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# Comparison of En-Masse Retraction in Sliding Mechanics with Different Bracket Slot Using Mini-Implants at Different Vertical Levels- A 3d Fem Study

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**Type of Publication:** Original Research Paper

**Conflicts of Interest:** Nil

## Abstract

**Aims and Objectives:** The present study was done to evaluate and compare vertical and sagittal teeth movement during en masse retraction in sliding mechanics by altering the vertical levels of force application in posterior region. i.e. High Pull, Medium Pull, Low Pull and from a conventional Molar hook in 0.018 x 0.028 and 0.022 x 0.028 bracket slot by using 3 D Finite Element analysis.

**Materials and Methods:** Two maxillary 3 D finite element models, one for 0.022 x 0.028 bracket slot, one for 0.018 x 0.028 bracket slot were generated using ANSYS (version 14.5) software, simulating sliding mechanics for en-masse retraction of maxillary anterior teeth by altering the vertical levels of force application in posterior region. The results were expressed in form of Von Mises scale depicting the coloured chart.

**Results:** when force is applied from molar hook, 4.5mm mini-implant height and 13.5 mm mini-implant height, less tipping and more intrusion movement of anterior teeth was found in 0.018 x 0.028 bracket slot size than that in 0.022 x 0.028 bracket slot size. When the force is applied from 9mm implant height, similar movement of anterior teeth was seen in 0.018 x 0.028 as well as 0.22 x 0.028 slot bracket size.

**Conclusion:** It can be concluded from this study that, Out of four different levels of force application, Medium pull implant serves as an ideal position for en masse retraction in both 0.018 bracket slot as well as 0.022 bracket slot.. According to severity of vertical dentoalveolar excess or gummy smile, amount of intrusion with en mass retraction of anterior teeth can be varied by varying the height of implant placement in which higher the implant placement more will be the intrusion.

**Key word:** FEM, 0.022 x 0.028 bracket slot size, 0.018 x 0.028 bracket slot size, En masse retraction, Mini-implant, Displacement.

## Introduction

Dental protrusion is a most common finding in many ethnic groups around the world. It is characterized by flaring of maxillary or both the maxillary and mandibular anterior teeth with resultant protrusion of the lips and convex profile. [1] The major orthodontic treatment goal is to reduce the proclination of the incisors, and therefore, stability of anchorage is crucial in the success of treatment. Obtaining maximum or absolute anchorage has always been a difficult task for orthodontists to reach. To overcome the problems of conventional anchorage, nowadays skeletal anchorage is commonly used. The first successful orthodontic implant which was used for intrusion was placed by Creekmore and Eklund in 1983, but it was Kanomi in 1997 who described a mini-implant specifically designed for orthodontics use. By using mini-implants in the mechanics of en masse retraction of six anterior teeth, treatment time can be reduced effectively and clinicians can move teeth to satisfy the treatment goal without patient compliance for anchorage devices.[2]

During space closure, orthodontic tooth movement is achieved by 2 types of mechanics. The first type, frictionless, involves closing loops fabricated either in full or sectional arch wires. The second type, frictional, mechanics, involves either moving teeth along an arch wire or sliding the arch wire through brackets and tubes. Several studies have been undertaken to find out various biomechanical factors affecting tooth movement in friction mechanics, such as the flexural rigidity of the archwire, friction, and height of the retraction force. "It was observed that the anterior tooth movement varied depending on the amount of play between archwire and bracket. The dimension of the play that is determined by the combination of the bracket slot size and the archwire size has a great impact on the control of the anterior tooth movement. The greater the archwire/bracket play becomes, the more difficult it is to apply an effective torque to the anterior teeth."[3]

Orthodontic research has undergone many changes in the last two decades. In order to find out the mechanical changes taking place within a biological system numerous studies such as photo elastic strain gauge, laser holographic interference techniques and finite element methods have been attempted. The finite element method was introduced to orthodontics in 1972 by Yettram et al., since then numbers of studies have been carried out using this method.[2]. It provides the orthodontist with quantitative data that can extend the understanding of the physiologic reactions that occur within the dento-alveolar complex.[4] It also quantitatively assesses the distribution of such forces through the wire & related structures.[1].

A study was done to determine the type of anterior tooth movement during the time when force was applied from different mini screw placements to the anterior power arm with various heights. Another Study was done by changing vertical levels of point of force application in the posterior region by keeping the anterior point of force application constant and its effect on anterior teeth during space closure in one bracket slot size. One another study was done to calculate the amount of torque loss in maxillary anterior teeth by applying force vectors from different levels to the anterior retraction hook at various heights and comparing with that of molar anchorage system But till now no study has been done to evaluate and compare the teeth movement while doing en masse retraction in different bracket slot size with different levels of force application.

Hence, the purpose of this study was to evaluate and compare vertical and sagittal teeth movement during en masse retraction in sliding mechanics by altering the vertical levels of force application in posterior region. i.e. High Pull, Medium Pull, Low Pull and from a conventional Molar hook in 0.018 x 0.028 and 0.022 x 0.028 bracket slot using 3 D Finite Element analysis.

**Material and Method**

- **Construction of geometric model**

The geometric models of the maxillary central incisor, lateral incisor, canine, second premolar, first molar and second molar were constructed using the dimensions and morphology found in Wheeler's text book.[5] Maxillary first premolar was not constructed in order to simulate retraction in 1st premolar extraction cases. In order to establish mesio-distal angulations and labio-lingual inclination of the teeth, the maxillary dentition was arranged according to MBT norms. These teeth were arranged in ovoid archform.[6]

In order to establish the natural anatomy, PDL was constructed with an average thickness of 0.25mm around the roots of all the teeth. Next, alveolar bone was constructed and the thickness of cortical bone was considered 2 mm; PDL and the teeth were fitted into the bone.[7]

- **Conversion of geometric model to finite element model**

Geometric models were converted into finite element models i.e. finite number of elements and nodes. 4-node tetrahedron elements were used. Four 3D finite element models of maxilla were generated by using the ANSYS software system. These Four models were divided equally into Two groups; Group-A and Group-B. Group-A models were fabricated with bracket slot size of 0.022” × 0.028”. Group-B models were fabricated with bracket slot size of 0.018” × 0.028” In Both the groups, One model had conventional molar hook and other model had mini-implant (1.3mm x 8mm) as an attachment where retraction force was delivered.

Brackets were attached to the crowns such that the Facial axis point was coinciding with the center of the bracket slot. Crimpable hook of 5mm height was positioned between the brackets of maxillary lateral incisor and canine on arch wire in upward direction and distally to bracket of lateral incisor. Mini-implant was placed buccally between roots of second premolar and first molar at three different vertical levels from arch wire.

Three different vertical levels were:-

1. Low pull implant (4.5mm from archwire)
2. Medium pull implant (9mm from archwire)
3. High pull implant (13.5mm from archwire)

In Both the groups, Anterior en-masse retraction was done using sliding mechanics. During Anterior en mass retraction, In group (A), Stainless steel arch wire of dimension 0.019” × 0.025” and in group (B), Stainless steel arch wire of dimension 0.017” × 0.025” were used as a final arch wires.

- **Material Property Data Representation**

Teeth, PDL, alveolar bone, brackets, arch wire were considered to be isoparamertic and analogous. Brackets and archwire were given the properties of stainless steel.[9]

- **Defining the boundary condition**

At the connected nodes between the archwire and the brackets, translational degrees of freedom in the two flexural directions of the archwire was coupled to deform together, and translational degrees of freedom in the axial direction of the archwire was unconstrained.

During friction between the archwire and brackets, free axial rotation movement of the archwire in the brackets was allowed.

The boundary conditions were also defined to mimic how the model was constrained and to prevent it from free body motion. The nodes attached to the area of the outer surface of the bone were fixed in all directions to avoid free movement.[1]

- **Application of forces**

In Both the Groups, Anterior en-masse retraction was done with force vectors from four different levels using a force of 150gm/side.

- Force was delivered from Four different vertical levels:-

1. Molar hook to crimpable hook
2. Low pull implant (4.5mm from archwire)
3. Medium pull implant (9mm from archwire)
4. High pull implant (13.5mm from archwire)

Coefficient of friction between the bracket slots and archwire was assumed to be 0.2.[1]

- **Evaluation of En-masse retraction**

When any force is applied to a tooth, an initial tooth movement is produced followed by orthodontic tooth movement. So, it was important to specify the forces applied to the teeth. The model was analysed using software ANSYS and displacement was calculated on vertical direction and sagittal direction , when force was applied from four different locations and compared in different bracket slot 0.018 x 0.028 and 0.022 x 0.028.

Initial displacement of the teeth at the crown and root tip was calculated on Y and Z axis, where Y and Z axis represented movements in the sagittal and vertical plane respectively. Positive value indicated distal movement in Y axis and the upward movement in Z axis. The negative value indicated mesial movement in Y axis and downward movement in Z axis.

**Result**

Initial movement of the teeth at the crown and root tip was calculated on Y and Z axis.

**MODEL - 1 (0.022 x 0.028)**

**Displacement of teeth in Y axis [Table-3]**

In sagittal plane when force was applied from

1. **From Molar hook**:- central incisor, lateral incisor and canine tipped palatally. Amount of tipping was seen more in canine, then central incisor and least in Lateral incisor.
2. **At Low Pull implant:-**Here also tipping was seen. The amount of tipping was seen more in central incisor and lateral incisor when compared to from the molar hook, while canine showed least tipping movement.
3. **At Medium pull implant**:- Here also tipping was seen. The amount of tipping was seen less in central incisor and lateral incisor that occurred from Low pull implant. The amount of tipping was seen more in canine when compared with Low pull implant.
4. **At High pull implant:-** Here also tipping was seen, but the amount of tipping was almost same as that occurred from Medium pull implant.

- **Displacement of teeth in Z axis [Table-4]**

In vertical plane when force was applied from

1. **From Molar hook**: Extrusion of central incisor, lateral incisor and canine was seen. Amount of extrusion was seen more in canine, then lateral incisor and least in central incisor.
2. **At Low Pull implant:-** Intrusion of central incisor, lateral incisor and canine were seen. Amount of intrusion was seen more in lateral incisor, then canine and less in central incisor.
3. **At Medium pull implant:-** Intrusion of central incisor, lateral incisor and canine were seen but the amount of intrusion was seen more in central incisor and canine when compared with Low pull implant, while lateral incisor showed less intrusion.
4. **At High pull implant:-** Intrusion of central incisor, lateral incisor and canine were seen but the amount of intrusion was seen more in lateral incisor and canine when compared with Medium pull implant, while central incisor showed less intrusion.

**MODEL -2 (0.018 x 0.028 )**

- **Displacement of teeth in Y axis [Table-5]**

In sagittal plane when force was applied from

1. **From Molar hook**:- central incisor, lateral incisor and canine tipped palatally. Amount of tipping was seen more in canine, then central incisor and least in Lateral incisor.
2. **At Low Pull implant:-**Here also tipping was seen. The amount of tipping was seen more in central incisor

and lateral incisor when compared to from the molar hook, also canine showed least tipping movement.

3. **At Medium pull implant**:- Here also tipping was seen. The amount of tipping was seen less in central incisor and lateral incisor that occurred from Low pull implant. The amount of tipping was seen more in canine when compared with Low pull implant.
4. **At High pull implant:-** , Here also tipping was seen, but the amount of tipping was seen more that occurred from Medium pull implant. Amount of tipping was almost similar in central incisor and lateral incisor and more in canine.

At all levels, there was tipping of central incisor, lateral incisor and canine when force was applied.

- **Displacement of teeth in Z axis [Table-6]**

In vertical plane when force was applied from

1. **From Molar hook**: Extrusion of central incisor, lateral incisor and canine were seen. Amount of extrusion was seen more in canine, then lateral incisor and least in central incisor.
2. **At Low Pull implant:-** Intrusion of central incisor, lateral incisor and canine were seen. Amount of intrusion was more in central incisor, then lateral incisor and least intrusion seen in canine.
3. **At Medium pull implant:-** Intrusion of central incisor, lateral incisor and canine were seen, but the amount of intrusion was seen less in central incisor and lateral incisor when compared with Low pull implant, while canine showed more intrusion compared with Low pull implant.
4. **At High pull implant:-** Intrusion of central incisor, lateral incisor and canine were seen however the amount of intrusion was more than that from Medium pull implant. Amount of intrusion was almost similar in central incisor and lateral incisor and least intrusion was seen in canine.

**Discussion**

According to **Park et al**[10], with increased use of preadjusted appliances, various forms of sliding mechanics have replaced closing loop arches. Sliding mechanics might have great benefits, such as minimal wire-bending time and sufficient space for activation of en masse retraction.

The present study evaluated and compared vertical and sagittal teeth movement during **en masse retraction** in **sliding mechanics** by altering the **vertical levels of force** application in posterior region. i.e. From conventional Molar hook, Low Pull, Medium Pull, and High Pull implant in 0.018 x 0.028 and 0.022 x 0.028 bracket slot by using 3 D Finite Element analysis.

According to **Kusy et al**[11] the advent of stainless steel alloys facilitated the use of smaller dimension wires with the same rigidity as that of the larger gold alloy archwires. This enabled the bracket slot size to be reduced, and as a result the 0.018-inch bracket slot was established into orthodontics. However, the introduction of the 0.018-inch bracket slot did not eliminate fixed appliance systems using 0.022-inch bracket slots from clinical practice.[10]

The 3D FEM used in the present study provides the freedom to simulate orthodontic force applied clinically and to analyse the response of the dentition to the force in three-dimensional space. The point of force application, magnitude and direction of force may easily be varied to simulate the clinical situation.

Force of 150gms/side was used as it is within the physiologic limits for en masse retraction.

❖ **Displacement of teeth when force applied from Molar hook :-**

**1) Model- 1**

In Sagittal plane uncontrolled tipping of all the teeth was seen, central incisor, lateral incisor and canine tipped distally. As the point of force application was below the center of resistance, tipping was observed. Amount of tipping was seen more in canine, then central incisor and least in Lateral incisor. (Table.3)

In Vertical plane small amount of extrusion was seen. As the point of force application was below the center of resistance, extrusion of teeth occurred. Amount of extrusion was seen more in canine, then lateral incisor and least in central incisor. (Table.4)

The results obtained in our study are similar to study done by **Chetan et al**[1], who found that when force was applied from molar hook, uncontrolled tipping of central incisor, lateral incisor and canine was seen in sagittal plane and in vertical plane extrusion was seen.

**2) Model- 2**

In Sagittal plane Central Incisor, Lateral Incisor and Canine tipped palatally. Amount of tipping was seen more in canine, then central incisor and least in lateral incisor. (Table.5).

In Vertical plane Extrusion of central incisor, lateral incisor and canine were seen. Amount of extrusion was seen more in canine, then lateral incisor and least in central incisor. (Table.6)

While comparing between two models when force was applied from molar hook, tipping movement was seen more in model- 1 sagittally and extrusion was seen more in model- 1 vertically.

**Displacement of teeth when force applied from Low Pull implant**

**1) Model- 1**

In Sagittal plane uncontrolled tipping of the central incisor, lateral incisor and canine was seen. Here tipping occurred because point of force application was still below the center of resistance. However amount of tipping is more when compared to force from molar hook. (Table.3).

The result obtained in our study is in contradiction to the study done by **Chetan et al**[1], who found that placing the implant at 4.5mm height from archwire lead to less uncontrolled tipping of central incisor, lateral incisor and canine. This might be because of the difference in the construction of geometric model.

In Vertical plane intrusion was seen but it was less as compared to medium and high pull implant. Here intrusion occurred because of the vertical component of force. (Table.4)

**2) Model- 2**

In Sagittal plane when force was applied from Low pull implant, tipping was seen. Here amount of tipping is more in central and lateral incisor when compared to force from the molar hook, while canine showed least tipping movement. (Table.5).

In Vertical plane intrusion was seen. Here intrusion occurred because of the vertical component of force. (Table.6).

While comparing between two models when force was applied from implant at 4.5mm from archwire, tipping movement was seen more in model- 1 sagittally and intrusion was seen more in model- 2 vertically.

- **Displacement of teeth when force applied from Medium Pull implant**

**1) Model- 1**

In sagittal plane when force was applied from Medium pull implant, Here also tipping was seen. Here amount of tipping is less when compared to force from implant at 4.5mm from archwire. (Table.3)

In Vertical plane intrusion was seen. Here intrusion occurred due to the vertical component of force. Amount of intrusion is more when compared to force from implant at 4.5mm from archwire (Table.4).

The results obtained in our study are similar to study done by **Chetan et al**[1], who found that placing the implant at 9 mm height from archwire lead to less uncontrolled tipping of central incisor, lateral incisor and canine in sagittal plane and in vertical plane intrusion was seen.

**2) Model- 2**

In sagittal plane when force was applied from medium pull implant, here also tipping was seen. Here amount of tipping is less when compared to force from implant at 4.5mm from archwire. (Table.5)

In Vertical plane intrusion was seen. Here intrusion occurred due to the vertical component of force. Amount of intrusion is more when compared to force from implant at 4.5mm from archwire (Table.6)

Here tooth movement observed almost similar to that which occurred when force was applied from low pull implant. As the line of action was slightly nearer to center of resistance, the amount of intrusion is slightly more than low pull implant. The angle between the line of action and the horizontal component of force is increased when compared to low pull implant, as this angle increases intrusion component of the force causing more intrusion.

While comparing between two models when force was applied from implant at 9mm from archwire, sagittal movement and vertical movement were similar occurred in model- 1and model- 2.

**Displacement of teeth when force is applied from High Pull implant:-**

**1) Model- 1**

In Sagittal plane when force was applied from implant ar 13.5mm from archwire, Here also tipping was seen, but the amount of tipping was found to be slightly more in High pull implant than that in Medium pull implant. (Table.3)

In Vertical plane intrusion was seen. Here intrusion occurred due to the vertical component of force. Amount of intrusion is even more when compared to force from implant at 9mm from archwire. (Table.4).

These results are in accordance to the previous study done by **Parashar et al** [2]**.** He observed that when force was applied from High orthodontic traction (HOT: 13.5 mm from archwire) to anterior retraction hook of 5mm, controlled tipping of the anterior teeth was seen as the force was applied more close to the centre of resistance. However, There was no statistically significance between the displacements of the crown apex and root tip.

The results obtained in our study are also in co-relation with the study done by **Chetan et al**[1], who found that placing the implant at 13.5 mm height from archwire lead to controlled tipping of central incisor, lateral incisor and canine in sagittal plane and in vertical plane intrusion was seen.

**2) Model- 2**

In Sagittal plane when force was applied from implant at 13.5mm from archwire, Here also tipping was seen, but the amount of tipping was slight more when compared to force from Medium pull implant. (Table.5)

In Vertical plane intrusion was seen. Here intrusion occurred due to the vertical component of force. Amount of intrusion is more when compared to force from implant at 9mm from archwire. (Table.6)

Here tooth movement occurred almost similar to that which occurred when force was applied from 13.5mm and 9mm implant levels. But the amount of tipping was slightly more in 13.5mm than that in 9mm implant height level and the intrusion was slightly more in 13.5mm implant height level when compared to the other two levels of implants.

While comparing between two models when force was applied from implant at 13.5mm from archwire, tipping movement was seen less in model- 2 sagittally and intrusion was seen more in model- 2 vertically.

In present study, in both 0.018 and 0.022 slot bracket prescription, it was found that controlled lingual tipping and intrusion of anterior teeth occurs when the mini-implant is placed at 9mm height from the archwire in comparison to force applied from either molar hook, 4.5mm implant height and 13.5 mm implant height from archwire.

In the study done by **Ashekar S et al**[12], he found that when the force was applied from 5mm anterior traction hook, at 6mm mini-implant height, lingual tipping of anterior teeth was observed; at 8mm mini-implant height, lingual tipping and intrusion of anterior teeth was observed; at 10mm mini-implant height, intrusion of anterior teeth was observed but it was lesser than that in 0mm anterior traction hook.

While in the FEM study done by **Deng et al**[13], found that with 4-mm anterior traction hook, the retraction and extrusion of protruded central incisors was observed when mini-implants were placed at 4-mm heights while the higher (8-mm) MIs appeared to cause intrusion of the anterior teeth.

**Tominaga et al**[3], in his study, found that in 0.018 ix 0.022 slot, when the retraction is carried out through mini-implant from 9mm of traction hook, no rotation was observed and controlled lingual crown tipping was observed at the 8.3-mm anterior traction hook.

**Hedayati et al**[14], in his study found that in 0.018 inch slot bracket prescription, intrusion along with controlled lingual tipping of anterior teeth take place when mini-implant is placed at 6mm height from the archwire.

According to **Upadhayay et al**[15]**,** when the force is applied from implants: A large and predominant retractive force and a smaller intrusive force will be acting, causing en-masse retraction and some intrusion of the anterior teeth. Furthermore, there is a clockwise moment on the anterior segment as the total force passes beaneath the estimated center of resistance of the anterior teeth.

**Figures**

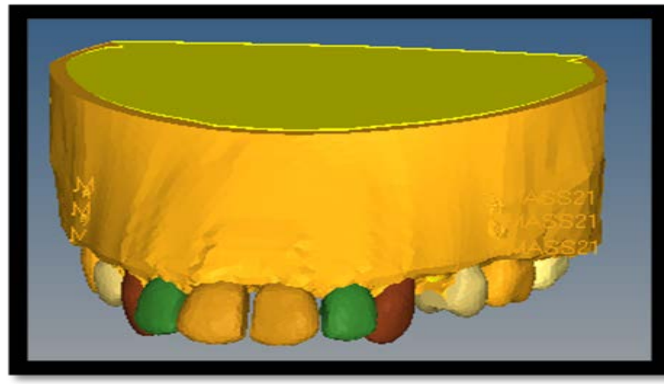

Figure 1: Geometrical Model

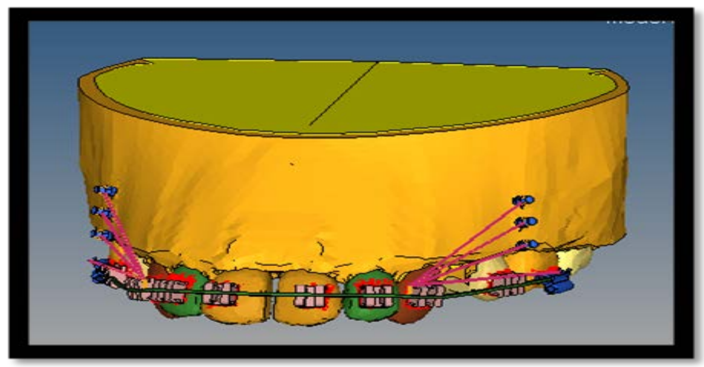

Figure. 2: Model - 1 Front view of maxilla showing sliding mechanics for en masse retraction

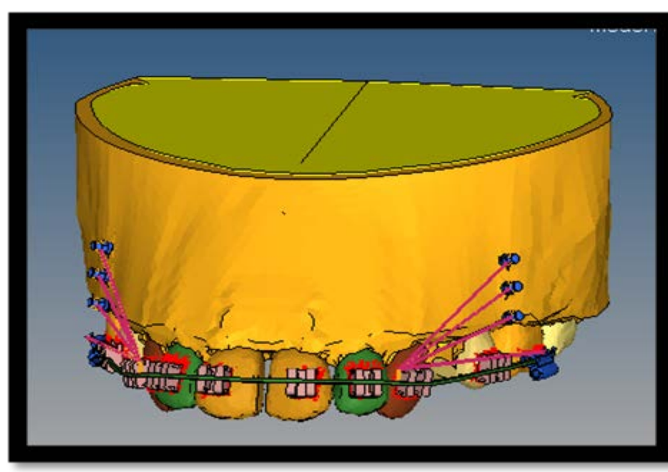

Figure. 3: Model - 2 Front view of maxilla showing sliding mechanics for en masse retraction

**Tables**

The number of elements and nodes used in this study are listed in following tables.

| | Model-1 | | Model-2 | |
|---|---|---|---|---|
| | **Elements** | **Nodes** | Elements | Nodes |
| Total | 264834 | 322506 | 265274 | 322875 |
| Cortical bone | 15660 | 30387 | 15660 | 30387 |
| Cancellous bone | 75993 | 117500 | 75993 | 117500 |
| Teeth | 53475 | 87250 | 53475 | 87250 |
| Brackets | 48952 | 83143 | 49212 | 83365 |
| Periodontal ligament | 8996 | 18235 | 8996 | 18235 |
| Mini-implant | 5561 | 10062 | 5561 | 10062 |
| Archwire | 2706 | 5514 | 3286 | 5898 |
| Central incisor | 10333 | 16311 | 10333 | 16311 |
| Lateral incisor | 5335 | 8899 | 5335 | 8899 |
| Canine | 6525 | 10880 | 6525 | 10880 |
| Second premolar | 5104 | 8567 | 5104 | 8567 |
| First molar | 14272 | 23300 | 14272 | 23300 |
| Second molar | 11906 | 19293 | 11906 | 19293 |
| Power arm and links | 16 | 17 | 16 | 17 |

**Table 1: Number of nodes and elements in model - 1 and model- 2**

| Material | Young's modulus ratio ($kg/mm^2$) | Poisson's ratio |
|---|---|---|
| **Tooth** | $2.0 \times 10^3$ | 0.30 |
| **Periodontal ligament** | 6.8 x 102 | 0.49 |
| **Alveolar bone** | $1.4 \times 10^3$ | 0.30 |
| **Bracket** | $21.4 \times 10^3$ | 0.30 |
| **Arch wire/Power arm** | $21.4 \times 10^3$ | 0.30 |

**Table 2: Material properties used in the FEM model**

| Tooth | Central Incisor | | Lateral incisor | | Canine | |
|---|---|---|---|---|---|---|
| | Crown tip | Root tip | Crown tip | Root tip | Crown tip | Root tip |
| **From Molar Hook** | .558E - 05 | .119E - 05 | .472E - 05 | .981E - 06 | .669E - 05 | .137E - 06 |
| **At 4.5 mm** | .843E - 06 | .120E - 06 | .877E - 06 | .203E - 06 | .110E - 05 | .129E - 06 |
| **At 9 mm** | .108E - 05 | .249E - 06 | .113E - 05 | .375E - 06 | .141E - 05 | .268E - 06 |
| **At 13.5mm** | .125E - 05 | .366E - 06 | .132E - 05 | .531E - 06 | .165E - 05 | .409E - 06 |

**Table.3 Model -1** Displacement of teeth in Y axis (Sagittal)

| | Central Incisor | Lateral Incisor | Canine |
|---|---|---|---|
| From Molar Hook | -.353E - 05 | -.314E - 05 | -.222E - 05 |
| At 4.5 mm | .105E - 06 | .528E - 07 | .189E - 06 |
| At 9 mm | .134E - 06 | .396E- 07 | .211E - 06 |
| At 13.5 mm | .109E - 06 | .889E - 07 | .312E - 06 |

**Table. 4 Model - 1** Displacement of teeth in Z axis (Vertical)

| Tooth | Central Incisor | | Lateral incisor | | Canine | |
|---|---|---|---|---|---|---|
| | Crown tip | Root tip | Crown tip | Root tip | Crown tip | Root tip |
| From Molar Hook | .556E - 05 | .118E - 05 | .470E - 05 | .965E - 06 | .665E - 05 | .139E - 06 |
| At 4.5 mm | .802E - 06 | .115E - 06 | .843E - 06 | .196E - 06 | .104E - 05 | .126E - 06 |
| At 9 mm | .108E - 05 | .249E - 06 | .113E - 05 | .375E - 06 | .141E - 05 | .268E - 06 |
| At 13.5mm | .121E - 05 | .363E - 06 | .129E - 05 | .526E - 06 | .159E - 05 | .406E - 06 |

**Table.5 Model - 2** Displacement of teeth in Y axis (Sagittal)

| | Central Incisor | Lateral Incisor | Canine |
|---|---|---|---|
| From Molar Hook | -.353E - 05 | -.314E - 05 | -.222E - 05 |
| At 4.5 mm | .932E - 07 | .573E - 07 | .186E - 06 |
| At 9 mm | .134E - 06 | .396E - 07 | .211E - 06 |
| At 13.5 mm | .955E - 07 | .940E - 07 | .309E - 06 |

**Table. 6 Model - 2** Displacement of teeth in Z axis (vertical)

## Limitation

Limitations of this study were

As this study calculated only the initial tooth displacement, one more point that should be noted is: as retraction progresses anterior teeth keeps coming nearer to the point of force application, so force vector keeps on changing. As a result intrusion component of force will be more during final stages of space closure. In case of retraction with molar hook, throughout the retraction procedure force vector will not change.

Another limitation of this study is the inability to predict long-term tooth movement quantitatively through simulation. Until the physiologic and biomechanical processes of orthodontic tooth movements are fully understood and represented mathematically in a patient-specific model.

The further direction of FEM studies should include the tissue reactions, more precise simulation of loading and estimation of material behaviors as well as variations in geometries of PDL, bone and teeth in 3D finite element analysis.

## Conclusion

- It can be concluded from this study that, when force is applied from molar hook, 4.5mm mini-implant height and 13.5 mm mini-implant height, less tipping and more intrusion movement of anterior teeth was found in 0.018 x 0.028 bracket slot size than that in 0.022 x 0.028 bracket slot size.
- When the force is applied from 9mm implant height, similar movement of anterior teeth was seen in 0.018 x 0.028 as well as 0.22 x 0.028 slot bracket size.
- Out of four different levels of force application, Medium pull implant serves as an ideal position for en masse retraction in both 0.018 bracket slot as well as 0.022 bracket slot.

According to severity of vertical dento-alveolar excess or gummy smile, amount of intrusion with en mass retraction of anterior teeth can be varied by varying the height of implant placement in which higher the implant placement more will be the intrusion giving more vertical control.

## References


1. Chetan.S, Kanhoba M Keluskar, Vikram N Vasisht, Siddharth Revankar. En-masse Retraction of the Maxillary Anterior Teeth by Applying Force from Four Different Levels – A Finite Element Study. (Journal of Clinical and Diagnostic Research. 2014 Sep, Vol-8(9): ZC26-ZC30)
2. Parashar A, Aileni K, Rachala M. Torque Loss in En-Masse Retraction of Maxillary Anterior Teeth Using Miniimplants with Force Vectors at Different Levels: 3D FEM Study (Journal of Clinical and Diagnostic Research. 2014 Dec, Vol-8(12): ZC77-ZC80)
3. Tominaga J, Ozaki H, Chiang P, Sumi M. Effect of bracket slot and archwire dimensions on anterior tooth movement during space closure in sliding mechanics: A 3-dimensional finite element study. American Journal of Orthodontics and Dentofacial Orthopedics (August 2014 , Vol 146, Issue 2)
4. Va´squez M, Calao E, Becerra F, Ossa J. Initial Stress Differences Between Sliding and Sectional Mechanics with an Endosseous Implant as Anchorage: A 3-Dimensional Finite Element Analysis (A n g l e O r t h o d o n t i s t , V o l . 7 1 , N o . 4 , 2 0 0 1)
5. McLaughlin RP, Bennett JC, Trevisi HJ. Systemized orthodontic treatment mechanics. Mosby. 2001: Chapters 1-4; 27-85.
6. Ash M, Nelson S J. Wheeler's dental anatomy, physiology and occlusion. 1993, 8th edition. Elsevier 8th edition, 1993: Chapters 6-11; 149-333.
7. Junjie XUE, Niansong YE et al. Finite element analysis of rapid canine retraction through reducing

resistance and distraction. Journal of Applied Oral Science 2014;22(1):52-60.

8. Dr. Jayade V, Dr. Jayade C. Essentials of Orthodontics Biomechanics, First Edition: Ch:- 16, Biomechanics of Temporary Skeletal Anchorage devices(TAD's): page-208.
9. Chang Y, Shin SJ, Baek SH. Three-dimensional finite element analysis in distal en masse movement of the maxillary dentition with the multiloop edgewise archwire. Eur J Orthod. 2004; 26:339-45
10. Park H, Kwon T. Sliding Mechanics with Microscrew Implant Anchorage (Angle Orthod 2004;74:703–710.)
11. Kusy RP: "Two" much of a good thing? Then let's pick one slot size and make it metric. Am J Orthod Dentofac Orthop 2002, 121:337–338
12. Ashekar S, Deshpande R. Evaluation of Optimal Implant Positions and Height of Retraction Hook for Intrusive and Bodily Movement of Anterior Teeth in Sliding Mechanics: A FEM Study. J Indian Orthod Soc 2013;47(4):479-482
13. Deng W, Wang F. The effects of mini implant and anterior arch hook heights on en masse retraction: A finite element analysis. Applied Mechanics and Materials Vol. 461 (2014) pp 993-1001
14. Hedayati Z, Shomali M. Maxillary anterior en masse retraction using different antero-posterior position of miniscrew: a 3D finite element study ( Progress in Orthodontics (2016) 17:31)
15. Upadhyay M,Yadav S, Nanda R. Vertical-dimension control during en-masse retraction with mini-implant anchorage. Am J Orthod Dentofacial Orthop. 2010;138:96-108.