ABSTRACT

Aim: -

The aim of this study was to do a Finite element analysis (FEA) to evaluation the stress distribution and displacement of skull with Mini Screw Assisted Rapid Palatal Expander. The Finite Element model of skull was obtained from the Computed Tomographic (CT) scan images of a patient who had undergone transverse maxillary expansion by means of Mini Screw Assisted Rapid Palatal Expander.

The objectives are: -

1. To compare and evaluate the simulated results of the FEM with the actual post expansion results of the patient by the means of superimposition
2. To evaluate the magnitude and pattern of displacement of the Cranio-facial complex
3. To study Von Mises stress distribution of the craniofacial bones namely Maxilla, Nasal bone, Temporal bone, Sphenoid bone, Zygomatic bone and the Mandible.
4. To evaluate the Von mises stress distribution in and around (a) Implants, (b) Expander device, (c) permanent upper first Molar.

Materials and Methods:

In this present study a CT model of a 19 year old female patient, who had undergone mini screw assisted rapid maxillary expansion was used to create the FE model. The subject had a class II skeletal base with Angles class II div 1 malocclusion and had a constricted maxillary arch. The model of the MARPE appliance was constructed to closely resemble the device used in the subject. The design had four mini-screws implants (MSI) placed in line with the molars taking the upper first molar as an anchor unit. The MSI's had a Bi-cortical bone engagement with length of 11mm and 1.8mm diameter and the connecting arm from the device to the upper first molars had a diameter of 1.2mm. Displacement of 5mm was given in the FE model since the subject had a 5mm expansion.

To validate the results, the post expansion simulated FE model was superimposed on the immediate post CBCT model (stereolithographic model-STL).

Results:

The simulated post treatment FE model when superimposed with the post expansion CBCT image showed more than 95% correlation.

A near parallel expansion of the mid palatal suture (MPS) was seen in the Occlusal view with a deviation of 1mm more near to the ANS when compared with PNS. In the frontal view a V-shaped expansion could be seen with base towards the dentition and apex towards the nasal bone. The zygomatico-maxillary complex had a lateral rotation with the fronto-zygomatic suture as the fulcrum of rotation. There was very minimal amount of changes that could be noticed in the temporal, nasal and sphenoid bone. A good amount of lateral bending of the pterygoid plates could be noticed with disjunction in the Pterygo-maxillary complex. The upper first molars had more of translation and negligible amount of tipping

When Von misses stress were evaluated, high amount of stress were seen near the MPS, posterior part of the palate and around peri-implant area. The cervical region of the bone-implant interface and the anchor teeth had less amount of stress.

Conclusions:

- Posterior placement of the expansion device and Bi-cortical bone engagement of MSI's brings about more expansion in the posterior region, by exerting more force to successfully overcome the resistance offered by the pterygomaxillary complex and zygomatic buttress resulting in a near parallel split of the MPS.

- Bi-cortical bone engagement of the MSI's decreases the stress around the cervical region of the bone implant interface and thereby increasing the success rate of the MSI's.
- Decreasing the rigidity of the connecting wires reduced the tipping of the anchor teeth since considerable amount of stress was dissipated within itself before it reaches the anchor teeth.

Keywords:

Stress distribution, Von Mises stress displacement, Finite element model (FE model), finite element analysis (FEA), circum maxillary suture (CMS), fronto zygomatic suture (FZS), mid palatal suture (MPS), mini-screw/ mini-implants (MSI's).