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To evaluate the effects of varying positions and heights of power arms and locations of temporary anchorage devices in sliding mechanics on en-masse retraction of maxillary anterior teeth: A FEM study

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Abstract

Introduction: To get controlled movement of anterior teeth the present study was used to determine and evaluate the efficiency of the varying positions and heights of power arm (PA) as well as the effect of varying locations of Temporary Anchorage Devices (TAD_S) on en-masse retraction of maxillary anterior teeth in sliding mechanics by employing a Finite Element Method.

Methods: A 3D Finite Element Method (FEM) was used to simulate en-masse anterior teeth retraction in sliding mechanics. The degree of Bucco palatal tipping of the maxillary anterior teeth was calculated when the retraction force was applied to different heights of a power arms and set mesial or distal to the canine and different locations of powerarm with varying different positions of TAD_S.

Results: Initially all teeth showed maximum palatal crown tipping than palatal root tipping. As the height of power arms and TAD_S increases correspondingly palatal root tipping increases. When PA placed mesial to canine at 8 mm,

10 mm,12 mm of heights from archwire and TAD_s at 10 mm,8 mm,6 mm respectively from achwire bodily movement of maxillary anterior teeth occurred. However when PA placed distal to canine at 10mm and TAD_s at 6mm and 8mm from arch wire bodily movement occurred.

Conclusion: To achieve better controlled movement during sliding mechanics use of power by varying height and positions and by varying locations of TAD_s speeds orthodontic results. Use of power arm makes the unit more stable and stronger. Use of TAD_s achieved maximum anchorage than conventional method during maxillary anterior teeth retraction.

Keywords: Sliding mechanics; Power arm; Anterior teeth retraction; Finite Element Method; Deformation of Archwire.

Introduction

Movement of teeth occurs in all three planes of space. In order to achieve desired results in orthodontics, it is essential to control tooth movement in all spaces. Tooth movement can be classified as tipping, translation, torqueing and rotation. This classification is based on the movement to force ratio, which in turn depends on the distance between line of action of force and centre of resistance.

In extraction space closure controlled tooth movement is required. Space closure can be carried out either by sliding or loop mechanics. Sliding mechanics utilizes the force element tied to the Power Arm. The controlled movement of anterior teeth can be readily achieved using Power Arm(PA) attached to arch wire by varying heights and position of PA, force system for desired type of tooth movement like palatal crown tipping, palatal root tipping or bodily movement can be easily achieved[1,2]. Slidding teeth in combination with implant anchorage has become more and more popular throughout the world[3].

The present study intended to find the effects on maxillary anterior teeth during en-masse retraction using sliding mechanics by varying positions and height of PA and locations of Temporary Anchorage Devices (TAD_S) by Finite Element Method(FEM).

Materials And Methods

Materials utilized were a dry skull, PEA MBT extraction series bracket of slot size 0.022 x 0.028’’ (3M unitek, USA), molar tubes,0.019 x 0.025’’ Stainless Steel arch wire(Quality Ortho),Temporary Anchorage Devices (TADs) of 1.6 x 8 mm dimension, NiTi closed coil spring as force element.

Laser scanning of dry skull was done to obtain 3D scan. This 3D image was utilized to generate a FEM Model of maxilla with the help of FEM software Optistruct. Model consisted of maxilla , all maxillary teeth up to 3rd molar ,pdl and alveolar bone. The FEM Model was directed in to number of small elements and nodes with the use of Hypermesh software. The different entities involved in the study like teeth, PDL, alveolar bone, Stainless Steel brackets, archwire and titanium microimplants (TADs) were assigned specific material properties as follows:

Material	Young’s Modulus($n/mm^{2)}$	Poisson’s Ratio
teeth	20300	0.30
PDL	0.667	0.49
alveolar bone	1.37E+04	0.38
stainless steel	2.1E+05	0.3
titanium	1.1E+05	0.342

Boundary conditions was defined to simulate, how the model was constrained and to prevent it from free body motion. The nodes attached to the bone shall get fixed in all direction to avoid free body movement of the tooth. In the FEM model extraction space of first premolar was created , A computer program was used to refine the geometric morphology and the 3- D alignment of the teeth by manipulating key points. The corrected morphology and alignment of tooth model can be visualized and inspected in the finite element program. 0.022 MBT brackets on all the teeth except molars which had tubes.0.019 x 0.025” SS wire will be inserted in the segment. Altair Hypermesh for windows was used to fuse the model of maxilla with maxillary teeth, brackets, wire, power arm and TADs. Power arm of 0 mm, 2 mm, 4 mm, 6 mm, 8 mm, 10 mm, 12 mm of height placed mesial to canine or distal to canine from archwire.TAD_S of 8mm length and 1.6mm in diameter, TAD_s placement site at 6mm,8mm,10mm from bracket slot, with an angulation during its insertion: 30º to the long axis of 2nd Premolar.The retraction force magnitude of 150g was applied bilaterally from anterior to posterior to evaluate the resultant tooth movement. To check the effect of retraction force on en-masse retraction of maxillary anterior teeth movement either it is palatal crown tipping, palatal root tipping or bodily movement by using varying heights and position of power arm and varying locations of temporary anchorage devices in sliding mechanics using Finite Element Method (FEM), effort was made to identify a better combination of these factors that were enable orthodontists to maintain better control of anterior teeth movement. Different Locations of TAD_s And Different Heights And Position Of Power Arms The TADs were then placed in the interradicular region between 2nd premolar and first molar at an angulation of 30º to the long axis of second premolar. A NiTi Closed Coil spring was extended from the TAD_S to the base arch wire in a direction perpendicular to the arch wire thereby applying a predetermined retrusive force on the maxillary arch. The retrusive effect on the maxillary dental arch was determined with respect to two basic variations: the vertical positional location of the TADs and force was applied. First situation was to vary the site of placement of TADS from a vertical perspective at 7 mm, 8 mm, 10 mm from archwire. The other variable was variations in point of force application heights of power arm at 0 mm, 2 mm, 4 mm, 6 mm, 8 mm, 10 mm, 12 mm and also at two different position of power arms one at mesial to canine and other at distal to canine. The effect of retrusive force was determined at each of the aforementioned 3 positions of TAD_s placement. This created 42 possible combinations which are designated as separate groups in this study with measuring displacement at crown and at tip of root the total no. of observations came to 84 and recording the values of retraction .

A. Loading configuration

Different points of force applications were used and categorized in seven groups as follows:

a. Load case 1 (L1)

TAD_s was placed between the maxillary second premolar and 1st molar at 6 mm, 8 mm, 10 mm from the archwire. A retraction force of 150 gms was applied from TAD to a Power Arm of 0 mm of height was placed between lateral incisor and canine and other one placed between canine to 1st premolar using close coil spring.(Fig.1 and Fig.2)

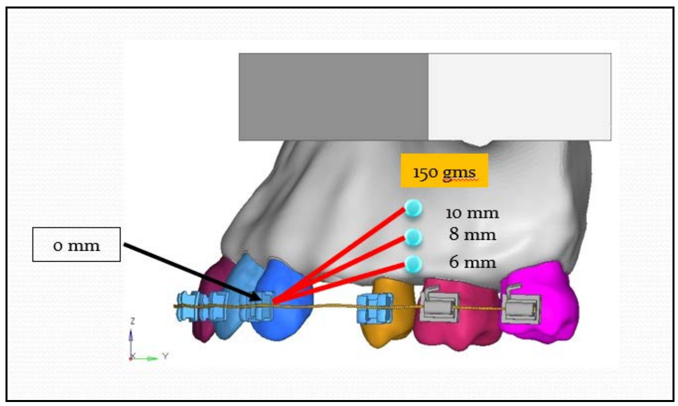

Fig.1: Simulation of Archwire, brackets, coil spring, TAD_s and power arm placed to a point on the arch wire (0 mm) distal to canine in FEM model.

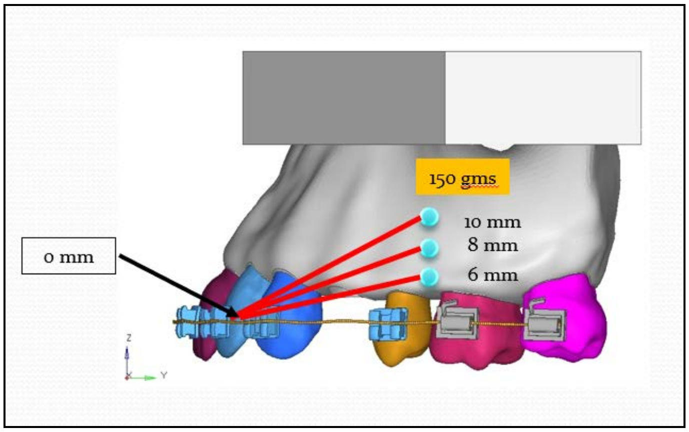

Fig.2: Simulation of archwire, brackets, coil spring, TAD_s and power arm placed to a point on the arch wire (0 mm) mesial to canine in FEM model.

b. Load case 2 (L2)

TAD_s was placed between the maxillary second premolar and first molar at 6 mm , 8 mm, 10 mm from the archwire. A retraction force of 150 gms was applied from TAD to Power Arm of 2 mm height was placed between the lateral incisor and canine and other one placed between canine and 1st premolar using close coil spring.(Fig.3 and Fig.4)

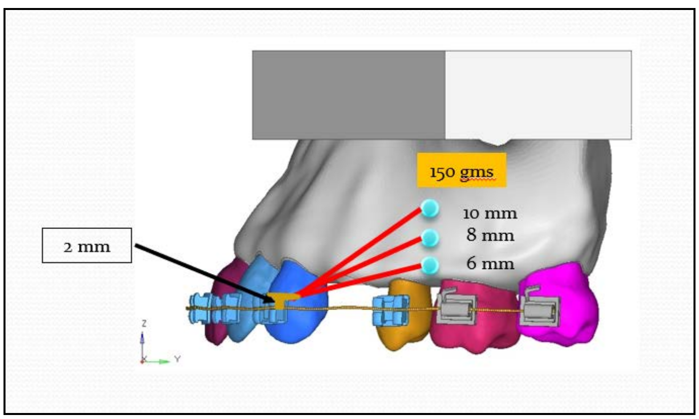

Fig.3: Simulation of archwire, brackets, coil spring, TAD_s and power arm placed to a point on the arch wire (2 mm) distal to canine in FEM model.

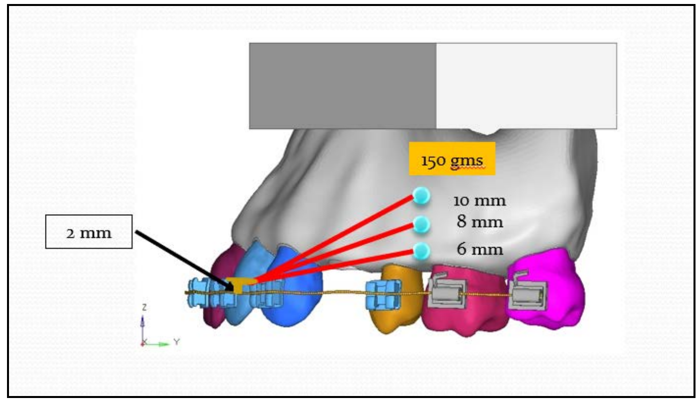

Fig.4: Simulation of archwire, brackets, coil spring, TAD_s and power arm placed to a point on the arch wire (2 mm) mesial to canine in FEM model.

c. Load case 3 (L3)

TAD_s was placed between the maxillary second premolar and first molar at 6 mm, 8 mm, 10 mm from the archwire. A retraction force of 150 gms was applied from TAD to Power Arm of 4 mm height was placed between the lateral incisor and canine and other one placed between canine and 1st premolar using close coil spring.(Fig.5 and Fig.6)

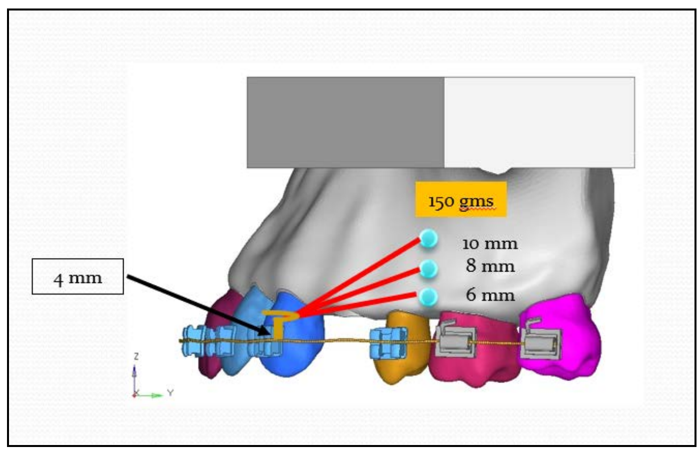

Fig.5: Simulation of archwire, brackets, coil spring, TAD_s and power arm placed to a point on the arch wire (4 mm) distal to canine in FEM model.

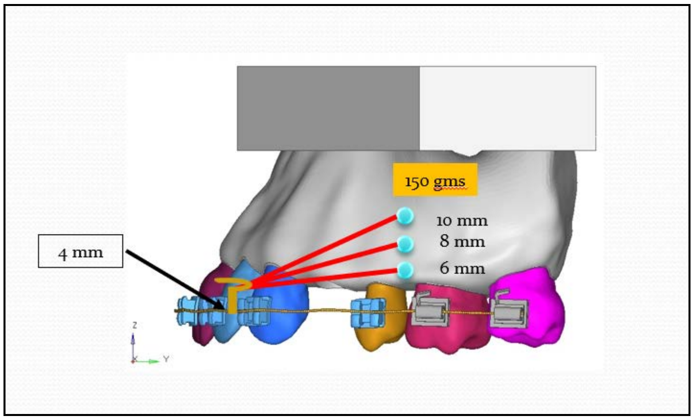

Fig.6: Simulation of archwire, brackets, coil spring, TAD$_s$ and power arm placed to a point on the arch wire (4 mm) mesial to canine in FEM model.

d. Load case 4 (L4)

TAD$_s$ was placed between the maxillary second premolar and first molar at 6 mm, 8 mm, 10 mm from the archwire. A retraction force of 150 gms was applied from TAD to Power Arm of 6 mm height was placed between the lateral incisor and canine and other one placed between canine and 1st premolar using close coil spring.(Fig.7 and Fig.8)

e. Load case 5 (L5)

TAD$_s$ was placed between the maxillary second premolar and first molar at 6 mm , 8 mm, 10 mm from the archwire. A retraction force of 150 gms was applied from TAD to Power Arm of 8 mm height was placed between the lateral incisor and canine and other one placed between canine and 1st premolar using close coil spring.(Fig.9and Fig.10)

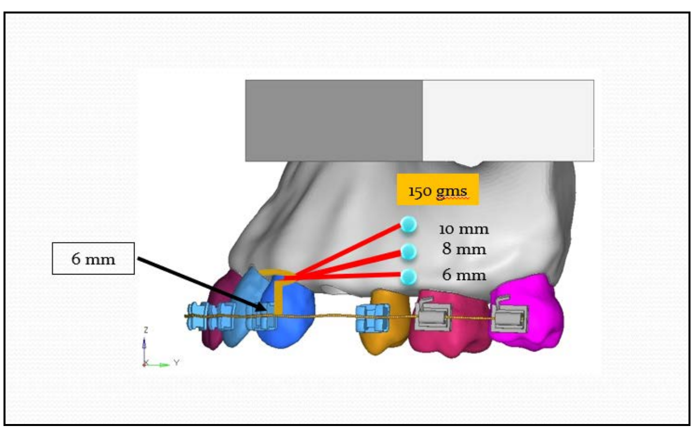

Fig.7: Simulation of archwire, brackets, coil spring, TAD$_s$ and power arm placed to a point on the arch wire (6 mm) distal to canine in FEM model.

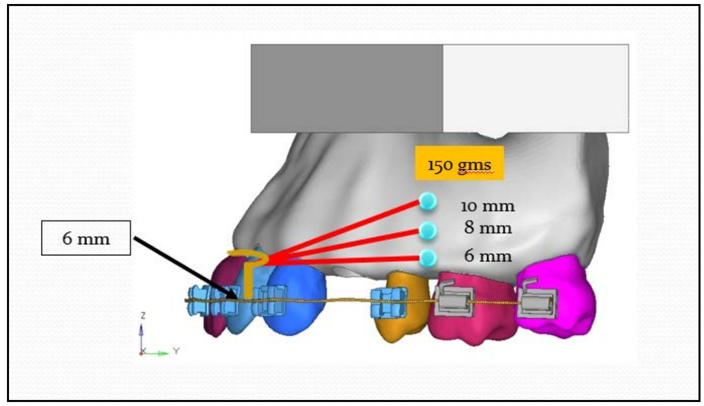

Fig.8: Simulation of archwire, brackets, coil spring, TAD$_s$ and power arm placed to a point on the arch wire (6 mm) mesial to canine in FEM model.

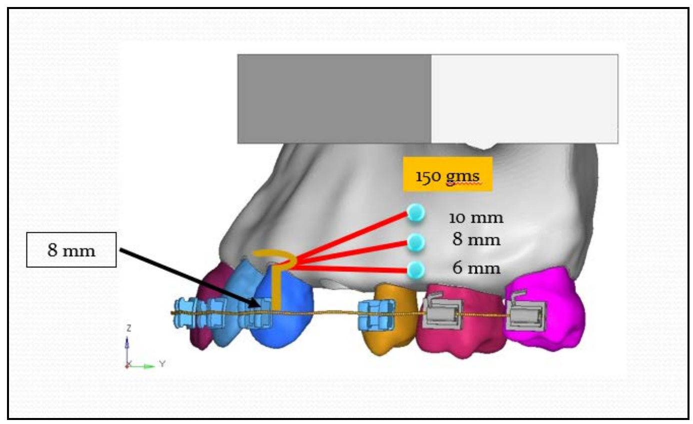

Fig.9: Simulation of archwire, brackets, coil spring, TAD$_s$ and power arm placed to a point on the arch wire (8 mm) distal to canine in FEM model.

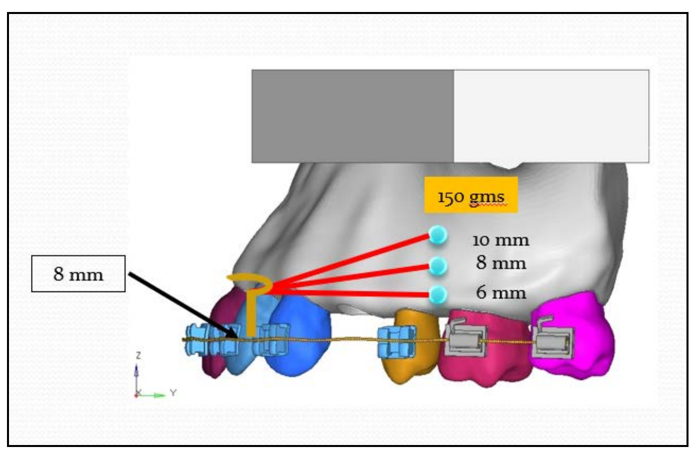

Fig.10: Simulation of archwire, brackets, coil spring, TAD_s and power arm placed to a point on the arch wire (8 mm) mesial to canine in FEM model.

f. Load case 6 (L6)

TAD_s was placed between the maxillary second premolar and first molar at 6 mm, 8 mm, 10 mm from the archwire. A retraction force of 150 gms was applied from TAD to Power Arm of 10 mm height was placed between the lateral incisor and canine and other one placed between canine and 1st premolar using close coil spring.(Fig.11and Fig.12)

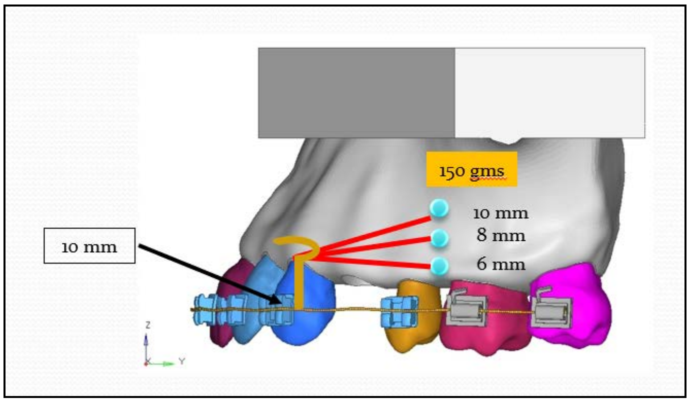

Fig.11: Simulation of archwire, brackets, coil spring, TAD_s and power arm placed to a point on the arch wire (10 mm) distal to canine in FEM model.

g. Load case 7 (L7)

TAD_s was placed between the maxillary second premolar and first molar at 6 mm, 8 mm, 10 mm from the archwire. A retraction force of 150 gms was applied from TAD to Power Arm of 12 mm height was placed between the lateral incisor and canine and other one placed between canine and 1st premolar using close coil spring.(Fig.13and Fig.14)

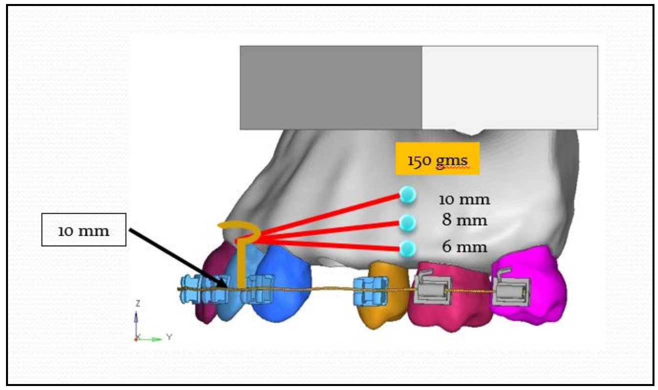

Fig.12: Simulation of archwire, brackets, coil spring, TAD_s and power arm placed to a point on the arch wire (10 mm) mesial to canine in FEM model.

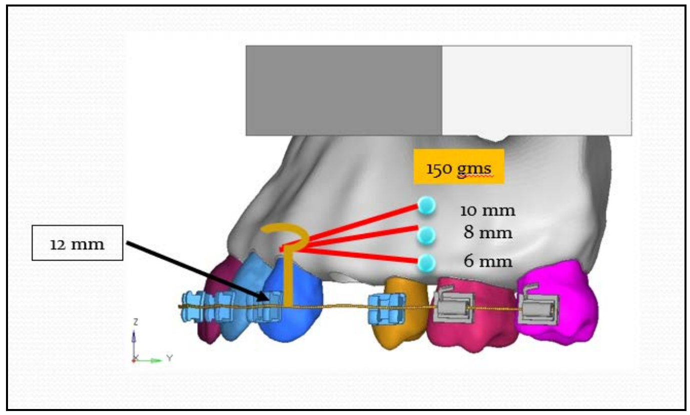

Fig.13: Simulation of archwire, brackets, coil spring, TAD_s and power arm placed to a point on the arch wire (12 mm) distal to canine in FEM model.

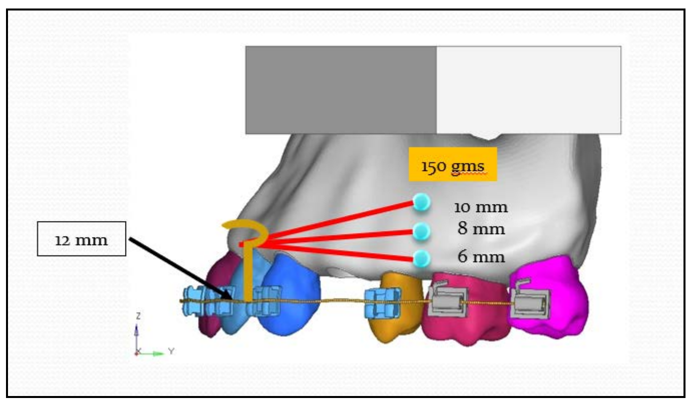

Fig.14: Simulation of archwire, brackets, coil spring, TAD_s and power arm placed to a point on the arch wire (12mm) mesial to canine in FEM model.

Retrusive effect on maxillary dental arch was observed in each of the aforementioned groups. The retrusive movement and labial flaring for the anterior segment was measured at the incisal edge of crown of the anterior teeth and apical tip of root of anterior teeth. We consider critical anchorage so there was no movement measured for the posterior segment.

Results

Post processing was done to analyze the results in FEM. Evaluation of en-masse displacement of maxillary anterior teeth was done after applying 150 gms of force per side. Seven load cases were analyzed. Displacement of the teeth at crown and root apex was calculated.

The controlled movement of anterior teeth was readily achieved using power arms attached to the arch wire. Varying the heights and position of power arms as well as locations of TADS, the force system for the desired type of tooth movement such as palatal crown tipping, palatal root tipping or bodily movement was easily achieved.

Displacement of the teeth at crown and root apex was calculated in sagittal plane. Displacement of teeth in sagittal plane i.e. antero-posterior plane. Positive value indicated posterior movement and negative value indicated anterior movement. All the values were expressed in millimeters (mm).

Based on the objectives of the study. the results of the present study are presented under following headings. Initially palatal crown tipping movement occurs as the height of PA and TADs increases palatal root tipping movement. During anterior tooth retraction with sliding mechanics controlled palatal crown tipping and controlled palatal root tipping movement achieved by attaching PA and TADs lower and higher than the level of centre of resistance.

Based on objectives of the study. Results were presented under following headings.

a. Load Case 1 (L1)

There was maximum crown tipping of canine was seen i.e. more retraction or posterior movement of canine showed when power arm was placed mesial to canine and TAD_s placement at 6mm.There was no bodily movement seen.(Table No.1)

b. Load case 2 (L2)

There was maximum crown tipping of canine was seen i.e. more retraction or posterior movement of canine showed when power arm was placed distal to canine and TAD_s placement at 6mm.There was no bodily movement seen. (Table No.2)

c. Load case 3 (L3):

There was maximum crown tipping of Central Incisor was seen i.e. more retraction or posterior movement of canine showed when power arm was placed distal to Canine and TAD_s placement at 6mm.There was no bodily movement seen.

(Table No.3)

d. Load case 4 (L4)

There was maximum crown tipping of Central Incisor was seen i.e. more retraction or posterior movement of canine showed when power arm was placed distal to Canine and TAD_s placement at 6mm.There was no bodily movement seen.

(Table No.4)

e. Load case 5 (L5)

There was maximum crown tipping of Central Incisor was seen i.e. more retraction or posterior movement of central incisor showed when power arm was placed mesial to Canine and TAD_s placement at 6mm.There was bodily movement of maxillary anterior teeth seen when PA placed mesial to canine and TAD_S placed at 10mm from archwire. (Table No.5)

f. Load case 6 (L6)

There was maximum crown tipping of root of Canine was seen i.e. more retraction or posterior movement of showed when power arm was placed mesial to Canine and TAD_s placement at 10 mm. There was bodily movement of maxillary anterior teeth seen when PA placed distal to canine and TAD_S placed at 6mm as well as 8mm from archwire. (Table No.6)

g. Load case 7 (L7)

There was maximum root tipping of Central Incisor was seen i.e. more retraction or posterior movement of central incisor showed when power arm was placed distal to Canine and TAD_s placement at 10mm. There was bodily movement of maxillary anterior teeth seen when PA placed mesial to canine and TAD_S placed at 8mm from archwire. (Table No.7).

	TAD	6mm		8mm		10mm	
	P.A.	Mesial	Distal	Mesial	Distal	Mesial	Distal
Tooth Displacement							
Central Incisor	CROWN	6.000	5.900	5.500	5.200	5.000	4.500
	ROOT	1.900	2.300	2.400	2.800	2.900	3.300
Lateral Incisor	CROWN	5.800	5.700	5.400	5.100	4.900	4.400
	ROOT	1.400	1.800	1.900	2.300	2.300	2.700
Canine	CROWN	6.100	6.000	5.600	5.400	5.200	4.700
	ROOT	0.560	0.830	0.980	1.300	1.400	1.700

Table No.1- Displacement of each tooth when power arm placed at 0 mm of height ($x10^{-4}$ mm)

	TAD	6mm		8mm		10mm	
	P.A.	Mesial	Distal	Mesial	Distal	Mesial	Distal
Tooth Displacement							
Central Lateral	CROWN	6.200	6.300	5.700	5.700	5.300	5.000
	ROOT	1.700	2.000	2.200	2.600	2.700	3.100
Lateral Incisor	CROWN	6.000	6.100	5.600	5.500	5.100	4.900
	ROOT	1.200	1.500	1.700	2.000	2.100	2.500
Canine	CROWN	6.400	6.500	5.900	5.900	5.500	5.200
	ROOT	0.370	5.600	0.800	1.100	1.200	1.500

Table No.2- Displacement of each tooth when power arm placed at 2 mm of height ($x10^{-4}$ mm)

	TAD	6mm		8mm		10mm	
	P.A.	Mesial	Distal	Mesial	Distal	Mesial	Distal
Tooth Displacement							
Central Incisor	CROWN	7.400	8.400	6.600	8.000	5.800	7.600
	ROOT	0.970	0.820	1.700	1.300	2.400	1.800
Lateral Incisor	CROWN	7.200	8.100	6.500	7.800	5.700	7.400
	ROOT	0.730	0.680	1.300	1.200	1.900	1.700
Canine	CROWN	6.900	7.800	6.300	7.500	5.700	7.200
	ROOT	0.038	0.051	0.530	0.580	1.000	1.100

Table No.3- Displacement of each tooth when power arm placed at 4 mm of height ($x10^{-4}$ mm)

	TAD	6mm		8mm		10mm	
	P.A.	Mesial	Distal	Mesial	Distal	Mesial	Distal
Tooth Displacement							
Central Incisor	CROWN	6.200	6.600	5.500	6.400	4.700	6.100
	ROOT	1.400	1.500	2.100	2.100	2.900	2.500
Lateral Incisor	CROWN	6.000	6.400	5.300	6.200	4.600	5.900
	ROOT	0.940	1.000	1.500	1.500	2.100	2.000
Canine	CROWN	5.800	6.100	5.200	6.000	4.600	5.800
	ROOT	0.015	1.600	0.520	0.520	1.000	1.100

Table No.4 - Displacement of each tooth when power arm placed at 6 mm of height ($x10^{-4}$ mm)

	TAD	6mm		8mm		10mm	
	P.A.	Mesial	Distal	Mesial	Distal	Mesial	Distal
Tooth Displacement							
Central Incisors.	CROWN	4.900	4.600	4.200	4.400	3.500	4.200
	ROOT	1.900	2.200	2.600	2.800	3.300	3.300
Lateral Incisors	CROWN	4.700	4.400	4.100	4.300	3.400	4.400
	ROOT	1.200	1.300	1.800	1.900	2.400	2.400
Canine	CROWN	4.600	4.400	4.100	4.300	3.600	4.200
	ROOT	-0.003	- 0.140	0.500	0.530	1.000	1.100

Table No.5 - Displacement of each tooth when power arm placed at 8 mm 0f height ($x10^{-4}$ mm)

	TAD	6mm		8mm		10mm	
	P.A.	Mesial	Distal	Mesial	Distal	Mesial	Distal
Tooth Displacement							
C.I.	CROWN	3.600	2.600	3.600	2.500	2.200	2.400
	ROOT	2.300	2.800	2.300	3.400	3.800	4.000
L.I.	CROWN	3.500	2.500	2.900	2.400	2.200	2.300
	ROOT	1.400	1.600	3.000	2.200	2.600	2.700
C	CROWN	3.600	2.800	3.100	2.800	2.600	2.700
	ROOT	-0.024	- 0.045	4.800	0.490	9.800	1.000

Table No.6 - Displacement of each tooth when power arm placed at 10 mm of height ($x10^{-4}$ mm).

	TAD	6mm		8mm		10mm	
	P.A.	Mesial	Distal	Mesial	Distal	Mesial	Distal
Tooth Displacement							
C.I.	CROWN	2.400	0.760	1.700	0.620	1.000	0.470
	ROOT	2.700	3.300	3.400	4.000	4.200	4.600
L.I.	CROWN	2.300	0.670	1.600	0.550	0.960	0.430
	ROOT	1.500	1.800	2.200	2.400	2.800	3.000
C	CROWN	2.600	1.300	2.100	1.200	1.600	1.200
	ROOT	-0.050	- 0.080	0.450	0.440	0.950	0.990

Table No.7 - Displacement of each tooth when power arm placed at 12 mm of height ($x10^{-4}$ mm)

Discussion

Present study showed the suitable combination of PA and TADs to get desired results. With the help of above combinations we can move maxillary anterior teeth bodily, it reduces the multiple use of TADs. During Orthodontic tooth movement many clinicians always pay considerable attention because it always been limited to ‘action-reaction: reciprocal-force mechanics’ in anchorage control10. Anchorage is critical component of en-masse retraction17. Anchorage control is fundamental to successful orthodontic treatment.These forwardly placed maxillary anterior teeth are retracted by creating space after extraction of maxillary premolars .The retraction method is determined depending on factors such as smile line, incisor display and vertical dimension. Burstone20 suggested that in extraction cases how to manage anchorage, determines the magnitude of anterior dental reduction and the resulting change in lip position. Williams and Hosila21 found that, only 66.5% of the available extraction spaces occupied by anterior segment during retraction, in patients whose 4 first premolars were extracted. Creekmore22 stated that, when first premolars are extracted , according to rule of thumb posterior teeth move one third of extraction space that can be expected by leaving two third of space for incisor retraction to relieve crowding. Anchorage control is important because maintenance of posterior buccal segment position is critical.It is now possible that during anterior teeth retraction to obtain absolute anchorage of posterior teeth and close the extraction spacing completely with the introduction of dental implants18, miniplates23, and microscrews24-26 as anchorage units. Temporary Anchorage Devices (TADS) have been reported to be effective anchorage for en-masse space closure50 . Several authors have demonstrated TADs placement between the second premolar and the first molar after premolar extraction for retraction of the anterior segment . Similarly the height of implant placement can be altered to bring about desired tooth movement. In this study TADs was used by varying locations i.e. TADs placed at 6mm, 8mm,10mm apically from bracket slot.Optimal loading conditions to bring about the desired tooth movements are still unknown. The use of power arms attached to the archwire enables one to readily achieve controlled movement of the anterior teeth28. In this present study was included seven varying heights of power arm placed at 0mm,2mm,4mm,6mm,8mm,10mm,12mm from arch wire and varying placement of power arm i.e. power arm placed at mesial to canine and power arm placed distal to canine.Orthodontic forces induces the stress and strain in periodontium, to study the orthodontic biomechanics requires understanding of the nature of stress and strain in periodontium. The Finite Element Method (FEM) is a powerful computer-simulation tool in solving stress-strain problems in the mechanics of solids and structures in engineering. Finite Element Method (FEM) used to analyze the retraction of teeth in sliding mechanics. FEM is an approximation method that divides the entire region of the structure into a set of elements (two dimensional or three-dimensional) and each element is assigned material properties (Young's modulus). The forces and boundary conditions are defined to simulate applied loads and constraint of the structure29The purpose of this study is to determine the force systems which bring about the retraction and the bodily movement of anterior segment during retraction. Evaluation of en-masse displacement of anterior teeth of maxilla was done after applying 150 gms of force per side. Seven load cases were analyzed. Crown displacement and root apex displacement was calculated. Bodily movement was produced in following loading conditions i.e.

1) Load Case (L5)- When power arm placed mesial to canine at 8mm and TADS at 10mm from archwire.
2) Load Case (L6)- When power arm placed mesial to canine at 10mm and TADS at 8mm from archwire.
3) Load Case (7)- When power arm placed mesial to canine at 12mm and TADS at 6 mm from archwire.
4) Load Case(6)- When power arm placed distal to canine at 10mm and TADS at 6mm And 8 mm from archwire.

Clinical implications of these combinations gives speedy results of en-masse retraction with faster space closure.

Limitations of Study

FEM Model used in this study cannot have intrinsic variations present in the oral environment. FEM Model which is generated may differ from actual biological structure. In this FEM Model PDL was considered as linear but in actually it is non-linear and varies in thickness. Alveolar bone consider as homogeneous, cancellous and cortical bone properties were not considered in the model. Teeth were considered as uniform solid structures. Factors like saliva, muscle forces and biological factors were not taken in to consideration during tooth movement. The play between bracket slot and wire was considered as 00. However clinically some amount of play is present in bracket slot and wire.

There is lots of difference in FEM Model and in what the teeth undergoing orthodontic treatment experience in the actual oral environment. In this present study, it was found that a close relationship between optimal loading conditions and corresponding retraction movement achieved was determined, but FEM study cannot define the period of time required to achieve this movement. Therefore further studies are required after accurate incorporation of all material properties to replicate the clinical scenario to the maximum.

Scope for future study

The present study can be taken to the next level by corroborating the findings of this study with clinical trials. Future studies are required to determine the effects on retrusive movement when the force from TADs is applied at an angle to the arch wire, the angle being different than the 90° angulation used in this study

Conclusion

Use of FEM with simulations and loading different conditions clarifies movement of tooth and magnitude of force in en-masse retraction by sliding mechanics. To achieve better controlled movement during sliding mechanics use of power arm by varying height and positions and by varying locations of TADs that speeds orthodontic results. Use of power arm makes the unit more stable and stronger. Use of TADs achieved maximum anchorage than conventional method during maxillary anterior teeth retraction.

The result of this study proved the different possibilities of achieving bodily movement of anterior teeth in maxillary arch by applying 7 loading conditions.

When PA placed Mesial to canine at 8mm,10mm,12mm of heights from archwire and TADs at 10 mm,8mm,6mm respectively from archwire bodily movement of maxillary anterior teeth occurred.

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