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ARTICLE

ZYGOMATIC IMPLANTS IN INTRA-SINUS *VERSUS* EXTRA-MAXILLARY APPROACHES FOR PROSTHETIC REHABILITATION IN SEVERELY ATROPHIC MAXILLAE. FINITE ELEMENT ANALYSIS.

Implantes cigomáticos en abordajes intra sinusal *versus* extra maxilar para rehabilitación protésica en maxilares severamente atróficos. Análisis de elementos finitos.

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ABSTRACT:

Objetive: To compare the stresses and deformations generated on the surrounding bone of the zygomatic implants when using an intra sinusal and extra-maxillary approach, through the finite element method.

Material and Methods: Computer aided designs (CADs) were constructed using SolidWorks Software of a skull with bone resorption to be rehabilitated through a fixed hybrid prosthesis using two zygomatic and two conventional straight implants. For the boundary conditions (load conditions), symmetry in the sagittal plane was assumed and that all the materials were isotropic, homogeneous and linearly elastic. Two zygomatic implantation techniques were simulated: intra sinusal (Is) and extra maxillary (Em). Vertical and lateral loads of 150 N and 50 N were applied to the finite element models to obtain Von Mises equivalent stress and strain (displacement).

Results: The average measurement of the Von Mises stress (MPa) recorded were as follows: Approach of the implant body (Is: 0.24- Em: 0.28,) effort of implant body with vertical load: Is: 0.69 - Em: 0.96; effort of peri-implant surface under horizontal load: Is: 2.11 - Em: 0.94. Average displacement under vertical load of peri-implant surface Is: 0.35 - Em: 0.40, and of implant body Is: 1.34 - Em: 2.04. Average total deformation in approach Is: 2.23 mm - Em: 0.80mm, and average total deformation in the implant body under horizontal load was Is: 0.14 - Em: 0.21.

Conclusion: The results of this study indicate that despite the differences that occurred in both stress and strain (displacement) between the intra-sinus and extra-maxillary approaches, the static strength of the bone, which is approximately 150 MPa in tension and 250 MPa in compression was not exceeded. Considering the limitations of finite element analysis, there seems to be no biomechanical reason to choose one approach over the other.

KEYWORDS:

Jaw, edentulous, partially; dental implants; finite element analysis; computer-aided design; weight-bearing; maxillary sinus.

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RESUMEN:

Objetivo: Comparar por el método de elementos finitos los esfuerzos y deformaciones generados sobre el hueso circundante de implantes cigomáticos tratados con un abordaje intra sinusal y extra maxilar.

Material y Métodos: Se construyeron los diseños asistidos por computadora (CAD) utilizando el Software SolidWorks de un cráneo con una reabsorción ósea para ser rehabilitado, a través de una prótesis híbrida fija, mediante dos implantes cigomáticos y dos rectos convencionales. Para las condiciones de frontera (condiciones de carga) se asumió simetría en el plano sagital y que todos los materiales eran isotrópicos, homogéneos y linealmente elásticos. Se simularon dos técnicas de implantación cigomática: una intra sinusal (Is) y otra extra maxilar (Em). Se aplicaron cargas verticales y laterales de 150 N y 50 N a los modelos de elementos finitos para obtener el esfuerzo equivalente de Von mises y la deformación (desplazamiento).

Resultados: La medición promedio del esfuerzo de Von Mises (MPa) registró: abordaje del cuerpo de implante (Is: 0.24- Em: 0.28) esfuerzo del cuerpo de implante con carga vertical: (Is:0.69 – Em: 0.96); esfuerzo de la superficie peri implantar ante carga horizontal(lateral):(Is:2.11 – Em:0.94). Desplazamiento promedio ante carga vertical de la superficie peri implantar (Is:0.35 – Em:0.40) y del cuerpo del implante (Is:1.34 – Em:2.04). Deformación total promedio en mm en abordaje (Is: 2.23 – Em:0.80) y deformación total promedio en el cuerpo del implante ante carga horizontal (Is:0.14 – Em:0.21).

Conclusión: Los resultados de este estudio indican que a pesar de las diferencias que se presentaron tanto en el esfuerzo como en la deformación (desplazamiento) entre los abordajes intra sinusal y extra maxilar, la resistencia estática del hueso, que es de aproximadamente 150 MPa en tensión y 250 MPa en compresión no se superó. Considerando las limitaciones de los AEF, parece no haber razones biomecánicas para elegir uno u otro enfoque.

PALABRAS CLAVE:

Arcada parcialmente edéntula; implantes dentales; análisis de elementos finitos; diseño asistido por computadora; carga axial; seno maxilar.

INTRODUCTION.

In recent decades, the rehabilitation of partial or total edentulism by means of implant-supported prostheses has become commonplace, yielding reliable long-term results.[1] However, severe bone defects, resulting from long-term edentulism, periodontal disease, or trauma, can significantly hinder the placement of oral implants. In such cases, different bone reconstruction techniques have been proposed to create more favorable conditions.[2]

These reconstruction techniques have a series of disadvantages, such as the need for multiple surgical interventions, the use of extra-oral bone donor sites along with the morbidity involved in performing surgery in these areas, and the time during which patients must remain without rehabilitation during graft consolidation and healing intervals. These factors complicate patient acceptance of restorative treatment and limit the number of procedures performed.[3]

The placement of implants in the zygomatic bone as an alternative to maxillary reconstruction with autogenous bone grafts has been considered a viable option in the rehabilitation of atrophic maxillae.[4-8]

The original Brånemark technique[9] for zygomatic implant placement proposes an intra-sinus implant route with a palatal entry into the maxillary sinus. Possible complications of zygomatic implant treatment, especially those that occur long-term and recurrently, can be extremely complex to treat.[10] Some patients may present a deep buccal concavity of the lateral surface of the maxilla. Such concavity may make it impossible to extend the zygomatic implant through the sinus or maxillary bone and into the zygoma, while still having the implant head emerge in an appropriate place on the alveolar crest. To adapt to this anatomy, the extra-sinus approach[3] was developed.

In this technique, the implant will pass from the alveolar ridge, then through the lateral surface of the maxilla, to avoid entering the sinus cavity, before re-entering the maxilla into the zygomatic buttress, and then eventually entering in the zygoma itself.[9]

Maló *et al*.,[10] developed another method, known as the extra-maxillary technique, to simplify the surgical technique and contribute to a more appropriate prosthodontic emergence of the implant head. In this approach, it is said that the alveolar ridge only accommodates the implant, which means that it will pass through a channel made just on the lateral surface of the alveolus, in order to allow ideal prosthetic placement at the level of the ridge; however, there is no real anchorage or osseointegration. All support for the implant comes from the osseointegration that occurs within the zygoma itself.[4]

In the extra-maxillary approach, complications such as mobility of the implant and fracture of the abutment screw have been reported. Most of the complications are caused by insufficient primary stability of the zygomatic implant in the prosthesis support. Quoting Ishak-Mish, it can be suggested that a key factor for the success or failure of dental implants is the transmission of stress to the surrounding bone.[11] Improper loading can result in stress concentration in the bone around the implant, which could lead to bone resorption. The vertical component of load is known to play an important role in masticatory load. On the contrary, the horizontal load component cannot be compromised, although its value is minimal, especially when using an angled implant.[12]

It is not possible, ethically, or technologically, to test stresses in living tissues as a result of an applied force. Therefore, it has been suggested that stress analysis studies should be performed on models.[13] In this sense, few studies have been carried out that have compared the intra-sinus and extra-maxillary approach through the finite element method.[11] Consequently, there is no consensus on the ideal approach for the placement of zygomatic implants with respect to the degree of bone anchorage and the inclination of the implant. Thus, little is known about the amount of bone that accumulates around zygomatic implants through different techniques on the effects of the mechanical stability of the implant.

The present work studied the distribution of stress and deformations for the intra-sinus and extra-maxillary approaches through a finite element analysis. A differentiating element of this research is that the results will be shown making a discrimination of the displacement in the three axes: the X axis (palatal-vestibular displacement), Y axis (apical-occlusal displacement, and in the Z axis (mesiodistal displacement).

MATERIALS AND METHODS.

From a point cloud obtained from TurboSquid and using the software SolidWorks version 2019 and Ansys SpaceClaim version 2019, a skull was reconstructed by means of Boolean operations and surface patches in such a way as to produce a model that was very similar to the geometry of a skull. This resulting human skull presented bone resorption that, according to the Cawood and Howell classification[14] can be rehabilitated by means of a fixed hybrid prosthesis using two zygomatic implants and two straight conventional implants in the area of the lateral incisors joined by a bar of cobalt-chrome.

The patches were connected to each other, and a 3D solid was generated. The selected region of interest was the upper maxilla and the zygomatic bone on the left side. It was reconstructed from the supraciliary region to the zygomatic portion of the temporal bone, the zygomatic bone and the infraorbital area of the maxilla, where symmetry in the sagittal plane was assumed. The physical and mechanical properties of the elements used were based on the literature and a CAD modeling of the

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different components involved was performed: zygomatic implants, conventional implants for the anterior part, mini conical abutments, cobalt-chrome bar, and hybrid prosthesis.

All materials were assumed to be isotropic, homogeneous, and linearly elastic. The material properties of all the models are shown in Table 1. Based on previous studies,[2,5,7] the following table is presented showing the elasticity modulus of the different elements used for the simulation.

The zygomatic implant for this study was based on a Neodent Zygomatic GM™ with a Grand Morse® implant connection, having a length of 40.0 mm, and an implant diameter of ø 4.0 mm. This implant was modeled using the software SolidWorks 2019 through Boolean operations and measured by a digital caliper (Uberman MR). Zygomatic implants emerging on the first molar at the residual ridge were left in ideal prosthetic positions (implant heads emerge in the center of the ridge).

Then, the modeling of the mini conical abutments (GM MiniConical Abutment 45° with 1.5mm Gingival Height (115.267)) from Neodent was carried out, using the SolidWorks 2019 software and Boolean operations, taking the measurements with a digital caliper (Uberman MR). The bar was modeled using Boolean operations following the classic morphology of a standard bar for hybrid prostheses. The hybrid prosthesis from an existing CAD obtained from TurboSquid was modeled using Boolean operations to build a prosthesis assuming symmetry in the sagittal plane.

Once the CAD was performed, the physical and mechanical properties were assigned to the different components involved. The two zygomatic implantation techniques considered in this study served to define two model groups: An intra-sinus group (Group Is) and an extra-maxillary group (Group Em). In total, the FEA study involved 2 reconstructed models according to the modeled surgical technique. In the Is technique group, all zygomatic implants were inserted from the first maxillary molar site. In both the IS and Em models, a zygomatic implant was included on each side, with a dental implant in the lateral incisor also on each side. In the extra-maxillary technique group, the Em model included a zygomatic implant in the first maxillary molar and a dental implant in the lateral incisor on each side. Once the implants were placed, the modeled mini conical abutments and the modeled bar were placed, and subsequently the modeled hybrid prosthesis was placed.

The contact between the different parts of the simulated model was considered to be of the bond type. It was assumed that there was a complete union between the implants and the bone since the implants are assumed to be osseointegrated. All components were considered homogeneous, isotropic, and linearly elastic in this study.[2] The boundary conditions in this study were as follows: fixed support on the top (A) and posterior surface of the skull. (B), condition of symmetry in the sagittal plane of the skull and of the hybrid prosthesis (C), these can be seen in Figure 1.

According to protocols used in similar studies,[15-18] simulated occlusal loads of 150 N and 50 N were applied in separate fashion as vertical and lateral loads, respectively (different load cases), on the upper surface of the prosthetics in the region of the first molar, and on the surfaces of the teeth: lateral, canine, and first molar.

Figure 2 shows these loads. Either mesh convergence or mesh independence was generated; mesh independence was performed by means of an analysis of the strain (displacement) or the equivalent von Mises stress and the number of nodes and elements was gradually increased to find a point where the change of the strain or the stress was less than 5%.

Two indices were used to verify the result of this finite element study. The first index was a comparison of the equivalent Von Mises stress distribution (EQV) between the two types of approach. The results were presented in tables and color contour graphs to represent low and high magnitude stresses. The second index was the comparison of the displacement value of the zygomatic implant body (deformation) for both approaches. The results were presented in tables and in color contour graphs to represent the displacements; the aforementioned indices provided significant information on the influence of the different approaches. For the present model, a simulation was carried out using a 3D structural static model.

RESULTS.

The CAD of a skull was generated in its external anatomy (a) and a section of the skull in which the maxillary sinus is observed. CADs were generated for an angled mini conical abutment which was attached to the zygomatic implant, a straight mini conical abutment, which was attached to the straight implant, Figure 2. CADs were generated of a bar (a) and a hybrid prosthesis (b). The assembly of the different approaches was carried out.

The results obtained under a vertical load of 150 N in the occlusal-apical (axial) direction of the peri-implant surface indicated that in the extra-maxillary approach the mean von Mises equivalent stress was 0.02 MPa higher than the stress generated in the intra-sinus approach. The maximum stresses are located for both cases in the crestal bone around the implants.

The same force analyzed on the implant body allowed researchers to observe that in the extra-maxillary approach the mean von Mises equivalent stress was 0.27 MPa higher than the stress generated in the intra-sinus approach. The maximum stresses were located for both cases in the crestal bone around the implants. The results obtained under a horizontal load of 50 N in the vestibular-palatal direction (horizontal), on the peri-implant surface, indicate a difference in the mean von Mises stress on the peri-implant surface in the intra-sinus approach.

The maximum stresses are located for both cases in the crestal bone around the implants. The results obtained under a horizontal load of 50 N in the vestibular-palatal direction, in the implant body, registered a mean von Mises stress in the intra-sinus approach of 12.51 MPa, being greater than that in the extra-maxillary approach. The maximum stresses for both cases are located in the crestal bone around the implants (Table 3, Figure 3).

The CAD of a skull was generated in its external anatomy (a) and a section of the skull in which the maxillary sinus is observed. CADs were generated for an angled mini conical abutment which was attached to the zygomatic implant, a straight mini conical abutment, which was attached to the straight implant, Figure 2. CADs were generated of a bar (a) and a hybrid prosthesis (b).

The assembly of the different approaches was carried out. In the extra-maxillary approach, the mean total displacement was 0.88 mm, which was greater than in the intra-sinus approach. When the displacement is discriminated in the three axes, it can be observed that in the X axis (vestibular-palatal displacement) it is greater for the intra-sinus approach 4.8e-2mm. On the other hand, the displacement in the Y axis (apical-occlusal displacement) is greater in the extra-maxillary approach 0.75 mm. In the same way that in the Z direction (mesiodistal displacement) it is greater in the extra-maxillary approach 0.40 mm, the maximum displacements are located for both cases in the crestal bone around the implants.

The mean total displacement of the peri-implant-bone surface in the extra-maxillary approach was 1.01 mm, greater than that in the intra-sinus approach. When the displacement is discriminated in the three axes, it can be observed that in the X axis (vestibular-palatal displacement) it is greater for the intra-sinus approach -2.40E-2 mm.

On the other hand, the displacement in the Y axis (occlusal-apical displacement) is greater in the extra-maxillary approach 0.85 mm. In the same way that in the Z direction (mesiodistal displacement) it is greater in the extra-maxillary approach 0.49 mm, the maximum displacements are located for both cases in the crestal bone around the implants. (Table 4).

The total displacement in the peri-implant surface registered in the extra-maxillary approach was the

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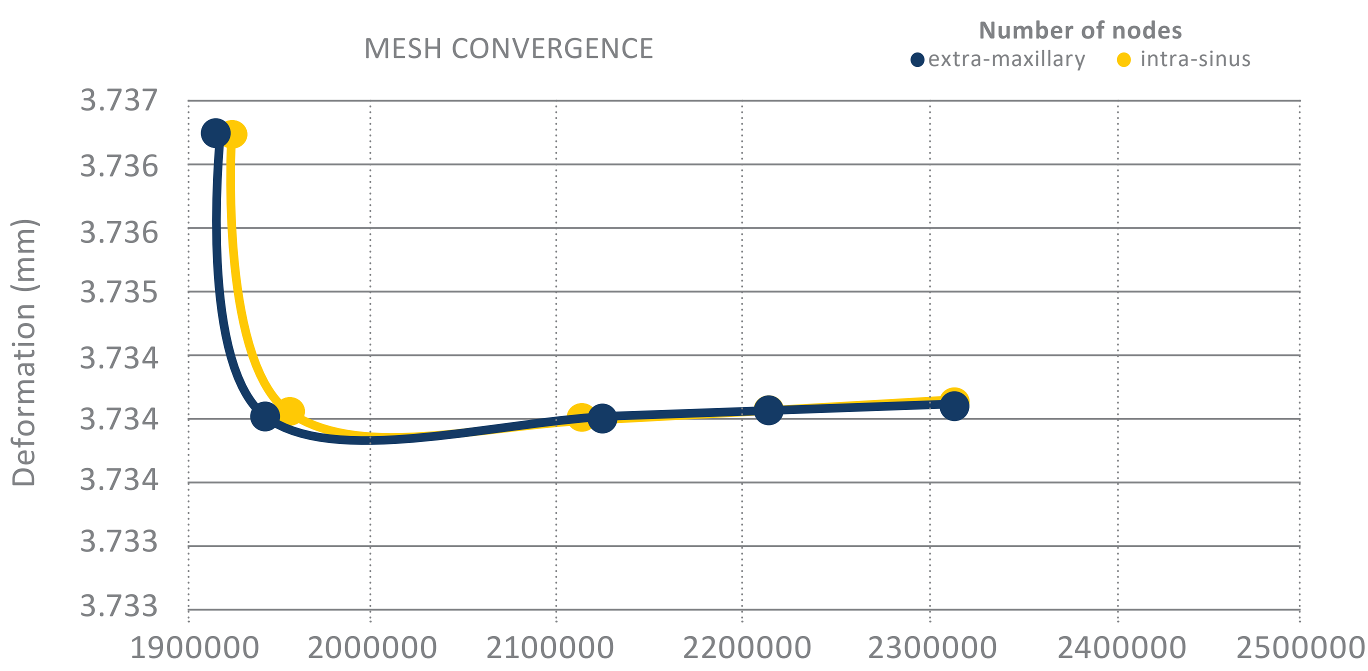
mean total displacement of 0.18 mm, which was greater than in the intra-sinus approach. When the mean displacement is discriminated in the three axes, it can be seen that in the X axis (vestibular and palatal displacement) it is greater for the extra-maxillary approach -0.12 mm. In the same direction, the displacement in the Y axis (apical-occlusal) is greater in the intra-sinus approach -0.11 mm. In the same way, in the Z direction (mesiodistal displacement), a displacement of -1.49E-2 mm is found in the intra-sinus approach, the maximum displacements for both cases are located in the crestal bone around the implants.

In the analysis of the mean total displacement at the bone-implant interface in the intra-sinus approach, the mean total displacement was 0.21 mm, which was greater than in the extra-maxillary approach. When the displacement is discriminated in the three axes, it can be observed that in the X axis (vestibular-palatal displacement) it is greater for the extra-maxillary approach -0.14 mm. In the same direction, the displacement in the Y axis (apical-occlusal displacement) is greater in the intra-sinus approach -0.12 mm. In the same way, in the Z direction (mesiodistal displacement), a displacement of -1.02E-2 is found in the intra-sinus approach.

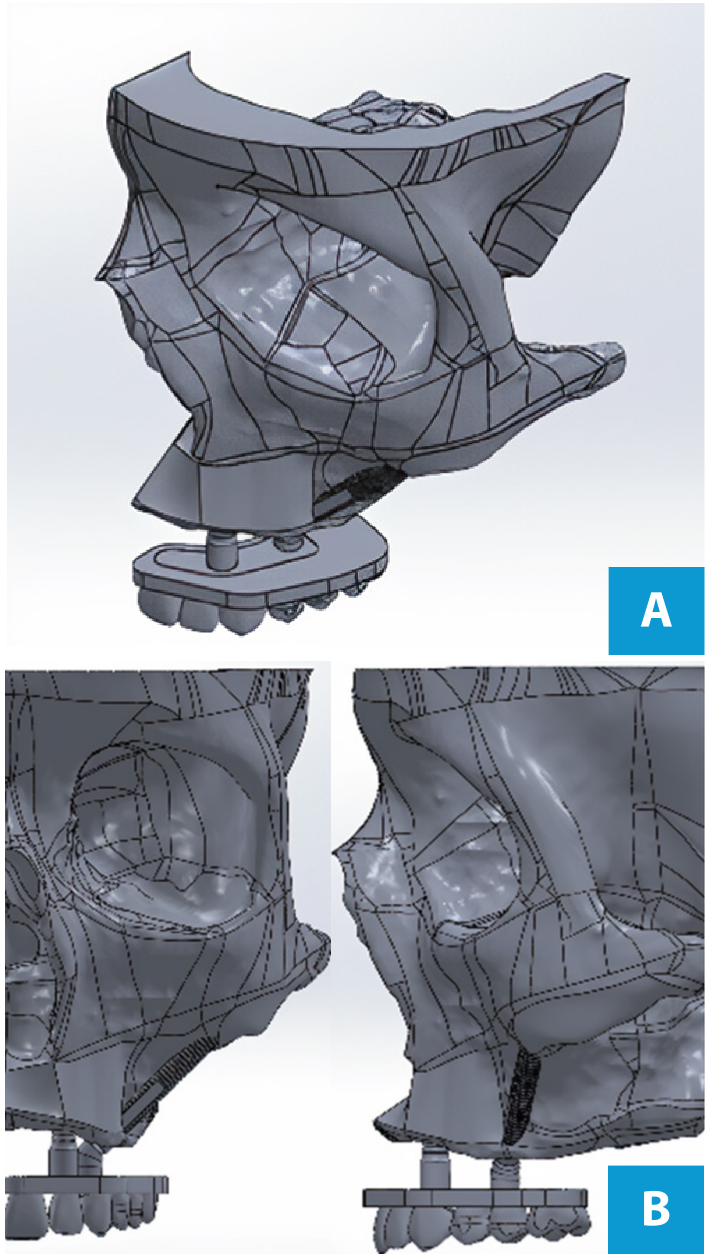
The maximum displacements are located for both cases in the crestal bone around the implants. Although there are some discrepancies in the results, they are not significantly different since they are in the same order of magnitude. (Table 5).

Figure 1. Mesh convergence for the present study.



Note: Convergence is shown in blue for the intra-sinus approach and in orange for the extra-maxillary approach. For both studies, a mesh of approximately 2,100,000 nodes was taken, the elements used in this study were 10-node tetrahedral elements, which can adapt excellently to complex shapes such as the skull, teeth, and implants[19] (Table 2).

Figure 2: CAD of the assembly of the different parts generated.



A: For both extra-maxillary and intra-sinus. **B:** After generating the CADs of a bar and a hybrid prosthesis, the assembly of the different approaches was performed.

Table 1. Mechanical properties of the materials.

Materials	Elastic modulus (MPa)	Poisson's modulus
Zygomatic implants and abutments (titanium alloys) (fixation, abutment screw and abutment)	110.000	0.33
Cobalt-chromium alloy (prosthesis)	220.000	0.30
Support bone	18.500	0.30
Acrylic	3.000	0.30

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Table 2. Number of nodes of each element.

APPROACH	REGION						
	Skull	Prosthesis	Bar	Mini straight conical abutment	Straight implant	Mini angled conical abutment	Zygomatic implant
Intra-sinus	365846	217356	51439	39819	314523	68095	747325
Extra-maxillary	617707	196707	55255	39576	312461	68220	34169

Source: Author's elaboration based on (7, 2, 5)

Table 3. Results of the stress of the peri-implant surface under vertical and horizontal load.

		Maximum Von Mises stress (MPa)	Mean Von Mises stress (MPa)
Results of the stress of the peri-implant surface under vertical load	Intra-sinus	6.33	0.24
Approach (implant bone)	Extra-maxillary	7.54	0.28
Results of the stress of the implant body under vertical load	Intra-sinus	16.12	0.69
	Extra-maxillary	16.75	0.96
Results of stress on the peri-implant surface under horizontal load	Intra-sinus	9.07	0.39
Approach (Implant body)	Extra-maxillary	3.70	0.20
Results of the stress of the implant body under horizontal load	Intra-sinus	35.79	2.11
	Extra-maxillary	10.24	0.94

Table 4. Results of the maximum displacement of the peri-implant surface, mean displacement of the peri-implant surface and of the implant body under vertical load.

		Total Deformation (mm)	Deformation X (mm)	Deformation Y (mm)	Deformation Z (mm)
Results of the maximum displacement of the peri-implant surface under vertical load					
Approach (implant bone)	Intra-sinus	2.09	0.26	1.59	1.33
	Extra-maxillary	2.77	0.23	2.22	1.63
Mean displacement of the peri-implant surface under vertical load	Intra-sinus	0.81	4.8e-2	0.70	0.35
	Extra-maxillary	0.88	3.7e-2	0.75	0.40
Results of implant body displacement under vertical load					
Approach (Implant body)	Intra-sinus	2.13	0.26	0.40	1.34
	Extra-maxillary	2.92	0.23	2.26	2.04

Table 5. Result of the maximum displacement of the peri-implant surface, displacement in the implant body and mean displacement of the implant body under horizontal load. Total deformation in X, Y and Z.

		Total Deformation (mm)	Deformation X (mm)	Deformation Y (mm)	Deformation Z (mm)
Approach (implant bone)	Intra-sinus	2.23	-2.75E-2	0.32	5.72E-2
	Extra-maxillary	0.80	-6.13E-2	0.35	5.66E-2
	Intra-sinus	0.14	-6.88E-2	-9.42E-2	-5.50E-3
	Extra-maxillary	0.18	-0.12	-0.11	-1.49E-2
Results of the maximum displacement in the implant body under horizontal load	Intra-sinus	2.23	-2.74E-2	0.49	6.77E-2
	Extra-maxillary	1.06	-6.12E-2	0.51	5.67E-2
Results of the mean displacement in the implant body under horizontal load	Intra-sinus	0.14	-6.96E-2	-0.10	2.51E-3
	Extra-maxillary	0.21	-0.14	-0.12	-1.02E-2

DISCUSSION.

As found in other studies, the stresses generated on the body of the zygomatic implants in the present study were similar for the two approaches and negative effects would not be expected because it is known that titanium alloys tolerate stresses of up to 360 MPa[20] without irreversible deformation. Consequently, a force of 150 N would probably not cause dental implant failure.[19] One of the most important aspects to highlight are the stresses generated in the bone-implant interface, which could cause some type of bone resorption in the surrounding area. The stress results on the peri-implant surface models indicated that the two techniques resulted in homogeneous force transfer.

In the present study, the total deformation (displacement) of the peri-implant surface was greater in the extra-maxillary approach than in the intra-sinus approach. This result is explained by the difference that exists in the initial anchorage in the intra-sinus approach, in which the alveolar cortex helps in primary stability, whereas in the extra- maxillary approach the alveolar ridge only accommodates the implant. The latter means that it will pass through a channel made just on the lateral surface of the socket, in order to allow ideal prosthodontic placement at ridge level, but no real anchorage or osseointegration will occur and it is considered that the entire support for the implant comes from the osseointegration that occurs within the zygoma itself.[10,4]

Unlike the present study, Ishak *et al.*,[11] found in their work that the bone-implant interface and the zygomatic implant body for the intra-sinus approach produced a stress 1.41 and 4.27 times higher, respectively, compared to the extra-maxillary approach under vertical load. These same authors found that, under lateral load, the extra-maxillary approach caused a stress 2.48 times greater than the intra-sinus one at the bone-implant interface. The zygomatic implant in the extra-maxillary approach had twice as much micromovement than those with the intra-sinus approach under lateral load.[11]

In another study[21] it was found that the extra-maxillary technique presented the highest stress values. The lack of bone support in the coronal

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portion of the implant to resist load in the buccal direction was different from the displacement pattern of other approaches, in which the implant head is highly constrained by alveolar bone in the buccal-lingual and mesiodistal directions, which is compatible with the higher stress peaks found in the extra-maxillary technique. This situation is similar to that found in the present research and in other studies.[11]

Due to the specific biomechanics of extra-maxillary-placed zygomatic implants, where little or no anchorage is achieved at head level, different degrees of implant stability can be found. Occasionally, when implants placed outside the sinuses are tested individually, slight mobility may be detected with no other associated pathological signs. That mobility comes from the elastic modulus of the anchoring zygomatic bone when it is bent by a remotely applied force.[22]

The movement should not be rotational and will disappear when the implants are splinted through a bar and the prosthesis. A rotational movement should be considered a sign of implant failure.[22] Although there are not many studies on the biomechanics of zygomatic implants, previous work has shown that the transmission of masticatory forces can create a lever arm that is larger in inclined implants than in straight ones, causing secondary forces and a significant moment of force on the bone.[23]

However, the angled head of the zygomatic implant is designed to allow placement of the prosthesis at 45 degrees to the long axis of the implant, providing excellent ability to retain, support, and stabilize the prosthesis, minimizing leverage.[24] In this study, the simulation of the mini conical abutments made it possible to approach the clinical reality and therefore the previous explanation is applicable.

When considering the conclusions of systematic reviews on complications and failures of zygomatic implants, very few studies relate failures to biomechanical reasons,[25] and some studies suggest that the implants failed because initial stability was lacking due to the poor-quality condition of the bone during insertion. This situation may be due to the rotation of the apical part of the implant to a more lateral position compared to the initial drilling.[25]

Lastly, long-term bone reactions at interfaces in response to biomechanical loads and biomechanically mediated bone remodeling have been of interest in orthopedics.[12] In oral implantology, the search for a quantitative understanding of the biomechanics of bone remodeling in relation to implant design and load transfer at the interface should continue.[12] The present study attempts to provide some of these answers, considering a complete osseointegration.

Like any finite element analysis study, there are some limitations. In the present study, osseointegration between the implants and the surrounding bone was assumed. This study, like those reported in the literature, used forces of 150 N, which are different from those exerted in normal chewing. Further research is required to evaluate the osseointegration of zygomatic implants in different situations and under different loads.

CONCLUSION.

The results of this study suggest that despite the differences that occurred in stress and strain (displacement) between the intra-sinus and extra-maxillary approaches, the static strength of the bone, which is approximately 150 MPa in tension and 250 MPa in compression, was not exceeded. Considering the limitations of finite element analysis, there seems to be no biomechanical reason to choose one approach over the other.

Conflict of interests:

None of the authors has conflicts of interest to declare.

Ethics approval:

This project was conducted fully using technological software and it does not require authorization from a Bioethics Committee.

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Authors' contributions:

Aristizabal-Hoyos J: Conceptualization, methodology, analysis, data interpretation, draft writing and critical review of substantial content, final approval of the version to be published.

Aristizabal-Mulett J: Methodology, analysis, data interpretation, draft writing and critical review of substantial content, final approval of the version to be published.

López-Soto O: Methodology, analysis, data interpretation, draft writing and critical review of substantial content, final approval of the version to be published.

Mulett J: Analysis, data interpretation, draft writing and critical review of substantial content, final approval of the version to be published.

Bazurto-Aguirre J: Methodology, analysis, data interpretation, draft writing and critical review of substantial content.

Zambrano-Elizondo Y: Methodology, analysis, data interpretation, draft writing and critical review of substantial content.

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