



Comparative Evaluation of the Forces Produced by Tongue on Circummaxillary Sutures in Skeletal Class-III Malocclusion with Maxillary Hypoplasia Using Tongue Crib with that of Facemask Therapy: A FEM Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Study Protocol

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ABSTRACT

Introduction: The tongue exerts its force during swallowing, while it rests behind the crib. Magnitude of forces tongue exerts through tongue crib at various sutures, its implication in various grades of maxillary hypoplasia in Class III malocclusion is not provided in literature. The rationale of this study is to investigate stress distributions in the sutures of craniofacial region produced by forces applied by tongue through tongue crib in comparison with facemask therapy in Class III malocclusion with maxillary hypoplasia in maxillary protraction.

Objectives: The rationale of this study was to compare forces generated by tongue through tongue crib and facemask therapy in Class III malocclusion with maxillary hypoplasia in child of pubertal age group.

Methodology: Finite element model of skull would be generated and simulation of tongue crib and

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facemask therapy would be done and stresses would be studied at various sutures. Quantitative analysis is done by elucidating values of finite element analysis.

Expected Results: The forces produced by tongue on circummaxillary sutures in skeletal Class III malocclusion with maxillary hypoplasia using tongue crib with that of facemask therapy would be substantial.

Conclusion: Stress distribution produced by protraction forces exerted by tongue through tongue crib in comparison with facemask therapy in Class III malocclusion with maxillary hypoplasia would be studied through finite element analysis to promote growth in maxilla.

Keywords: Maxillary hypoplasia; finite element method; myofunctional therapy; facemask therapy; tongue crib.

1. INTRODUCTION

Class III malocclusion incidence is 5.93% of world population, it is found prevalent in permanent dentition when compared with mixed dentition. In Indian children aged 5 to 15 years, prevalence varied between 0% to 4.76%. Comparing it to the scenario of the world, Indian population has lowest prevalence of 1.19% among all races. Class III malocclusions is found with maxillary deficiency, mandibular prognathism, or includes both [1].

Maxillary hypoplasia presents with deficiency of upper arch in 3 planes of height, width and anteroposterior relationship, which necessitate treatment. The treatment in a growing child, will help correct it skeletally by the clinician. Harmful psychological impact on patients include physical and functional abnormalities during mastication, speech and airway constriction necessitating an early intervention [2-5]. In patients with maxillary deficiency where the mandible is normal, intervention may involve maxillary protraction by orthopaedic forces. In maxillary deficiency, for developing arch we need to initiate expansion in transverse, sagittal and vertical plane [6]. In order to explain vital biomechanical adaptation in the skull, researchers have used photo-elastic, strain gauge and holographic interference technique [7-10]. The need for precise evaluation in living tissues led to more advanced studies like finite element analysis being used in orthodontics [11-14].

Myofunctional therapy in growth modification is the best way to correct jaw discrepancy as it allows patient to get rid of skeletal disharmony. Facemask therapy with expansion in maxilla corrects Class III malocclusion with maxillary hypoplasia, it is very effective in protraction of maxilla by exerting heavy and continuous force. But patient compliance is an issue every practicing dentist has to deal with, so various

efforts are directed to decrease the bulk and complexity of appliance. When tongue crib appliance is placed in mouth it produces substantial force, which promotes growth. The tongue exerts its force during the physiological process of swallowing, while it rests behind the crib. Magnitude of forces tongue through tongue crib exerts at various sutures, its applied implication in various grades of maxillary hypoplasia in Class III malocclusion is not provided in literature [15,16]. Craniofacial complex will be modeled for finite element analysis. Forces are loaded, which will be followed by evaluation of stresses acting on the sutures. The rationale of this study is to investigate stress distributions in the sutures of craniofacial region produced by maxillary protraction forces applied by tongue through tongue crib in comparison with facemask therapy in Class III malocclusion with maxillary hypoplasia [17].

1.1 Aim

“To compare and evaluate effect of forces produced by tongue on circummaxillary sutures in skeletal Class III malocclusion with maxillary hypoplasia using tongue crib with that of facemask therapy using finite element method (FEM).”

1.2 Objectives

1. To evaluate stress pattern in the circum-maxillary sutures produced by tongue through tongue crib in minimal to moderate Class III cases with maxillary hypoplasia.
2. To evaluate stress pattern in the circum-maxillary sutures produced by facemask with screw protraction appliance in minimal to moderate Class III cases with maxillary hypoplasia.
3. To evaluate the transverse stresses in tongue crib and facemask with screw

protraction appliance in minimal to moderate Class III cases with maxillary hypoplasia.

4. To compare stress pattern in the circum-maxillary sutures in tongue crib and facemask with screw appliance in minimal to moderate Class III cases with maxillary hypoplasia.

2. METHODOLOGY

2.1 Study Design

The observational study will be conducted in the Department of Orthodontics and Dentofacial Orthopedics, Sharad Pawar Dental College, Sawangi (M), Wardha in collaboration with Department of Radiodiagnosis, Jawaharlal Nehru Medical College, Sawangi (M), DMIMS (DU), Wardha.

A patient having skeletal Class III malocclusion with mild to moderate maxillary hypoplasia would be selected for CT scan of skull to be done. Patient would be selected from the ones coming at the outpatient department (OPD) of Orthodontics and Dentofacial orthopaedics of Sharad Pawar Dental College, Wardha.

3. METHODS

3.1 Inclusion Criteria

- Class III malocclusion where maxilla is retrognathic and mandible is normognathic..
- Straight to mild concave facial profile.
- Minimum to moderate negative overjet.
- Patient in pubertal age group.

3.2 Exclusion Criteria

- Patients with previous orthodontic treatment.
- Class III malocclusion with mandibular prognathism.
- Patient in post pubertal age group.

The steps undertaken would be-

1. CT scan of skull will be done of the patient. Image generated is converted to DICOM format.
2. Geometric model would be made. Tongue crib and facemask will be modelled using values in literature.

3. Geometric model would be converted to finite element model.

4. Materials would be assigned their property by incorporating Young's modulus and Poisson's ratio values from literature.

5. Boundary condition would be defined on basis of nature of modelling system.

6. Incorporation of forces at different points of geometry and their configuration. Forces would be incorporated according to values in literature.

7. Stresses would be arbitrated using Hooke's law whereas strains are obtained from displacement function within element combined with Hooke's law.

8. Quantitative analysis is done by elucidating values of finite element analysis [15,16].

4. EXPECTED RESULTS

The forces produced by tongue on circummaxillary sutures in skeletal Class III malocclusion with maxillary hypoplasia using tongue crib with that of facemask therapy would be substantial. If this hypothesis is proven it would provide a simpler and effective modality to correct and intercept Class III malocclusion.

5. DISCUSSION

Myofunctional therapy is a efficient modality in treatment of skeletal deficiency but the drawback is bulk of the appliance it led to clinicians exploring less bulkier modality. Tongue forces should be harnessed via tongue crib for growth in mild maxillary discrepancy to promote growth. Few of the related articles were reported [18-21].

Christof Holberg et al. (2007) had examined strain in midface and cranial base sutures and stretching effect applied by facemask during maxillary protraction. Using finite element method, simulation was done on the model-which includes application of forces in anterior and anterior caudal direction. They concluded it had apparent effect on dental component.

Rahman et al. (2012) compared effect of tongue through tongue crib appliance and facemask in treatment of Class III malocclusion with deficit of growth in maxilla in children of pubertal age group. They had assigned two group one treated with facemask and other with tongue crib appliance. He concluded that both modalities treated Class III patients with maxillary deficit, maxilla had moved forward.

Rahman et al. (2015) had compared effectiveness of face mask and fixed tongue crib appliance in stimulation of growth in maxilla. Disturbance in buccinator mechanism in both modalities had caused lingualization of lower incisors in tongue appliance due to elimination of tongue pressure whereas in facemask it was caused by chin cup pressure. Further evaluation of discontinuing the appliances had found increase in IMPA and decrease in overjet.

6. CONCLUSION

Finite element method helps study impact of stimulation in patient with considerable precision. If this hypothesis is proven it would provide a simpler and effective modality to correct and intercept Class III malocclusion.

CONSENT

An informed consent would be obtained from the parents of the child to use computed tomography (CT) images of skull after clarifying the aim and the rationale of the research.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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