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Research Article

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Comparision of Biomechanical Effects of Infrazygomatic Crest Bone Screws and Modified C-Palatal Plate Appliance for Total Maxillary Arch Distalization in Treatment of Class II Malocclusion: A Finite Element Study

Farath Naseem Romana, Shaik Mobeen*, Soja Sara George, Shibu MP, Sravanthi Jagati, Juveria Fathima, Aiysha Nudrath, Mohammad Noorez Nasir

Abstract

Class II malocclusions may be corrected by combinations of restriction or redirection of maxillary growth, distal movement of maxillary dentition, Experimental studies have shown that forces for Class II correction produced by extraoral traction and intermaxillary elastics cause posterior repositioning of the maxillary dental complex, as well as of the maxilla itself [1]. Besides exploiting the periodontal anchorage potential (teeth), additional anchorage aids are often needed to achieve maximal anchorage. The aids conventionally used for intraoral anchorage to enhance periodontal anchorage quality are trans palatal and lingual bars, Nance holding arch and intermaxillary elastics [2]. The anchorage in edgewise treatment is the most important factor that affects the treatment plan and result. Until now, various techniques to reinforce anchorage have been devised and used in orthodontic practice. Recently, several kinds of implant anchors providing absolute anchorage have attracted the attention of orthodontists. Among them, titanium screws, which were originally used for intermaxillary or bone fixation, have the following advantages: minimal anatomic limitation for placement, lower medical cost, simpler placement surgery, and less discomfort after implantation when compared with dental implants for abutment. Therefore, titanium screws of various sizes have gradually come to be used for orthodontic absolute anchorage. However, there have been few human studies in which the success rates for various kinds of implant anchors were examined [3]. Anchorage is a critical component of en-masse retraction. Clinicians pay considerable attention to Newton's third law- the law of action and reaction. They know that every action they take will have an equal and opposite reaction. Many approaches to treatment mechanics have been developed to efficiently retract anterior teeth [4]. In tooth-borne anchorage cases, complicated mechanics or supplementary appliances are needed to control anchorage. Extraoral appliances can provide stable anchorage but depend totally on patient cooperation. Lack of cooperation can result in anchorage loss and unsatisfactory treatment results; these have led to greater use of intraosseous anchorage [5]. It has become more practical to use implants for anchorage in orthodontic patients, Orthodontic screws expand the horizons of orthodontic treatment because they allow treatment to proceed successfully with virtually no anchorage loss and minimal patient cooperation. However, they are typically used as auxiliaries to the posterior anchor teeth during en-masse retraction with sliding mechanics. The mechanics of force application can be simple or complicated, according to the anchorage control. For anterior retraction, if the mini-implants are designed to accommodate arch wires, the number of teeth requiring bands or brackets can be reduced,

Affiliation:

MNR Dental College and Hospital Sangareddy, Telangana, India

***Corresponding author:**

Shaik Mobeen, Department of Oral medicine and Radiology, MNR Dental College and Hospital Sangareddy, India

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moderating the risk of damage to the periodontium or enamel surfaces. Distalization of the maxillary dentition has been recognized as an important treatment approach for the correction of Class II malocclusions and it has been traditionally performed using headgear. However, known disadvantages of headgear appliances include poor aesthetics and dependence on patient compliance. In an attempt to overcome the limitations of headgear, several noncompliance devices such as distal jet and pendulum appliances were introduced. However, they often resulted in undesirable side effects such as extrusion and protrusion of the maxillary anterior teeth and extrusion, distal tipping, and distal rotation of the maxillary first molars [6].

The advent of temporary anchorage devices (TADs) has allowed better control over unwanted reciprocal movement of the anchor units, although miniscrew insertion in the interradicular region is associated with serious limitations, including a short range of action, coupled with the risk of root injury. Miniplates have been advocated as an alternative to avoid contact with adjacent roots in the area of insertion; however, their placement and removal require more invasive surgical procedures.[6]Orthodontics in its century of existence have had a lot of landmarks in its evolution, but very few can match the clinical impact made by micro-implants and the recently introduced infra-zygomatic crest (IZC) and buccal shelf (BS) orthodontic bone screws. Orthodontics in its century of existence have had a lot of landmarks in its evolution, but very few can match the clinical impact made by micro-implants and the recently introduced infra-zygomatic crest (IZC) and buccal shelf (BS) orthodontic bone screws. Many studies have been reported on the application and clinical efficiency of total arch distalization mechanics; however, studies about biomechanical effects such as stress and displacements on the teeth and the surrounding tissues are limited. finite element analysis (FEA), a common method in engineering, became a valuable option for evaluation of biomechanical factors in orthodontics [7,8].

The purpose of this study was to (1) Evaluate three-dimensional stress distribution and initial displacement of maxillary dentition under total arch distalization mechanics for correction of Angle's Class II malocclusion using IZC bone screws and C-Palatal plate appliance in Pre-adjusted Edgewise Appliance (PEA) setup and finite element models and to (2) To compare biomechanical effects of the IZC bone screws and MCPP for total maxillary arch distalization.

Aims and Objectives

To evaluate three-dimensional stress distribution and initial displacement of maxillary dentition under total arch distalization mechanics for correction of sagittal maxillary excess using posteriorly placed infra-zygomatic crest (IZC) bone screws with pre-adjusted edgewise fixed appliance and palatally placed modified C- palatal plate appliance (MCPP).

To evaluate the dental and skeletal effects of the IZC bone screws and MCPP for total maxillary arch distalization in treatment of Angle's class II malocclusion by using finite element analysis.

To compare biomechanical effects of the IZC bone screws and MCPP for total maxillary arch distalization in treatment of Angle's class II malocclusion by using finite element analysis.

Materials and Methods

In this study a maxillary arch was modelled on the basis of their CBCT images._For creating a finite element model, a computer aided design model was constructed from a dry young skull of an approximate age of 18 years. Age estimation was carried out by dental eruption pattern. Human maxillary skull bone without mandible was checked for defects or discontinuity in the craniofacial anatomy. FEM has been applied successfully to study stress and strain in the field of engineering and in living structure. A FEM was created from computed tomography (CT) images of dry skull of an adolescent (slice thickness, 0.5mm) Altair Hyperworks (Altair Engineering Inc., Troy, Michigan, USA) was used.

Study design

- Maxillary digitalized model had been made on the basis of CBCT maxilla model.
- Arch wire size of 0.019x0.025" Stainless steel was inserted into a 0.022x0.028 MBT bracket slot, respectively.
- Finite element study will be done to evaluate changes in center of resistance and stress and strain of maxillary anterior teeth by finite element analysis.

Selection criteria

Inclusion criteria

Adult patient with Angle's class II malocclusion.

Maxillary model with all other permanent teeth present and with 3rd molar missing or extracted.

Exclusion citeria

- Maxillary model comprising of deciduous or mixed dentition.
- Patient should not have any deformities like
    - Cleft lip and Palate
    - Craniofacial deformity

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Material

- A Cone Beam Computed Tomography (CBCT) of the maxillary jaw of fully developed adult skull with maxillary bone was taken.
- CBCT output was taken as an *.stl file & was sent for processing.
- Computer Aided Design (CAD) was constructed using the information of CBCT.
- A Finite Element Model (FEM) will be created with the help of a CAD model.

Procedure

Apply Material Prosperities for Bone, PDL, teeth etc.

A force of 300 grams was applied on either side of the maxilla in **model 1** with infrazygomatic crest bone screws (IZC).

In **model 2** with modified C- palatal plate appliance (MCPP) 300 grams of force was applied on both the sides using elastomeric chains attached to palatal hooks of the MCPP.

Steps involved in the finite element model preparation:

1. Construction of the geometric model of the maxillary dentition with its periodontal structures.
2. (PDL, alveolar bone)
3. Conversion of the geometric models to a finite element model
4. Incorporation of material properties of tooth structure and periodontium
5. Defining boundary condition
6. Loading configuration
7. Translation of results and interpretation

Construction of the geometric model of the maxillary dentition with its periodontal structures (PDL, alveolar bone)

In this study, the geometry of 3D finite element model of the maxilla and mandible with their periodontal structures, i.e., PDL, alveolar bone were constructed from a CBCT scan image of a skull [9]. These data were exported to 3D image processing and editing software- 3D-Doctor (Able Software Corp., Lexington, Massachusetts, USA), stereolithographic (STL) model of each tooth was constructed).

A 0.019x0.025”-Stainless steel last archwire had been inserted in the bracket slot before starting the arch distalization.

Conversion of the geometric models to a finite element model

With the help of GEOMAGIC modelling software, the geometric models were converted into finite element models. The finite element model represents geometry in terms of finite elements and the nodes. This process is called “discretization [10].” In this study, to model the irregular geometry of the teeth for maxilla, 4-noded tetrahedral shape was selected as the finite element.

Incorporation of material properties of tooth structure and periodontium

The material properties of teeth, PDL, and alveolar bone used were the average values reported in literature. All materials employed for the finite element model study were taken to be isotropic, homogenous, and linearly elastic

Construction of Finite Element Model involved the following steps

1. Pre-Processing: As the name says, this is the process before FEA calculations are run. At this step the model was constructed. Mesh were generated. Finally, boundary conditions were applied. Software used at pre-processing stage was Altair Hypermesh.
2. FEA Solver: The Input is processed and the FEA Solver calculates results for the FEM. Software used at solver stage was Altair Optistruct.
3. Post-Processing: This is the stage where results were seen, extracted, reviewed and stored.

All 3 Steps have been shown as a diagram below

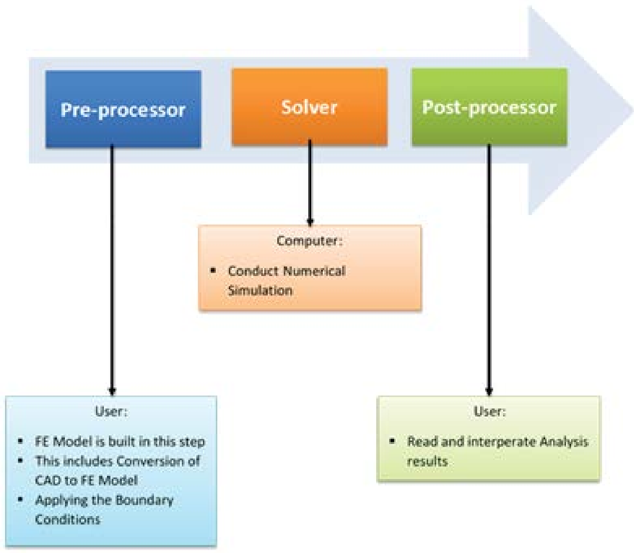

Figure 1: Flow chart showing the steps in the construction of FEA model.

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Generation od CAD Model

- CBCT scan of normal adolescent skull without any skeletal defects, trauma, lesions etc. and with full complement of teeth up to 2nd molar were obtained from the archives of a reputed CBCT scan center.
- Sequential CT images were acquired at xx-mm intervals in the axial direction, parallel to the Frankfort plane. A 3D CAD model was developed employing Mimics software.
- Generation of CAD model is depicted in further slides.
- CAD model of maxilla with the meshing details is shown meshing Slide.
- Mimics software assists in transporting the data, envisions and aids in 3D interpretation and calculating the CT scan details.
- CT scan images processed utilizing Mimics software, were then transported into a stereo-lithography model.
- Files in stereo-lithography (STL) format were converted into FEM model.
- The FEM is composed of an aggregate of small elements that are sufficient to describe the geometry of the subjects. This is called 'creating the mesh or meshing'[11]. The software used for geometric modeling was Altair HyperWorks.
- Computed tomography (CT) scan data of a healthy person with complete permanent dentition and no craniofacial anomaly was used for generating CAD Model.
- The X-ray & Scanning Data was obtained as *.stl format form the Scanning Centre
- This Scanned Data was then imported into **Altair HyperMesh** Software.
- Imported Data was CAD Model used for this FE Simulation.
- Images of this Model is as shown in next slide.

CT Scan Images

- DICOM files were imported into MIMICS & were converted into *.STL file.
- Masking of the model with different bon densities was performed & STL file was exported.

Final CAD model:

From the raw CAD model proper base is formed for the jaw. This is used to apply constraints (fixed support) to the jaw.

This study has 2 models as follows:

Maxillary Model 1: Design consists of IZC bone screws (2mm ×12 mm) with PEA setup.

Maxillary Model 2: Design consists of MCPP with PEA setup.

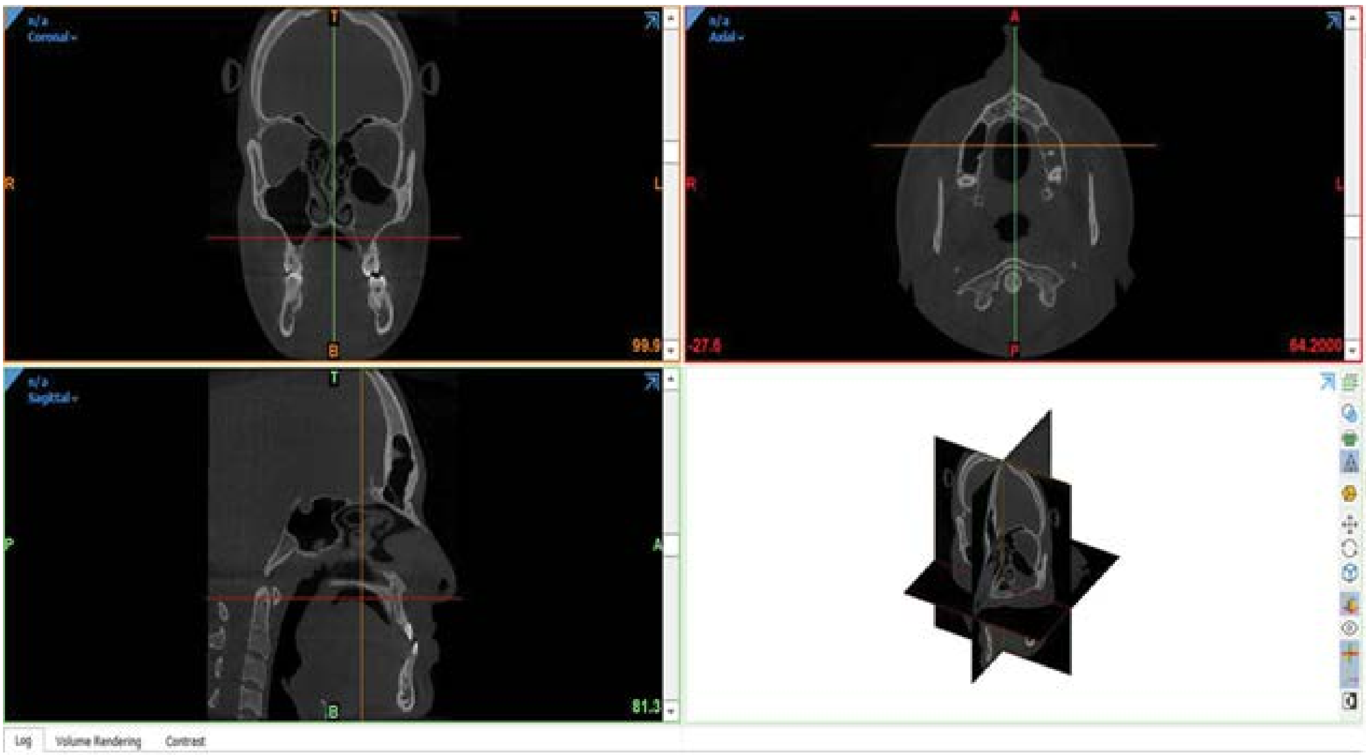

Figure 2: CT scan images.

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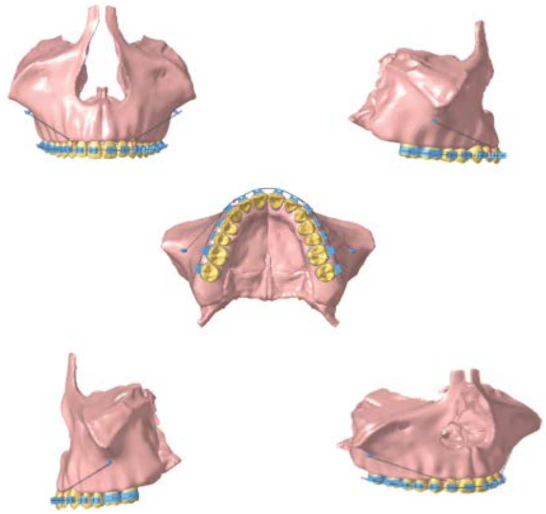

Figure 3: Maxillary Model 1: Design consists of IZC bone screws (2mm ×12 mm) with PEA setup.

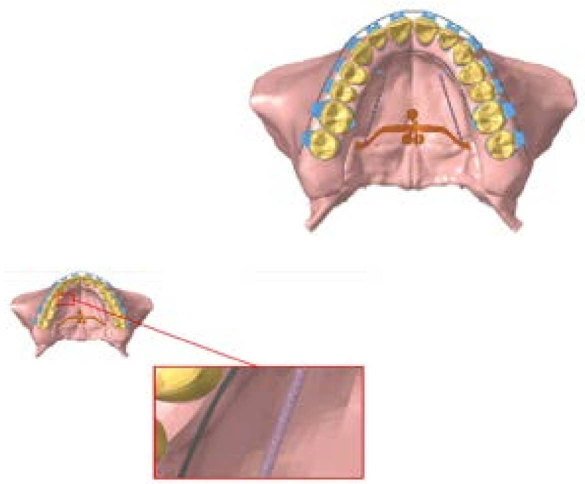

Figure 4: Maxillary Model 2: Design consists of MCPP with PEA setup.

Construction of MBT prescription brackets and archwire

This is the first step in FEM Study for any dental FEA Model Setup. Brackets are aligned and placed first so that there is no bend in the arch wire [12].

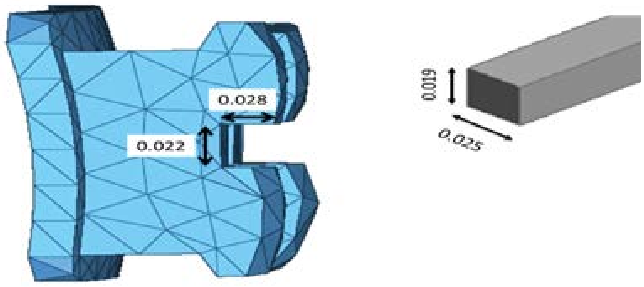

Figure 5: Bracket & Archwire Model (Dimensions are in inches).

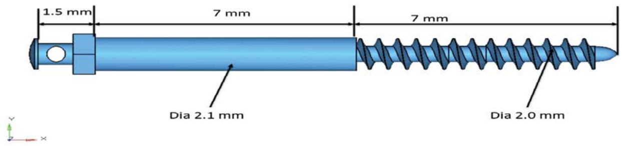

Figure 6: Construction of IZC Screw.

Meshing:

- Subdivide i.e., discretize the complex geometry into suitable set of smaller "elements" of finite dimensions (2D or 3D).
- The points connecting two or more discrete elements are called as nodes or nodal points. The corner nodes are called primary external nodes.
- The additional nodes which occur on the sides of the elements are called secondary external nodes. The secondary nodes have fewer displacement than corner nodes.
- Collection of nodes and element result in formation of element mesh that could be in shape of tetrahedron prism and hexahedron [13]
- Number, size and type of element are decided. Practical knowledge and judgement are needed to limit the number of elements to minimum amount conductive to acceptable results.
- 3D-Tetrahedron elements were used to generate mesh for the maxilla & brackets etc. Archwire was modelled in 3D-Hexhedron.

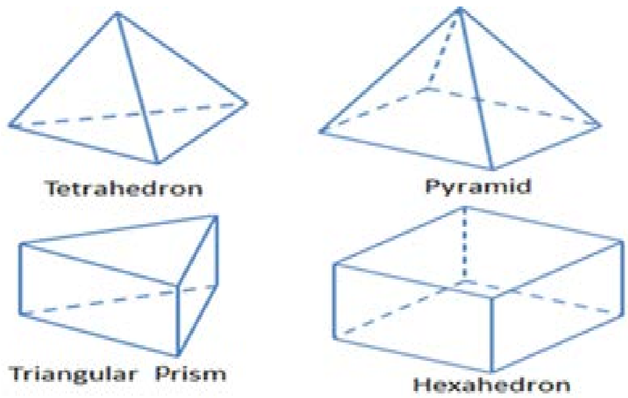

Figure 7: Shapes of nodes seen in FEM during Meshing

Validation of Model

This was a stage for trial RUN of FEA. It was a stage for element quality check. Element qualities like Warpage, Aspect Ratio, Tet Collapse were checked & required modification were done in the model to improve the element quality.

Local re-meshing in some areas was considered to improve

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the overall mesh quality of the Finite Element Model[14]. All this was done to ensure generated mesh/element quality is within acceptable limit for FEA Solver. This process was performed for both Maxilla models.

Application of Boundary Conditions

Boundary Conditions define the way model is held or fixed in the FE space & the way forces are applied on the model.

Fixing the Model

Jaw Bone (Maxilla) need to be fixed at a point in FEA. Following images gives details on how the model was fixed in this study.

As per FEM, nodes on the selected surfaces were locked in all Degrees of Freedom. This restricted the displacement of these nodes in all direction. This way model was locked / fixed in the FEA space for solving [15].

Fixing Maxilla in FEA

Red path in image below for maxilla shows the location where nodes were locked in all degrees of freedom. This is the top face of the maxilla cast.

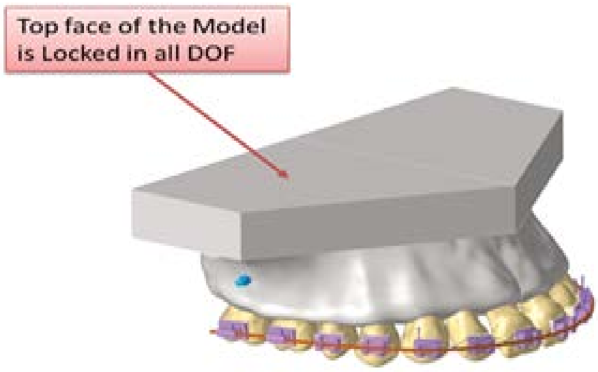

Figure 8: Top face of the maxilla.

Orthodontic Force Application:

Model – 1:

- 300 grams of force per side will be used for total maxillary arch distalization.
- As it is an IZC bone screws based distalization, 300 grams of equal force will be applied on both the sides of the maxilla.

Model – 2:

- In model 2 with modified C- palatal plate appliance (MCPP) 300 grams of force will be applied on both the sides using elastomeric chains attached to palatal hooks of the MCPP.

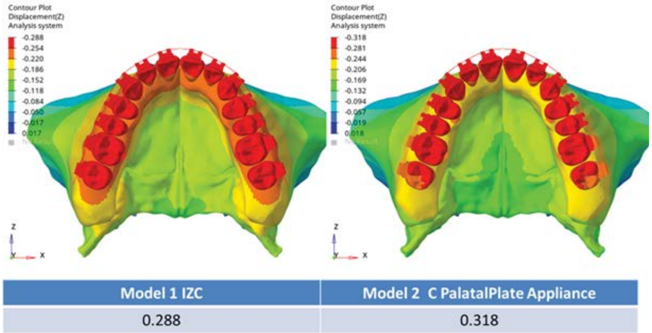

Figure 9: Occlusal views showing displacement of teeth and bone assembly.

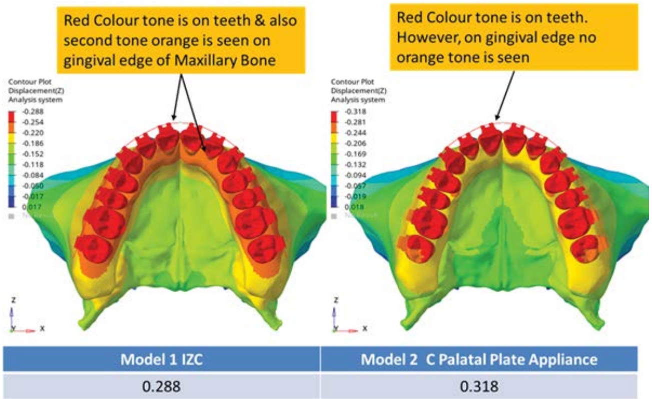

Figure 10: Occlusal views showing displacement of teeth and bone assembly.

Results

FEA displacement result explanation:

Displacement results:

Displacement plotted on same scale:

From above figure we can draw some conclusion. However, the images are brought on same scale for comparison. 2nd value on scale is set at 0.25 mm which is common for both the models. With this change we see both the models have same or similar displacement pattern.

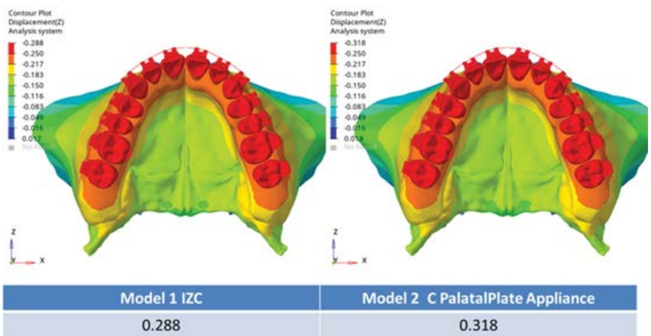

Figure 11: Occlusal views showing displacement of teeth and bone assembly.

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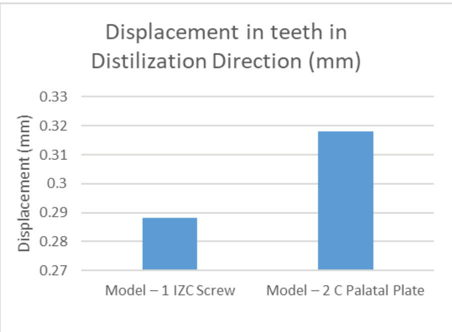
As both images now have same pattern, we can say that the model with modified C - palatal plate appliance is having higher distillation compared to IZC bone screw. We see the same in result table for Displacement.

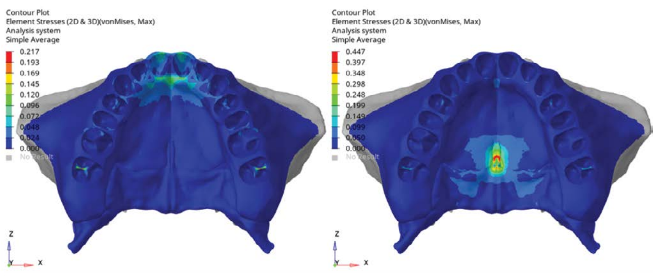
Table 4: Displacement in teeth in Distillation Direction in model 1 and 2

Maxillary Models	Displacement in teeth in Distillation Direction (mm)
Model – 1 IZC Screw	0.288
Model – 2 C Palatal Plate	0.318

We can see from above table that displacement in C Palatal Plate is about 9% higher than in IZC Screw. This means that the C Palatal Plate will have higher / faster distillation compared to IZC in clinical practice.

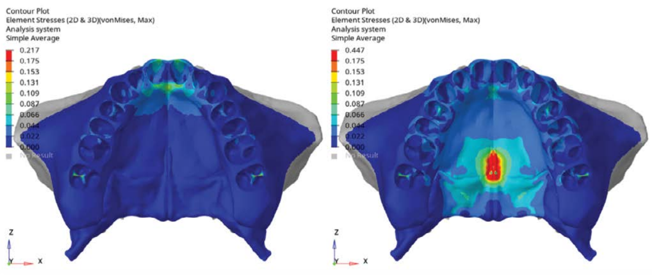


Graph 1: Displacement graph in distalization directionFEA Stress Result Explanation



Model 1 IZC	Model 2 C Palatal Plate Appliance
0.217	0.447

Figure 12: Occlusal view showing Von. Mises Stress for Maxilla with both IZC & modified C - palatal plate Appliance.

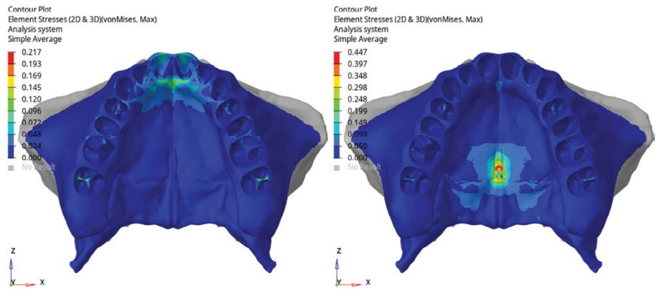


Model 1 IZC	Model 2 C Palatal Plate Appliance
0.217	0.447

Figure 13: Plotting the same Von. Mises Stress on same scale plot for better comparison.

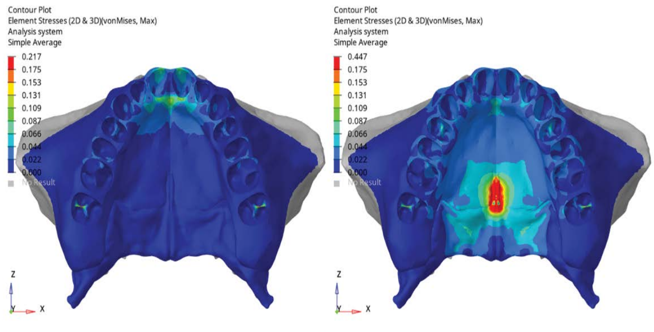
FEA Stress Result Explanation

Following image shows Von. Mises Stress for Maxilla with both IZC & modified C - palatal plate Appliance.



Model 1 IZC	Model 2 C Palatal Plate Appliance
0.217	0.447

Just as we did for displacement results, we are plotting the same Von. Mises Stress on same scale plot for better comparison and following are the result images.



Model 1 IZC	Model 2 C Palatal Plate Appliance
0.217	0.447

From the Von. Mises Stress for maxilla in same scale we see following observations:

- Max. Stress in C - palatal plate is almost double of max. Stress in IZC Screws; 0.217 MPa and 0.447 MPa respectively.
- However, the Max stress in C - palatal Model is more concentrated at the palatal region where we got the anchoring screws of the appliance.
- We have observed that the stress concentrated at the anterior region of the maxilla in IZC Model. But, in C - palatal plate Model it is spread evenly across all teeth.

We can see the similar results for Compression & Tension Stress.

- From the above table we can see that Von. Mises Stress in infrazygomatic crest bone screws (IZC) is almost 49% of that in modified C - palatal plate appliance (MCPP). Tension stress is also 45% in IZC that of MCPP.
- Compression Stress in IZC model is 26% that of MCPP.

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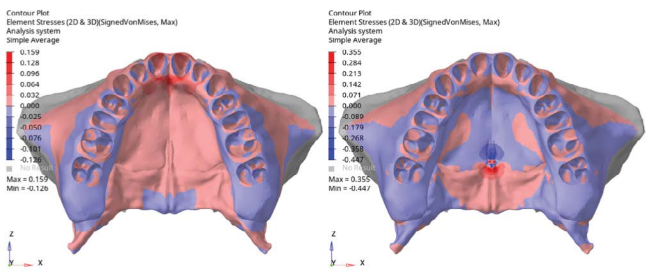

Model 1 IZC	Model 2 C Palatal Plate Appliance
Tension = 0.159 Compression = 0.126	Tension = 0.355 Compression = 0.447

Table 4:

Maxillary Models	Stress in Mpa		
	Von. Mises in Jaw Bone	Tension Stress	Compression Stress
Model – 1 IZC bone Screw	0.217	0.159	0.126
Model – 2 Modified C Palatal Plate Appliance	0.447	0.355	0.477
% Difference	49%	45%	26%

- From the above table we can see that Von. Mises Stress in infrazygomatic crest bone screws (IZC) is almost 49% of that in modified C - palatal plate appliance (MCPP). Tension stress is also 45% in IZC that of MCPP.
- Compression Stress in IZC model is 26% that of MCPP.

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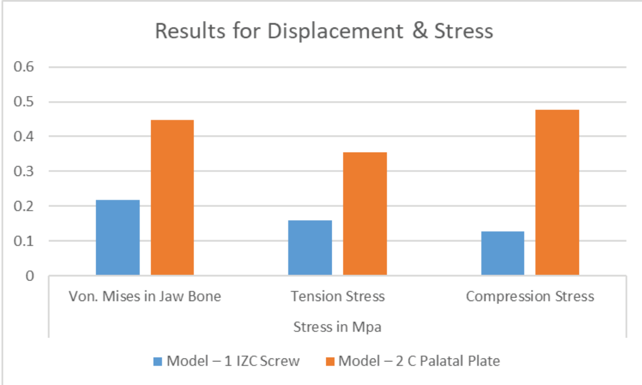

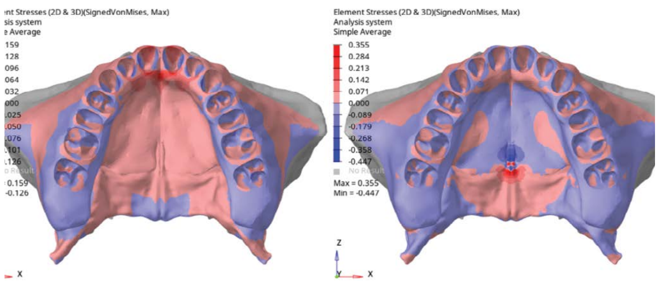

Model 1 IZC	Model 2 C Palatal Plate Appliance
Tension = 0.159 Compression = 0.126	Tension = 0.355 Compression = 0.447

Figure 16: Occlusal view showing tension and compression stress in model 1 and 2.

Table 5: Tension and compression stress in model 1 and 2.

Maxillary Models	Stress in Mpa		
	Von. Mises in Jaw Bone	Tension Stress	Compression Stress
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% Difference	49%	45%	26%

We can see the similar results for Compression & Tension Stress.

Miniscrews are commonly used for anchorage in distal movement of the maxillary dentition for treatment of Class II malocclusion, because of their advantages of minimal anatomic limitation, simple placement, and limited complications. Placement of miniscrews in the buccal interradicular region is one of the most common approaches used in distal tooth movement. Although the interradicular miniscrews may reduce complications related to soft tissue irritation, the limited interradicular space can obstruct tooth movement. Therefore, the infrazygomatic crest region is frequently selected for miniscrew insertion, because it not only has the thickest maxillary cortical bone but also is far

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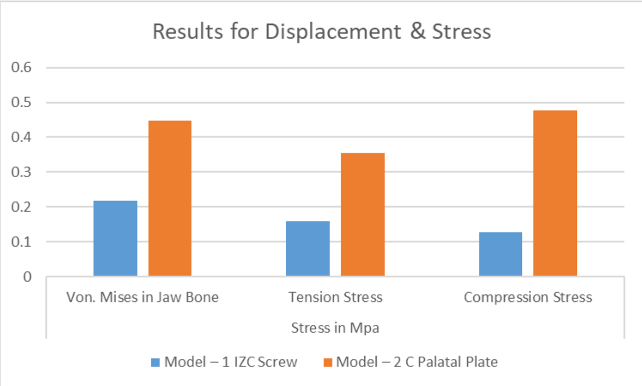

Graph 2: Displacement and Stress result graph in model 1 and 2.

from the dentoalveolar region [16]. The anatomic advantages of the infrazygomatic crest region contribute to better primary stability of miniscrews and provide the possibility for unobstructed tooth movement. However, because no well-accepted insertion protocol or sophisticated assistive device has been available for operators, anatomic research is needed for safe miniscrew insertion in this region. The FEM has been widely used in engineering; however, its application to the health sciences is relatively new, and because of multiple variables in real life, certain approximations and assumptions are needed [17]. The results of this study were obtained from a simulated model, from which biologic variabilities may occur. The resultant values should be interpreted only as a reference to aid clinical judgment. The limitations of the 3D FEM model include approximations in the material behaviours and shapes of the tissues."

Venkateswaran S, Rao V and Krishnaswamy NR. performed a study to describe the challenges of anchorage conservation in orthodontics, especially when multiple teeth are moved simultaneously. Headgear and intermaxillary elastics have traditionally been used in such situations, despite the unpredictability of headgear, the side effects of incisor extrusion and excessive rotation of the occlusal plane from Class II or Class III elastics, and the difficulty of obtaining patient compliance [18].

A finite element method was used for modelling maxillary teeth and bone structure. Brackets, wire, and hooks were also designed for modelling. Two appropriate positions for mini screw in the mesial and distal of the second premolar were designed as fixed nodes. Forces were applied from the mini screw to four different levels of anterior hook height: 0, 3, 6, and 9 mm. Initial tooth movement in eight different conditions was analysed and calculated with ANSYS software.

They concluded that according to the findings of their study, the best control in the sagittal plane during anterior en masse retraction was achieved by mesial placement of the mini screw and the 9-mm height of the anterior power arm. Where control in the vertical plane was concerned, distal placement of the mini screw with the 6-mm power arm height had minimum adverse effect on anterior dentition.

Many studies have been conducted on the application and clinical efficiency of total maxillary arch distalization mechanics [19]; however, studies about biomechanical effects such as stress and displacements on the teeth and the surrounding tissues are limited. In-vivo studies are not quite sufficient in assessing biomechanical effects such as stress and displacement, finite element analysis, a common method in engineering, became a valuable option for evaluation of biomechanical factors in orthodontics.

The purpose of the study was to evaluate three-dimensional stress distribution and initial displacement of maxillary dentition under total arch distalization mechanics for correction of maxillary excess using posteriorly placed infra-zygomatic crest (IZC) bone screws - Model 1and modified C – palatal plate appliance (MCPP) – Model 2. Two geometric Maxillary models converted into finite element models; Model 1 and Model 2 with PEA setup.

Force levels for Model 1 with IZC bone screw includes total of 300 grams on either side of maxillary posterior segment and in Model 2 with modified C- palatal plate appliance (MCPP) 300 grams of force was applied on both the sides using elastomeric chains attached to palatal hooks of the MCPP.

Results showed that in the Model 1 with PEA setup the Von. Mises Stress in infrazygomatic crest bone screw (IZC) is almost 49% of that in Model 2 with modified C – palatal plate appliance (MCPP). Tension stress is also 45% in IZC of that in MCPP. Compression Stress in IZC model is 26% of that in MCPP.

Present study results showed that the displacement in modified C-palatal plate appliance (0.318 mm) is about 9% higher than in IZC screw (0.288). Von Mises stress in MCPP is 0.447 mm and the IZC is 0.217mm. Tension stress (mPa) in MCPP is 0.355 mm and 0.159 mm in IZC Screw. Compression stress in MCPP is 0.477mm and IZC screw is 0.126 mm.

To conclude **Model 1** and **Model 2** design provided an effective en masse distalization of the full maxillary arch. This study has shown that the displacement in MCPP is more than the IZC screw and the stress in MCPP is higher than the IZC screw. The study also shows that en masse distalization as a treatment option was predominantly chosen in late adolescence and young adults by using MCPP and IZC for treating class II div 1 malocclusion [20].

Conclusion

The study concluded that the modified C-palatal plate appliance (MCPP) anchorage showed significant en mass distalization of the maxillary arch. However, this was not significantly different from the Infrazygomatic crest (IZC) bone screws.

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The displacement in modified C - palatal plate is about 9% higher than in IZC Screw. This means that the MCPP will have higher / faster distalization compared to IZC bone screws in clinical practice.

The posterior alveolus of the palate is a good alternative site for implant placement to bring about distal movement of the entire maxillary arch. The biomechanics involved appears to produce good treatment results with less risk of mini-implant failure and lesser need for repeated procedures.

Therefore, these results suggest that clinicians should consider using modified C – palatal plate appliance, especially in noncompliant Class II adolescent patients.

References

1. Fidler BC, Artun J, Joondeph DR, et al. Long-term stability of Angle class II, division 1 malocclusion with successful occlusal results at the end of active treatment. Am J Orthod Dentofacial Orthop 107 (1995): 276-285.
2. Wehrbein H, Glatzmaier J, Mundwiller U, et al. The Orthosystem-a new implant system for orthodontic anchorage in the palate. J Orofac Orthop 57 (1996): 142-153.
3. Miyawaki S, Koyama I, Inoue M, et al. Factor associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Orthod Dentofacial Orthop 124 (2003): 373-378.
4. Chung KR, Nelson G, Kim SH, et al. Severe bi-dento alveolar protrusion treated with orthodontic micro-implant-dependent en-masse retraction. Am J Orthod Dentofacial Orthop 132 (2007): 105-115.
5. Hedayati Z, Shomali M. Maxillary anterior en masse retraction using different antero-posterior position of mini screw: a 3D finite element study. Prog Orthod 17 (2016): 31.
6. Park CO, Sa'aed NL, Bayome M, et al. Comparison of treatment effects between the modified C-palatal plate and cervical pull headgear for total arch distalization in adults. Korean J Orthod 47 (2017): 375-383.
7. Ghosh A. Infra-zygomatic crest and buccal shelf - Orthodontic bone screws: A leap ahead of micro-Implants–Clinical perspectives. J Indian Orthod Soc 52 (2018): S127-141
8. Shoaib AM, Park JH, Bayome M, et al. Treatment stability after total maxillary arch distalization with modified C-palatal plates in adults. Am J Orthod Dentofacial Orthop 156 (2019): 832-839.
9. Gracco A, Lombardo L, Cozzani M, et al. Quantitative cone-beam computed tomography evaluation of palatal bone thickness for orthodontic miniscrew placement. Am J Orthod Dentofacial Orthop 134 (2008): 361-369.
10. Chung KR, Choo H, Kim SH, et al. Timely relocation of mini-implants for uninterrupted full-arch distalization. Am J Orthod Dentofacial Orthop 138 (2010): 839-849.
11. Park JH, Saito T, Yoo SK, et al. Distalization with a modified C-palatal plate for severe upper crowding and a missing lower incisor. Korean J Orthod 50 (2020): 52-62.
12. Chang CH, Lin LY, Roberts WE. Orthodontic bone screws: A quick update and its promising future. Orthod Craniofac Res 1 (2021): 75-82.
13. Alfaifi M, Park JH, Tai K, et al. Comparison of Treatment Effects with Modified C-Palatal Plates vs Greenfield Molar Distalizer Appliances in Adolescents. J Clin Pediatr Dent 44 (2020): 202-208.
14. Bechtold TE, Kim JW, Choi TH, et al. Distalization pattern of the maxillary arch depending on the number of orthodontic miniscrews. Angle Orthod 83 (2013): 266-273.
15. Paul P, Mathur AK, Chitra P. Stress distribution patterns in mini-implant and bone in the infra-zygomatic crest region at different angulations: A finite element study. J World Fed Orthod 10 (2021): 29-34.
16. Park JH, Kim S, Lee YJ, et al. Three-dimensional evaluation of maxillary dentoalveolar changes and airway space after distalization in adults. Angle Orthod 88 (2018): 187-194.
17. Murugesan A, Sivakumar A. Comparison of bone thickness in infrazygomatic crest area at various miniscrew insertion angles in Dravidian population - A cone beam computed tomography study. Int Orthod 18 (2020): 105-114.
18. Lima A Jr, Domingos RG, Cunha Ribeiro AN, et al. Safe sites for orthodontic miniscrew insertion in the infrazygomatic crest area in different facial types: A tomographic study. Am J Orthod Dentofacial Orthop 161 (2022): 37-45.
19. Chou AHK, Park JH, Shoaib AM, et al. Total maxillary arch distalization with modified C-palatal plates in adolescents: A long-term study using cone-beam computed tomography. Am J Orthod Dentofacial Orthop 159 (2021): 470-479.
20. Kook YA, Park JH, Kim Y, et al. Sagittal correction of adolescent patients with modified palatal anchorage plate appliances. Am J Orthod Dentofacial Orthop 148 (2015): 674-684.

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