A THREE-DIMENSIONAL ANALYSIS OF RAPID MAXILLARY EXPANSION ON MAXILLA BONE

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INTRODUCTION

This paper investigates the computational modeling method to assess maxillary expansion using rapid maxillary expansion device (Figure 1) in patient with constricted arch. Expansion is possible because the maxilla bone that make up the upper jaw is connected by a midline suture which is malleable until the age shortly after puberty [1]. The device is attached to the teeth which serve as the anchor for orthpedic movement. The objective of the study is to analyze the displacement caused by maxillary expansion using finite element analysis (FEA). Here, using 58849 elements , we simulated a normal displacement for which the bony structures of an adolescent maxilla can withstand without fracture.

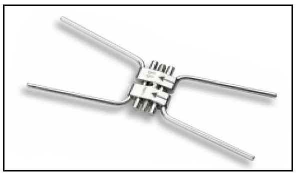

Figure 1: Rapid Maxillary Expansion Device

METHODS

The maxilla bone and teeth model was acquired from a CT scan of a 15 year old patient with a narrow upper arch. A 3D model generating software, MIMICS (Materialise, Belgium) was used to analyze the specific cranio-facial region. The 3D model was carefully segmented, smoothened and exported to ABAQUS software for finite element analysis. The analyzed model consists of 58849 elements and 12544 nodes.

The model is restrained from moving or rotate in x, y or z direction on the outer edge of the maxilla bone. The respective teeth are assigned to move 0.125 mm on each side. This is concomitant with the conventional rapid maxillary expansion practice, whereby each activation will separate 0.25 mm of the maxilla halves. The generated 3D maxilla model was referenced by cortical bone and teeth properties. Referring to previous studies on modeling the maxilla [2], we specified the Young's Modulus value of 1370 MPa and 20 GPa for maxilla bone and teeth respectively. The Poisson Ratio of 0.3 was also identified. The 3D model was assumed to have an isotropic material property.

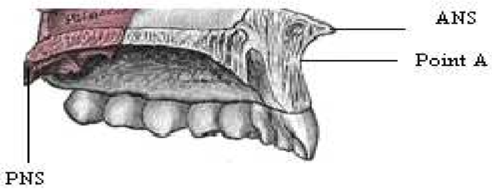

Figure 2: 4 Points of measurement used.

RESULTS AND DISCUSSION

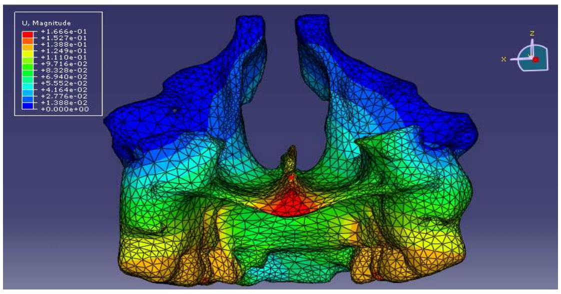

Figure 3: Posterior view of spatial displacement of maxilla bone model after 0.25 mm expansion

The points of interest for analysis are the anterior nasal spine, posterior nasal spine (PNS) and point A (Figure 2). From the spatial displacement contour presented in figure 3 and in Table 1, the maximum displacement occurs at the most posterior region, or the PNS. Significant movement is also seen at the anchored teeth. The separation of the maxilla bone is due to the presence of the mid-palatine suture which serves as an opening of the maxilla halves. To ensure a balanced separation of the maxilla, the points of force application play a significant role in predicting the displacement of the maxilla. This entails an expansion device which is rigid in producing a controlled force.

CONCLUSIONS

1 Rigid and stable appliance is required to produce stable orthopedic effect on the maxilla.

2. The simulation proves that the point of force application plays a significant role in producing expansion.

REFERENCES

1. Krebs A.A, *Trans Eur Orthod* Soc **34** : 163-171, 1958
2. Tanne K, et al., *Am J Orthod Dentofacial Orthop* **95**: 200-7,1989

Table 1: Displacement of the points of interest during rapid maxillary expansion

Selected Maxilla region (Selected Node)	**Displacement (m)**			
	x- direction (axial)	**y-direction (sagittal)**	**z-direction (coronal)**	**Magnitude**
ANS (Node 3310)	-5.19564e-002	9.37477e-002	-1.10654e-001	1.54053e-001
PNS (Node 2508)	3.97759e-002	6.19769e-003	-3.08834e-001	3.11446e-001
Point A (Node 2391)	-4.02970e-002	1.04482e-001	-1.09722e-001	1.56778e-001