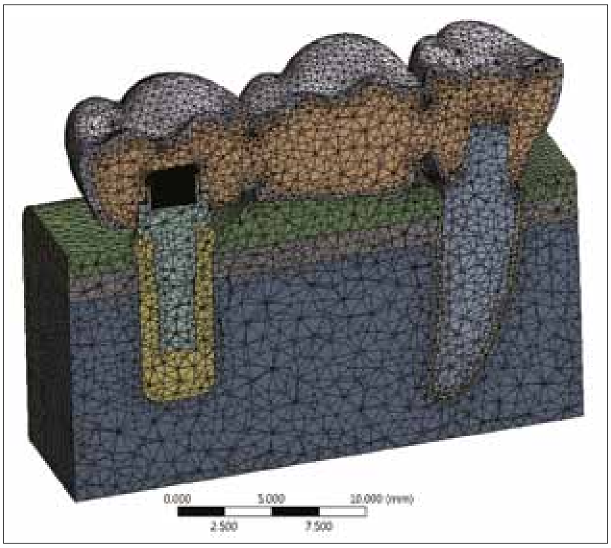

Figure 3. Network of elements and knots of the tooth-implant supported FPD

Table 1. Elastic modulus (E) and Poisson's coefficient (ν) of the material

Material	E (MPa)	ν
Dentin	18.6 × 103	0.3
Implant	1.1 × 105	0.3
Cortical bone	15.0 × 103	0.3
Spongious bone	1.5 × 103	0.3
Ceramics	69 × 103	0.28
Co-Cr alloy	2.2 × 105	0.3
Mucous membranes	19.6	0.3
PDL	2 × 103	0.45

PDL – periodontal ligament

objects (elastic modulus – E, Poisson's coefficient – ν) are taken from the literature (Table 1) [9].

The experiment used a vertical force of 500 N, applied in three different cases of axial load – to the FPD above the tooth, to the FPD above the implant, and to the FPD above all three units simultaneously, after which the distribution of stress and deformations was analyzed. In this way, six different cases of load were monitored depending

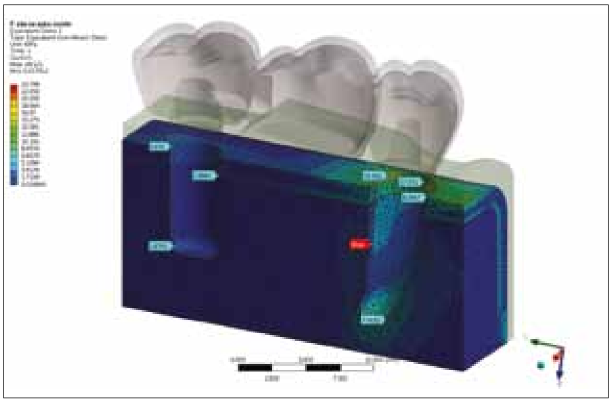

Figure 4. Model with non-resilient abutment and 500 N force on the tooth. Maximum stress values are recorded in the bone around the tooth neck and the middle third of the tooth root (23.7 MPa)

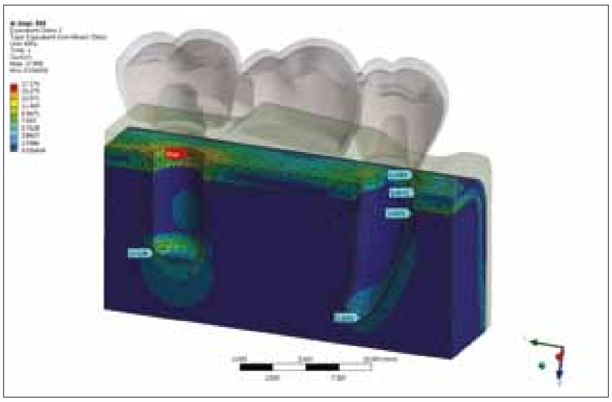

Figure 5. Model with non-resilient abutment and 500 N force on the implant. Maximum stress value is in the cortical bone around implant neck (17.1 MPa)

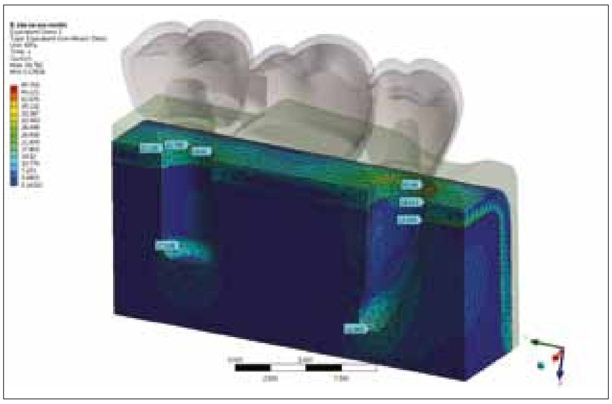

Figure 6. Model with non-resilient abutment and 500 N force on all three units. Maximum stress value is in the cortical bone around abutment tooth neck (49.7 MPa). High values are also recorded around the implant neck (22.8 MPa)

on whether the resilient abutments were used, and on the point of force application.

Calculations of von Mises equivalent stresses of the tooth root and periodontium, implants, and peri-implant tissue were made.

Numeric values are also presented graphically for clear interpretation and understanding.

ANSYS Workbench Platform (ANSYS, Inc., Canonsburg, PA, USA) was used for creation of the model and analyzing. The modelling used four types of finite elements:

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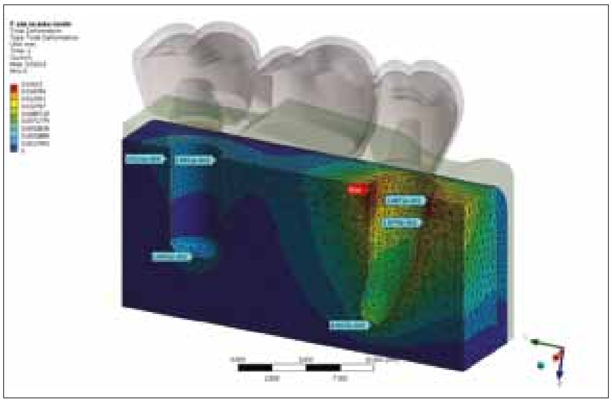

Figure 7. Model with non-resilient abutment and 500 N force above natural tooth. Maximum deformation was present in cortical bone around abutment tooth neck (0.02 mm)

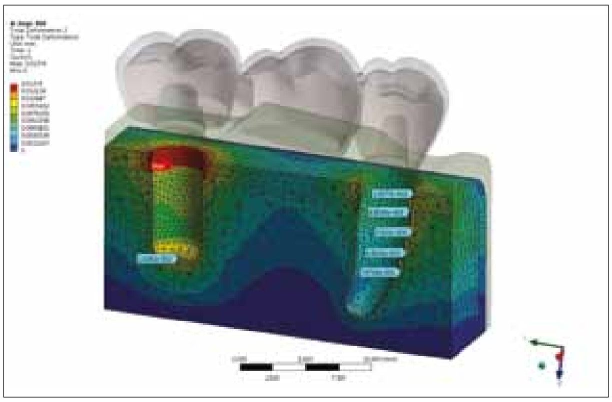

Figure 8. Model with non-resilient abutment and 500 N force above implant. Maximum deformation was present in cortical bone around implant neck (0.01 mm)

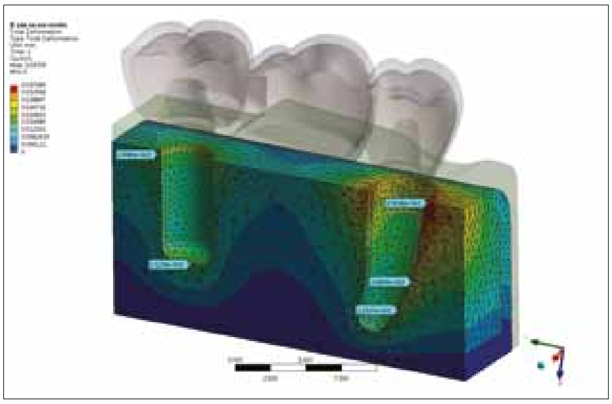

Figure 9. Model with non-resilient abutment and 500 N force above all three units at the same time. Maximum deformation was present in cortical bone around abutment tooth neck, mesial side (0.04 mm)

solid 187, conta 174, targe 170, and surf 154. Created models contain 1,260,905 elements and 1,915,789 knots (Figure 3).

RESULTS

For the model to which non-resilient abutment was applied, analysis were made of the 500 N force applied to the FPD above the tooth, 500 N force applied to the FPD above the implant, and 500 N force applied to the FPD above all three units simultaneously. For all three situations of force application, our results showed maximum stress values in the cortical part of the bone around the tooth and implant. When the force was applied above the natural tooth, stress values at the apex of the tooth were lower than in the cortical part of the bone and in the middle third. In contrast, when the force was applied above the implant, very high stress values were also recorded in the bone under the implant. By far the largest stress values were recorded in the case when the force was applied simultaneously to all three FPD units (49.7 MPa). These values were observed in the cortical bone around the implant neck (Figures 4, 5, and 6).

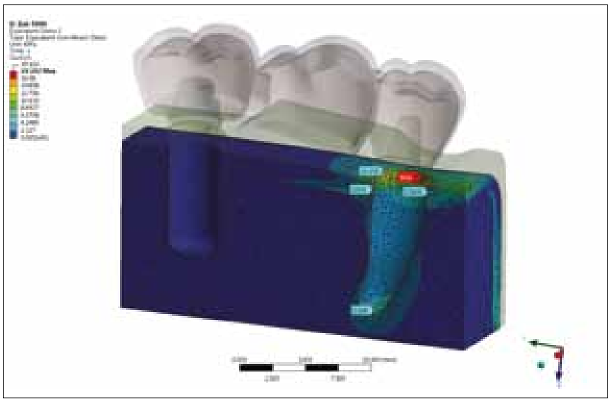

Figure 10. Model with resilient TSA abutment and 500 N force above the tooth. High values are recorded in the bone around the tooth neck and under the tooth root peak. Maximum recorded value is around the abutment tooth neck (19.1 MPa)

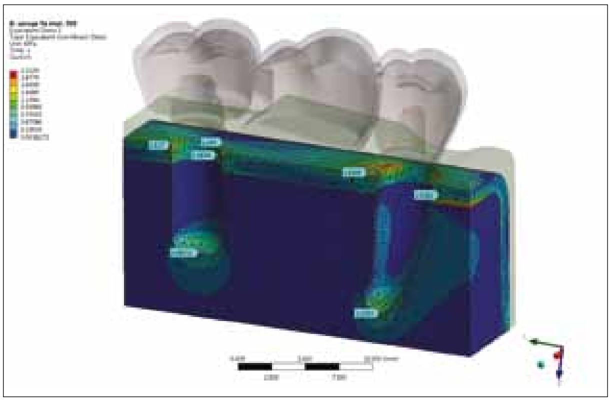

Figure 11. Model with resilient TSA abutment and 500 N force above the tooth. Maximum values are recorded in the bone around the tooth, mesial side of abutment tooth (2.1 MPa)

Measurements related to deformation in the bone tissue correlated to the measurements of stress condition. Deformation was the greatest in cortical bone around the tooth and implant. Maximum values were recorded when the force was applied to all three FPD units, in cortical bone around the natural tooth (0.04 mm) (Figures 7, 8, and 9).

Measurements of stress and deformation in the bone tissue in the model with application of the resilient TSA abutment demonstrated similar distribution in the bone, with highest values in the cortical bone around the tooth and implant. However, these values are many times lower than in the model with non-resilient TSA abutment (Figures 10–15).

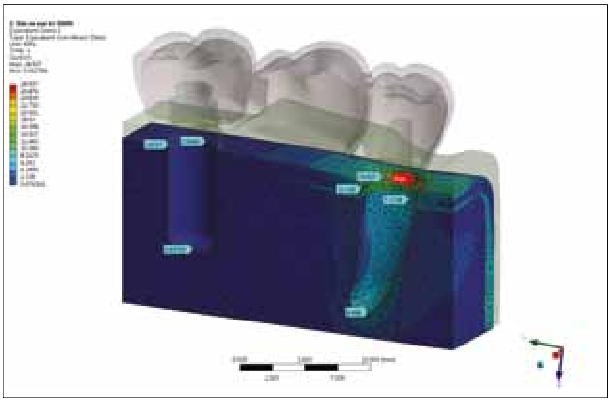

Figure 12. Model with resilient TSA abutment and 500 N force above all three FPD units. The highest stress is also in the bone around abutment tooth neck (28.9 MPa)

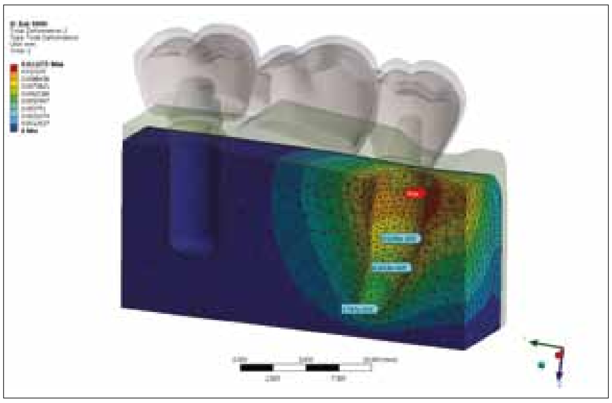

Figure 13. Model with resilient TSA abutment and 500 N force above the tooth. Maximum deformation values are recorded in the bone around the tooth neck, mesial side (0.01 mm)

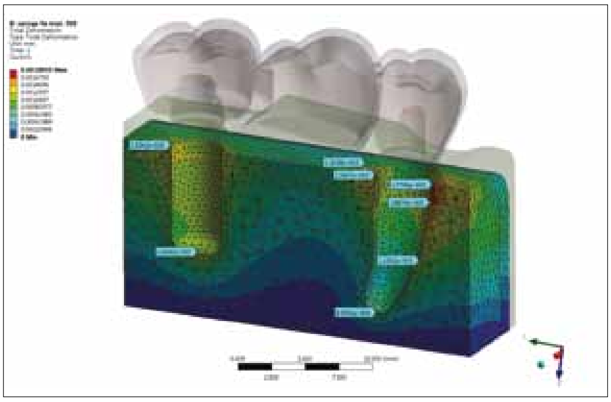

Figure 14. Model with resilient TSA abutment and 500 N force above the implant. Maximum deformation when the force is applied to implant is around the neck of tooth mesial side (0.001 mm)

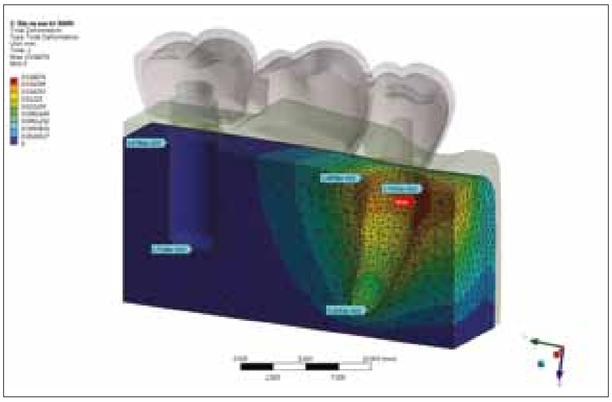

Figure 15. Model with resilient TSA abutment and 500 N force above all three units. The highest deformation values are also recorded around the tooth neck, mesial side (0.02 mm)

Table 2. Stress distribution in the system (MPa) when 500 N force is applied

Bone	Model without spring			Model with spring		
	Force on tooth	Force on implant	Force on all three units	Force on tooth	Force on implant	Force on all three units
Bone around tooth (MPa)	23.7	6.3	49.7	19.1	2.1	28.9
Bone around implant (MPa)	3.3	17.1	22.8	0.005	1.5	2.8

Table 3. Deformation in the system (mm) when 500 N force is applied

Bone	Model without spring			Model with spring		
	Force on tooth	Force on implant	Force on all three units	Force on tooth	Force on implant	Force on all three units
Bone around tooth (mm)	0.02	0.01	0.04	0.01	0.001	0.02
Bone around implant (mm)	0.003	0.01	0.02	0.001	0.001	0.002

Comparison of maximum values of stress and deformation for both tested models in all analyzed cases is given in Tables 2 and 3.

DISCUSSION

In situations of tooth-implant supported FPD, one of the most important factors, when it comes to long-term success, is the design of the denture, i.e. the use of the fixed or resilient connection between two different supports. However, neither *in vitro* experiments nor clinical studies provide precise recommendations for a specific design of the prosthesis that connects teeth and implants.

Finite element method has been widely used in dentistry and in studies dealing with the application of occlusal force, i.e. stresses and deformations caused by such forces [3, 20–23]. Although this method is very helpful, it doesn't only have advantages, but also drawbacks. Since the mathematical models are models of real objects, precision and reliability of obtained results depend on the precision of the model itself, its geometry, input parameters defining the characteristics of the material, loads and boundary conditions [24, 25, 26]. Geometry of teeth, supporting structures, bone, and temporomandibular joints is complex, which makes it impossible to make a full replica of real objects. Also, the experiments assume that the materials, in regard to their characteristics, are homogenous, linear elastic isotropic materials, except for periodontal ligament. In addition, the forces applied in the mouth are complex by their intensity, direction, distribution and time of application. On the other hand, it should be taken into account that this is a computer model, and as such the experiment can be fully controlled; thus, it is possible to change the test conditions, and the simulations can be repeated as many times as it is desired. Having all this in mind, it should be noted that a well-defined model and correct implementation of the program and interpretation of obtained results make this method extremely important not only for preliminary and control investigation, but also as a method of choice in *in vitro* studies [24, 25, 26].

Perhaps the results presented in this paper are not real values of load in the mouth, but they indicate different form of distribution of stress and deformations subject to the implemented model, as well as what design of the tooth-implant supported FPD and abutment would be most efficient. This method also provides numeric values and visual data available for further interpretation and analysis.

Compared to 2D models used in similar experiments, 3D model is much more precise and reduces potential errors, and therefore obtained data can be deemed more reliable [2, 6, 19].

Vertical load of the tooth-implant FPD with standard abutment and rigid construction, without connection elements, causes tooth intrusion and consequently higher load of mesial-cervical region of the implants, due to bending of the whole structure. These normal forces tend to rotate the implant around the support, which is at a higher position in relation to the intruded tooth at the time of load. This reason, together with the higher elastic modulus of the cortical bone, leads to the stress concentration in the mentioned region [6, 8]. Due to aforementioned reasons, in the case of non-resilient abutments, according to the experimental results, it can be concluded that the bending forces occur in the FPD structure and lay stress on the implant to a great extent. These results match the results of a large number of clinical and experimental studies that dealt with these problems [3, 5, 7, 9, 14, 18, 19, 20, 21, 27, 28].

The results obtained in this experiment point at different distribution of stress and deformations in the model which used resilient TSA abutment in relation to the model that used non-resilient abutment.

In the model with resilient TSA abutment, stress and deformation values around the implant are significantly lower compared to the natural tooth in the same model. Also, the measured values are many times lower compared to the non-resilient abutment model for all three cases of vertical forces. Distribution model is similar for deformations in the bone around the tooth and implant, with significantly lower values when a resilient abutment is used.

Such results can be explained by the fact that a resilient abutment cushions and absorbs a large portion of the force, and then transfers a portion of the total load to the surrounding structures and bone. In this way, a certain equalization of load on the support is achieved, especially when the force is applied to all three FPD units at the same time.

According to the results of this experiment, excessive load on the implant caused by tooth intrusion is prevented, owing to the resilient abutment spring, which absorbs a portion of the force.

CONCLUSION

According to the results of this experiment the following conclusions can be made.

Application of the resilient TSA abutment results in more equal distribution of stress and deformations in the bone tissue around the tooth and implant under vertical forces.

Stress and deformation values in the model with the resilient abutment are many times lower than in the model with the non-resilient abutment.

Proposed design of the FPD with the mixed load and resilient TSA abutments could be a reliable and successful therapy method when a tooth needs to be connected with the implant.

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REFERENCES

1. Sekine H, Komiyama Y, Hutta H, Yoshida K. Mobility characteristics and tactile sensitivity of osseoIntegrated fixture-supported systems. In: Van Steenberghe D, editor. Tissue-integration in oral and maxillofacial reconstruction. Amsterdam: Exerpta Medica; 1986. p.326–332.
2. Richter EJ. Basic biomechanics of dental implants in prosthetic dentistry. J Prosthet Dent. 1989; 61:602–609. [DOI: 10.1016/0022-3913(89)90285-0] [PMID: 2664148]
3. Menicucci G, Mossolov A, Mozzati M, Lorenzetti M, Preti G. Tooth-implant connection: some biomechanical aspects based on finite element analyses. Clin Oral Implants Res. 2002; 13:334–341. [DOI: 10.1034/j.1600-0501.2002.130315.x] [PMID: 12010166]
4. Stamenković D. Stomatološka protetika – parcijalne proteze. Beograd: Interprint; 2006. p.44–67.
5. Lindh T. Should we extract teeth to avoid tooth-implant combinations? J Oral Rehab. 2008; 35:44–54. [DOI: 10.1111/j.1365-2842.2007.01828.x] [PMID: 18181933]
6. Lundgren D, Laurell L. Biomechanical aspects of fixed bridgework supported by natural teeth and endosseous implants. Periodontol 2000. 1994; 4:23–40. [DOI: 10.1111/j.1600-0757.1994.tb00003.x] [PMID: 9673191]

7. Chee WW, Mordohai N. Tooth to implant connection: A systematic review of the literature and a case report utilizing a new connection design. Clin Implant Dent Relat Res. 2010; 12(2):122–33. [DOI: 10.1111/j.1708-8208.2008.00144.x] [PMID: 19220844]
8. Glantz PO, Nilner K. Biomechanical aspects of prosthetic implant-borne reconstructions. Periodontol 2000. 1998; 17:119–124. [DOI: 10.1111/j.1600-0757.1998.tb00129.x] [PMID: 10337319]
9. Ozcelik BT, Ersoy E, Yilmaz B. Biomechanical Evaluation of Tooth- and Implant-Supported Fixed Dental Prostheses with Various Nonrigid Connector Positions: A Finite Element Analysis. J Prosthodont. 2011; 20:16–28. [DOI: 10.1111/j.1532-849X.2010.00654.x] [PMID: 21251117]
10. Cordaro L, Ercoli C, Rossini C, Torsello F, Feng C. Retrospective evaluation of complete-arch fixed partial dentures connecting teeth and implant abutments in patients with normal and reduced periodontal support. J Prosthet Dent. 2005; 94:313–320. [DOI: 10.1016/j.prosdent.2005.08.007] [PMID: 16198167]
11. Naert IE, Duyck JA, Hosny MM, Quirynen M, Van Steenberghe D. Freestanding and tooth-implant connected prostheses in the treatment of partially edentulous patients Part II: an up to 15-years radiographic evaluation. Clin Oral Implants Res. 2001; 12:245–251. [DOI: 10.1034/j.1600-0501.2001.012003245.x] [PMID: 11359482]
12. Block MS, Lirette D, Gardiner D, Li L, Finger IM, Hochstedler J, et al. Prospective evaluation of implants connected to teeth. Int J Oral Maxillofac Implants. 2002; 17:473–487. [PMID: 12182290]
13. Velásquez-Plata D, Lutonsky J, Oshida Y, Jones R. A close-up look at an implant fracture: a case report. Int J Periodontics Restorative Dent. 2002; 22:483–491. [DOI: 10.11607/prd.00.0491] [PMID: 12449308]
14. Gunne J, Astrand P, Lindh T, Borg K, Olsson M. Tooth-implant and implant supported fixed partial dentures: a 10-year report. Int J Prosthodont. 1999; 12:216–221. [PMID: 10635188]
15. Lindh T, Dahlgren S, Gunnarsson K, Josefsson T, Nilson H, Wilhelmsson P, et al. Tooth-Implant Supported Fixed Prostheses: A Retrospective Multicenter Study. Int J Prosthodont. 2001; 14:321–28. [PMID: 11508086]
16. Brägger U, Aeschlimann S, Bürgin W, Hämmerle CH, Lang NP. Biological and technical complications and failures with fixed partial dentures (FPD) on implants and teeth after four to five years of function. Clin Oral Impl Res. 2001; 12:26–34. [DOI: 10.1034/j.1600-0501.2001.012001026.x] [PMID: 11168268]
17. Brägger U, Karoussis I, Persson R, Pjetursson B, Salvi G, Lang N. Technical and biological complications/failures with single crowns and fixed partial dentures on implants: a 10-year prospective cohort study. Clin Oral Implants Res. 2005; 16:326–334. [DOI: 10.1111/j.1600-0501.2005.01105.x] [PMID: 15877753]
18. Lin CL, Wang JC. Nonlinear finite element analysis of a splinted implant with various connectors and occlusal forces. Int J Oral Maxillofac Implants. 2003; 18:331–340. [PMID: 12814307]
19. Schlumberger TL, Bowley JF, Maze GI. Intrusion phenomenon in combination tooth-implant restorations: a review of the literature. J Prosthet Dent. 1998; 80:199–203. [DOI: 10.1016/S0022-3913(98)70110-6] [PMID: 9710822]
20. Lin CL, Chang SH, Wang JC, Chang WJ. Mechanical interactions of an implant/tooth-supported system under different periodontal supports and number of splinted teeth with rigid and non-rigid connections. J Dent. 2006; 34:682–691. [DOI: 10.1016/j.jdent.2005.12.011] [PMID: 16439048]
21. Oruc S, Eraslan O, Tukay HA, Atay A. Stress analysis of effects of non-rigid connectors on fixed partial dentures with pier abutments. J Prosthet Dent. 2008; 99:185–192. [DOI: 10.1016/S0022-3913(08)60042-6] [PMID: 18319089]
22. Stamenković D. The Biomechanics of Dental Implants and Dentures. Srp Arh Celok Lek. 2008; 136(Suppl 2):73–83. [PMID: 18924477]
23. Radović K, Čairović A, Todorović A, Stančić I, Grbović A. Comparative analysis of unilateral removable partial denture and classical removable partial denture by using finite element method. Srp Arh Celok Lek. 2010; 138(11-12):706–13. [DOI: 10.2298/SARH1012706R] [PMID: 21365883]
24. Stamenković D, Grbović A. Metoda konačnih elemenata u ispitivanju gradivnih stomatoloških materijala. In: Stamenković D, editor. Gradivni stomatološki materijali, Beograd: Stomatološki fakultet; 2007. p.83–108.
25. Grbović A, Balać I. Primer primene MKE u stomatologiji. In: Stamenković D, editor. Stomatološki materijali, knjiga 2. Beograd: Stomatološki fakultet; 2012. p.351–70.
26. Grbović A, Stamenković D. Primeri primene MKE u dizajniranju i ispitivanju stomatoloških metrijala. In: Stamenković D, editor. Stomatološki materijali, knjiga 2. Beograd: Stomatološki fakultet; 2012. p.371–84.
27. Lin CL, Wang JC, Chang WJ. Biomechanical interactions in tooth-implant-supported fixed partial dentures with variations in the number of splinted teeth and connector type: a finite element analysis. Clin Oral Implants Res. 2008; 19:107–117. [DOI: 10.1111/j.1600-0501.2007.01363.x] [PMID: 17944965]
28. Ozçelik T, Ersoy AE. An investigation of tooth/implant-supported fixed prosthesis designs with two different stress analysis methods: an in vitro study. J Prosthodont. 2007; 16:107–116. [DOI: 10.1111/j.1532-849X.2007.00176.x] [PMID: 17362420]

Анализа дистрибуције оптерећења код мешовито ношених мостова применом резилијентних абатмената

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КРАТАК САДРЖАЈ

Увод Разлике у одговору зуба и имплантата на оптерећење могу имати за последицу низ биолошких и техничких компликација у условима деловања оклузалних сила.

Циљ рада Циљ овог рада је да се анализира дистрибуција оптерећења код мешовито ношених мостова са применом резилијентног *TSA* абатмента (*Titan Shock Absorber*, *BoneCare GmbH Germany*), као и конвенционалног нерезилијентног абатмента применом методе коначних елемената (МКЕ).

Методе рада У овом раду направљена су два основна 3*D* модела. На једном имплантату и моделу коришћен је стандардни нерезилијентни абатмент, а на имплантату другог модела коришћен је резилијентни *TSA* абатмент. На виртуелном моделу су моделиране контуре зуба, ПДЛ-а, слузокоже, имплантата, кортикалне и спонгиозне кости, абатмента и супраструктуре. У експерименту је коришћена вертикална сила од 500 *N*, која је примењена у три различита случаја аксијалног оптерећења. Методом коначних елемената израчунавани су потом Фон Мизесови еквивалентни напони у корену зуба и пародонцијуму, имплантату и периимплантатном ткиву.

Резултати На моделу код кога је примењен нерезилијентни абатмент, максималне вредности напона и деформације у сва три случаја су регистроване у кортикалном делу кости око зуба и имплантата у зависности од нападне тачке силе (максималан напон 49,7 *MPa*). Вредности напона и деформација на моделу са применом резилијентног *TSA* абатмента показале су сличну расподелу у кости, међутим ове вредности су вишеструко мање него код модела са нерезилијентним абатментом (максималан напон 28,9 *MPa*).

Закључак Примена резилијентног *TSA* абатмента доводи до равномерније расподеле напона и деформације у коштаном ткиву око зуба и имплантата под дејством вертикалних сила. Измерене вредности су вишеструко мање него на моделу са нерезилијентним абатментом.

Кључне речи: имплант абатмент; мост; дистрибуција напона

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