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# A Finite Element Analysis of Orthodontic Single Buccal Tube with Hook, on Molar Tooth Movement

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***Abstract*—** Buccal tubes are usually attached to the molar bands during orthodontics fixed appliance therapy. The molar tooth provides area of anchorage and forces are applied from the buccal tube hook. The hook is positioned in the mesial part of the tube, and force is applied (minimum 50 grams to maximum 150 grams) on hook. Because of the applied force on hook, there is a reactive change in molar position in the form of translation. The aim of this work is to show the molar tooth mesial translation for the applied force on the buccal tube hook.

***Keywords***- *Orthodontics, Buccal tube with hook, Finite element analysis, Molar tooth.*

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Orthodontics is a dental specialty concerned with the diagnosis and treatment of teeth irregularities such as crowding, deep bite, protruding teeth and poor jaw alignment. Its aim is to produce a healthy, functional bite, improving and bringing to teeth to normal position. Orthodontic treatment is also carried out in craniofacial deformities. Orthodontic fixed appliances have brackets, buccal tubes, archwires and ligatures.

Orthodontic Buccal tube is placed on the molar teeth and thus also called as molar tubes. Buccal tube is a small stainless steel component welded on the buccal side of a molar band, which contains a base, rectangular hole and a hook on the mesial part of the tube. The tube usually holds the archwires, lip bumpers, and other devices used to move the teeth. Molar tooth usually provides good anchorage control. Molar tube plays a vital role in transmitting force from the hook. An elastic band attached to the hook is used in applying forces to move tooth. General components in teeth-bone complex are tooth, PDL, cancellous bone, composite resin layer (bonding material) and buccal tube.

The periodontal ligament (PDL) is the fibrous connective tissue filled with the periodontal space between the root of the tooth and alveolus [1]. The molar tooth is the strongest tooth and having trifurcated or bifurcated roots which is used to grind the food [1]. Cancellous bone has a higher surface area to mass ratio because it is less dense. This gives it softer, weaker, and more flexible characteristics. The greater surface area in comparison with cortical bone makes cancellous bone suitable for metabolic activity e.g. exchange of calcium ions.

There are many methods available like experimental, analytical, computational methods to study the behavior of biological structure when it is subjected to loading. Among the available methods computational method is best one and provides graphical display of biological structure.

## I. MODELING AND ASSEMBLING

### A. *Geometric model of the tooth -PDL-bone system:*

The problems of a biomechanical complex structure with irregular geometry models such as the tooth can be analyzed using the FEA [3]. The initial 3D model of the molar section from the Maxillary bone structures was constructed based on computerized tomography (CT) scan data. The individual scans were processed using image processing software and SolidWorks, where the final 3D solid model of the bone was created with a 13mm thick layer of cancellous bone. The human molar tooth model was constructed primarily using computer tomography (CT) images; the periodontal ligament (PDL) of 0.3mm thickness is modeled. Figure.1 shows the skull CT image used in this study.

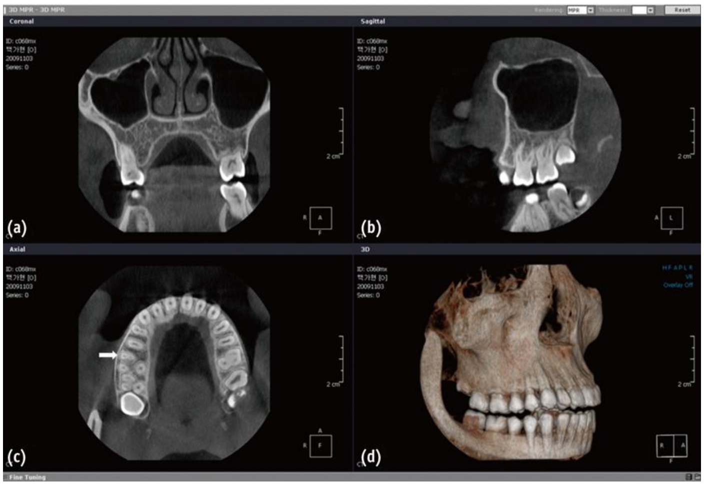


**Fig. 1**. CT image of skull

### *B. Geometric modeling:*

Buccal tube 3D model is created after measuring the dimensions of buccal tube through profile projector. The profile projector obtained dimensions are imported to Auto cad, the 3D model of buccal tube is then created using solid modeling software. Figure. 2 show the 3D model of buccal tube.

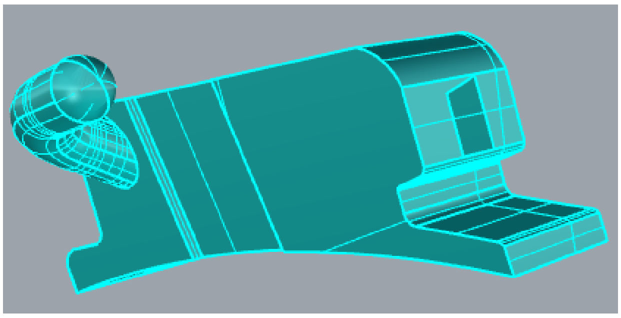

**Fig. 2**. 3D model of Buccal tube

The material propertices consider for this study are presented in Table 1. Material propertices are taken from the previously published study [2].

**Table. 1**. Material properties

| Sl.No. | Components | Young's modules(MPa) | Poisson's ratio |
|---|---|---|---|
| 1 | Tooth | 19600 | 0.30 |
| 2 | PDL | 0.66 | 0.49 |
| 3 | Cancellous Bone | 1340 | 0.30 |
| 4 | Resin layer | 8823 | 0.25 |
| 5 | Buccal tube | 200000 | 0.31 |

## II. MESHING AND ANALYSIS

### *A. Meshing:*

Assembled model is imported to hyper mesh, the meshing is done with isoparametric tetrahedral element. The element size and number of element used for tooth, PDL, cancellous bone, composite resin layer, buccal tube are presented in Table 2. Figure.3 shows the Assembled model and meshed.

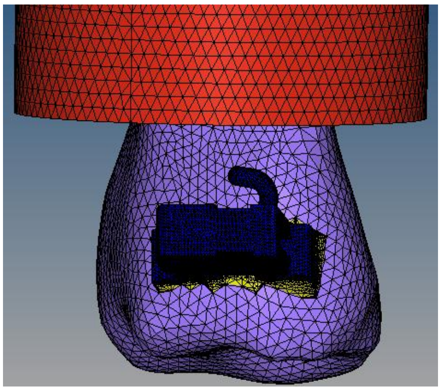

Fig 3. Assembled model and meshed

**Table 2**. Element size and No. of elements

| Sl. No | Components names | Size of Elements | No. of elements |
|---|---|---|---|
| 1 | Tooth | 0.25 | 295500 |
| 2 | PDL | 0.25 | 125468 |
| 3 | cancellous bone | 0.25 | 254152 |
| 4 | Resin composite layer | 0.25 | 54685 |
| 5 | Buccal tube | 0.1 | 2458941 |

The surface to surface contact is established between, tooth to composite resin layer, composite layer to buccal tube, tooth to PDL, and PDL to cancellous bone. Figure. 4 shows surface to surface contact of PDL to cancellous bone.

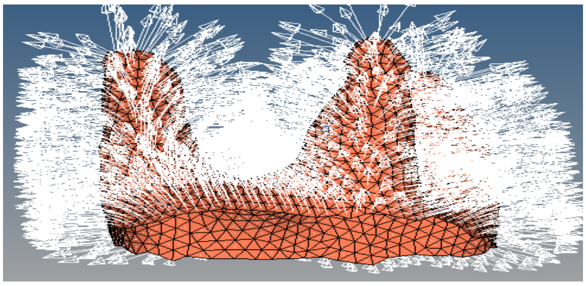

**Fig. 4.** PDL-Bone Surface to surface contact

### *B. Analysis:*

The meshed model is imported to Ansys and material properties are assigned. The element solid 185 is considered for all components. Figure. 5 shows imported model into Ansys.

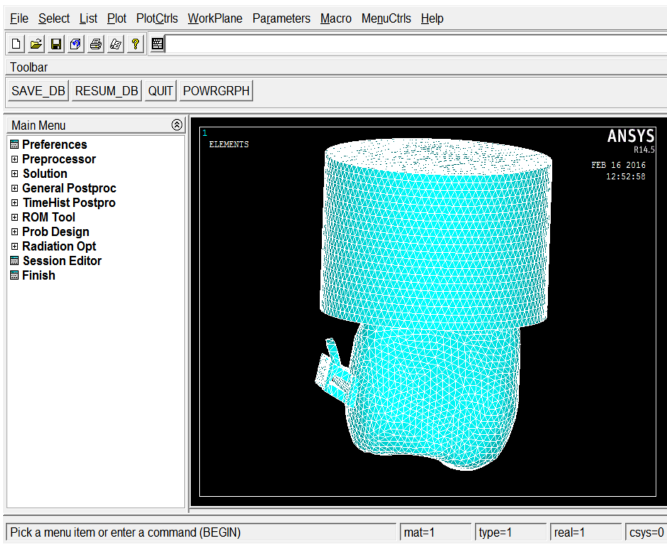


**Fig. 5**. Imported model into Ansys

The boundary conditions considered was one side of the cancellous bone all degrees of freedom arrested because to avoid the displacement of bone. The force is applied on the buccal tube hook, ranging from 50 grams to 150 grams. Fig. 6 shows the model with boundary conditions.

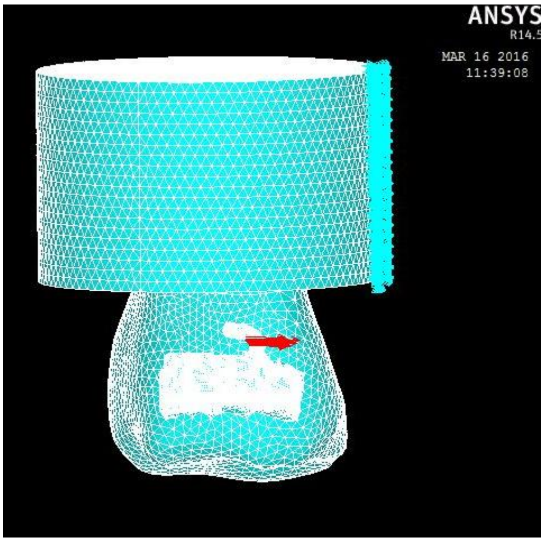


**Fig. 6**. Model with boundary conditions

### III. Results And Discussions

Because of the applied force on hook, the molar tooth is translated from its original position. In this study the rotation of tooth is not considered. The translated tooth with all the components is shown in fig. 7. The overall translation of assembled model for various forces is presented in Table 3.
Since the load is applied on mesial side, the tooth is also translated towards mesial direction. When the tooth is translated the PDL and cancellous bone are subjected to stress. In this analysis the tooth is allowed to freely translate and it is having contact with PDL and PDL is forced to translate and made to contact bone.

**Table. 3** Forces and translation

| Sl. N0. | Load (grams) | Forces(N) | Translation(mm) |
|---|---|---|---|
| 1 | 50 | 0.012 | 0.0572 |
| 2 | 75 | 0.01899 | 0.0816 |
| 3 | 100 | 0.0253 | 0.1096 |
| 4 | 125 | 0.03166 | 0.1384 |
| 5 | 150 | 0.03795 | 0.1639 |

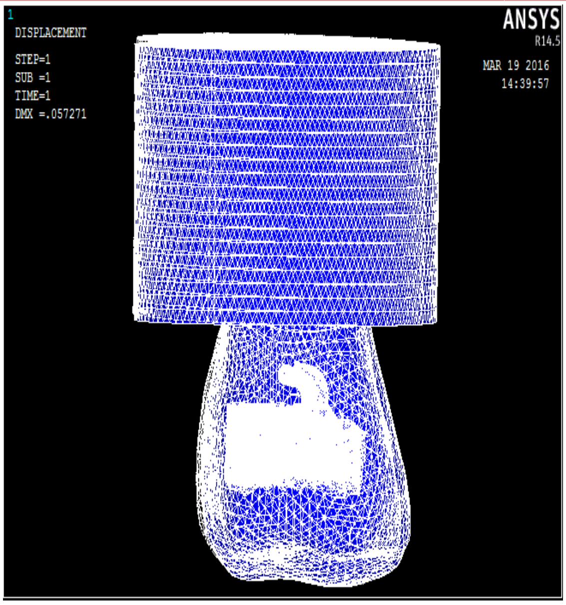


**Fig. 7.** Translated tooth with all components

**Conclusion:**

The finite element method simulates real clinical condition of tooth movement. This study shows that tooth is translated because of applied force on molar tube hook. The 3-dimensional translation magnitude of tooth for each load is part of our ongoing work. This study addresses clear information on molar tooth movement which will be helpful for clinicians to improve the force applications.

### IV. ACKNOWLWDGEMENT

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