Research Article

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Comparision of Efficiency of MBT and Butterfly Brackets: An FEM Study

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ABSTRACT

Background: Several studies have been carried out to investigate various biomechanical factors affecting tooth movement in sliding mechanics, such as the flexural rigidity of the arch wire, friction, and height of the retraction force. The aim of the study was to compare the effect of MBT and butterfly bracket slot and arch wires for anterior tooth movement during space closure in sliding mechanic using FEM model.

Materials and Method: The 3D FE model had the combination of brackets with 0.022 x 0.028-in slot brackets and a 0.019 X 0.025-in arch wire and the other had 0.022 X 0.28 butterfly brackets with 0.019 X 0.025 in arch wire.. Retraction force of 150 g was applied in both models

Results: The results of this study showed that retraction using MBT brackets were more efficient than Butterfly brackets in anterior tooth movement with sliding mechanics

Conclusion: Thus it was concluded from the present study that MBT brackets are more efficient than butterfly brackets in anterior tooth movement and in closure of extraction space.It was observed that maximum displacement was seen on lateral incisor region.

Keywords: MBT brackets, Butterfly system, Sliding mechanics, FEM.

INTRODUCTION

The demand for speedy, effective, and accurate orthodontic treatment systems has increased to shorten the treatment period. In addition to this system, sliding mechanics with the combined use of power arms has gradually been applied for obtaining controlled anterior tooth movements during space closure. Several studies have been carried out to investigate various biomechanical factors affecting tooth movement in sliding mechanics, such as the flexural rigidity of the arch wire, friction, and height of the retraction force. A few attempts with the finite element (FE) method have been reported on tooth displacement when a single canine retraction or an en-masse retraction is performed in sliding mechanics. There are only few studies that simulate en-masse retraction when brackets were modelled and a coefficient of friction was given to the interface between bracket slots and an arch wire including contact-sliding problems. It was found that the anterior tooth movement varied depending on the amount of arch wire/bracket play.

In sliding mechanics, in 2-step retraction, which involves canine retraction with sliding mechanics, mechanical simulation by using a finite element method has been carried out, and the forces transferred to the teeth have been estimated.

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The results showed that friction had no effect on the movement ratio of the canine and anchor teeth. The friction acted not only on the canine but also on the anchor teeth. The latter friction prevented the anchor teeth from moving.[1] Studies of various biomechanical factors affecting tooth movement in sliding mechanics such as flexural rigidity of the arch wire, friction, and height of retraction force have been reported. Nevertheless, optimal loading conditions for controlled movement of anterior teeth in sliding mechanics by using power arms is still not fully understood

The Butterfly System is based on a new low-profile, twin-wing bracket. The bracket's reduced profile, its miniature twining design and rounded tie wings, and the elimination of standard hooks results in an appliance that is more comfortable, esthetic, and hygienic[2].

AIMS AND OBJECTIVES

The study will be conducted with the following aims and objectives:

- To compare the effect of MBT and butterfly bracket slot and arch wire for anterior tooth movement during space closure in sliding mechanics.
- To draw an inference from the above results.

MATERIALS AND METHODS

SOURCE OF DATA

The data was collected from previous records of patients reported for investigations

MATERIALS

Computed tomography scan of 14 maxillary teeth was taken as DICOM data

METHODS

The sample size was two models

Case 1: Ormco MBT bracket

Case 2: American orthodontics Butterfly bracket

PROCEDURE

Computed tomography images of the 14 maxillary teeth, taken with a multi-image cone-beam computed tomography scanner, will be saved as DICOM data and exported to three dimensional image processing and editing software. The 3D solid model was created and converted to a 3D FE model using FE analysis preprocess and postprocess software. Each 3D FE model for the periodontal ligament (PDL), alveolar bone, bracket, arch wire, and power arm was separately constructed using the same software. The PDL had a uniform thickness of 0.2 mm. The bracket height of the maxillary central incisor was placed according to a prescription, which was 4.5 mm in height from the incisal edge of the tooth. [4]

The study was designed in two parts

1. Generation of finite element model.
2. Analysis of the models for determining the displacement of anterior and posterior Segments and change in orientation of occlusal plane with mini implants.

1. GENERATION OF FINITE ELEMENT MODEL

Finite element model is a representation of geometry in terms of a finite number of elements and these are the building blocks of numerical representation of the model. The "elements" present are of finite number as opposed to the theoretical model with complete continuity. The object of interest has to be broken up into a "meshwork" that consists of nodes. A "node" is a specific point in the finite element at which the value of the field variable is to be explicitly calculated. Exterior nodes are located on the boundaries of the finite element and may be used to connect an element to adjacent finite elements. Nodes that do not lie on element boundaries are interior nodes and cannot be connected to any other element.[32] these nodes then connected to form a system of elements. By knowing the mechanical properties of the object such as Modulus of elasticity and Poisson's ratio, one can determine how much distortion each part of the element undergoes when other part is moved by force. Steps involved in the Generation of Finite Element Model includes

a. Construction of a geometric model
b. Conversion of the geometric model to a finite element model
c. Material property data representation
d. Defining boundary condition

2. STEPS IN ANALYSIS OF THE MODELS

a. SOLVING THE SYSTEM OF LINEAR ALGEBRAIC EQUATION

Table 1: Details of Nodes and elements; Case 1

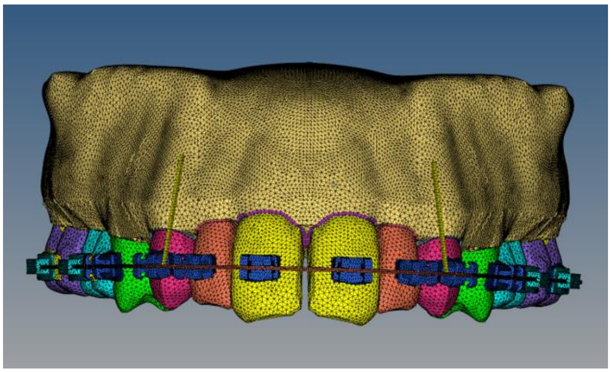
Part Name	No. Of Nodes	No. Of Elements
Bone	100801	470585
Teeth	65172	311124
Brackets	9450	26890
Wire and hook	5334	11625

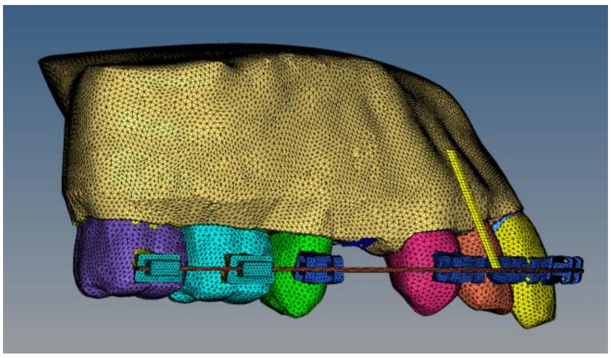
Table 2: Details of Nodes and elements; Case 2

Part Name	No. Of Nodes	No. Of Elements
Bone	100801	470585
Teeth	65172	311124
Brackets	8890	26018
Wire and hook	5334	11625

COLOUR PLATE – 1

Fig 1: CASE 1

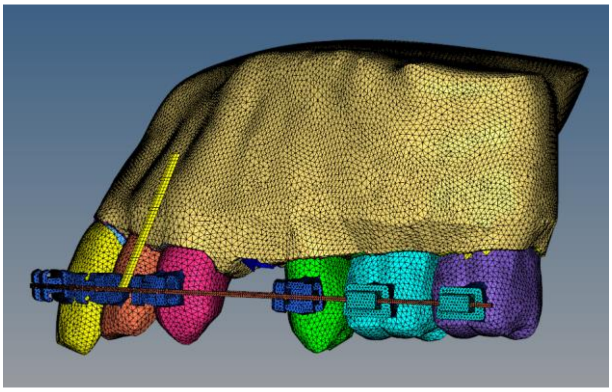




b. APPLICATION OF FORCE

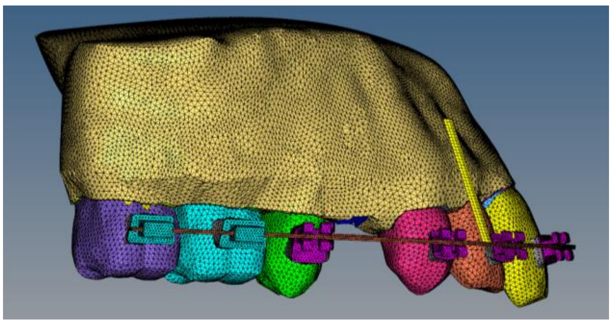
Hardware details

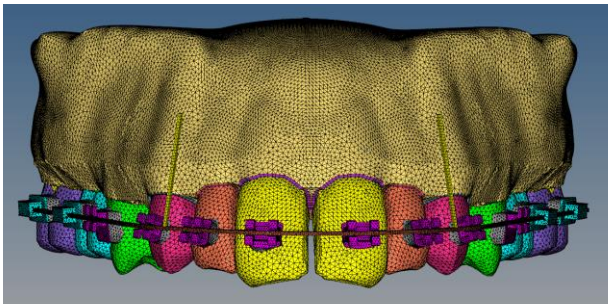
- Intel core 2 duo processor
- 4GB ram
- 320GB hard disk

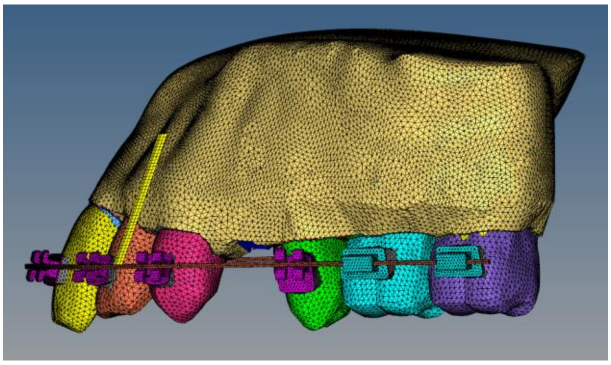


COLOUR PLATE – 2

Fig 1: CASE 2







RESULTS

In the present study, two different finite element models of maxilla with right first molar to Left first molar teeth were studied to evaluate and compare the effectiveness of en mass retraction using conventional MBT brackets and butterfly brackets using finite element Analysis. In first and second models 0.019”×0.025” stainless steel arch wires were used for sliding mechanics and implant supported retraction. All the models were placed with .022” PEA Metal brackets.

In both models, a retraction force of 150 g was applied to analyse the displacement of anterior segments. The (+) positive and (-) negative values in the results show the forward and backward movement of the dentition in anteroposterior direction.

Table 3: Retraction using sliding mechanics with conventional MBT brackets (All the values are in millimetres)

DISPLACEMENT REGION	MINIMUM	MAXIMUM
CENTRAL INCISOR	0.001073	0.001341
LATERALS	0.001609	0.002414
CANINE	0.001073	0.001609

Table 4: Retraction using sliding mechanics with Butterfly brackets (All the values are in millimetres)

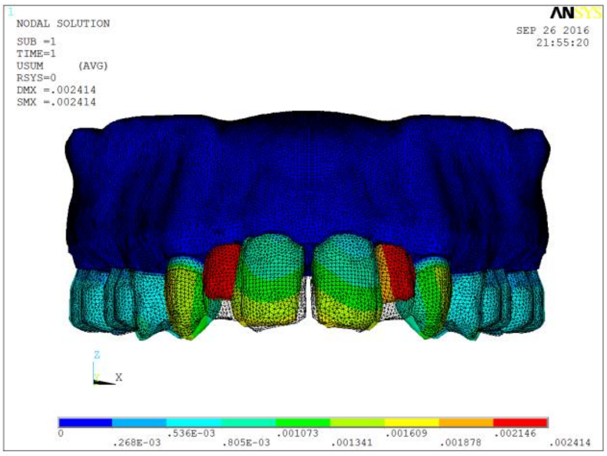
DISPLACEMENT REGION	MINIMUM	MAXIMUM
CENTRAL INCISOR	0.001198	0.001797
LATERALS	0.004192	0.00539
CANINE	0.002395	0.002994

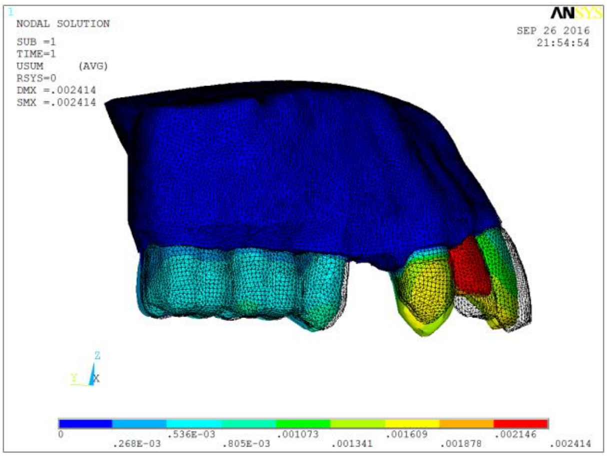
Table 5: Table for comparison of displacement of anterior teeth by sliding mechanics, with MBT and Butterfly brackets

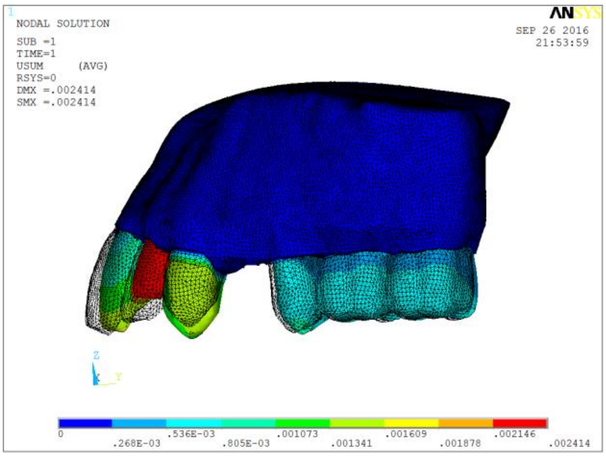
MECHANICS	MBT Bracket		Butterfly bracket	
	DISPLACEMENT		DISPLACEMENT	
REGION	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
CENTRAL INCISOR	0.001073	0.001341	0.001198	0.001797
LATERALS	0.001609	0.002414	0.004192	0.00539
CANINE	0.001073	0.001609	0.002395	0.002994

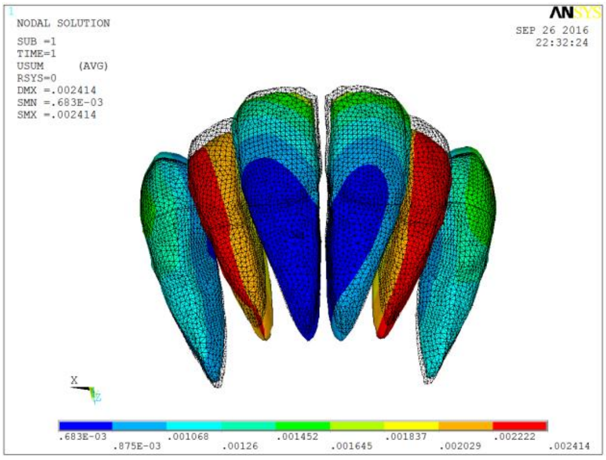
COLOUR PLATE – 3

Fig 1:CASE 1



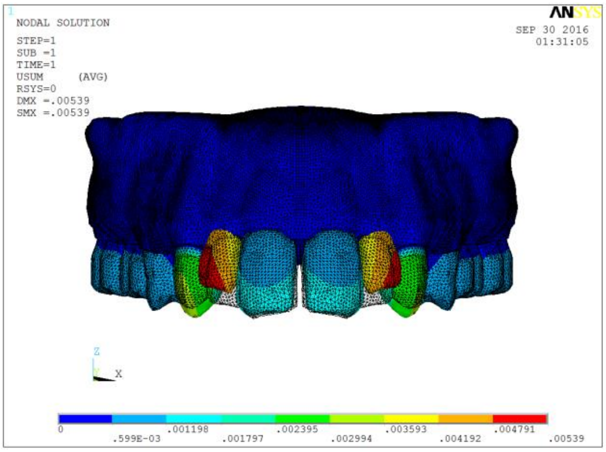


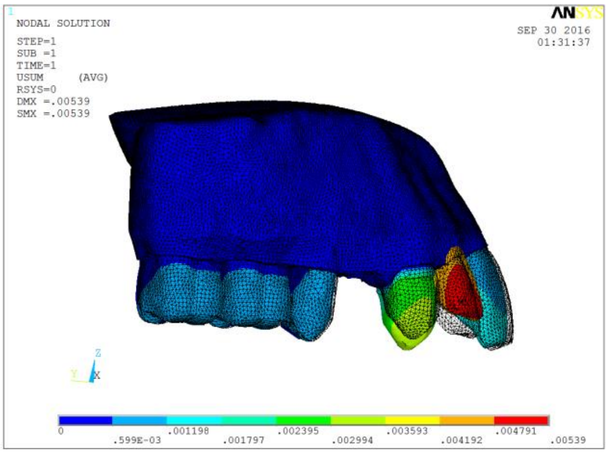


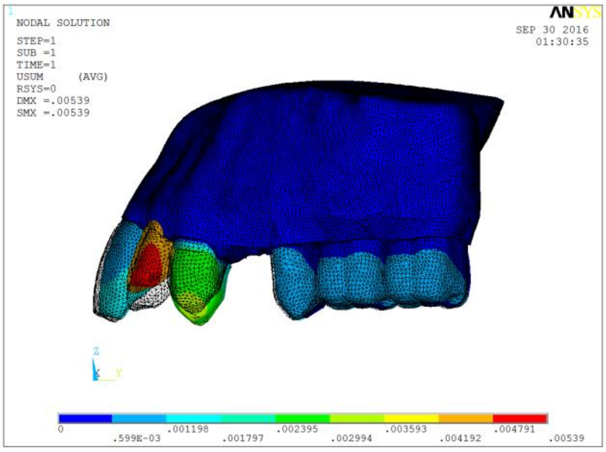


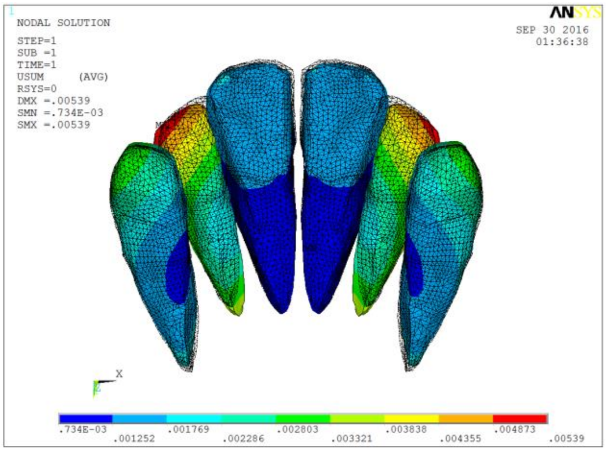
COLOUR PLATE –4

CASE 2









DISCUSSION

When long power arms were used, a substantial amount of bending moment is generated at the portion of the arch wire where the power arms were attached as a cantilever effect.[5] Finite element methods have been used to calculate stress in the PDL under initial tooth movement the most important factor affecting tooth movement is the bone remodelling law that describes the relationship between the apposition of the alveolar bone and the mechanical stimulus. An excessive orthodontic force produces hyalinization of the PDL and undermines bone resorption, impeding efficient bone remodeling[6]

Retraction using MBT brackets represented case I. Second molars were also included in the study in all the models. With the application of 150 g of force from the retraction hook in the anterior region (between lateral incisors and canines) to the first molar, it was observed the minimum displacement of 0.001073 was observed in central were as 0.02414 in the laterals region.

The co-ordinates locations of finite element nodes were defined by referring to a reference system, either local or global. The local systems are local coordinate systems specifically created by the user (pre /post-processing software for Finite Element Analysis (FEA), providing solid modelling, meshing, and analysis setup and post-processing for multiple solvers including MSC Nastran, Marc, Abaqus, LS-DYNA, ANSYS, and Pam-Crash[7] Case II represented the retraction using butterfly bracket with 150g of force. It was observed that minimum displacement was observed in central incisor region with value of 0.001198 and maximum displacement is in the region of lateral incisor with value of 0.00539.

Compared to MBT brackets, the anterior displacement was less in butterfly brackets as described above. This indicated that tipping and bodily movement of anterior teeth is more with conventional MBT brackets .The reasons can be attributed to presence of power arm near the center of resistance of anterior teeth also.

CONCLUSION

The present study was conducted to check the efficiency of anterior tooth movement during space closure using sliding mechanics with MBT and Butterfly brackets. Thus it was concluded from the present study that MBT brackets are more efficient than butterfly brackets in anterior tooth movement and in closure of extraction space. It was observed that maximum displacement was seen on lateral incisor region.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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