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Biomechanical Behavior Evaluation of a Mandibular Full-Arch Implant-Supported Prosthesis on ZrO_2 and TiO_2 Monotype Dental Implants

Evaluación del Comportamiento Biomecánico de una Prótesis Implante Soportada de Arcada Completa Mandibular sobre Implantes Dentales Monotipos de ZrO_2 y TiO_2

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ABSTRACT: This in silico study aimed to evaluate the biomechanical behavior of a full-arch implant-supported prosthesis on titanium and zirconia monotype implants. A 3D mandible containing 1.0 mm thick cortical and cancellous bone was modeled. Four dental implants (3.3 x 10 mm) were inserted into the jaw model in each model. The implants consisted of Titanium (Ti-S group) and Zirconia Monotype/one-piece (Zr-S group). Fixed full-arch implant-supported prostheses were cemented onto the implant. The models were exported to the analysis software and divided into meshes composed of nodes and tetrahedral elements. All materials were considered isotropic, elastic, and homogeneous. Therefore, all contacts were considered bonded, the mandible model was fixed in all directions, applying a static structural axial load of 300 N on the bottom of the fossa of the left molar teeth. Microstrain and von-Mises stress (MPa) were adopted as failure criteria. Comparable stress and strain values were shown in the peri-implant bone for both groups. However, the Ti-S group presented a lower stress value (1,155.8 MPa) than the Zr-S group (1,334.2 MPa). Regarding bone tissues, the Ti-S group presented 612 $\mu\varepsilon$ and the Zr-S group presented 254 $\mu\varepsilon$. The highest strain peak was observed in bone tissues around the implant closer to the load for both groups. Evaluating monotype zirconia and titanium implants, it is suggested that the greater the rigidity of the implant, the greater the concentration of internal stresses and the less dissipation to the surrounding tissues. Therefore, monotype ceramic implants composed of yttrium-stabilized tetragonal polycrystalline zirconia may be a viable alternative to titanium implants for full-arch prostheses.

KEY WORDS: dental implants, dental materials, finite element analysis.

INTRODUCTION

Oral rehabilitation is used for previously edentulous elderly patients via conventional complete dentures. However, with advances in implantology, new treatment options have become available, including fixed prostheses supported and retained by implants (Hermann *et al*., 2001; Andreiotelli *et al*., 2009).

In this sense, patients can be rehabilitated using prostheses supported by implants, even in cases of atrophied maxillary with high bone resorption, since different technique is adopted and implant geometry improve its stability (Andreiotelli *et al*., 2009; Sen & Us, 2019). Taking advantage of the remaining

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bone, implants can be placed between mental foramina to support a full-arch prosthesis (Sailer *et al*., 2007; Roehling *et al*., 2015; Sen & Us, 2019; Matos *et al*., 2021). Therefore, the concept of "all-on-four" treatment gains notoriety since this involves the installation of four implants in the anterior region of the mandible, the more posterior implants may be angled. (Roehling *et al*., 2015; Cionca *et al*., 2017; Bormann *et al*., 2018). This concept was successfully implemented because it allows the use of angled abutments while maintaining the passivity of the prosthesis and a reduction in the cantilevers (Sailer *et al*., 2007; Sen & Us, 2019; Matos *et al*., 2021). In addition, angled implants allow the use of implants of greater length (Roehling *et al*., 2015; Cionca *et al*., 2017; Bormann *et al*., 2018). Consecutively allowing to rehabilitate cases with significant loss of maxillary bones. Studies pointing to macrogeometry implants affect study distributions and biomechanical behavior in close contact bone. The implant can directly transmit force to implantation and occlusal can change stress distributions in the surrounding bone. Therefore, angled implants are more likely to receive oblique loads, leading to an overload that may increase the risk of marginal bone loss (Cionca *et al*., 2017; Matos *et al*., 2020).

The selection of an implantation system of the most important decision in the planning of the all-on-four treatment, and this decision can influence no participating bone (Matos *et al*., 2022a). Thus, an excellent rehabilitation option is implanted with a single body or monotype, since studies have shown promising results, as its surface seems to be less prone to biofilm formation (Cionca *et al*., 2017; Matos *et al*., 2020, 2022b). Furthermore, the survival and maintenance rates in the osseointegration process of implants are similar to different materials (Roehling *et al*., 2015; Cionca *et al*., 2017; Bormann *et al*., 2018). Osseointegrated titanium implants are the most studied restorative material in dentistry, allowing partial or rehabilitated patients with different restorative combinations (Cionca *et al*., 2017; Matos *et al*., 2020, 2021, 2022a,b,c). However, even with its numerous, there is a discussion about the benefit of metal alloys in the human body (Roehling *et al*., 2015; Cionca *et al*., 2017; Bormann *et al*., 2018; Matos *et al*., 2022a,b). In addition, aesthetic surgeries observed in major patients may be affected by aesthetic outcomes, as patients may be affected by aesthetic treatments (Larsson *et al*., 2010; Ravald *et al*., 2013; Tiossi *et al*., 2017).

Due to these specific limitations of titanium implants, zirconia-based ceramic mate-rials have gained notoriety as they are aesthetically restorative materials (Lee *et al*., 2012; Ouzer, 2015; Dal Piva *et al*., 2018). Zirconia is biocompatible and has optical and mechanical properties similar to natural teeth (Gracis *et al*., 2015; Matos *et al*., 2018). In addition, Zr has high physical properties such as flexural strength, fracture toughness, and high hardness (Haroun & Ozan, 2021; Tribst *et al*., 2022). In these circumstances, it is necessary to evaluate the biomechanical behavior of zirconia in the different situations of implant-supported re-habilitations, including for implant-supported full-arch prostheses (Tribst *et al*., 2022).

These restorations have a high density in their composition and, consequently, greater resistance, allowing aesthetic and functional rehabilitation (Larsson *et al*., 2010; Ravald *et al*., 2013; Tiossi *et al*., 2017). In this sense, a full-arch prosthesis allows aesthetic and functional rehabilitation (Belur & Nagy, 2018). The loss of teeth and adjacent tissues usually occurs simultaneously (Haroun & Ozan, 2021). Furthermore, after implant placement, there may be progressive bone loss and metallic abutments may affect the pe-ri-implant soft tissue color (Kohal *et al*., 2013). More studies are needed to assess the biomechanical behavior of monotype zirconia implants when compared to titanium implants in a full-arch-supported prosthesis.

This study aimed to determine the implants in the all-on-four implants and not determine the distributions of incisive studies on one implant and how implantations are not implemented during the study of occlusal, premolar, and molar loads of a full-arch-supported prosthesis. Both tests feature three-dimensional *in vitro* tests and finite element analysis (FEA) simulations were performed in the study to ex-plore this question.

MATERIAL AND METHOD

This study was conducted by Finite Element Analysis (FEA), a non-invasive tool and a mathematical method used to investigate the biomechanics and influence of mechanical forces on biological systems, such as different dental implant systems (Tribst *et al*., 2019). For the final model of each group, all structures were modeled according to the specifications and geometry of each material using CAD software (Rhinoceros 5.0, McNeel Europe™, Barcelona, Spain). Therefore, a three-dimensional (3D) structure was modeled to represent a mandible model, containing 1.0 mm cortical thickness and medullary bone tissue. Based on the therapeutic possibilities for the same clinical indication, two different protocol systems were modeled (Matos *et al*., 2021). The models were separated into two groups: Ti-S (control): Titanium Solid or monotype morse taper implant (3.3 x 10 mm implant, Bone Level, Titanium Implant Monotype, São Paulo, Brazil) and Zr-S: Zirconia Solid or monotype implant (3.3 x 10 mm implant, Bone Level, Straumann Dental System Implant, Basel, Switzerland), the implants were favorably distributed in the anterior region, between the space that avoids contact in the mental foramen region (Sailer *et al*., 2007; Roehling *et al*., 2015; Sen & Us, 2019; Matos *et al*., 2021).

Four implants were inserted into the mandible model accordingly to each group. Full-arch implant-supported fixed dentures were cemented into implant/abutment assembly. To simulate a closer clinical condition already reported in the literature (Matos *et al*., 2021), a thin layer of resin cement, 0.3 mm thickness was adopted (Dal Piva *et al*., 2018), as shown in Figure 1.

Then, the solids were exported to software (ANSYS 17.2, ANSYS Inc., Houston, TX, USA) to be analyzed in STEP (Standard for the Exchange of Product model data) format. The external surface of the bone model was fixed in all directions, applying a static structural vertical load of 300 N [42] on the fossa bottom of the left molar teeth. A mesh was created after the 10% convergence test (Tribst *et al*., 2018; Holanda *et al*., 2020) adding up to 523,251 nodes and 327,441 tetrahedral elements for the evaluated models (Fig. 2). All materials were considered isotropic, linear, elastic, and homogeneous. Between the implant and bone, the contact was used to simulate complete osseointegration (Tribst *et al*., 2018), and the other contacts were considered bonded. Two materials were used for the implant-supported prosthesis structure, framework (CoCr) with artificial teeth (acrylic resin).

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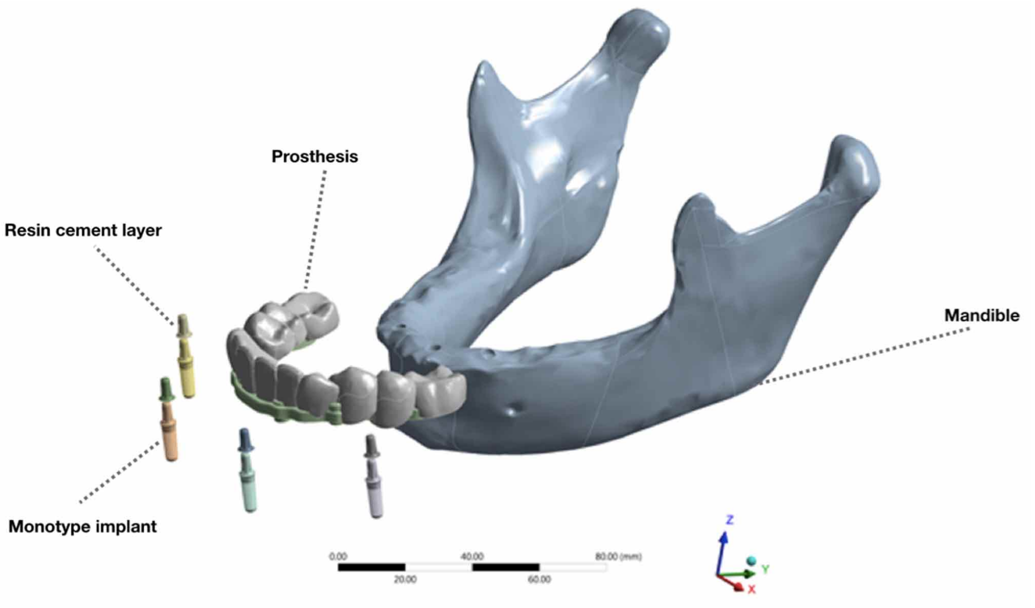

Fig. 1. 3D modeling schematic illustration of 3D modeling showing an implant-supported protocol prosthesis, using titanium and zirconia monotype implant systems, a resin cement layer, full-arch implant-supported fixed dentures, and a mandible.

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The structure's mechanical properties of the 3D model, materials' modulus of elasticity, and Poisson's ratio were defined based on the literature (Table I). Stress distribution results according to Von-Mises criteria were displayed using visual plots with a mega-pascals (MPa) scale for implants and ceramic structures. The microstrain was adopted to evaluate the cortical and cancellous bone, with their peak values shown in Table I (Cicciù *et al*., 2014; Moon *et al*., 2017).

Stress and strain results which presented with a difference of less than 10%, to be located in the convergence range of the analysis software, consecutively made it impossible to assume a significant difference. Thus, the results showed that a difference in peak values greater than 10% was defined as significant. Since this 10% of references are due to the results obtained by mesh convergence. Therefore, FEA is a numerical methodology and the results of mesh convergence can lead to an absolute numerical difference. Each structure result for both groups was qualitatively compared by visual comparison of the generated stress maps. Microstrain (me,), maximum principal stress, and Von-Mises stresses were adopted and compared between Ti-S and Zr-S groups.

Table I. Distribution of the mechanical properties of the materials.

Material	Young's Modulus (GPa)	Possion ratio
Y-TZP (Piconi & Maccauro, 1999)	220	0,30
Titanium (Osman *et al.*, 2013)	110	0,30
Cortical Bone (Madfa *et al.*, 2014)	13,7	0,30
Cancellous Bone (Madfa *et al.*, 2014)	1,37	0,30
Oral Mucosa (Geng *et al.*, 2001)	10	0,40
Co-Cr (Matos *et al.*, 2021)	218	0.30
Acrylic Resin (Yamaguchi *et al.*, 2014)	3.73	0.40
Resin Cement (Jongsma *et al.*, 2012)	7,5	0,25

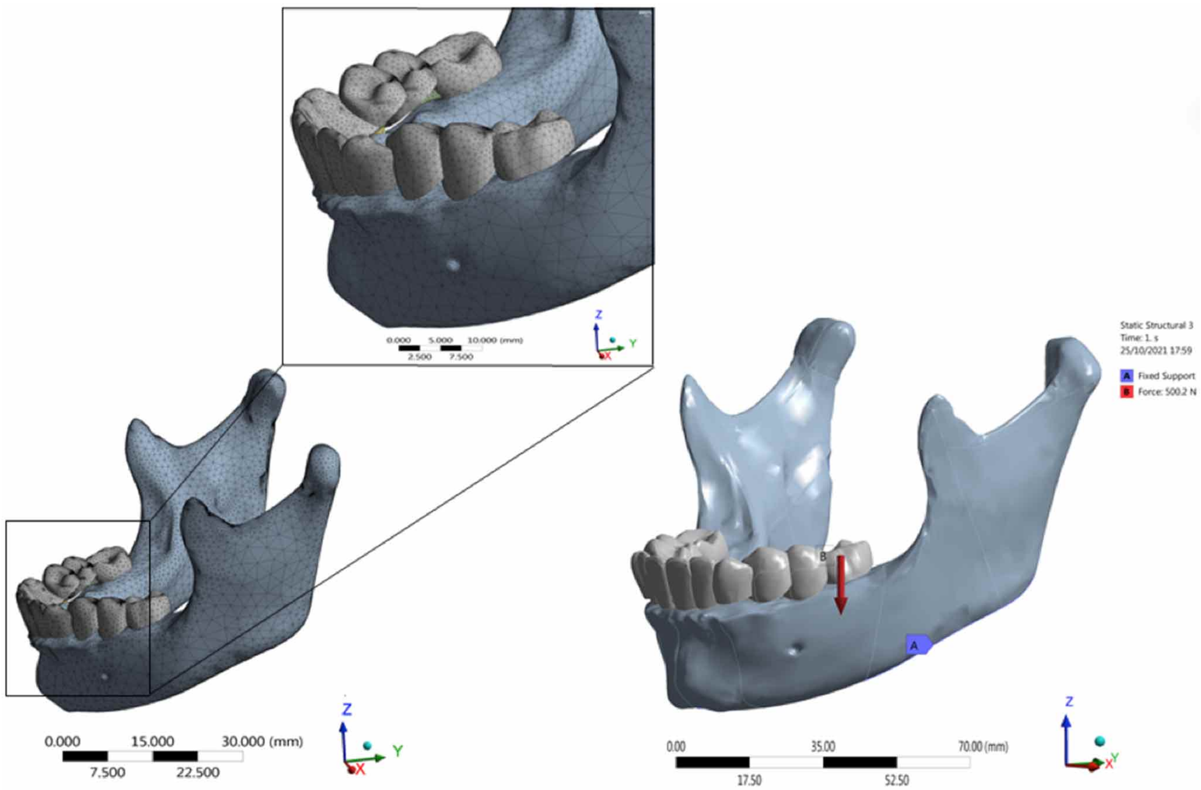

Fig. 2. FEA details - Mesh, boundary conditions, loads, and connections.

RESULTS

Stress peaks (in MPa) for both groups (implants, framework, prosthesis, and bone tissue) are shown in Figures 3 and 4. Figure 3 shows the stress values in the titanium and zirconia implants (A), in the frameworks (B), and in the prostheses (C). The Ti-S group presented lower values of maximum principal and von Mises stresses (1,155.8 MPa) when compared to the Zr-S group (1,334.2 MPa). However, comparing the same geometry of the solid groups, it was noticed that the material of the implant and the abutment also influenced the stress values, since the structure with titanium implants exhibited 1,524.5 MPa, while the group with zirconia showed 1,606.8 MPa. In the Ti-S and Zr-S groups, von Mises stresses were concentrated in the cervical third of the implants, in the implant-abutment interface region, extending up to the abutment collar. However, for the Zr-S group, there was a higher concentration of stress in the cervical region, extending to the last implant thread pitch (Fig. 3A). On the other hand, for the Ti-S group, there was a higher stress concentration in the implant and abutment interface region, that is, it was concentrated in the implant connection. For both groups, the stresses extended beyond the abutment region, mainly in the Ti-Zr group, where the stresses were concentrated below the prosthetic abutment. Although the greatest stress was found on the side and at the junction between the structure and the implant closest to the loading area. For the denture, the stress was well distributed along with the artificial teeth. The titanium group presented 290.67 MPa and the zirconia group presented 288.68 MPa.

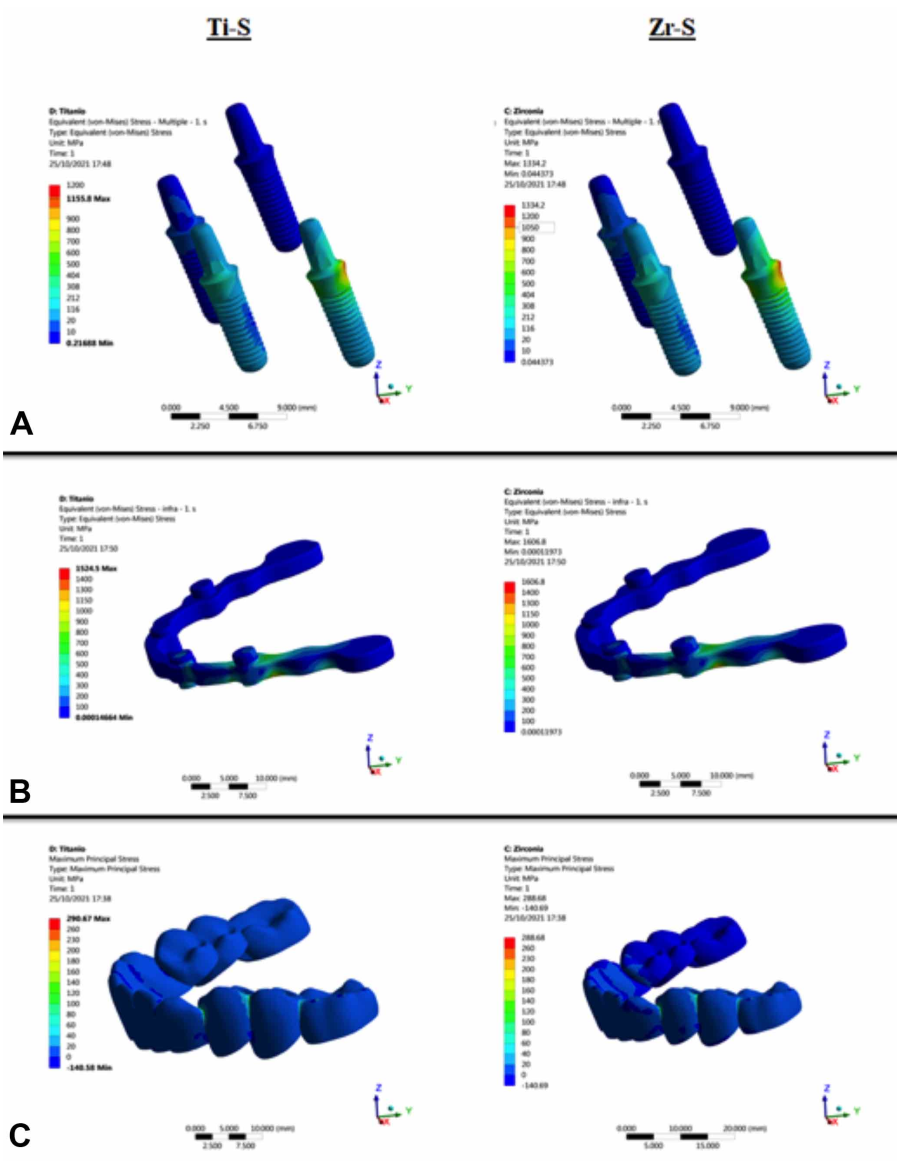

Fig. 3. Illustrative of the 3D modeling of the qualitative analysis of Maximum Principal Stress and Von Mises Mises (MPa) Criteria on the structures of each group. A) Von-Mises criteria for the implants. B) Von-Mises Stress for the framework. C) Maximum Principal Stress for the Prosthesis.

For the implants of both groups, the stress peaks were observed between the cervical thirds of the abutment and the first threads on the implant closest to where the load was applied, with higher values for the Zr-S group. (Fig. 3A). For the frameworks and prosthesis, the stress peaks were similar between groups, distributed in the connections of the structures and the abutment of the implant closest to the load point application (Figs. 3B and C). For the bone tissues, the results showed that the microstrains were influenced by the implant material. For both groups, the microstrain peaks were concentrated in the cervical region around the implant closest to where the load was applied (Fig. 4).

Regarding microstrain (Fig. 4), the Zr-S group (254 $\mu\varepsilon$) presented the lowest values than the Ti-S group (612 $\mu\varepsilon$). The highest tensile stress was found on the buccal side of the peri-implant area, while the highest compressive stress was observed on the lingual side. Bone tissue around implants placed far from the midline showed the lowest stress values.

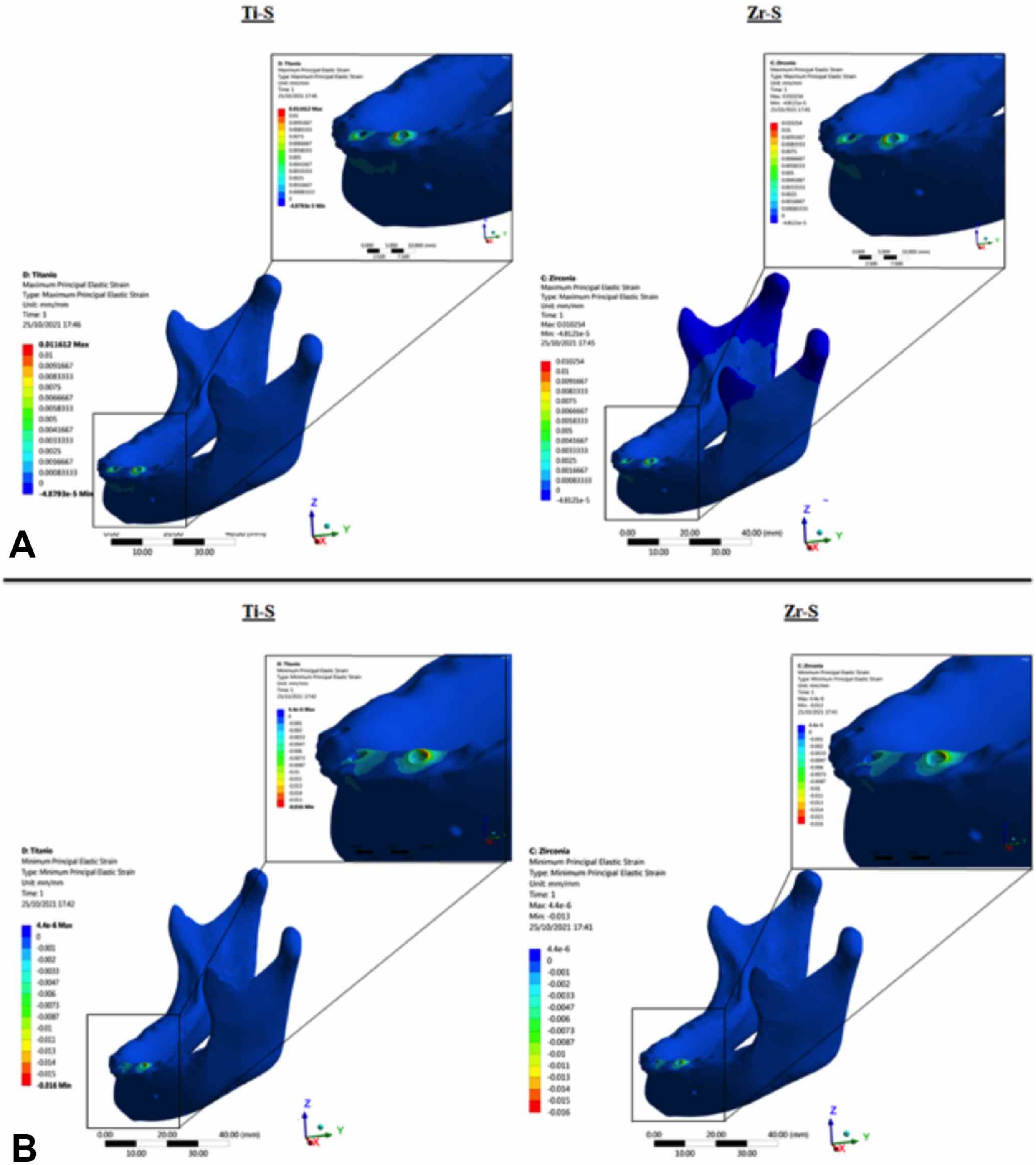

Fig. 4. Illustrates the 3D modeling of the qualitative analysis of Maximum and Minimum Principal Strain criteria for each group. A) Maximum Principal Strains (Ti-S and Zr-S group). B) Minimum Principal Strains (Ti-S and Zr-S group).

DISCUSSION

This study carried out a qualitative and quantitative analysis. For analysis, colorimetric patterns were used in which warm colors showed higher stress concentration and cold colors showed regions under minimum stress (Larsson *et al*., 2010; Cionca etal., 2017; ArRejaie *et al*., 2019). The redder, the more tension in the area. In this sense, failures can occur in isolation, that is, in the implant, structure, or dental prosthesis. However, any failure can lead to partial or total impairment of rehabilitation treatment (Mostafa *et al*., 2018; ArRejaie *et al*., 2019; Oliveira *et al*., 2019; Talmazov *et al*., 2020). Therefore, the analysis of the biomechanical behavior of implants and their superstructures in different restorative modalities is of great importance for understanding the clinical manifestations of these restorations (Matos *et al*., 2022a,b).

In the present study, it was observed that the materials of the implants influenced the values of the stress peaks in the implant and the bone tissue. The 300N load in the cantilever region caused the stresses to be located closer to where the load was applied. The pattern of stress distribution (von Mises, traction, and compression) for the groups evaluated may be associated with the application of oblique load and the macrogeometry of the monotype implant, which does not present a screw for the retention of the prosthesis or any misfit between the implant and abutment (Gracis *et al*., 2015). Since the implants of tetragonal zirconia polycrystals stabilized with yttria (Y-TZP) presented higher tension, this material has a higher modulus of elasticity and, consequently, greater rigidity when compared to titanium implants. Evaluating under static load, the results suggest that zirconia will fail later than a titanium implant, however, as it is a more rigid material, greater tension is transmitted to the supporting tissues (Mostafa *et al*., 2018; ArRejaie *et al*., 2019; Oliveira *et al*., 2019; Talmazov *et al*., 2020). Stress concentration exhibited a pattern of behavior when loading was applied to both groups. This tension created a fulcrum in the implant closest to the load, showing a tendency to rotate the prosthesis, which generated greater tension in this implant. This same behavior has been reported by other authors who also investigated the biomechanics of fixed partial dentures on implants (Chang *et al*., 2010; Osman *et al*., 2013; Giner *et al*., 2021).

The literature indicates that Young's modulus directly influences the bone-implant interface, as a higher Young's modulus causes less bone resorption in the peri-implant region against occlusal forces (Çaglar *et al*., 2011). Geng *et al*. (2001) recommend that Young's modulus of implants be at least 110 GPa, as a low modulus of elasticity leads to an increase in the concentration of these stresses in the bone tissue (Matos *et al*., 2022a,b). Therefore, a significant difference can be observed in cases where there are total restorations with titanium or zirconia. As previously reported, zirconia concentrates greater stress, so it can withstand situations that require a high strength of the material, on the other hand, when it fails, there is a complete fracture of the material, requiring complete replacement of the damaged structure (Koral *et al*., 2014; Holanda *et al*., 2020; Haroun & Ozan, 2021; Matos *et al*., 2022a,b). Titanium, due to its ductility property, can concentrate less stress, on the degree of strain that a material can withstand until the moment of its fracture. Therefore, when the titanium is under tension it dissipates the propagation of forces by other structures, and consecutively a smaller strain is emitted to it (Menini *et al*., 2015; Tribst *et al*., 2022).

It was possible to observe that the Zr-S group had the highest stress peaks in the implants. This result is in agreement with others (Schäfer *et al*., 2014; Joda *et al*., 2015) who observed a greater number of fractures in the implant connection region for zirconia abutments. However, these higher stress values do not compromise the use of monotype zirconia implants in oral cavity all-on-four protocols, since these implants presented clinical performance similar to titanium implants. Furthermore, this result shows that the abutment/implant interface also influences the stress distribution. In this sense, there are materials with different physical properties in close contact: friction coefficients (0.30 for the Ti-S group and 0.19 for the Zr-S group), roughness and hardness (Zr = 1800VHN Ti = ~ 260VHN) (Gracis *et al*., 2015; Matos *et al*., 2020). These differences could promote the different stresses at the abutment/implant interface, consecutively higher stress in the abutment collar region for the Zr-S group than for the Zr-S group. It should be noted that the tensile strength of zirconia is approximately 710MPa (Gracis *et al*., 2015). Therefore, even the highest values found (Zr-S group monotype implants, Fig. 3A) are outside this parameter defined as the limit for fracture of this structure in zirconia to occur. As for titanium, these values vary according to the type of titanium used: 240-550MPa for commercially pure titanium (Ticp; grade 4) (Osman *et al*., 2013). Therefore, the implants evaluated in the present study are made with Ticp (grade 4), therefore, all titanium monotype implants used in this study also presented stress values below the tensile strength values.

The maximum principal stress for the Ti-S group showed the lowest stress values observed between the first screws and the base of the prosthesis, similar to that observed in the Zr-S group. In addition to the convergence region, the stresses were distributed from the upper portion of the abutment to the last threads, in the implants closest to where the load was applied, corroborating other studies (Schäfer *et al*., 2014; Joda *et al*., 2015). This distribution behavior can be explained by the region where the load was applied, causing the prosthesis to rotate and, consequently, there is a fulcrum close to the posterior implant (Tribst *et al*., 2018; Silveira *et al*., 2021). Due to the geometry of the monotype implants that do not allow the angulation of the posterior implants, the full-arch prosthesis on these implants has a longer lever arm because it has a longer cantilever (Misch *et al*., 2001).

The zirconia (Zr) monotype implant induced lower values of modified von Mises in bone tissue when compared to titanium monotype implants. The cervical macrogeometry of titanium monotype implants causes high stresses in the bone tissue and close to the implant neck (Rieger *et al*., 1989), corroborating the results of the present study. In bone tissue, stresses accumulated in the posterior region of the socket in single-body zirconia (Zr-S) implants, being more evenly distributed for single-body titanium (Ti-S) implants. This result is due to the shape of the implant in this region of contact with the bone. The macrogeometry of the monotype zirconia implant provides, at the same time, a more uniform distribution of stresses in its body and is more concentrated in the alveolar region of the bone tissue. This is a characteristic of single-body implants, which minimize the concentration of stresses in the body, concentrating these stresses in the alveolar region (Kong *et al*., 2008). As in the present study, studies (Haroun & Ozan, 2021) showed that monotype zirconia implants are a feasible mechanical and aesthetic option for all-on-four rehabilitation in the mandible since the monotype zirconia implant showed good results after three years in function, showed satisfactory bone re-sorption and good survival and success rates. This result corroborates our study since the long-term success of the treatment with implants is closely related to the low values of tensions caused in the peri-implant bone structures and, consequently, to the lower bone resorption in this region (Frost, 1994; Misch *et al*., 2001; Bonnet *et al*., 2009; Larson *et al*., 2010; Kim *et al*., 2011; Kohal *et al*., 2013; Ouzer, 2015; Horita *et al*., 2017; Tiossi *et al*., 2017; Peter, 2017; Belur & Nagy, 2018; Castorina, 2019; Haroun & Ozan, 2021).

Prostheses with a rigid metallic structure must present a passive fit for successful treatment. The present study simulated a unique design of a full-arch implant-supported fixed prosthesis. This design of the structure of the prosthesis allows better ductility, and less strain and presents less deflection due to the higher modulus of elasticity, leading to a lower pattern of load dissipation, however, it continues to generate load throughout the whole assembly until the bone (Versluis *et al*., 1997; Castorina, 2019). Holst *et al*. (2008) demonstrated that the material used to manufacture implant-supported prostheses has a significant influence on the behavior of implants inserted into the artificial bone. According to the authors, the load distribution in prostheses with metallic structures seems to be favorable, both for the survival of the prosthesis and for a more homogeneous distribution of the absorbed occlusal loads (Kim *et al*., 2011; Jongsman *et al*., 2012; Horita *et al*., 2017). However, the study differed slightly between the groups, the difference in the properties of the evaluated monotypic implants was not able to change the mechanical behavior of the prosthesis structures, since they had the same positioning and the same macrogeometry.

The values of bone strain observed in the present study (Ti-S: 612 me; Zr-S: 254 $\mu\varepsilon$) would not cause bone resorption, since bone manifestations are within the physiological limits of bone (> 3,000 me) (Frost, 1994). The monotype implant has the abutment integrated into the implant design, with no gaps between the implant and the abutment, which is an important feature in cases of fixed partial dentures supported on implants, as there are a large number of problems with component misfits with the dental implant (Vasconcelos *et al*., 2022). Additional factors may affect the success of treatment with monotype dental implants, such as poor bone quality and lack of primary stability during implant insertion (Peláez *et al*., 2022; Nakamura *et al*., 2010; Peter, 2017). However, it can be observed that materials with lower Young's modulus (titanium implant) tend to concentrate less internal stresses and dissipate more stresses to the surrounding tissues, while more rigid materials (zirconia implant) tend to concentrate more internal stresses and dissipate fewer stresses to the surrounding tissue. surrounding structures (Sadowsky, 2020; Matos *et al*., 2022a,b).

It is worth mentioning that for the structure, artificial teeth, and peri-implant bone, the concentration of stress/microstrains presented the same pattern of behavior of the stress of the implant with a tendency to rotate the prosthesis, which generated greater stress close to the load application Matos *et al*., 2022a,b). Even simulating loads in the posterior region of the prosthesis cantilever, that is, the region with the greatest lever arm for the proposed rehabilitation project, all stresses were within the strength limits of the evaluated materials.

Recent studies support the hypothesis that zirconia oxide dental implants are a viable alternative to titanium implants (Frost, 1994; Misch *et al*., 2001; Bonnet *et al*., 2009; Larson *et al*., 2010; Kim *et al*., 2011; Kohal *et al*., 2013; Ouzer, 2015; Peter, 2017; Horita *et al*., 2017; Tiossi *et al*., 2017; Belur & Nagy, 2018; Castorina, 2019; Haroun & Ozan, 2021). Evaluating monotypic zirconia and titanium implants, it is suggested that the greater the rigidity of the implant, the greater the concentration of internal stresses and the less dissipation to the surrounding tissues. In this sense, the monotype zirconia implant is the system that presents and transmits lower values of tension to the peri-implant bone structures when compared to titanium implants. Therefore, the monotype zirconia implant is the system that presents and transmits lower stress values to the peri-implant bone structures when compared to titanium implants of the titanium monotypes type.

The limitations of this *in silico* study, which did not assume many factors inherent to the complexity existing in the oral cavity and the use of homogeneous structures in 3D models, do not allow internal defects in their geometries. However, these limitations do not invalidate the results presented in the present study but suggest caution in their interpretation and the need to associate the exposed data with others available in the literature. Thus, the need for more randomized controlled clinical studies using monotype zirconia implants with different partial denture designs, simulations with implants out of the ideal position, as well as long-term clinical studies to better understand the behavior of these implants supporting total implant-supported prostheses in the arc is evident.

CONCLUSION

Based on the outcomes of this *in silico* study, the following conclusions can be drawn:

1. Monotype ceramic implants composed of yttrium-stabilized tetragonal polycrystalline zirconia may be a viable alternative to titanium implants for full-arch prostheses.

2. The greater the rigidity of the implant, the greater the concentration of internal stresses and the lower the load dissipation to the surrounding tissues. Therefore, the monotype zirconia implant is the system with the lowest strain values to peri-implant bone structures compared to monotype titanium implants.

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RESUMEN: El objetivo de este estudio *in silico* fue evaluar el comportamiento biomecánico de una prótesis implanto soportada de arcada completa sobre implantes monotipo de titanio y zirconia. Se modeló una mandíbula en 3D que contenía tejido óseo cortical y esponjoso de 1,0 mm de espesor. En cada modelo, se insertaron cuatro implantes dentales (3,3 x 10 mm) en el modelo de mandíbula. Los implantes consistieron en Monotipo de Titanio y Zirconia. Sobre el implante se cementaron prótesis implanto soportadas de arcada completa fija. Los modelos se exportaron al software de análisis y se dividieron en mallas compuestas por nodos y elementos tetraédricos. Todos los materiales se consideraron isotrópicos, elásticos y homogéneos. Por lo tanto, todos los contactos se consideraron cementados, el modelo mandibular se fijó en todas las direcciones, aplicando una carga vertical estructural estática de 300 N en el fondo de la fosa de los dientes molares izquierdos. Se seleccionaron la microesfuerzo y la tensión de Von-Mises (MPa) como criterios de falla. Se mostraron valores de tensión y deformación comparables en el hueso periimplantario para ambos grupos. Sin embargo, el grupo Ti-S presentó un valor de estrés menor (1.155,8 MPa) que el grupo Zr-S (1.334,2 MPa). En cuanto a los tejidos óseos, el grupo Ti-S presentó 612 $\mu\varepsilon$ y el grupo Zr-S presentó 254 $\mu\varepsilon$. La mayor concentración de deformación en el tejido óseo se observó en los tejidos alrededor del implante más cerca de la carga para ambos grupos. Al evaluar los implantes monotípicos de

zirconia y titanio, se sugiere que cuanto mayor sea la rigidez del implante, mayor será la concentración de tensiones internas y menor la disipación a los tejidos circundantes. Por lo tanto, los implantes cerámicos monotipo compuestos de zirconia policristalina tetragonal estabilizada con itrio pueden ser una alternativa viable a los implantes de titanio para prótesis de arcada completa.

PALABRAS CLAVE: implantes dentales, materiales dentales, análisis de elementos finitos.

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