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Original paper

Masticatory Area Influence on Stress in Saddle in Attachments Implant Supported Dentures

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Abstract

The aim of study was to analyze if placing the second molar influences the maximum von Mises stresses on the saddle and artificial teeth of an implant supported removable partial denture (RPD) with ball attachments. Finite element analysis was used to study stress distribution of a mandibular class I Kennedy RPD with ball attachments and two distal implants, placed bilaterally in the second molar area, in two cases: with or without M2. The value of von Mises stresses was higher in all acrylic components in implant supported RPDs with ball attachments with M2 than the ones in implant supported RPDs with ball attachments without M2. From all acrylic components, the highest von Mises stresses were recorded on M1 in both cases. In metallic saddle, von Mises stresses were higher in RPD without M2 than in RPD with M2. Placing the second artificial molar on the saddle in implant supported RPD with attachments increases the maximum von Mises stresses recorded in the artificial teeth and in the acrylic saddle but lowers them in the metallic component of the saddle. The maximum von Mises stresses recorded in the acrylic saddle are much higher if the second molar is present.

Keywords Removable partial denture, attachments, implants, saddle, finite elements analysis.

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Introduction

Patients using classical distally extended RPDs complain about the lack of retention and stability of their dentures due to movement around its rotational axis. It is difficult to expect that nowadays, in the implant era, patients' acceptance of RPDs will increase. Still, we can expect that this type of dentures will be needed due to the increase in life expectancy combined with the decrease in tooth loss. The partially edentulous patient that cannot afford an exclusive implant treatment because of economic, systemic or anatomic reasons can be successfully restored using a combination of RPD and implants, combining the advantages that both treatment solution are offering: a lower cost of the RPD and the improvement in support, retention and stability offered by implants (L. LEVIN [1]).

Other authors also found that placing distal implants in these cases is a cost-effective treatment option for those that cannot afford a complete implant supported fixed solution, minimizing the dislodgement of the RPD during function (C. BURAL & al [2]). Associating RPDs with implants having incorporate attachments improves denture retention, stability, and support, resulting in greater patient satisfaction (M.C. FU & al [3], S. BORTOLINI & al [4], C.H. CAMPOS & al [5], E. MIJIRITSKY & al [6]). The length of the occlusal area of the saddle depends on the opposed arch and influences the masticatory efficiency. The aim of our study was to analyze if placing the second artificial molar on the acrylic saddle influences the level of maximum von Mises stresses on the saddle and artificial teeth. The null hypothesis is that the placement of the artificial second molar on the saddle of an implant supported RPD with ball attachments has no effect on the maximum von Mises stress levels registered on its components.

Materials and Methods

We used finite element analysis to study stress distribution of a mandibular class I Kennedy RPD with ball attachments on mesial natural teeth and on two distal implants, placed bilaterally in the second molar area, in the following two cases: with or without M2. The six anterior teeth used as abutments were covered with six united metal-ceramic crowns, milled with oral shoulders and 5 interlocks. The major connector was a double lingual bar with 5 pins matching the milled interlocks on the upper bar. All metallic parts of the denture were casted from Cr-Co Remanium GM 380 Dentaurum. The acrylic saddles were made of termopolymerizable acrylic material Acry-Pole Ruthinium, and the artificial acrylic teeth that replace the PM2, M1 and M2 were made from Acry-Rock Ruthinium. PM1 was made with light-cured composite (Solidex, Shofu) applied by the dental technician on the metallic matrix socket. We used dental implants with 3.75 mm diameter and 10 mm length and ball attachments. In this study, we considered a paraxial force of mastication with a normal component (axial) of 160 N and a tangential one of 23.5N applied on M1. We considered the mandibular bone as a type III bone for the 3D model design created using Autodesk Inventor 2016 software. All materials were considered homogeneous, isotropic and having linear elasticity. The material characteristics of the 3D model are shown in Table 1.

Table 1. Material characteristics of the 3D model

Material	Poisson's Ratio	Young's Modulus
Titan	0.3	113.8GPa
Cr-Ni alloy	0.3	172GPa
Ceramics	0.28	67.7GPa
Composite	0.24	16.6GPa
Acrylic	0.35	2.4GPa
Cortical bone	0.3	13.7GPa
Cancellous bone	0.3	0.69GPa

The discrete models are shown in Figure no. 1 and Figure 2. We compared the von Misses stress levels appeared in the saddle and acrylic teeth of RPD with ball attachments and distal implants in two cases, with or without M2.

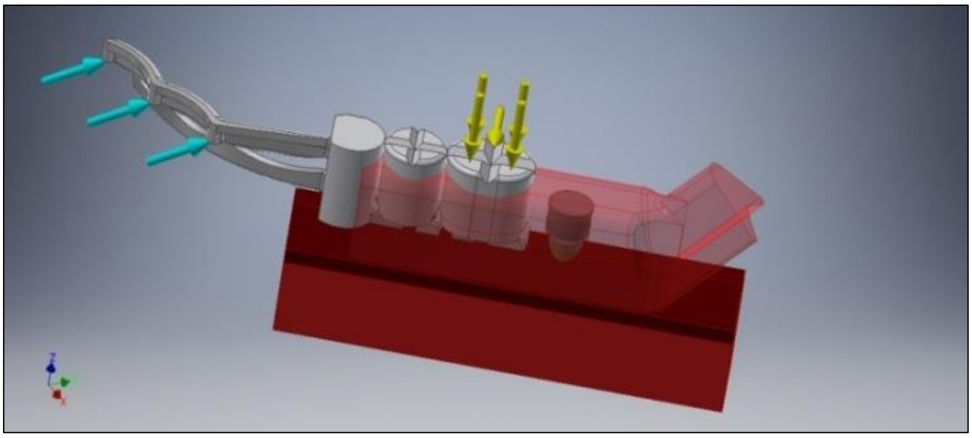

Figure 1. The 3D Model of half mandibular implant supported RPD with attachments without M2.

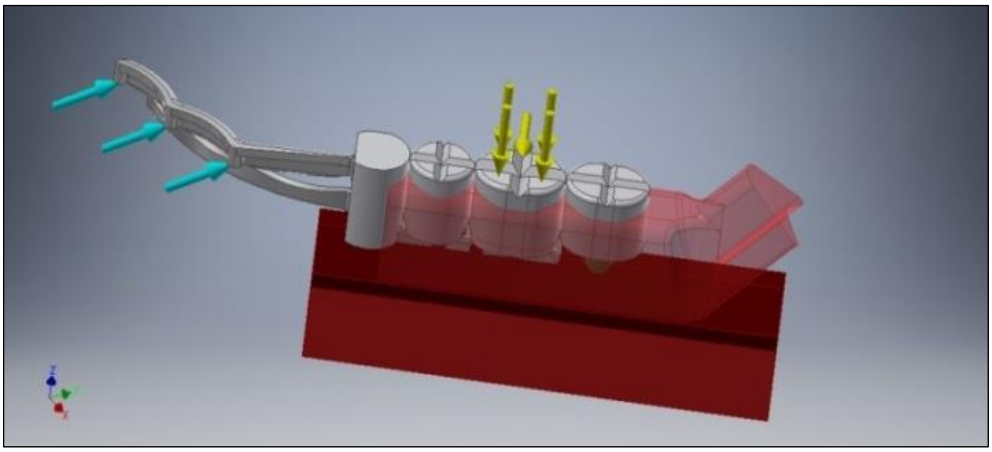

Figure 2. The 3D Model of half mandibular implant supported RPD with attachments with M2.

Results and Discussions

The value of von Mises stresses was higher in all acrylic components in case of implant supported RPDs with ball attachments with M2 than the ones which appear in case of implant supported RPDs with ball attachments without M2. From all acrylic components, the highest von Mises stresses value was recorded on M1 in both cases. In metallic saddle, von Mises stresses were higher in case of RPD without M2 than in case of RPD with M2 (Table 2).

In case of implant supported RPD with ball attachments without M2, the highest von Mises stresses appeared in the metallic component of the saddle (21.77MPa) (Figure 3) and the smallest in PM2 (8.072MPa) (Figure 4).

Table 2. Maximum von Mises stresses in the saddle and artificial teeth

Component	Maximum von Mises stress in case of implant supported RPD with attachments without M2	Maximum von Mises stress in case of implant supported RPD with attachments with M2
PM1	12.56MPa	12.6MPa
PM2	8.072MPa	8.287MPa
M1	17.53MPa	18.96MPa
M2		6.131MPa
acrylic saddle	9.614MPa	12.02MPa
metallic saddle	21.77MPa	21.57MPa

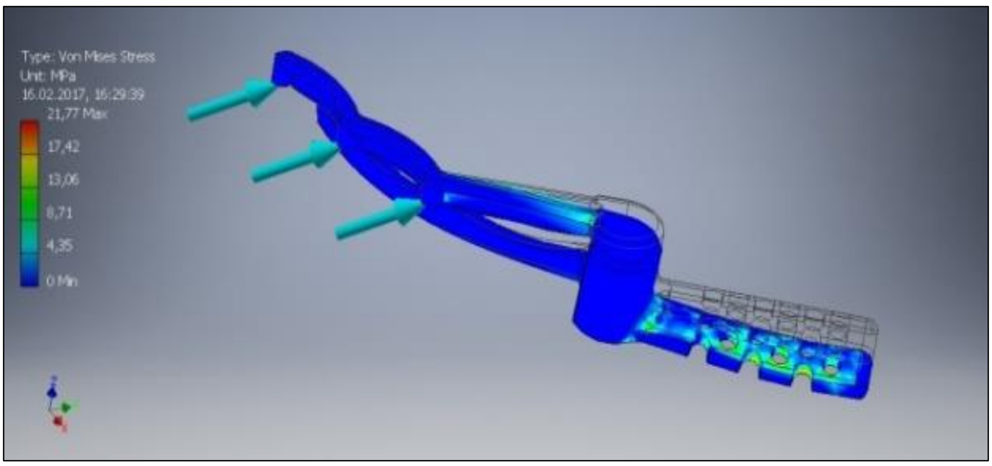

Figure 3. Maximum von Mises stress on the metallic saddle in case of implant supported RPD with attachments without M2.

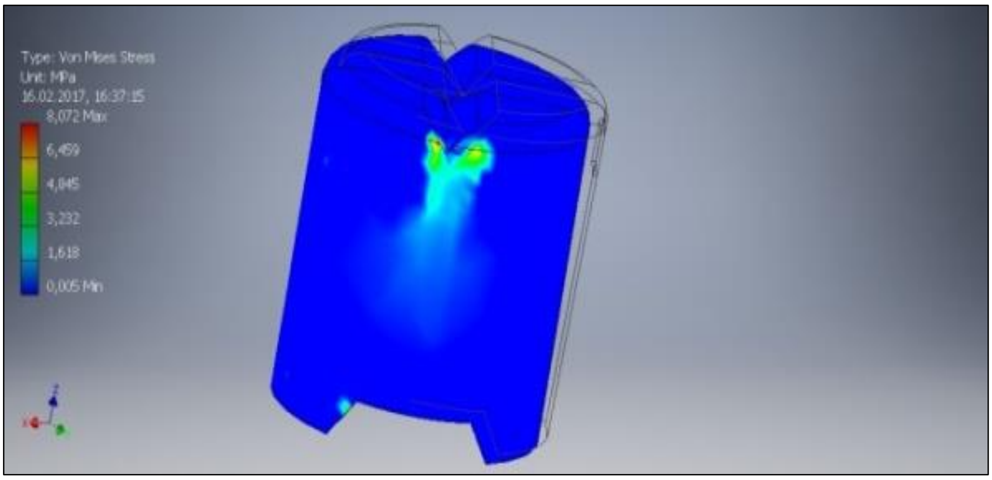

Figure 4. Maximum von Mises stress on PM2 in case of implant supported RPD with attachments without M2.

In case of implant supported RPDs with ball attachments with M2, the highest von Mises stresses appeared also in the metallic component of the saddle (21.57MPa) (Figure 5) but the smallest von Mises stresses were recorded on M2 (6.131MPa) (Figure 6).

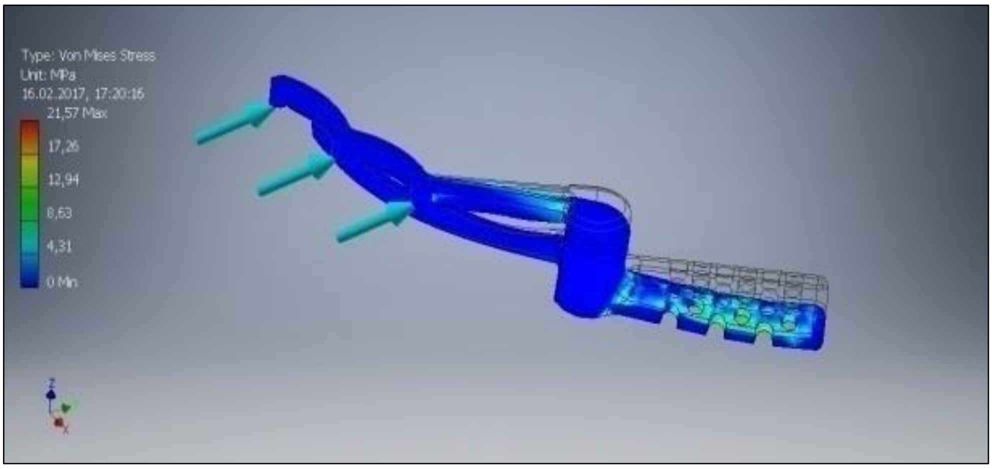

Figure 5. Maximum von Mises stress on the metallic saddle in case of implant supported RPD with attachments with M2.

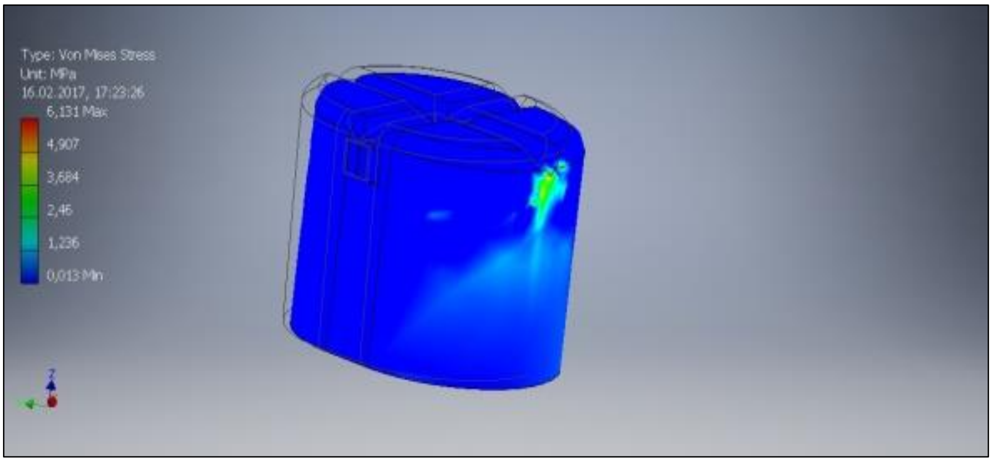

Figure 6. Maximum von Mises stress on M2 in case of implant supported RPD with attachments with M2.

Maximum von Mises stresses recorded in the artificial teeth and acrylic saddle in case of implant supported RPDs with attachments without M2 were 12.56MPa on PM1 (Figure 7), 17.53MPa on M1 (Figure 8) and 9.614MPa on the acrylic saddle (Figure 9).

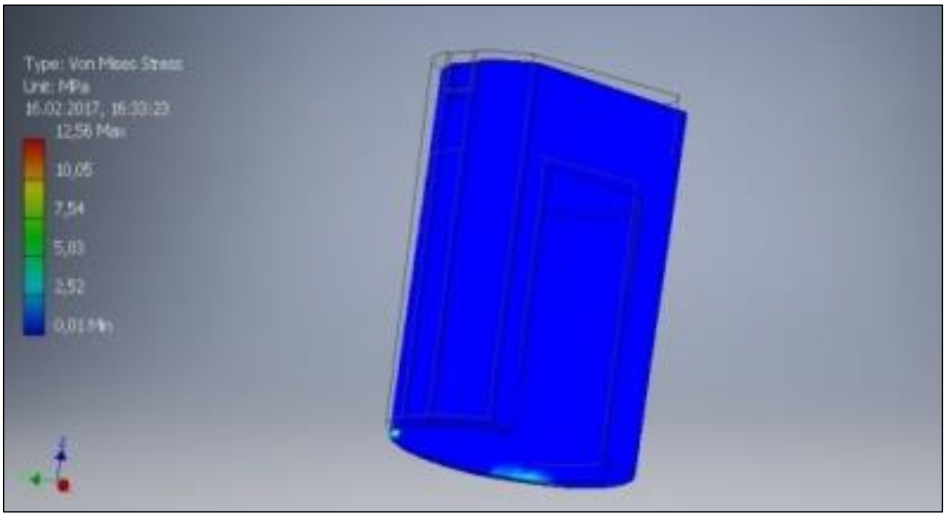

Figure 7. Maximum von Mises stress on PM1 in case of implant supported RPD with attachments without M2.

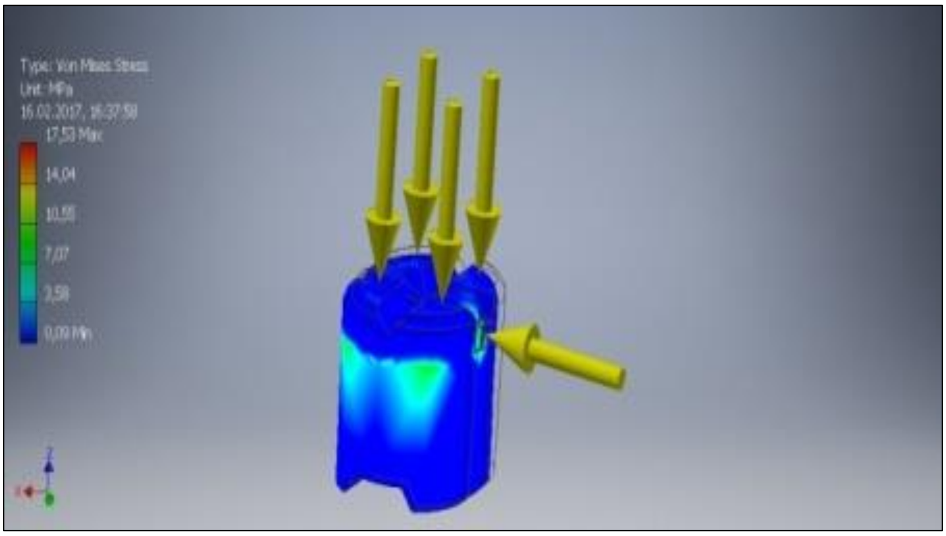

Figure 8. Maximum von Mises stress on M1 in case of implant supported RPD with attachments without M2.

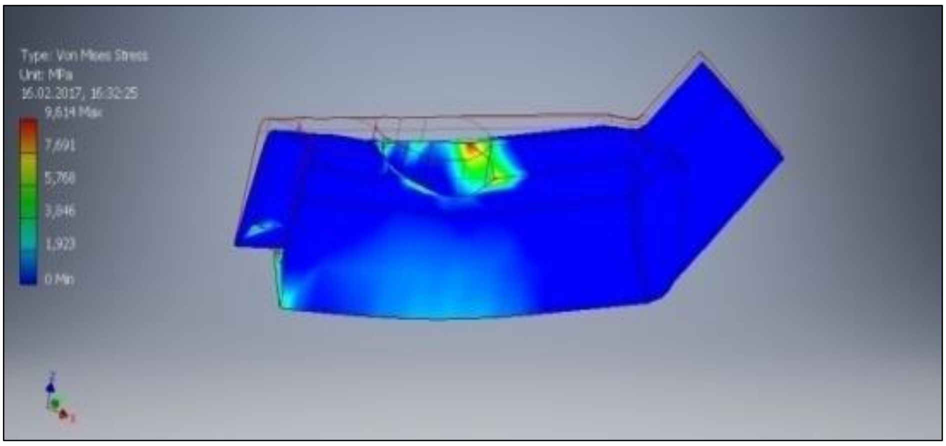

Figure 9. Maximum von Mises stress on the acrylic saddle in case of implant supported RPD with attachments without M2.

In case of implant supported RPD with ball attachments with M2, the maximum von Mises stresses recorded in the other artificial teeth and acrylic saddle were 12.6MPa on PM1 (Figure 10), 8.287MPa on PM2 (Figure 11), 18.96MPa on M1 (Figure 12) and 12.02MPa on the acrylic saddle (Figure 13).

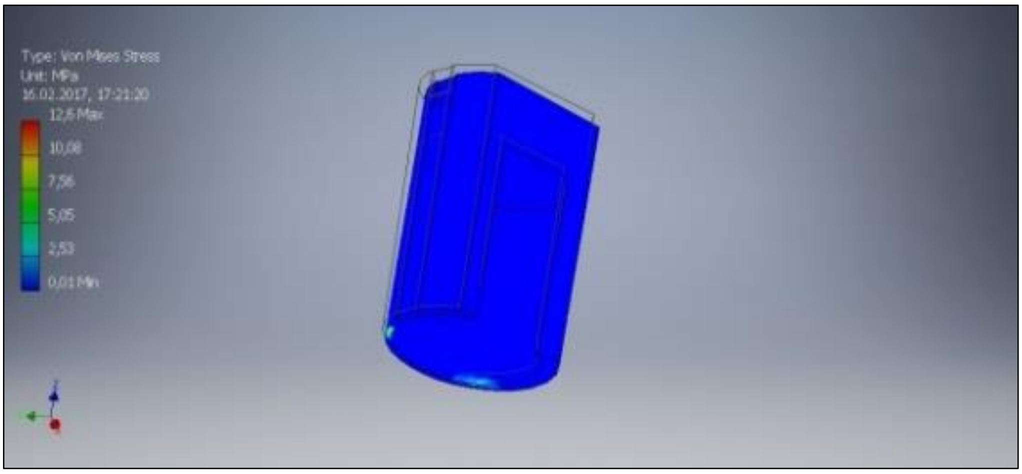

Figure 10. Maximum von Mises stress on PM1 in case of implant supported RPD with attachments with M2.

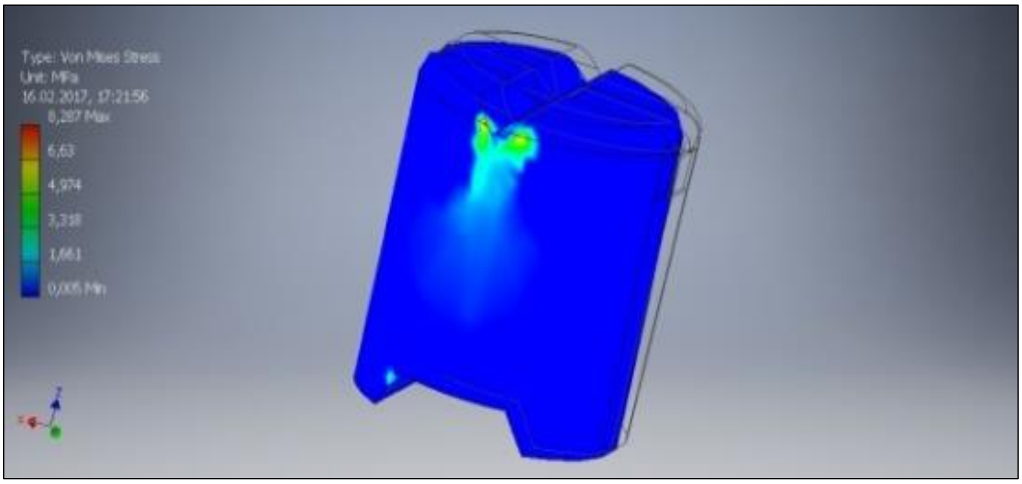

Figure 11. Maximum von Mises stress on PM2 in case of implant supported RPD with attachments with M2.

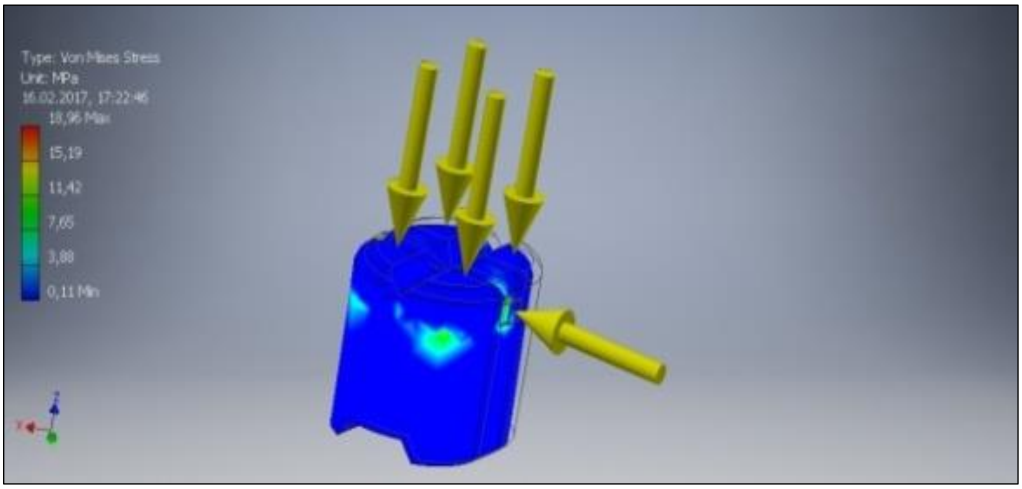

Figure 12. Maximum von Mises stress on M1 in case of implant supported RPD with attachments with M2.

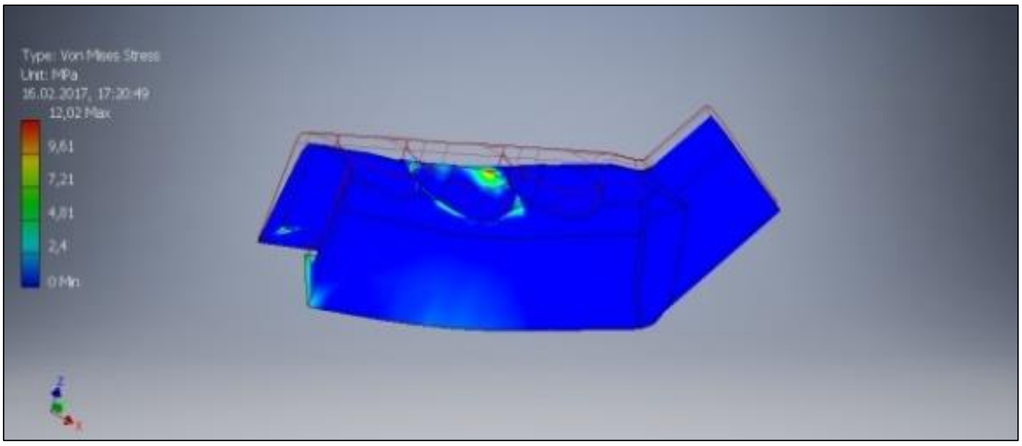

Figure 13. Maximum von Mises stress on the acrylic saddle in case of implant supported RPD with attachments with M2.

Finite element analysis for implant supported RPDs with attachments was used in various studies specially to evaluate the stress occurring in bone, implant, RPD's components and natural teeth (J.W. EOM & al [7], A. OMAR & al [8], W. XIAO & al [9], M. MAHSHID & al [10]). Some studies based on finite element analysis show that associating implants in a class I Kennedy edentulous situation reduces maximum von Mises stresses values in all support structures and also in the RPD's components (X. YANG & al [11]). In implant supported RPDs with attachments the implant location has impact on stress distribution. In our study, the implant was placed in the second molar area. Some authors show that implant placement in the second molar area decreases the stress around natural teeth, while the placement in the first molar area decreases the stress on implant, abutment tooth and cancellous bone. The highest stress was recorded when the implant was placed in the second premolar region, while the implant placement in the first premolar area was considered to improve the stress distribution (C.H. CAMPOS & al [5], E. MIJIRITSKY & al [6], W.S. OH & al [12], Y. MEMARI & al [13], R.C. RODRIGUES & al [14], F.R. VERRI & al [15]). The acrylic components of implant supported RPD with attachments are subjected to deformation and exposed to fractures (E. MIJIRITSKY & al [16], R. SHAHMIRI & al [17], Y. GROSSMANN & al [18], R. KAUFMANN & al [19]). In 2007 Brosh T & al recommended to apply the second molar on the acrylic saddle of RPD in order to increase the denture's resistance (T. BROSH & al [20]). In our study, we demonstrated that placing the second artificial molar on the saddle in implant supported RPDs with attachments increases the maximum von Mises stresses recorded in the artificial teeth and in the acrylic saddle, but lowers them in the metallic component of the saddle.

Conclusions

Placing the second artificial molar on the saddle in implant supported RPD with attachments increases the maximum von Mises stresses recorded in the artificial teeth and in the acrylic saddle, but lowers them in the metallic component of the saddle. The maximum von Mises stresses recorded in the acrylic saddle have much higher values if the second molar is present on the saddle. Considering that the acrylic components are the most susceptible to fracture and abrasion, our study shows that it is more appropriate to avoid mounting the second artificial molar on the saddle if the opposed arch allows it.

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In this article, all the authors have equal contributions with the first author.

Conflict of interests

The authors declare that they have no conflict of interests.

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