



EVALUACIÓN COMPARATIVA DE LOS EFECTOS DENTO ALVEOLARES DE TRES CORRECTORES DE CLASE II: UN ANÁLISIS DE ELEMENTOS FINITOS.

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INTRODUCCION

MALOCCLUSION CLASE II

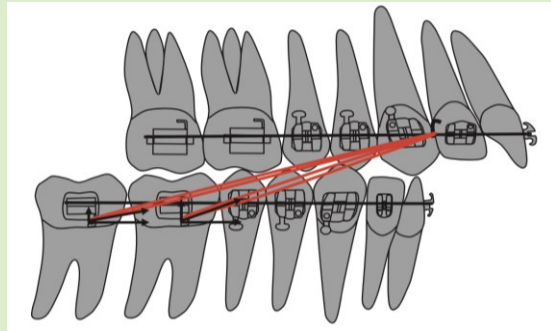
Las Maloclusion de Clase II tiene componentes dentales, esqueléticos y/o funcionales. De acuerdo al análisis esquelético, dental y oclusal en los planos sagital , vertical y transversal.



Relaciones molares y caninas son clase II y se acompañan de alteraciones de la inclinaciones de los dientes anteriores superiores e inferiores.



CORRECTORES DE CLASE II



Elásticos de Clase II

- Distalización del canino superior.
- Protracción del molar inferior.
- Retroinclinación de los incisivos superior .
- Distalización de los molares superiores.



CORRECTORES DE CLASE II



Forsus



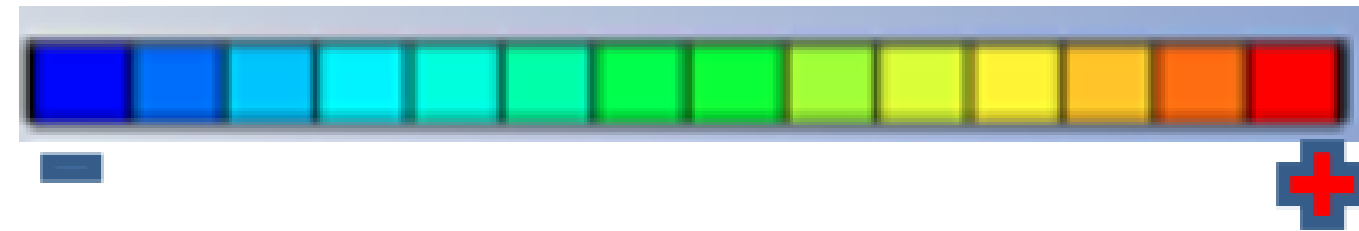
CORRECTORES DE CLASE II



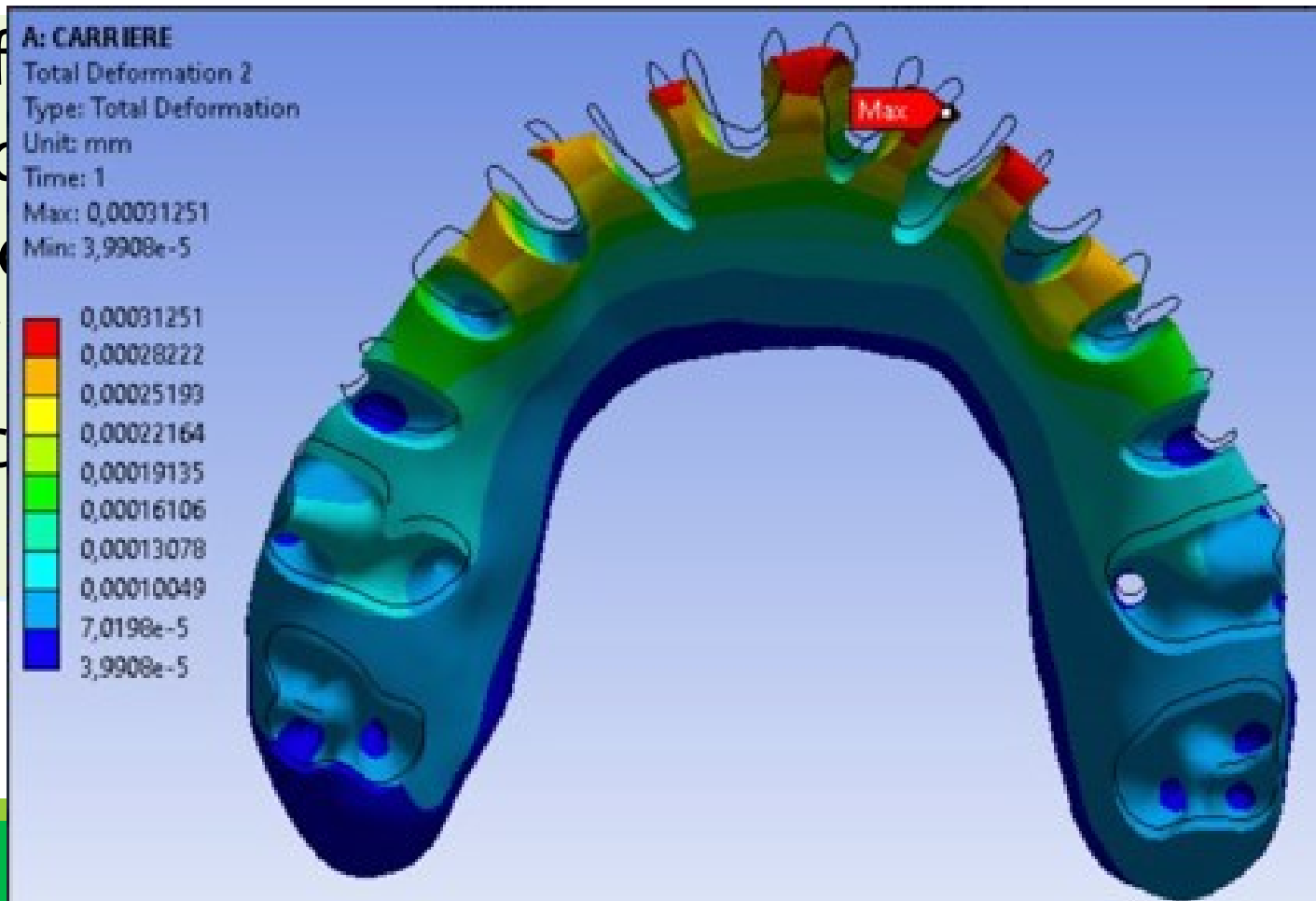
**Distalizador de
Carriere**



MÉTODOS FINITOS



resolver, las ecuaciones dif que rigen el comportamiento de un número de fenómenos estudiados como la flexión y deformación de estructuras sujetas a aplicaciones de cargas.



PROPIEDADES

Modulo de Young:

Es un parámetro que caracteriza el comportamiento de un material elástico, según la dirección en la que se aplica una fuerza.

Razón de Poisson:

El coeficiente de **Poisson** es una cantidad adimensional, característica de cada material. Es un indicativo de la deformación de un trozo de material ante la aplicación de ciertos esfuerzos.

PROPIEDADES



Isotrópico

Propiedades materiales idénticas en todas las direcciones en cada punto dado.



Anisotrópico

Dependen de la orientación del cuerpo del material.



Ortotrópico

Propiedades mecánicas o térmicas son únicas e independientes en tres direcciones mutuamente perpendiculares.

PROPIEDADES

Plástico:

Propiedad de un material de recuperar su forma inicial una vez que deja de aplicarse sobre él una fuerza.

Elástico:

La deformación plástica se mantiene incluso cuando cesa la fuerza .

Viscoelástico:

El objeto sobre el que se aplica la fuerza recupera parte de la deformación. La viscoelasticidad es un fenómeno que describe las características mecánicas de los materiales en función del tiempo.

PROPIEDADES



Esfuerzo
(stress)

Deformación
(strain)

Tensión principal

Tensión principal máxima

Tensión principal mínima



Tensión de von Mises

Es la combinación de tres tensiones principales en una tensión equivalente

Objetivo General

Evaluar mediante un análisis de elementos finitos la **distribución de esfuerzos y deformación total** en pacientes con maloclusión Clase II , evaluando **los efectos a nivel dentario que se generan** cuando se tratan con elásticos Clase II , Forsus o con Carrier Motion 3D.

Pregunta de Investigación

 Cual es la distribución de los esfuerzos y la deformación total, sobre la dentición, ligamento periodontal, hueso cortical y hueso trabecular, causada por los elásticos intermaxilares de clase II, Forsus y Carriere, evaluado desde una análisis de elementos finitos 

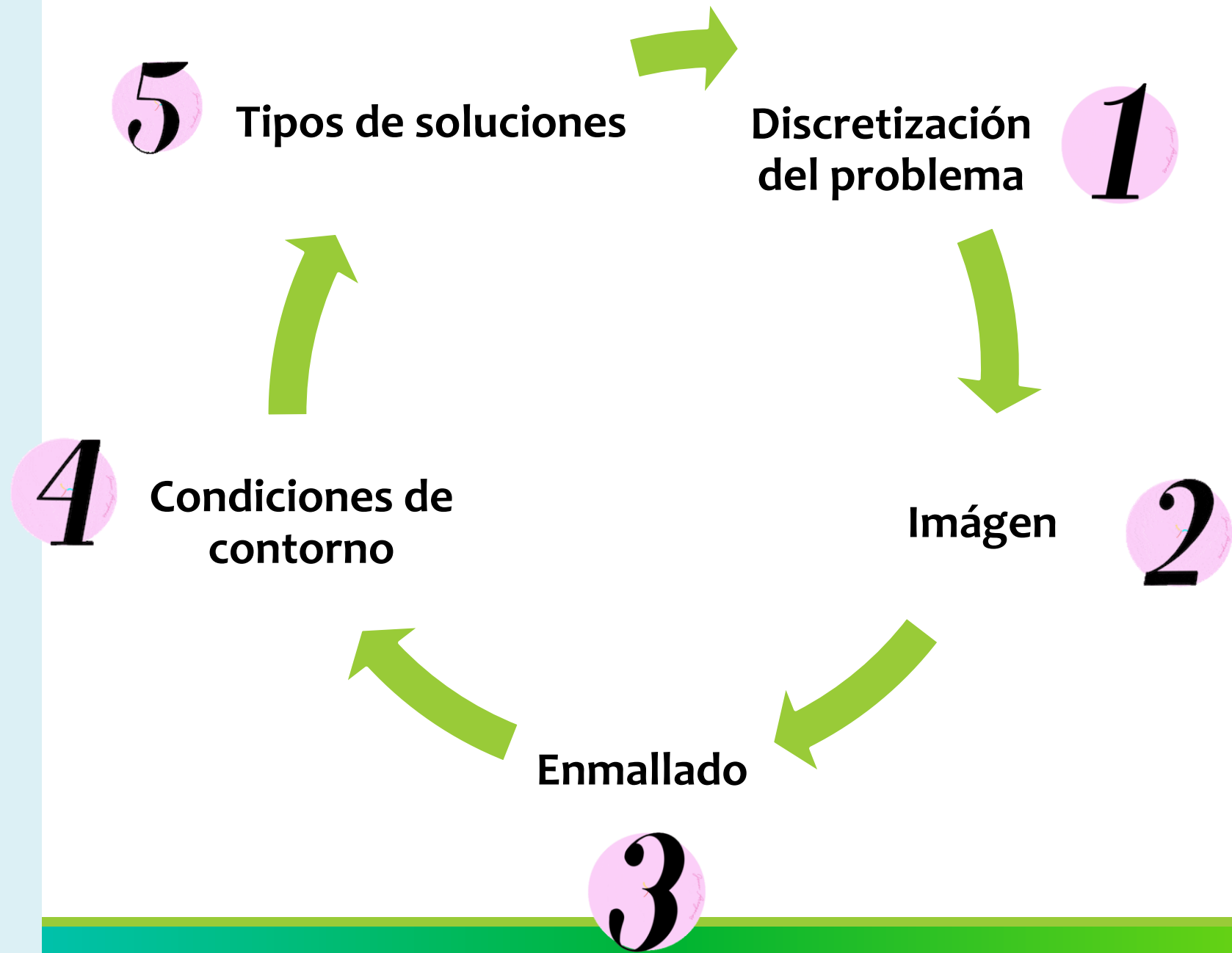
MATERIALES Y METODOS

TIPO DE ESTUDIO:

Estudio descriptivo por simulación de elementos finitos.

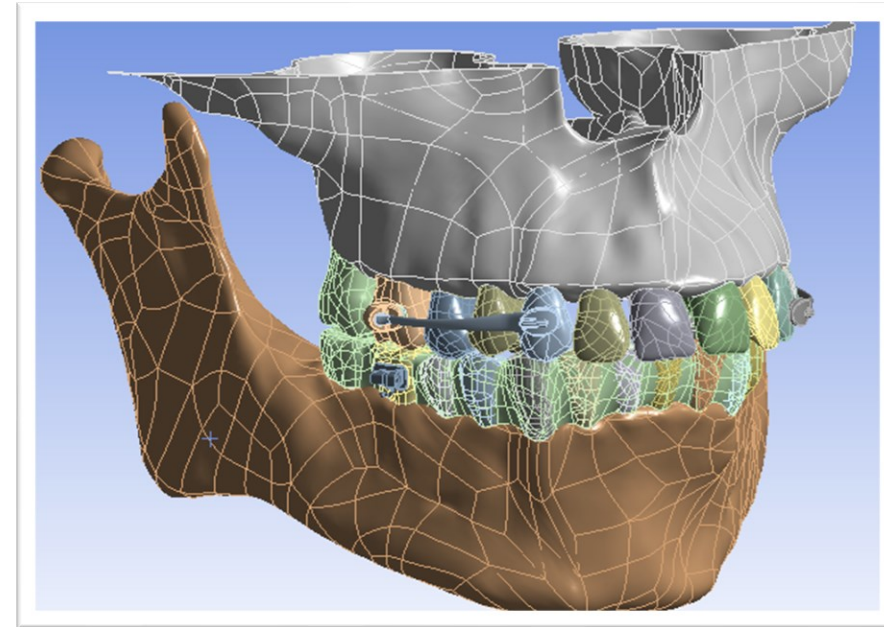
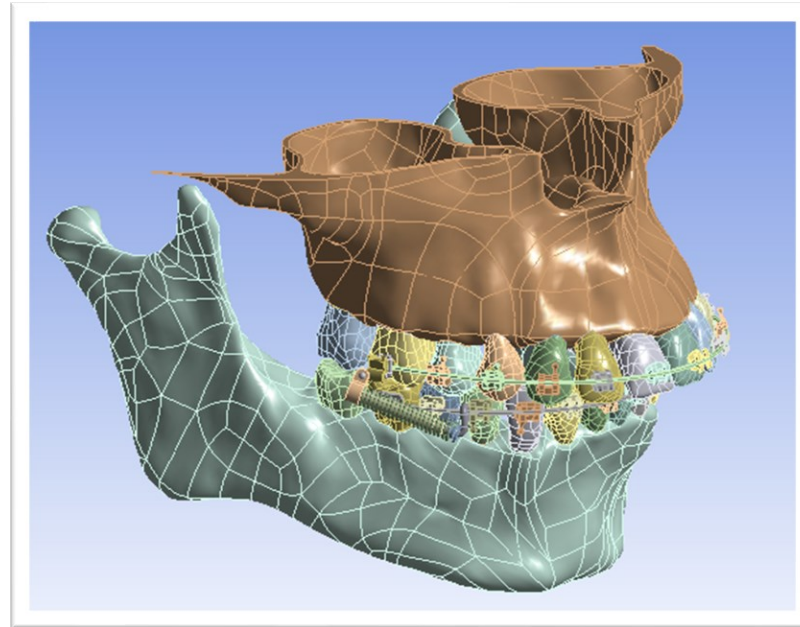
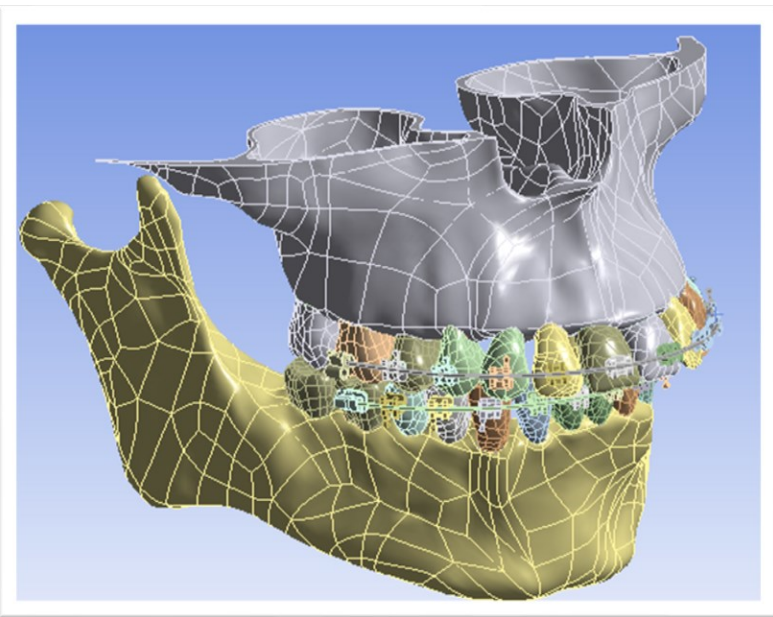
OBJETO DE ESTUDIO:

3 modelos Maxilo mandibulares (elásticos intermaxilares, Forsus y Carriere Motion)de un paciente Clase II división 1.



1

Discretización del problema



Distribución de los esfuerzos y deformación total.

Imágen

Reconstrucción en 3D

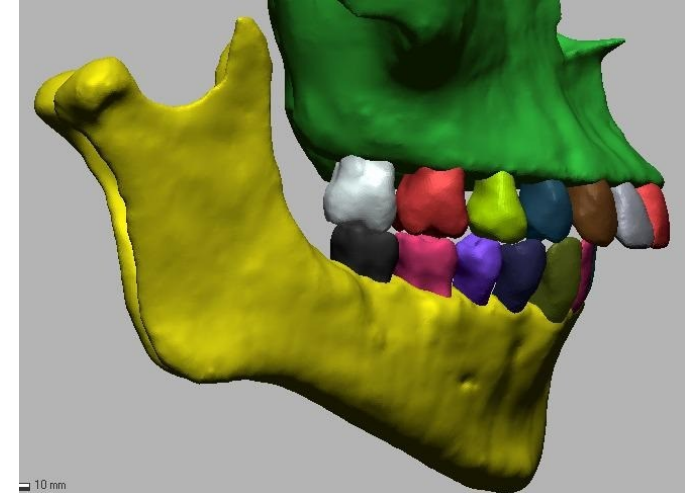
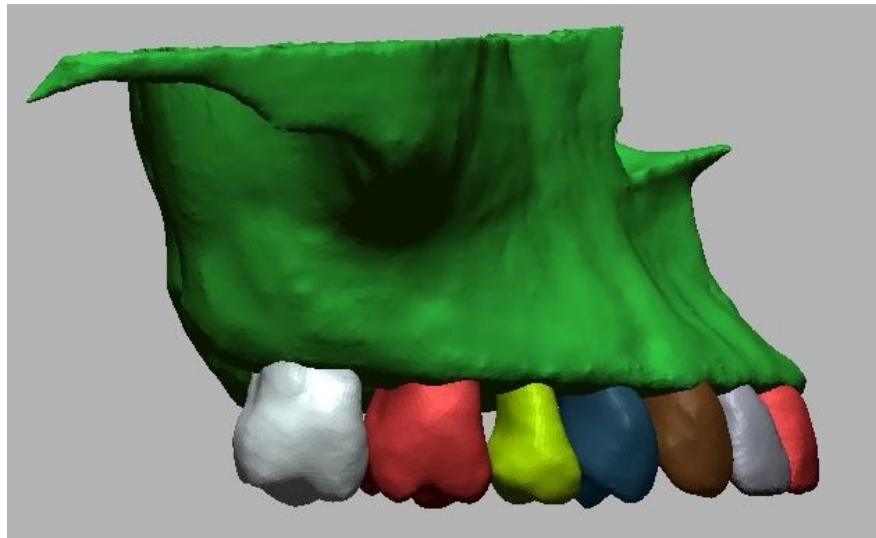
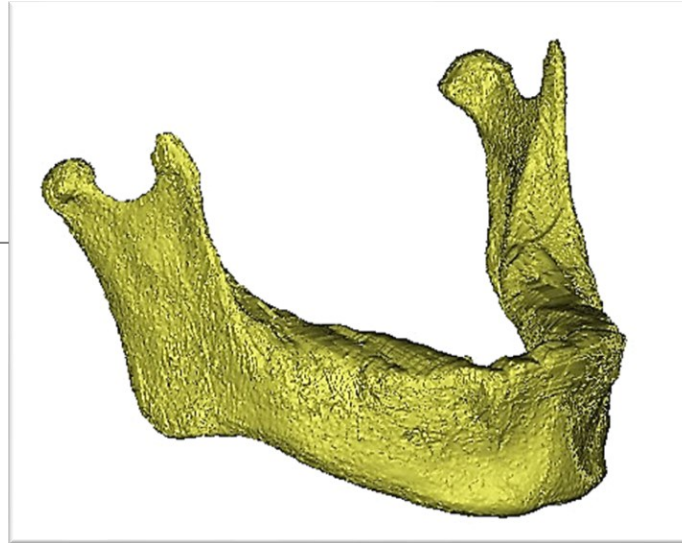
- Paciente 16 años.
- Mujer.
- Clase II división I.
- 6 mm de Over jet.

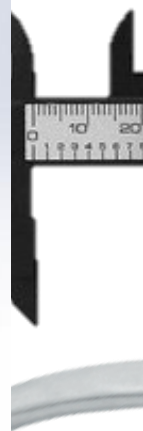
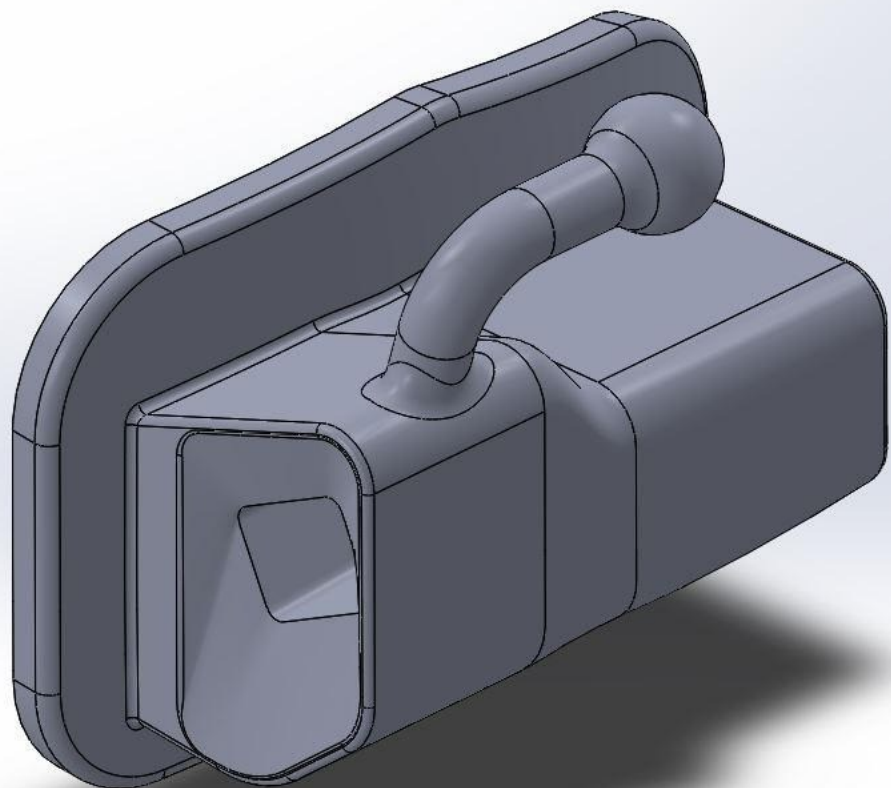
El CBCT se tomó con un equipo de tomografía dental Planmeca (Planmeca OY, Helsinki, Finlandia).

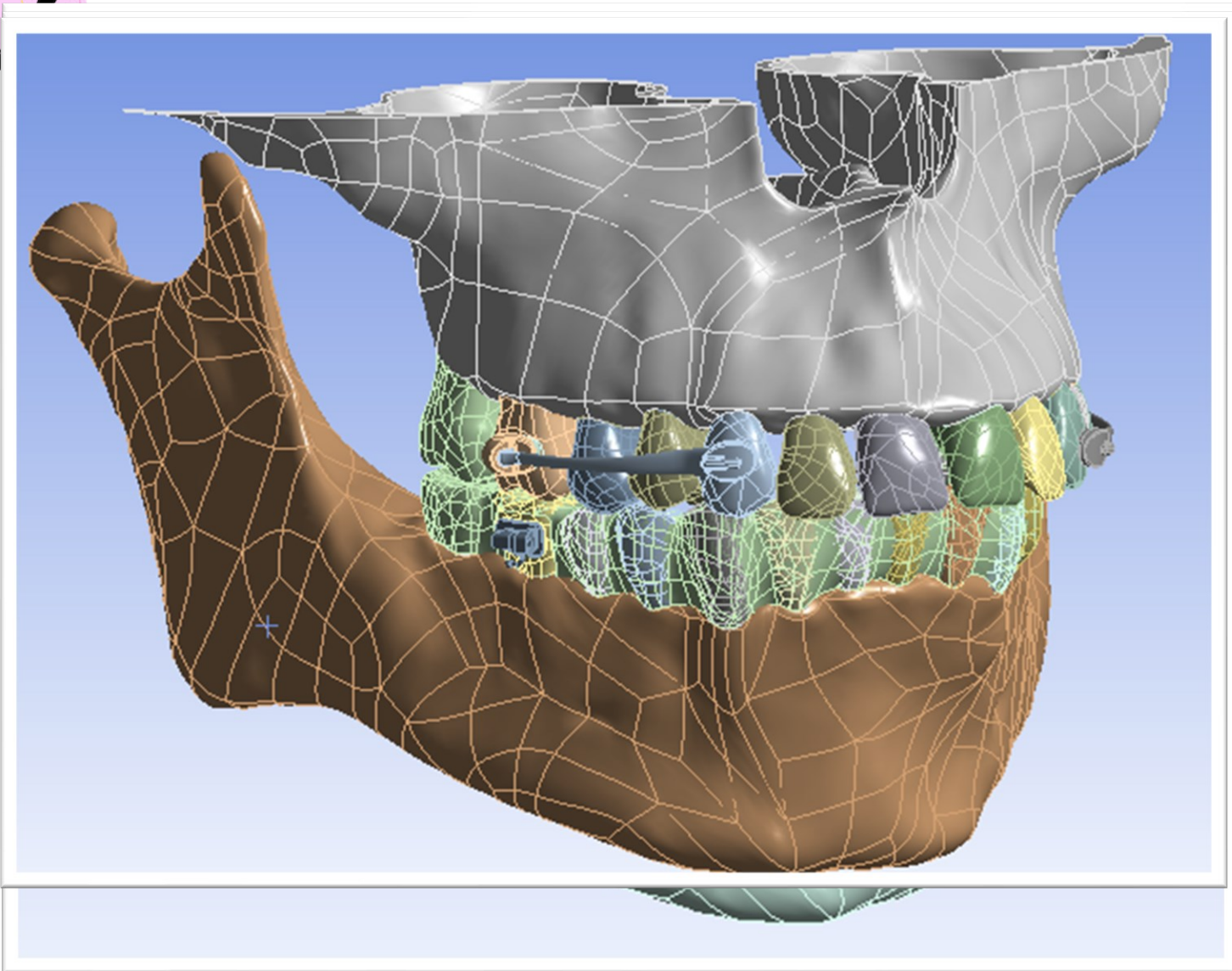
Imágen

**Reconstrucción
estructuras anatómicas**

Software 3D DOCTOR 4.0







**MODELO 3
CARRIERE
MOTION
(CMA)**

Enmallado

Mooney-Rivlin 3 Parameter		
Material Constant C10	-2,055E+05	Pa
Material Constant C01	4,2E+05	Pa
Material Constant C11	4,24E+05	
Incompressibility Parameter D1	0	

A	
Property	
1	
2	Material Field Variables
3	Density
4	Isotropic Secant Coefficient of Thermal Expansion
6	Isotropic Elasticity
7	Derive from
8	Young's Modulus
9	Poisson's Ratio

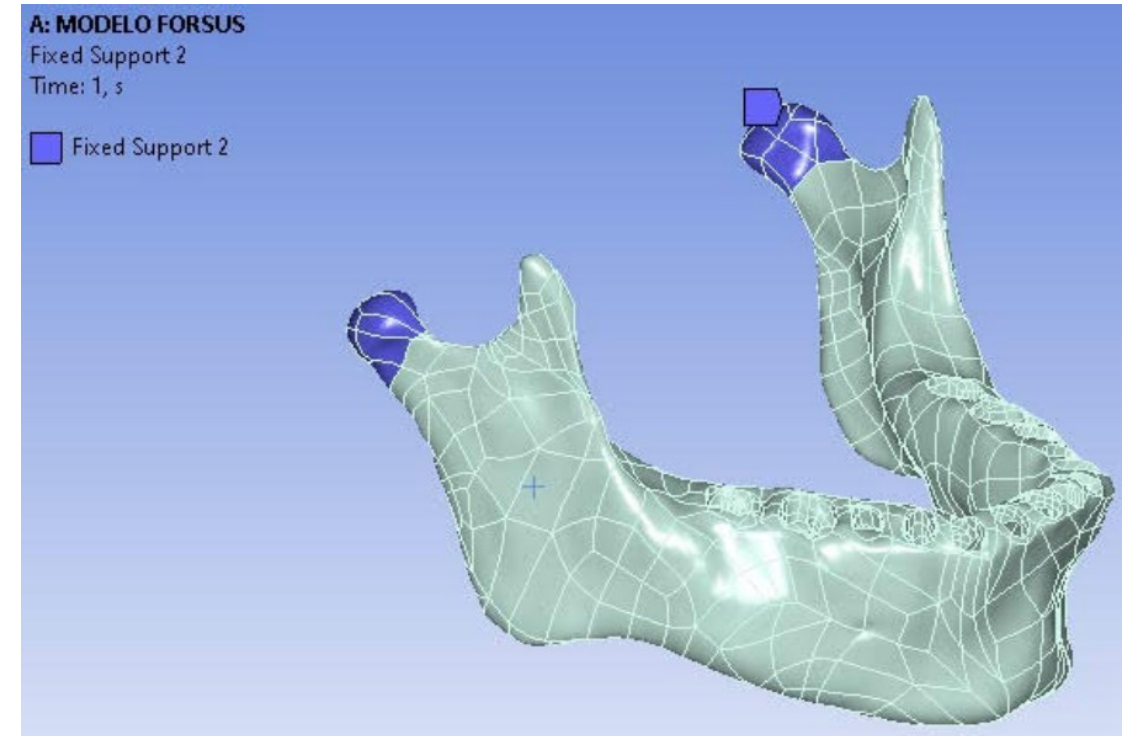
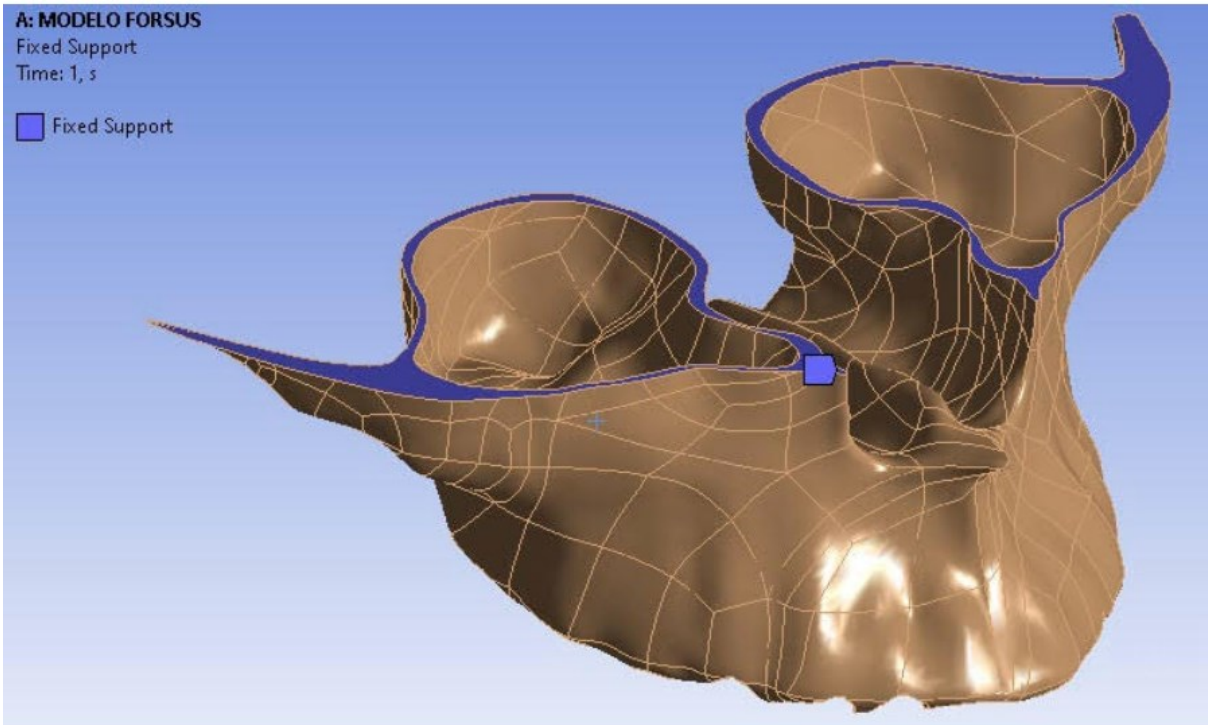
Modulo de Young y Razón de Poisson .

Los demás componentes se consideraron *lineales elásticos, isotrópicos y homogéneos.*

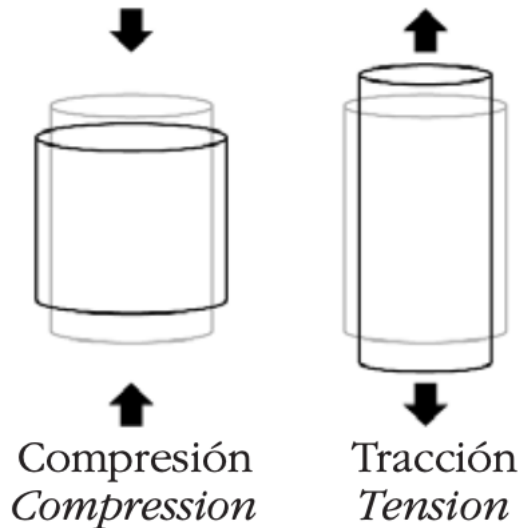
Se consideraron *elásticos y viscoelásticos* según la teoría de *Mooney-Rivly*, con un espesor de **0,25 mm**

ANSYS software

Condiciones de contorno



Condiciones de contorno

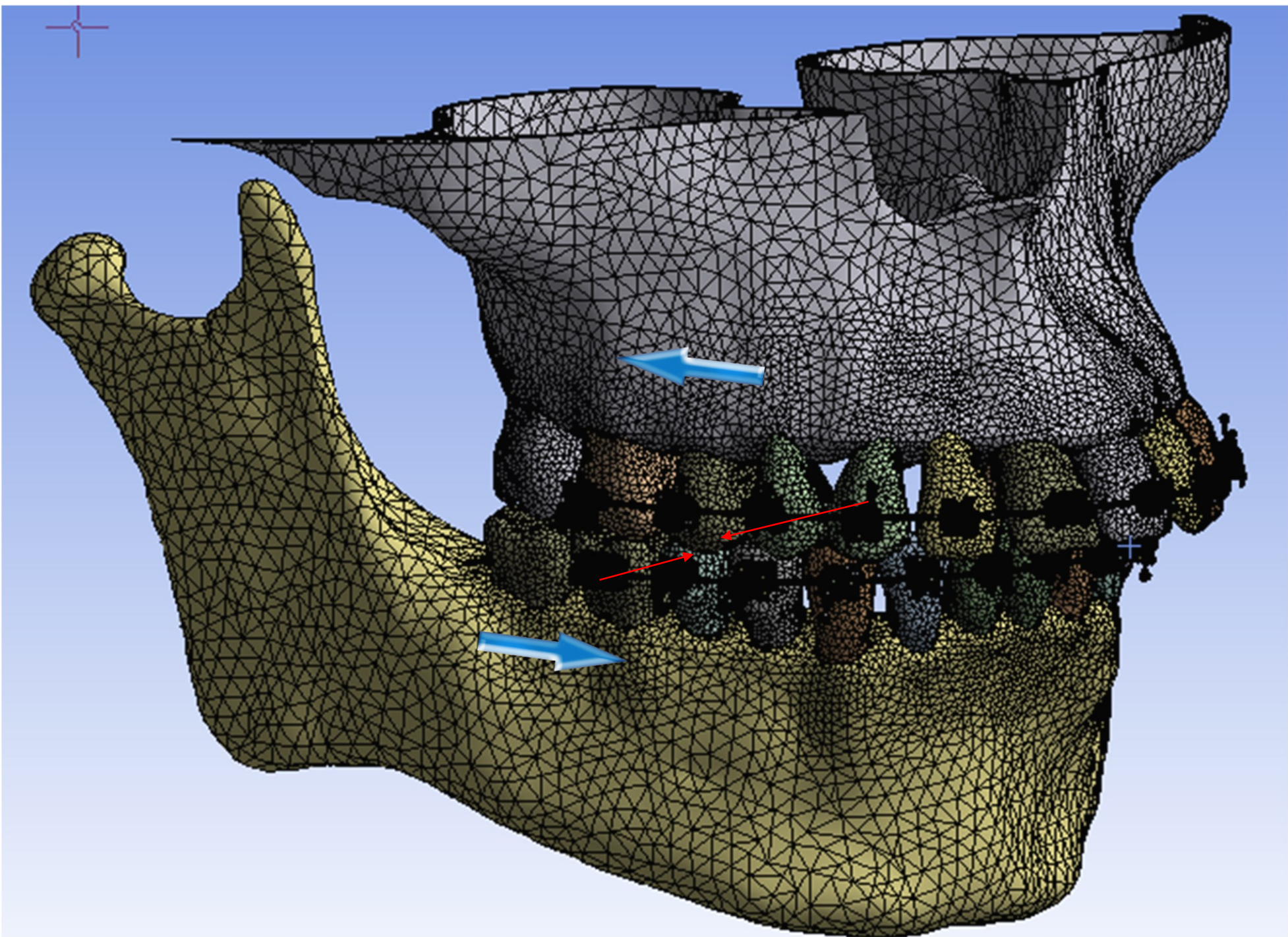


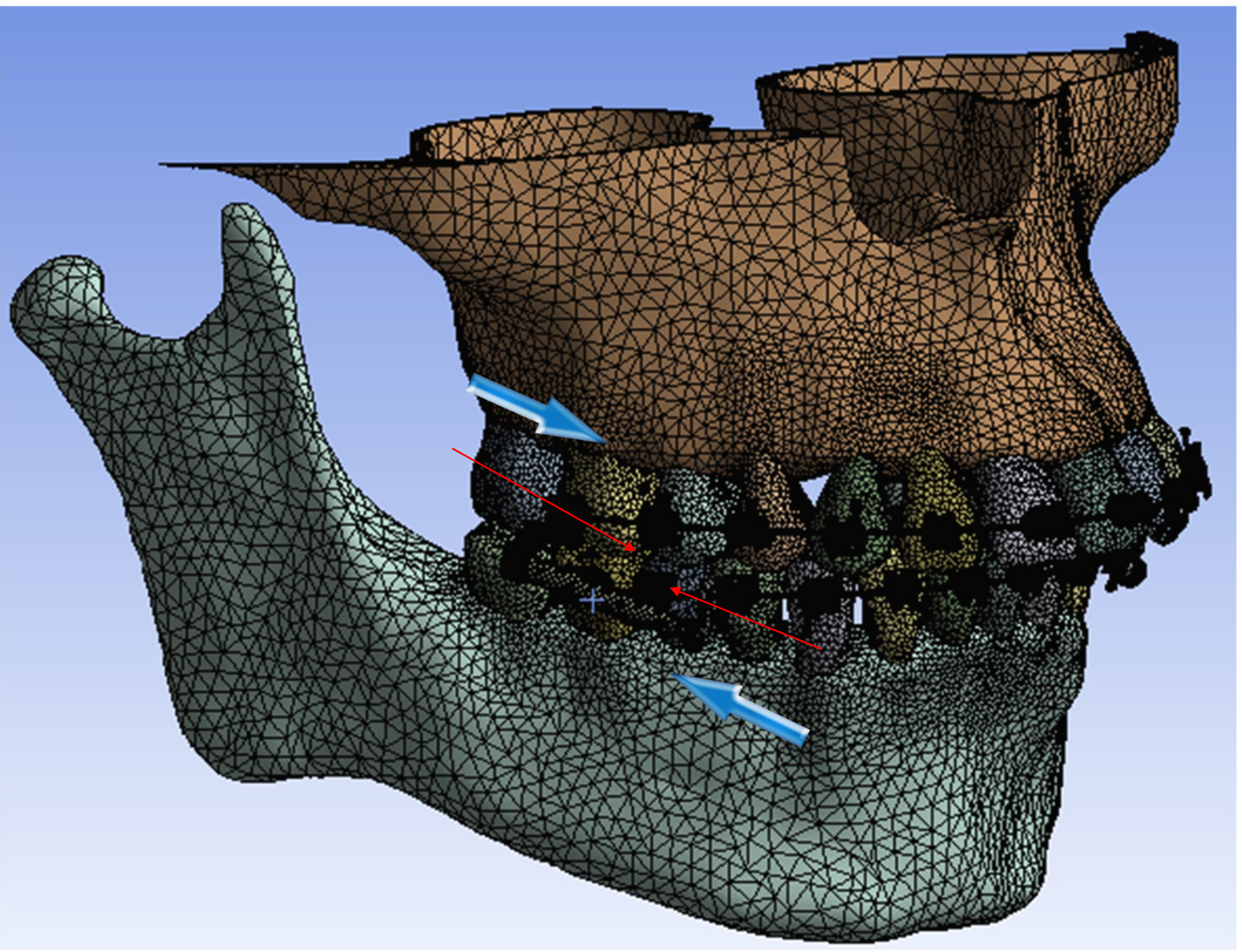
Guede D, & Jr, C. (2013). Biomecánica y hueso (I): Conceptos básicos y ensayos mecánicos clásicos. In REVISIONES / Rev Osteoporosis Metab Miner (Vol. 1).

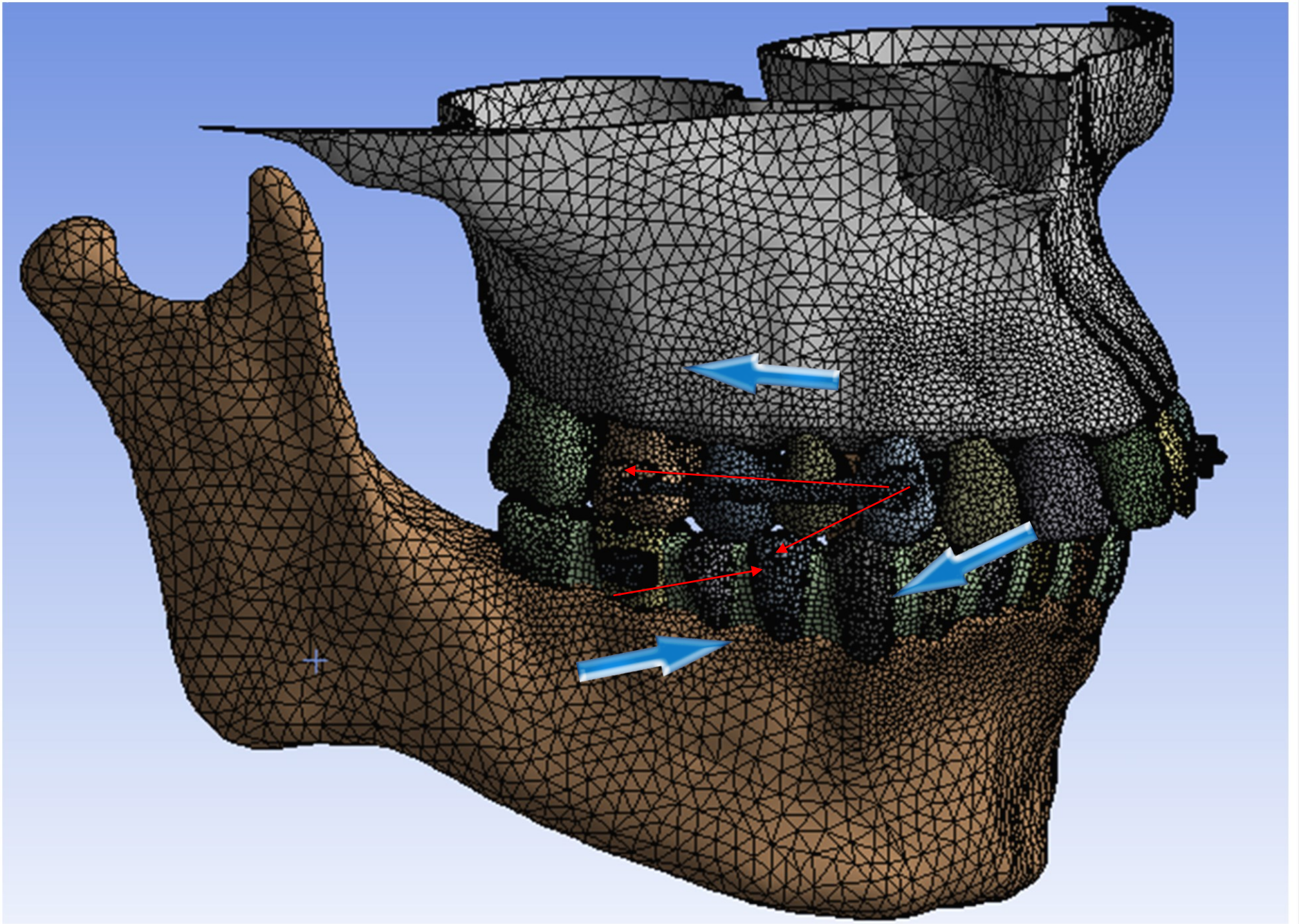
La fuerza fue de $2N$ para cada lado.

Aplicando **tensión** con los elásticos Clase II y CMA en canino superior y primer molar inferior.

Compresión para Forsus FRD en el primer molar superior y el primer premolar inferior.

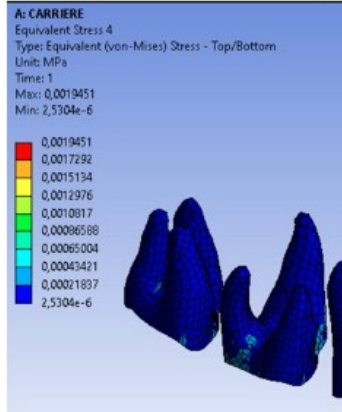




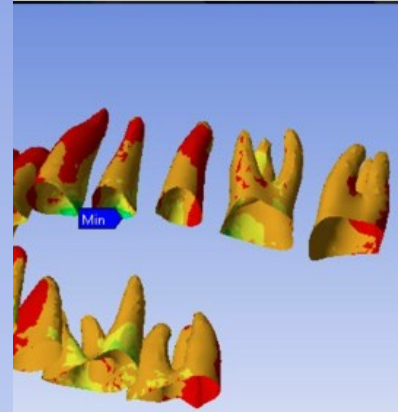
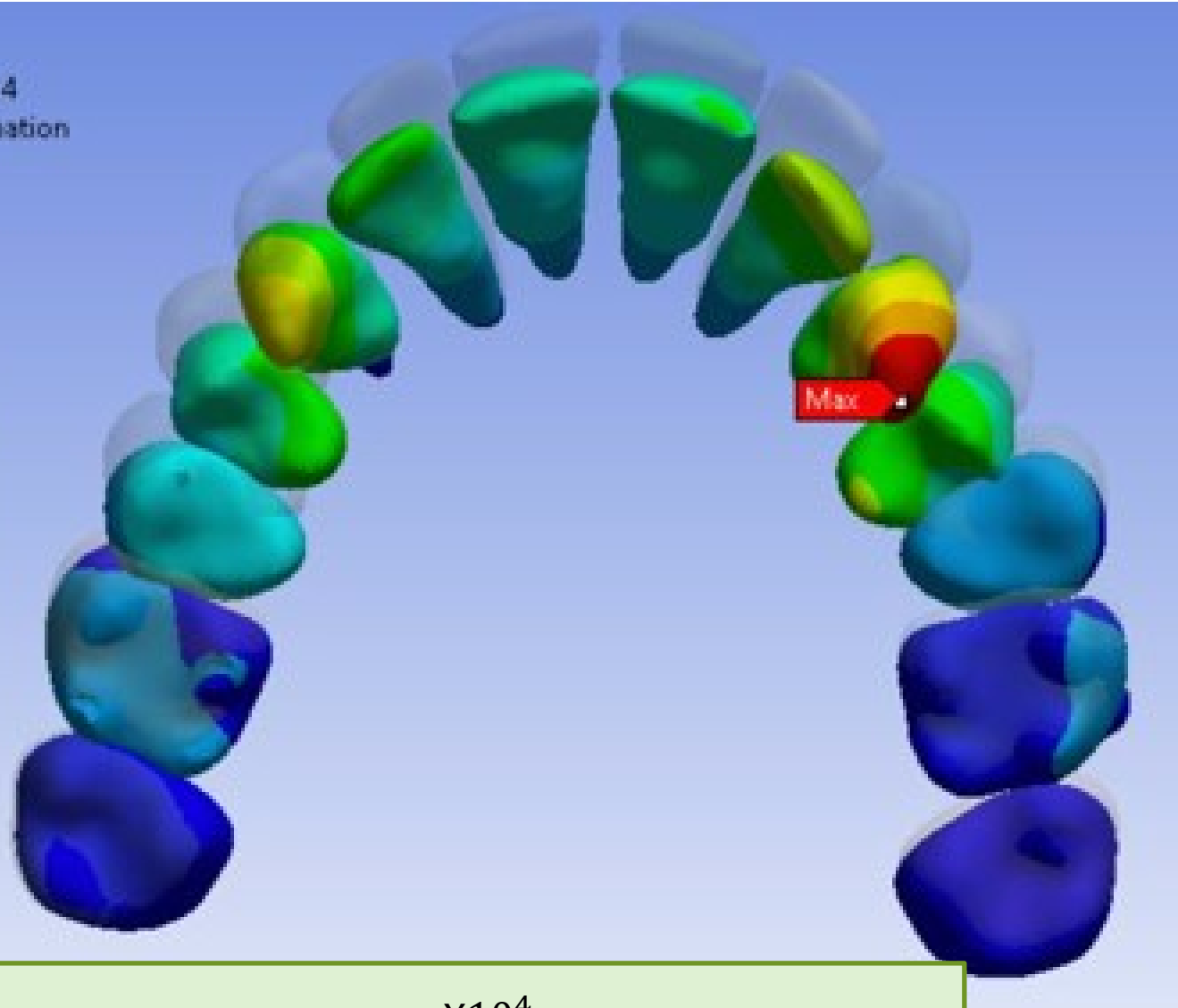


5

Tip



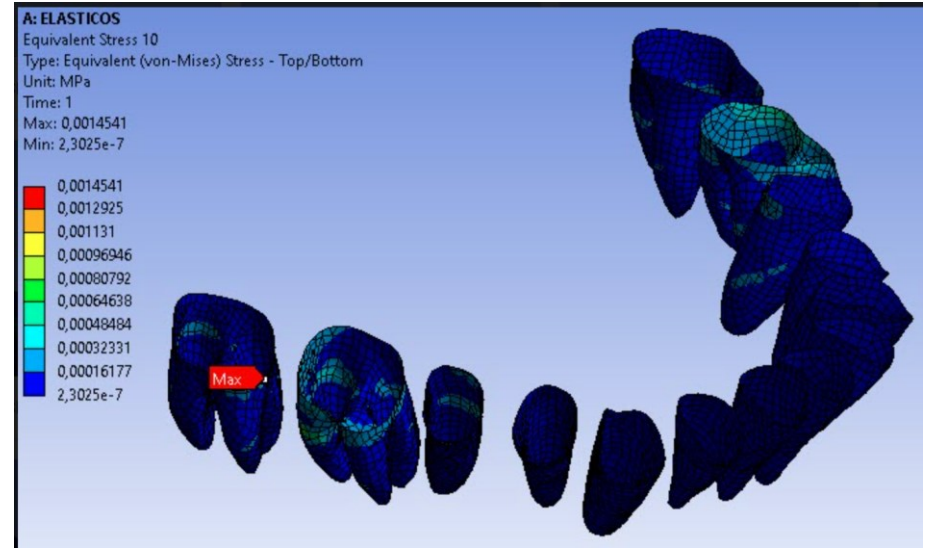
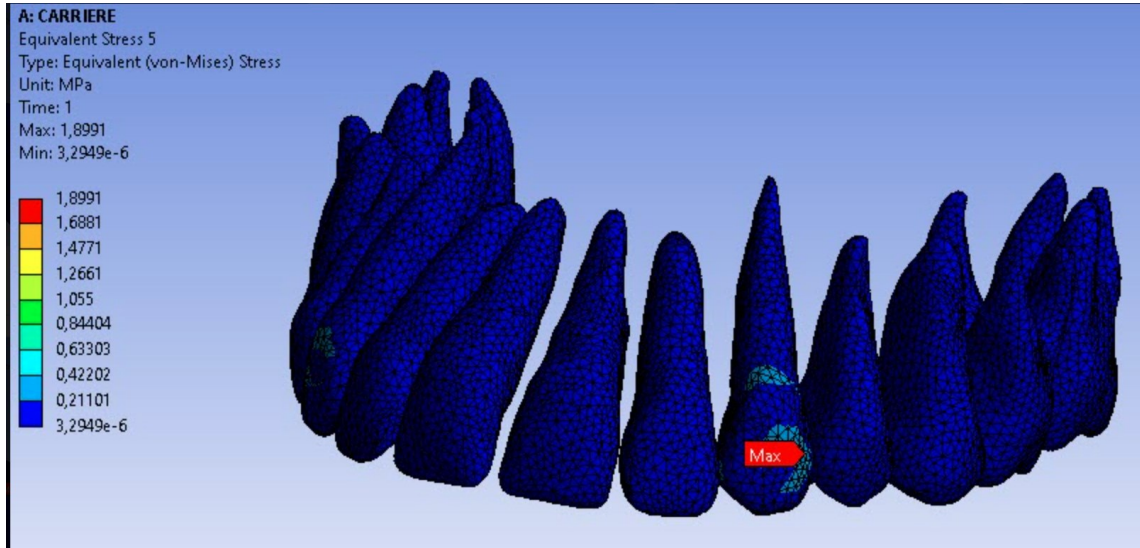
A: CARRIERE
Total Deformation 4
Type: Total Deformation
Unit: mm
Time: 1
Max: 0,0010067
Min: 3,7279e-5



RESULTADOS

Imagen del cráneo completo de cada aditamento/ pedir ingeniero

	Elásticos Clase II	FRD	CAM
# Nodos	1.207.182	1.280.801	933.279
#Elementos	748.983	771.350	5.99.868



Maxilar

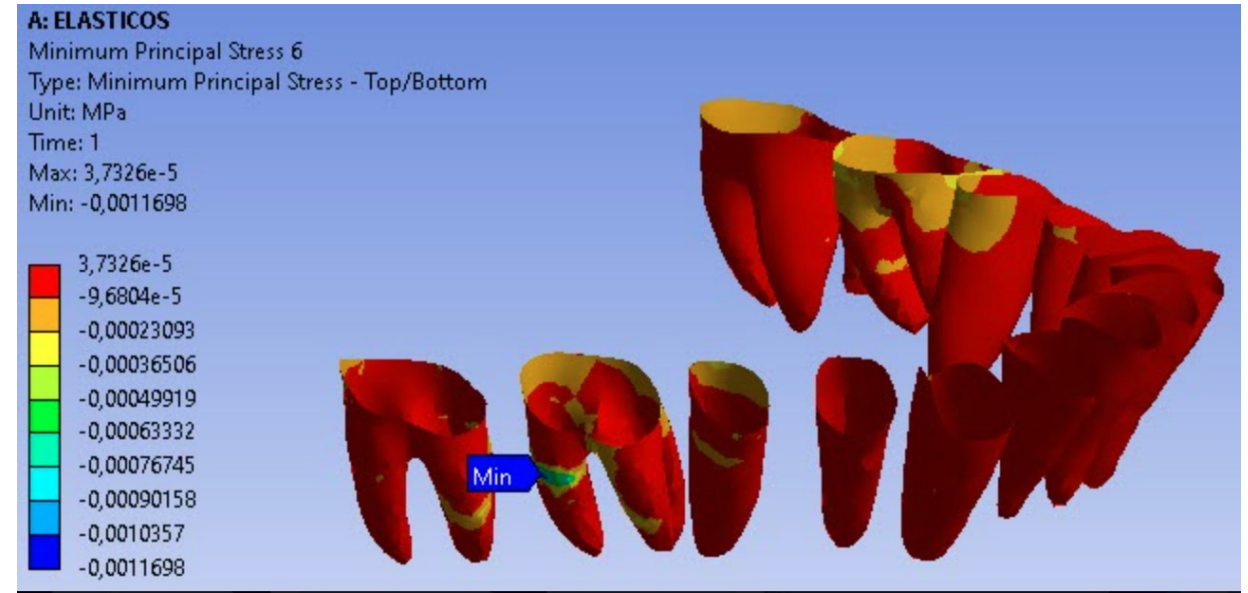
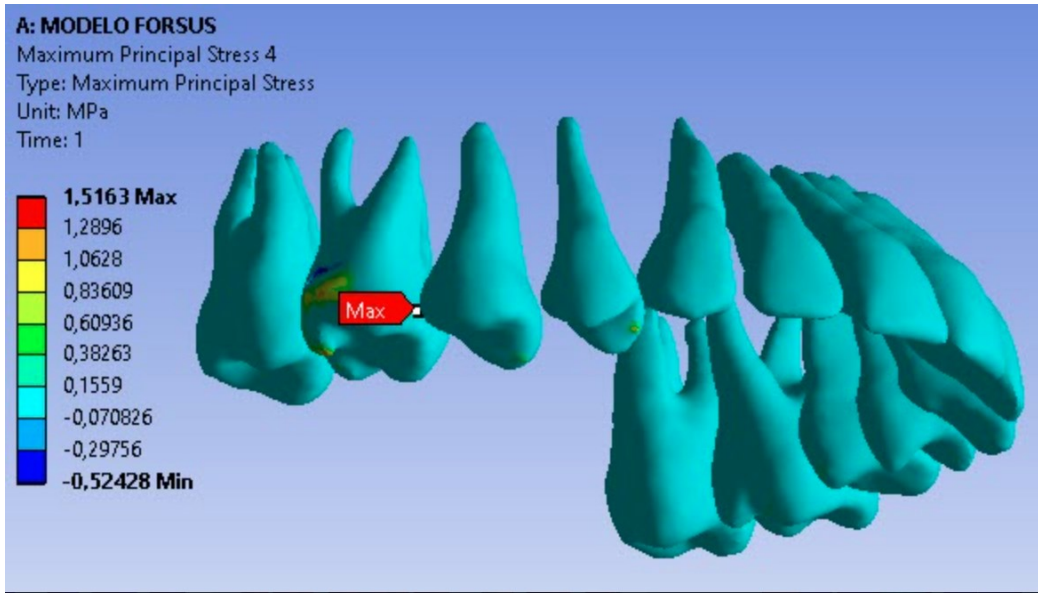
von Misses (Mpa)

Mandibular

Estructura	Elásticos Clase II	FRD	CAM
Hueso cortical	1.5116	0.15695	0.2353
Hueso trabecular	0.69233	0.0355369	0.037463
PDL	0.00533578	0.0036597	0.0019451
Diente	1.4963	1.768	1.8991

Estructura	Elásticos Clase II	FRD	CAM
Hueso cortical	0.11757	0.10481	0.14147
Hueso trabecular	0.01577	0.025965	0.028055
PDL	0.0014541	0.0019431	0.02955
Diente	1.2002	1.8195	1.1349

Estrés Máximo Principal



Maxilar

Estructura	Elásticos Clase II	FRD	CAM
Hueso cortical	0.78584	0.13943	0.13745
Hueso trabecular	0.38881	0.031887	0.033297
PDL	0.0060156	0.0035253	0.002048
Diente	1.4099	1.5163	1.4962

Mandibular

Estructura	Elásticos Clase II	FRD	CAM
Hueso cortical	0.11348	0.10482	0.17516
Hueso trabecular	0.017273	0.0019279	0.021999
PDL	0.0016788	0.0016986	0.031956
Diente	0.75376	1.2061	1.4676

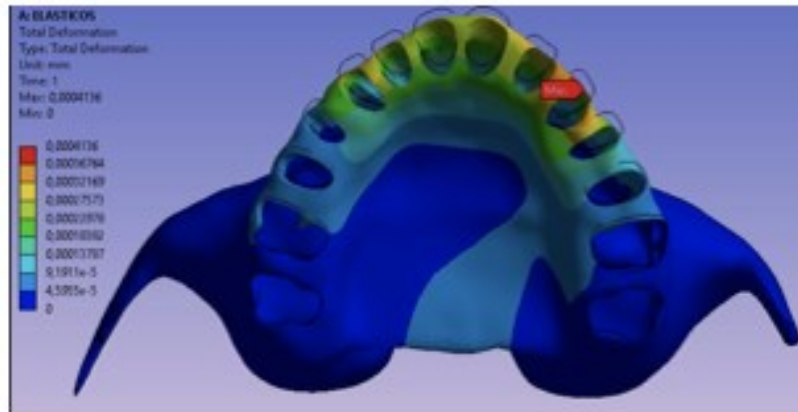
Deformación total

Class II Elastics

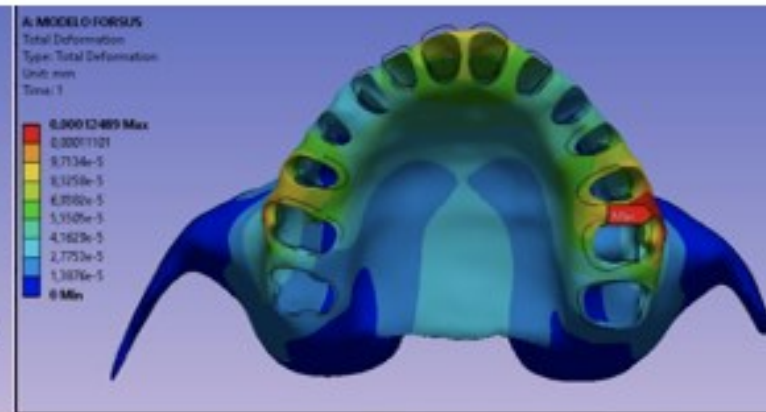
Forsus FRD

CAM

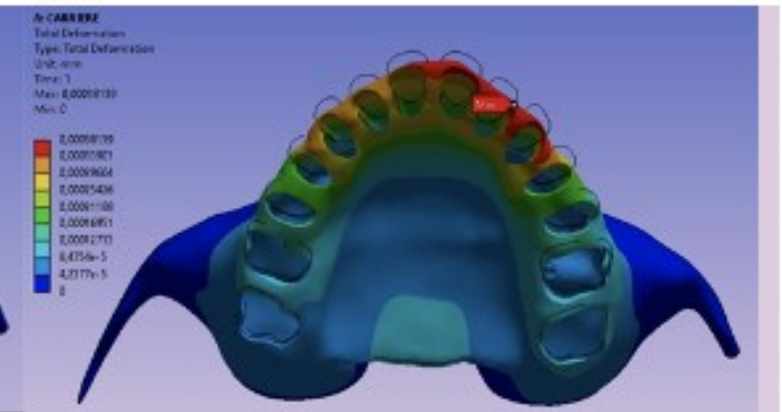
a. Cortical Bone



a1. Cortical Bone Class II elastics



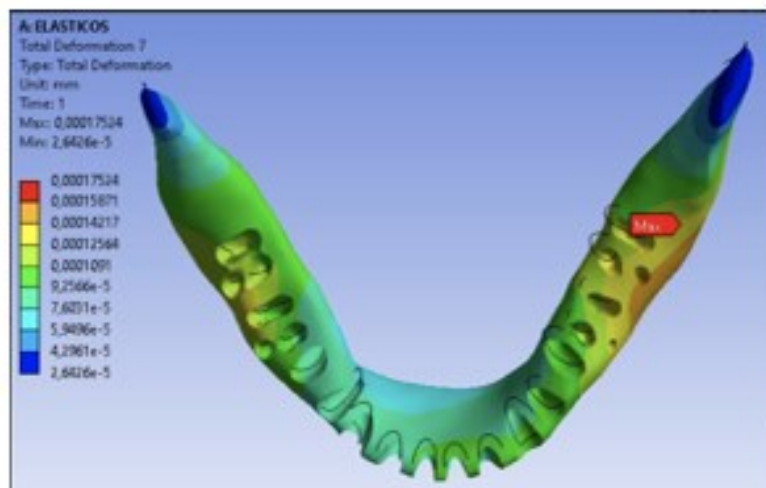
a2. Cortical Bone Forsus FRD



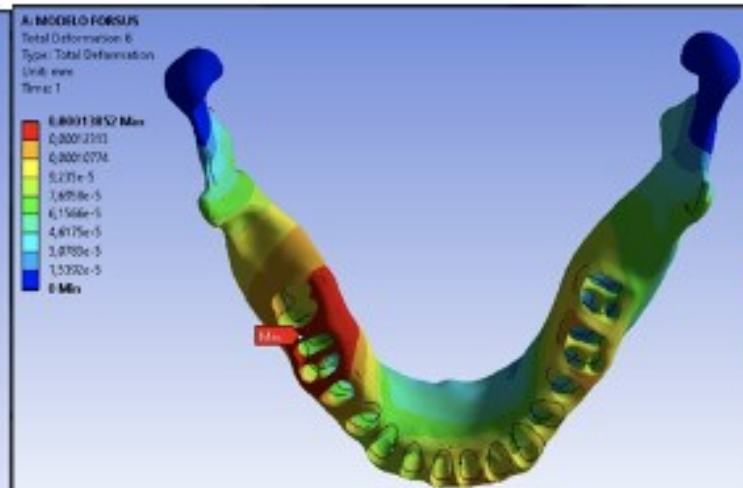
a3. Cortical Bone CMA

Deformación total

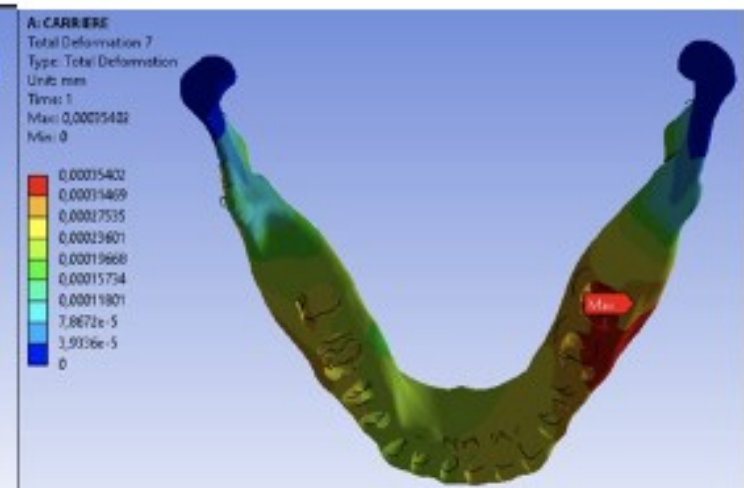
a. Cortical Bone



a1. Cortical Bone Class II elastics



a2. Cortical Bone Forsus FRD



a3. Cortical Bone CMA

DISCUSION

Cattaneo et al. 2005



The Finite Element Method: a Tool to Study Orthodontic Tooth Movement

Cattaneo, P M; Dalstra, M; Melsen, B
Journal of Dental Research; May 2005; 84, 5; ProQuest
pg. 428

RESEARCH REPORTS

Biomaterials & Bioengineering

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J Dent Res 84(5):428-433, 2005

The Finite Element Method: a Tool to Study Orthodontic Tooth Movement

ABSTRACT

Orthodontic tooth movement is achieved by (re)modeling processes of the alveolar bone, which are triggered by changes in the stress/strain distribution in the periodontium. In the past, the finite element (FE) method has been used to describe the stressed situation within the periodontal ligament (PDL) and surrounding alveolar bone. The present study sought to determine the impact of the modeling process on the outcome from FE analyses and to relate these findings to the current theories on orthodontic tooth movement. In a series of FE analyses simulating teeth subjected to orthodontic loading, the influence of geometry/morphology, material properties, and boundary conditions was evaluated. The accurate description of alveolar bone morphology and the assignment of non-linear mechanical properties for the PDL elements demonstrate that loading of the periodontium cannot be explained in simple terms of compression and tension along the loading direction. Tension in the alveolar bone was far more predominant than compression.

Knop et al. 2015



special article

Scientific use of the finite element method in Orthodontics

Lueggya Knop¹, Luiz Gonzaga Gandini Jr.², Ricardo Lima Shintcovsk¹, Marcia Regina Elisa Aparecida Schiavon Gandini³

DOI: <https://doi.org/10.1500/2176-0451.20151125>

Introduction: The finite element method (FEM) is an engineering resource applied to calculate the stress and deformation of complex structures, and has been widely used in orthodontic research. With the advantage of being a non-invasive and accurate method that provides quantitative and detailed data on the physiological reactions possible to occur in tissues, applying the FEM can anticipate the visualization of these tissue responses through the observation of areas of stress created from applied orthodontic mechanics. **Objective:** This article aims at reviewing and discussing the stages of the finite element method application and its applicability in Orthodontics. **Results:** FEM is able to evaluate the stress distribution at the interface between periodontal ligament and alveolar bone, and the shifting trend in various types of tooth movement when using different types of orthodontic devices. Therefore, it is necessary to know specific software for this purpose. **Conclusions:** FEM is an important experimental method to answer questions about tooth movement, overcoming the disadvantages of other experimental methods.



Chaudhry et al. 2015

ORIGINAL ARTICLE

AJO-DO

Evaluation of stress changes in the mandible with a fixed functional appliance: A finite element study

Anshul Chaudhry,^a Maninder S. Sidhu,^b Girish Chaudhary,^c Seema Grover,^d Nimisha Chaudhry,^e and Ashutosh Kaushik^f
Ludhiana, Punjab, Gurgaon and Rohatak, Haryana, and Moradabad, Uttar Pradesh, India

Introduction: The aim of this study was to evaluate the effects of a fixed functional appliance (Forsus Fatigue Resistant Device; 3M Unitek, Monrovia, Calif) on the mandible with 3-dimensional finite element stress analysis. **Methods:** A 3-dimensional finite element model of the mandible was constructed from the images generated by cone-beam computed tomography of a patient undergoing fixed orthodontic treatment. The changes were studied with the finite element method, in the form of highest von Mises stress and maximum principal stress regions. **Results:** More areas of stress were seen in the model of the mandible with the Forsus compared with the model of the mandible in the resting stage. **Conclusions:** This fixed functional appliance studied by finite element model analysis caused increases in the maximum principal stress and the von Mises stress in both the cortical bone and the condylar region of the mandible by more than 2 times. (*Am J Orthod Dentofacial Orthop* 2015;147:226-34)

Akis and Doruk 2018

Qin Xie and Duo Li 2021



Xie and Li *BMC Oral Health* (2021) 21:501
<https://doi.org/10.1186/s12903-021-01859-8>

BMC Oral Health

Duggal et al. 2021

ORIGINAL ARTICLE

Dentofacial Effects of Fixed Functional Appliances with or without Mini Screw Anchorage in the Treatment of Class II Division I Malocclusion: A Finite Element Analysis

Hallil Akış , Cenk Doruk



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Cite this article as: Akış H, Doruk C. Dentofacial Effects of Miniscrewed and Non-Miniscrewed Fixed Functional Appliances on the Treatment of Class II Division I Malocclusion: A Finite Element Analysis. *Turk J Orthod* 2018; 31: 7-12.

ABSTRACT

Objective: This study aimed to examine the biomechanical effects of the fixed functional appliances reinforced with miniscrews by finite elements analysis over the cranial and facial bones, temporomandibular joint, and maxillary-mandibular teeth, which are used for the treatment of Class II division I malocclusions characterized as mandibular retrognathia.

Methods: Three-dimensional (3-D) models of the cranial, mandibular, and maxillary bones were purchased from a company that produces 3-D models of the bones. Simulations of Forsus, screwed Forsus, Twin-Force and screwed Twin-Force appliances were conducted on the 3 D models. The miniscrew was placed in the inter-radicular area between the upper canine and first upper premolar teeth.

Results: It was observed in the models that the first upper molar tooth was the most affected. The compressive stress was observed in the anterior area of the mandibular condyle neck in the Forsus appliances; however, it was observed in the posterior area of the mandibular condyle neck in Twin-Force appliances.

Conclusion: It was observed that molar distalization and expansion decreases in the functional appliances with the support of miniscrew. The highest tension rates were determined in the areas of condylar and articular discs.

Keywords: Functional treatment, miniscrew, finite element analysis

RESEARCH

Open Access



The cross-sectional effects of ribbon arch wires on Class II malocclusion intermaxillary traction: a three-dimensional finite element analysis

Qin Xie and Duo Li*

Abstract

Background: The application of intermaxillary traction is often accompanied by the unexpected movement of dentition, especially anchorage teeth. The aim of this study was to comprehensively compare the influence of cross-sectional shape of ribbon arch wires with edgewise and round wires on intermaxillary traction in Class II malocclusion treatment using FEA simulation.

Methods: The dentofacial structure was simulated in finite element software. A retraction force of 1.5 N was applied to different cross-sectional orthodontic arch wires: a ribbon wire (0.025 × 0.017-in. and 0.025 × 0.019-in.), a rectangular wire (0.017 × 0.025-in. and 0.019 × 0.025-in.) and a round wire (Φ 0.018-in. and Φ 0.020-in.).

Results: Among the three groups, ribbon wire (0.025 × 0.017-in. and 0.025 × 0.019-in.) exhibited the lowest displacement in the X-axis (12.61 μm and 12.77 μm, respectively) and Z-axis (8.99 μm and 9.06 μm, respectively). However, the 0.025 × 0.017-in. ribbon wire showed the highest Y-axis displacement. In the round wire group, Φ 0.020-in. wire displayed less rotation than Φ 0.018-in. wire, where the sagittal, frontal and occlusal rotation of Φ 0.020-in. wire was almost half of that of Φ 0.018-in. wire. The movement of the first molar region was intermediate between the ribbon arch group and the round wire group. Notably, the values of the 0.025 × 0.017-in. arch wire displacement, which were higher than those of any other group, peaked at 0.019 mm in the central incisor region with a spike-like shape. The deformation range of the Φ 0.018-in. wire group was the largest in this study.

Conclusions: The cross-section of the arch wire influenced force delivery in Class II intermaxillary traction. With the same shape, a larger cross-sectional area led to less mandibular dentition movement. For the rectangular arch wire and ribbon arch wire groups, since the height and width were inverted, the vertical displacement of anchorage teeth in the ribbon wire group was reduced, but the possibility of buccal tipping in mandibular anterior teeth also increased.

Keywords: Finite element analysis, Orthodontic arch wire, Anchorage loss, Class II malocclusion, Intermaxillary traction, Ribbon wire



Effects of miniplate anchored Herbst appliance on skeletal, dental and masticatory structures of the craniomandibular apparatus: A finite element study

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Available online: 28 April 2021

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Summary

Objective > To analyze the stress distribution in the hard and soft tissue structures of craniomandibular complex during mandibular advancement with miniplate anchored rigid fixed functional appliance (FFA) using Finite Element Analysis (FEA).

Material and methods > The virtual model consisting of all the maxillofacial bones (up to calvaria), the mandible and temporomandibular joint (TMJ) was generated using the volumetric data from pre-treatment CBCT-scan of a growing patient. The masticatory muscles, other soft tissues, Herbst appliance and plate geometry were modelled mathematically. Force vectors simulating muscle contraction at rest and advanced mandibular positions, with protraction force of 8 N were applied. The final model was imported into ANSYS for analysis after assigning material properties.

Results > The maximum von Mises stress of 11.69 MPa and 11.96 MPa magnitude was observed in the region of pterygoid plates and at the bone-miniplate interface respectively, with the mandibular advancement of 7 mm. Stress patterns were also noted at the condylar neck. The stress values observed in the medial and lateral pterygoid muscles were of 10.42 MPa and 4.16 MPa magnitude, respectively. Stress was noted in the bucco-cervical region of the upper posterior teeth, but negligible change was seen on the lower anterior teeth and periodontal ligament.

Conclusion > Miniplate Anchored Herbst Appliance brought about Class II skeletal correction in growing children as it was accompanied by minimal changes in the inclination of the lower incisors. Soft tissue structures like pterygoid muscles and discal ligaments exhibited increased stress whereas masseter muscle displayed reduction in stresses.

Keywords

Skeletal anchorage
Fixed functional appliance
Herbst appliance
Mandibular protraction
Finite element analysis
Stress pattern
Convergence test
Virtual model
Muscle element modelling
Discal ligament

Young-II Chang et al 2004



European Journal of Orthodontics 26 (2004) 339–345

European Journal of Orthodontics vol. 26 no. 3
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Three-dimensional finite element analysis in distal *en masse* movement of the maxillary dentition with the multiloop edgewise archwire

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SUMMARY The purpose of this study was to compare the effects of a multiloop edgewise archwire (MEAW) on distal *en masse* movement with a continuous plain ideal archwire (IA). Three-dimensional finite element models (FEM) of the maxillary dentition in which the second permanent molars had been extracted were constructed to include the periodontal membrane, alveolar bone, standard edgewise bracket (0.018 × 0.025 inch), stainless steel IA (0.016 × 0.022 inch), and MEAW (0.016 × 0.022 inch). The stress distribution and displacement of the maxillary dentition were analysed when Class II intermaxillary elastics (300 g/side) and 5 degree tip-back bends were applied to the IA and MEAW for distal *en masse* movement of the maxillary dentition.

Compared with the IA, the MEAW showed that the discrepancy in the amount of tooth displacement was lower and individual tooth movement was more uniform and balanced. There was minimal vertical displacement or rotation of the teeth using the MEAW when compared with the IA. The MEAW seems to have advantages for distal *en masse* movement of the maxillary dentition.

Birgitta et al. 2007



ORIGINAL ARTICLE 

A long-term follow-up study of Class II malocclusion correction after treatment with Class II elastics or fixed functional appliances

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Introduction: The aim of this study was to compare dentofacial morphology and long-term follow-up changes in growing males with skeletal Class II malocclusions treated without extractions and with either Begg or Herbst appliances. **Methods:** Lateral cephalograms were obtained at the start of treatment, after active treatment, and after long-term follow-up. **Results:** Treatment effects differed between the groups, with usually more favorable effects in the Herbst group. However, during the follow-up period, many of the changes were reversed. During the total observation period, maxillary prognathism and lower anterior facial height increased more in the Begg group than in the Herbst group. **Conclusions:** Although there were initial marked differences in the treatment outcomes, most of these differences were not sustained over the longer term. (Am J Orthod Dentofacial Orthop 2007;132:499-503)

Giuniti et al.

Original Article



Treatment effects produced by the Twin-block appliance vs the Forsus Fatigue Resistant Device in growing Class II patients

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ABSTRACT

Objective: To compare the dentoskeletal changes produced by the Twin-block appliance (TB) followed by fixed appliances vs the Forsus Fatigue Resistant Device (FRD) in combination with fixed appliances in growing patients having Class II division 1 malocclusion.

Materials and Methods: Twenty-eight Class II patients (19 females and 9 males; mean age, 12.4 years) treated consecutively with the TB followed by fixed appliances were compared with a group of 36 patients (16 females and 20 males; mean age, 12.3 years) treated consecutively with the FRD in combination with fixed appliances and with a sample of 27 subjects having untreated Class II malocclusion (13 females and 14 males; mean age, 12.2 years). Mean observation interval was 2.3 years in all groups. Cephalometric changes were compared among the three groups by means of ANOVA and Tukey's post hoc tests.

Results: The FRD produced a significant restraint of the maxilla compared with the TB and control samples (SNA, -1.1° and -1.8° , respectively). The TB sample exhibited significantly greater mandibular advancement and greater increments in total mandibular length than either the FRD or control groups (SNB, 1.9° and 1.5° , respectively; and Co-Gn, 2.0 mm and 3.4 mm, respectively). The FRD produced a significantly greater amount of proclination of the mandibular incisors than what occurred with the TB or the control samples (2.9° and 5.6° , respectively).

Conclusion: The TB appliance produced greater skeletal effects in terms of mandibular advancement and growth stimulation while the Forsus caused significant proclination of the mandibular incisors. (Angle Orthod. 2015;85:784–789.)

KEY WORDS: Functional jaw orthopedics; Class II malocclusion; Cephalometrics

Fan-Fan Daia et al. 2018

Original Article



Comparison of achieved and predicted tooth movement of maxillary first molars and central incisors:

First premolar extraction treatment with Invisalign

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ABSTRACT

Objectives: To compare achieved and predicted tooth movements of maxillary first molars and central incisors in first premolar extraction cases treated with Invisalign.

Materials and Methods: The present study included 30 patients who received maxillary first premolar extraction treatment with Invisalign. The actual posttreatment model was registered with the pretreatment model on the palatal stable region and superimposed with the virtual posttreatment model. Achieved and predicted tooth movements of maxillary first molars and central incisors were compared using paired *t*-test. Linear mixed-effect model analyses were used to explore the influence of age (adolescents vs adults), attachment (G6-optimized vs 3-mm vertical, 3-mm horizontal, and 5-mm horizontal), and initial crowding on the differences between predicted and achieved tooth movement (DPATM).

Results: First molars achieved greater mesial tipping, mesial translation, and intrusion than predicted. Central incisors achieved less retraction and greater lingual crown torque and extrusion than predicted. Adolescents showed greater DPATM in the mesiodistal translation of first molars and labiolingual translation of central incisors and smaller DPATM in the occlusogingival translation of the first molars and crown torque of the central incisors than adults. The 3-mm vertical attachment group showed greater DPATM in the mesiodistal translation of the first molars vs the G6-optimized attachment group. Initial crowding had an inverse correlation with DPATM in angulation and mesiodistal translation of the first molars.

Conclusions: First molar anchorage control and central incisor retraction were not fully achieved as predicted in first premolar extraction treatment with Invisalign. Age, attachment, and initial crowding affected the differences between predicted and achieved tooth movement. (*Angle Orthod.* 2019;89:679–687.)

Mistrell et al. 1986



A cephalometric appraisal of nonextraction Begg treatment of Class II malocclusions

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Initial and final cephalometric evaluations are compared in a sample of 42 patients with Class II malocclusions treated in a nonextraction manner with the Begg appliance. The sample was analyzed as a group. Subgroups of patients with Division 1 and Division 2 characteristics were analyzed separately. To depict skeletal and dental changes, measurements were made using the sella nasion, palatal, and mandibular planes as reference planes. The findings show that on the average: (1) The upper first molar maintained its anteroposterior position at the same time that SNA was reduced. This suggests a restriction of anterior maxillary growth. (2) The mandibular first molar moved forward by 1.2 mm. Part of this change was attributed to anchorage consumption. (3) Vertical changes in both the maxilla and the mandible were found to be within the normal range. (4) No significant change in occlusal or mandibular plane angles was observed except for the Division 1 subgroup in whom a mild increase in the mandibular plane angle was observed. (*AM J ORTHOD DENTOFAC ORTHOP* 90: 286-295, 1986.)

Keilig et al. 2015



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In vivo measurements and numerical analysis of the biomechanical characteristics of the human periodontal ligament

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Abstract

The periodontal ligament is a complex tissue with respect to its biomechanical behaviour. It is important to understand the mechanical behaviour of the periodontal ligament during physiological loading in healthy patients as well as during the movement of the tooth in orthodontic treatment or in patients with periodontal disease, as these might affect the mechanical properties of the periodontal ligament (PDL). Up to now, only a limited amount of in vivo data is available concerning this issue.

The aim of this study has been to determine the time dependent material properties of the PDL in an experimental *in vivo* study, using a novel device that is able to measure tooth displacement intraorally. Using the intraoral loading device, tooth deflections at various velocities were realised in vivo on human teeth. The in vivo investigations were performed on the upper left central incisors of five volunteers aged 21–33 years with healthy periodontal tissue. A deflection, applied at the centre of the crown, was linearly increased from 0 to 0.15 mm in a loading period of between 0.1 and 5.0 s. Individual numerical models were developed based on the experimental results to simulate the relationship between the applied force and tooth displacement. The numerical force/displacement curves were fitted to the experimental ones to obtain the material properties of the human PDL. For the shortest loading time of 0.1 s, the experimentally determined forces were between 7.0 and 16.2 N. The numerically calculated Young's modulus varied between 0.9 MPa (5.0 s) and 1.2 MPa (0.1 s). By considering the experimentally and numerically obtained force curves, forces decreased with increasing loading time. The experimental data gained in this study can be used for the further development and verification of a multiphase constitutive law of the PDL.

CONCLUSIONES

CONCLUSIONS



En el maxilar, el máximo esfuerzo de von Mises se localizó en el canino superior para los elásticos Clase II y en el CMA y el máximo esfuerzo principales se ubicó en el primer molar para el Forsus FRD. En la mandíbula el máximo esfuerzo de von Mises fue en el primer molar inferior, en los elásticos Clase II y en el CMA. El máximo esfuerzo principal se observó en el primer premolar inferior para el Forsus FRD. Siendo estos los dientes en los que se anclan los aditamentos de cada modelo .

La deformación en la arcada superior se ubicó en los elásticos Clase II y modelo CMA en el canino superior, y en el Forsus FRD se localizó en el primer molar superior, la distribución de la deformación en los elásticos Clase II y CMA se concentró en los dientes anteriores ,de canino superior a canino superior, y en el Forsus FRD la distribución de la deformación se concentró en los dientes posteriores, en la mandíbula. El estudio mostró una mesialización de los dientes.

En los elásticos Clase II encontramos proinclinación de los incisivos inferiores, inclinación palatina en los dientes anteriores superiores, en los FRD encontramos menos proinclinación de los incisivos inferiores, inclinación palatina en los dientes anteriores superiores, desplazamiento bucal de los primeros molares superiores, distal movimiento del primer molar superior, en el CMA encontramos movimiento distal del primer molar superior, y más inclinación palatina en los dientes anteriores superiores que en los elásticos FRD y Clase II.