ORTHOPAEDIC TREATMENT OF MAXILLARY DEFICIENCY IN GROWING PATIENTS

Dr. Abdolreza Jamilian et.al

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Written by

Author

Dr. Abdolreza Jamilian

Module leader, City of London Dental School, University of Bolton, London, UK.

Professor, Orthodontic Department, Faculty of Dentistry, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran. Email info@jamilian.net.

Co-Author

Dr. Rosana Farjaminejad

School of Health & Psychological Sciences Department of Health Services Research and Management, City University of London, United Kingdom Rosana.Farjaminejad@city.ac.uk.

Dr. Ludovica Nucci

Multidisciplinary Department of Medical-Surgical and Dental Specialties, University of Campania Luigi Vanvitelli, Naples, Italy. Ludortho@gmail.com

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PREFACE

As an orthodontist, I have always been driven by a deep passion for improving the smiles and overall oral health of my patients. Throughout my career, I have encountered numerous cases of maxillary deficiency in growing patients, a condition that can have a profound impact on their facial aesthetics, dental function, and self-confidence. It is this motivation to provide the best possible treatment options for these individuals that inspired me to write this book.

" ORTHOPAEDIC TREATMENT OF MAXILLARY DEFICIENCY IN GROWING PATIENTS " represents the culmination of years of research, clinical experience, and a relentless pursuit of knowledge in the field of orthodontics. I have had the privilege of working with talented colleagues, mentors, and patients who have entrusted me with their care, and it is their collective stories and experiences that have shaped the foundation of this work.

Treating maxillary deficiency can be challenging, and it often requires jaw surgery. Many colleaguesrefer patients to maxillofacial surgeons for treatment after age 18. My main goal in writing this book was to introduce several modalities for treating maxillary retrusion and to save patients from surgical procedures.

This book aims to serve as a comprehensive guide for orthodontists, dentists, and other healthcare professionals who encounter cases of maxillary deficiency in growing patients. It is designed to provide a holistic understanding of the condition, from its etiology and diagnosis to the various treatment modalities available. Through the pages of this book, I hope to offer practical insights, evidence-based approaches, and innovative techniques that can be applied in clinical practice.

While every patient is unique and requires an individualized treatment plan, the principles outlined in this book will provide a solid framework for addressing maxillary deficiency in growing patients. From early intervention strategies to comprehensive orthodontic management, each chapter delves into the intricacies of treatment planning, mechanics, and the potential long-term outcomes of various interventions. I would be remiss not to acknowledge the invaluable contributions of my colleagues and the broader orthodontic community. The field of orthodontics is one that thrives on collaboration, shared knowledge, and continuous learning. It is through this collective effort that we are able to refine our techniques, challenge existing paradigms, and push the boundaries of what is possible.

I am humbled and honored to have the opportunity to share my insights and expertise through this book. My hope is that it will not only serve as a practical resource for fellow orthodontists, but also inspire a new generation of clinicians to embrace the complexities of maxillary deficiency treatment and continue to advance the field.

I extend my heartfelt gratitude to the patients who have entrusted me with their care and allowed me to be a part of their transformative journeys. Your trust and resilience have been my greatest motivation. I would also like to express my appreciation to my family and loved ones for their unwavering support and encouragement throughout this endeavour.

Finally, I want to emphasize that this book is a testament to the remarkable progress that can be achieved when science, art, and compassion converge. By sharing knowledge and expertise, we can positively impact the lives of countless patients and contribute to the advancement of orthodontics as a whole.

Professor. Abdolreza Jamilian

Orthodontist and Author

INTRODUCTION

Skeletal Class III malocclusion is a challenging issue to correct, as it can be associated with maxillary retrusion, mandibular protrusion, or both. The incidence of Class III malocclusions characterized by maxillary deficiency ranges from 65% to 67%. Treatment may involve stimulation and guidance of maxillary growth by orthopaedic forces, such as facemasks and reverse pull headgears. Dental implants, miniplates, and modified fixation screws provide bone anchorage in orthodontic treatment. Recently, minis crews (mini implants) have become popular due to their ease of use[1]. An Angle Class III malocclusion can exhibit various skeletal and dental components, including a large or prognathic mandible, retrusive maxilla, protrusive mandibular dentition, retrusive maxillary dentition, or a combination of these components. The incidence of Class III malocclusion varies among racial groups, with 1 to 4 per cent among Caucasian populations and 4 to 14 per cent in Asians. Ellis and McNamara reported that 30% of Class III subjects presented with maxillary retrusion and mandibular prognathism.[2] The literature reports several treatment approaches for Class III malocclusions due to maxillary deficiency. Delaire developed the orthopaedic facemask to stimulate maxillary development, Nanda and Goldin studied the effects of posteroanterior orthopaedic forces on the maxillary complex, and tongue appliances, Bollard modified miniplates, and miniscrews have also been employed for the treatment of maxillary deficiency. Treatment of Class III patients with mandibular prognathism is most likely to require orthognathic surgery.[3]

Class III patients who have a combination of maxillary deficiency and mandibular prognathism provide treatment challenges and require complex treatment plans. There are two methods of possible treatment: correcting maxillary deficiency at an early age and postponing mandibular surgery until completion of mandibular growth or delay all treatment until the completion of skeletal growth, after which orthognathic surgery would be considered and offered to the patient.[4] Each method has advantages and disadvantages, creating a clinical dilemma. Class III malocclusion can exhibit a variety of skeletal and dental components, including a large or protrusive mandible, retrusive maxilla, protrusive mandibular dentition, retrusive maxillary dentition, and combinations of these components. In view of the high frequency of maxillary retrusion, maxillary advancement by orthopedic forces has been considered a major treatment option in growing patients. One such treatment approach is Delaire's face mask, which uses modified protraction headgears to control force application and direction.[5] Other treatments include extraoral protraction forces, implants placed in the zygomatic processes of the maxilla, titanium lag screws, miniplates, bone-anchored maxillary protraction, and miniscrew implants.

The high frequency of maxillary retrusion in skeletal malocclusions has led to the development of various treatments for this condition.[6] Protraction of the maxilla with a face mask is a commontreatment for Class III malocclusions with maxillary retrusion, and it has been used for over a century. Face masks are an intraoral maxillary appliance with elastics stretched between the intra- and extra-oralparts, which can be either removable or fixed. Skeletal class III malocclusion is defined as a skeletal facial deformity characterized by maxillary skeletal retrusion, mandibular skeletal protrusion, or a combination of both.[7] The prevalence of class III malocclusion ranges between 1 and 4% in North American and 1.5 and 5.3% in Europeans. In Asian populations, the frequency of class III malocclusionis reported to be higher, and in Chinese populations, the prevalence can be as high as 12%. A series of approaches have been described in the literature regarding orthopaedic treatment in class III malocclusion, if the mandible is not markedly affected. Orthopaedic correction of class III malocclusion and maxillary deficiency has been described using face masks, Frankel FR-III, reverse headgear appliances, endosseous implants, surgically-assisted orthopedic protraction, distraction osteogenesis, tongue appliances, tongue plates, suborbital protraction appliances, and Nanda's modified protraction headgear. Recently, miniplates, mini-implants, and reverse chin cups have also been usedfor the treatment of this malocclusion.[8]

Several techniques have been described, including the use of a facemask, reverse chin cup, direct force application via ankylosed primary canines, or through implants placed in the zygomatic processes. Miniscrew implants and miniplates have also been used to provide the necessary orthodontic anchorage in these cases. The tongue plate and tongue appliance have also been used for the correction of maxillary deficiency in growing patients.[9] Many investigators have reported on the results of maxillary retrognathic patients treated with extraoral appliances such as face masks and reverse chin cap. Most studies noted a clockwise rotation of the mandible with the protraction of the maxilla. However, this rotation was not indicated in Class III cases with high-angle skeletal patterns and anterior open bites. Recent studies have revealed the beneficial treatment effects of tongue appliance on the maxilla. The aim of this study was to compare the effects of face mask and tongue appliance in Class III malocclusion growing patients with maxillary deficiency.[10]

Cleft lip and palate deformities are one of the most common congenital abnormalities in the craniofacial complex. Midfacial deficiency is a common feature of cleft lip and palate patients due to scar tissue from the lip and palate closure procedure. Numerous appliance designs, such as endosseous implants, ankylosed teeth, surgically assisted orthopedic protraction, and distraction osteogenesis, have been introduced to achieve maximum skeletal effects.[11] Treatment approaches to improve the maxillary position were performed by using the face mask, protraction headgear, and suborbital protraction appliances. Protraction of the maxilla at either the primary or mixed dentition period may improve nasomaxillary growth and soft tissue facial profile. However, the esthetic aspect and large size of extraoral appliances require high cooperation from patients, who prefer small-sized and more convenient appliances to maintain their esthetics. This study aimed to examine the effectiveness of tongue appliance to improve the growth of nasomaxillary complex in complete bilateral cleft lip and palate patients at mixed dentition periods.[12]

Class III malocclusion is a deviation in the sagittal relationship of the maxilla and mandible, characterized by a backward position of the maxilla, forward position of the mandible, or a combinationof both. It can also be caused by underdevelopment of the maxilla or overdevelopment of the mandible.For growing patients with skeletal Class III malocclusion characterized by maxillary retrognathism, extraoral appliances such as reverse headgear, reverse chin cup, or facemask are recommended in moderate to severe cases.[13] Bone-anchored maxillary protraction devices such as miniscrew and miniplate are also used for maxillary advancement. Systematic reviews (SRs) and meta-analyses are powerful tools for summarizing the contemporary evidence base. In recent years, the number of SRs that exist in relation to specific subjects has increased. The validity of these reviews is influenced by their methodology and in some cases, a SR of reviews can be conducted. Skeletal class III malocclusion is characterized by mandibular prognathism, maxillary deficiency, or some combination of the two. 14 Combined orthodontic and surgical treatments are the preferred approach to achieve a stable occlusion and a pleasing aesthetic outcome in more severe non-growing adult class III patients. However, treatment modality for class III malocclusion in growing patients can focus on orthopaedic interventions, which include growth modification with functional appliance, facemask, chin cup, and reverse chin cup therapies.[15]

Cleft lip and cleft palate are among the most common types of congenital dentofacial deformities, with the prevalence of these deformities being about one in every 500 to 550 births. Since patients undergo surgical procedures for closure of the cleft lip and cleft palate early in life, the resultant scar tissue constricts the growth of their nasomaxillary complex in all dimensions. These patients also have a characteristic retrognathic maxilla.[16] Therefore, the major focus of orthopedic treatments is to increase the dimensions of the nasomaxillary complex and protract the maxilla in order to improve the existing skeletal class 3 condition. Different modalities such as face mask, re-verse chin cap, and combination of rapid maxillary expansion protocols in conjunction with maxilary protraction have been used for correction of maxillary deficiency in growing patients. However, most of these devices are extraoraland bulky, imposing the risk of a low patient compliance. Tongue plate is an intraoral maxillary protractor device, proven useful in advancing the maxilla in growing class 3 patients with maxillary deficiency.[17,18]

One of the most difficult discrepancies to treat is Skeletal class III malocclusion due to maxillary deficiency. Early orthodontic treatment in patients with class III malocclusion depends on the patient's face's growth pattern and the treatment. With increasing age, the treatment becomes more difficult. Maxillary deficiency has been reported to be an important determinant of good prognosis. Treatment may involve stimulation and guidance of maxillary growth with orthopedic forces if the mandible is unaffected.[19] There are many methods to treat maxilla deficiency, such as Frankel's FR-III appliance for stimulating maxillary growth, endosseous implants, Protraction facemask therapy, surgically assisted orthopedic protraction, distraction osteogenesis, suborbital protraction appliances, and using ankylosed teeth as abutments for maxillary protraction. Skeletal Class III malocclusion is a challenging issue to correct, with prevalence varying among different ethnic groups. North American Caucasians have a prevalence of 1% to 4%, while Europeans have 1.5% to 5.3%. Asian societies have higher incidences, with Japanese and Chinese having rates between 4% and 5% and 4% and 14%, respectively. The frequency of Class III malocclusion varies depending on age, ethnicity, and classification method. Ellis and McNamara found that 65% to 67% of Class III malocclusions were characterized by maxillary deficiency, with maxillary retrusion being a major treatment option.[20]

Protraction facemask therapy, Frankel's FR-III appliance, and other appliance designs have been used to protract the maxilla. These orthopedic approaches provide a more favorable environment for normal growth, with skeletal and dentoalveolar effects mainly involving forward displacement, clockwise rotation of the mandible, protrusion of upper incisors, and retrusion of lower incisors. Tongue appliances have also been used to correct maxillary deficiency. The authors designed a new type of extraoral appliance called "Reverse Chin Cup" to evaluate its effectiveness in growing patients with Class III malocclusion and maxillary deficiency.[21-23]

Chapter 1

TREATMENT OF MAXILLARY DEFICIENCY BY MINISCREW IMPLANTS

Case history

The patient was a 12-year-old boy who was referred to an orthodontic private practice for treatment of maxillary deficiency. He had no medical problems and there were no signs of temporomandibular joint dysfunction. The patient had a mild skeletal Class III malocclusion due to maxillary deficiency.

Intraoral examination showed an edge-to-edge incisor relationship of the central incisors and cross-bites involving the upper lateral incisors, canines and first premolars. The patient had a Class III buccal relation- ship on both sides (Figure1-1). Facially, he had a straight profile because of maxillary deficiency, although the facial soft tissues masked the maxillary position. Cephalometric analysis confirmed the Class III skeletal pattern and normal mandibular position (Table 1-1) (Figures 1-2 and 1-3).

Treatment objectives

The treatment objectives for this patient were to:

1. correct the deficient maxillary arch, ideally by forward positioning of the maxilla;

2. obtain an ideal overjet and overbite;

3. correct the posterior cross-bites.

Treatment alternatives

Extraoral appliances, such as a protraction facemask, a Class III functional appliance, any modified maxillary protraction devices, and orthognathic surgery were considered as alternative treatments for correction of this Class III malocclusion; however, the patient refused the use of extraoral appliances and surgery. Instead in this case, it was decided to use miniscrew implants to protract the maxilla by application of Class III elastics.

Figure 1-1 Pretreatment photographs

	Pretreatment	Post-treatment
SNA	78u	81u
SNB	80u	80u
ANB	*2*2u	1u
U1 to MxPl	113u	114u
L1 to MnPl	91u	95u
Inter-incisal angle	127u	128u
MMPA	23u	25u
Facial proportion	57%	56%

L1 to A-Pog line	3 mm	2 mm
SN to MxPl	10u	9u

Table 1-1 Cephalometric analysis based on Eastman values

Figure 1-2 Pretreatment cephalometric radiograph

Figure1- 3: Pretreatment panoramic radiograph

Treatment Progress:

Self-drilling titanium alloy JeilTM miniscrews (Jeil Medical Corp., Seoul, Korea; 1.6 mm diameter, 8 mm length) were placed under local anaesthesia into the buccal alveolar bone between the mandibular canine and first premolar roots on both sides. The ideal position for screw insertion was evaluated by using a roots of the adjacent teeth and mental foramen. A tightly fitting and well retained upper removable appliance was fabricated with Adams clasps on the upper first permanent molars and premolars. C clasps were placed on the upper permanent canines and central incisors.

Orthodontic latex elastics (5/16 medium size) were connected from the miniscrews to the Adams clasps of the removable appliance to generate y450 g of anterior retraction. The patient was instructed to wear the elastics all the time, except for eating and to change the elastics every day. In order to retain these elastics, the Adams clasps on the molars and premolars were bent to form four loops; however in order to achieve optimal traction the elastics were only connected to the loops adjacent to the molars (Figure 1- 4). An expansion screw was placed in the midpalatal area of the upper removable appliance and the patient instructed to turn the screw once a week in order to correct the posterior cross-bites. Two Z-springs were inserted in the upper removable appliance to correct the cross-bite on the lateral incisors (Figure 1-5).

The upper removable appliance was changed three times because the patient broke the clasps once and lost the appliance twice.

Figure 1-4 Miniscrews and Class III elastics

Figure 1-5 Expansion of the maxillary arch

Treatment Results:

After 8 months of active treatment a positive overjet and Class I buccal segments were achieved and the cross-bites were corrected (Figure 1-6). The post-treatment cephalometric radiograph tracing showed a favourable increase of 3u in the SNA and ANB angles (Table 1-1; Figures 1-7 and 1-8). The pre and post-treatment cephalometric superimposition on the anterior cranial base is shown in Figure 1-9.

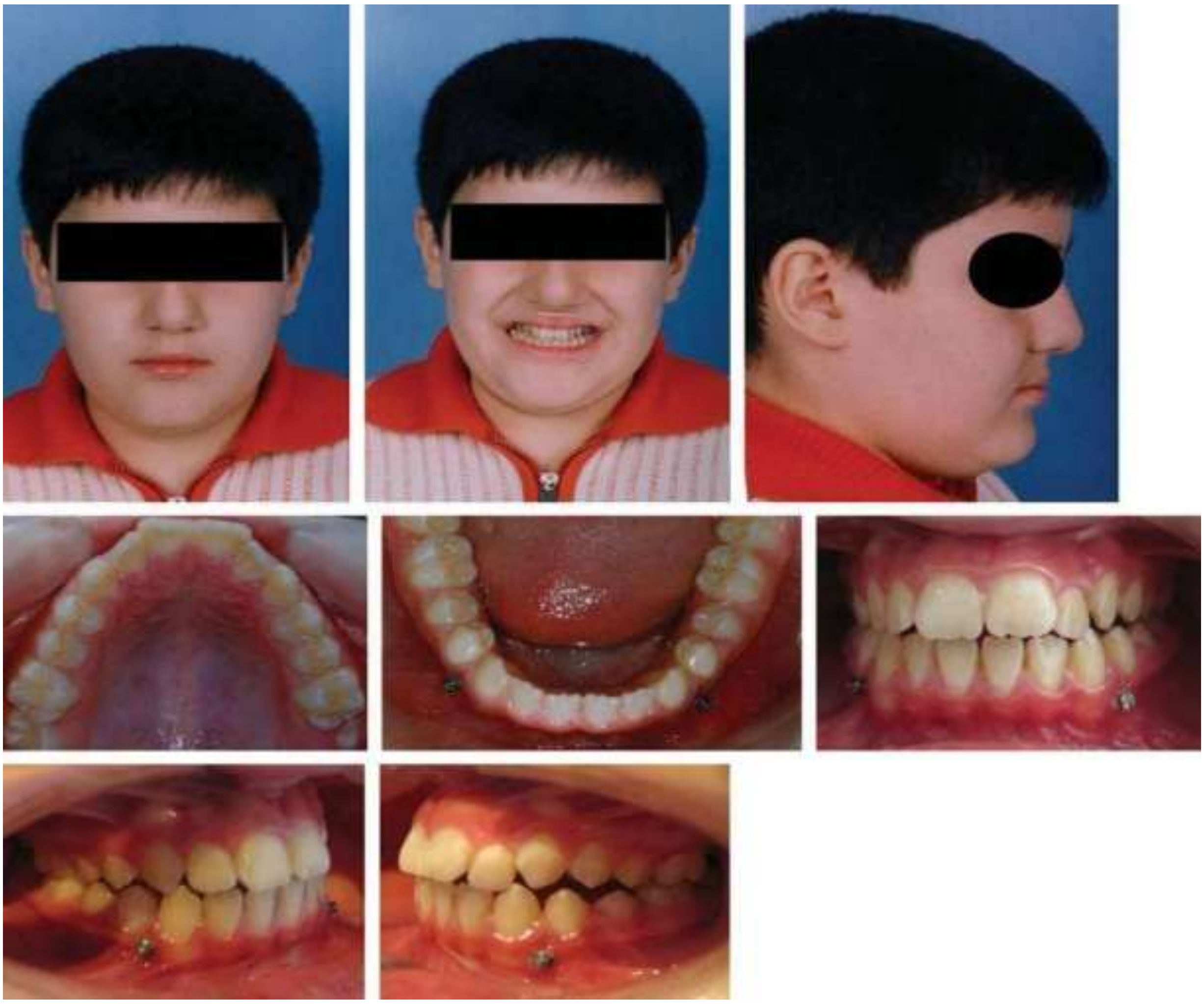


Figure1- 6 Post-treatment photographs

Figure1- 7 Post-treatment cephalometric radiograph

Figure 1-8 Post-treatment panoramic radiograph

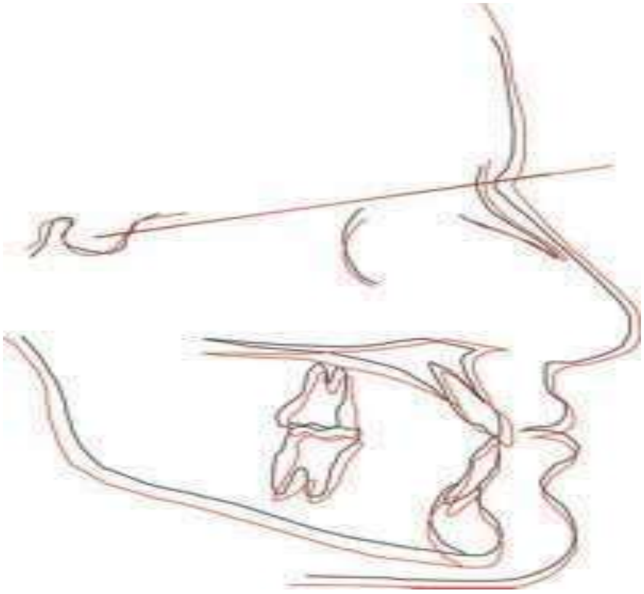


Figure1- 9 Superimposition of pretreatment (black) and post- treatment (red) cephalometric analysis of the patient, on SN, registered at sella

Discussion

This case demonstrates the clinical application of orthodontic miniscrews in the treatment of a 12-year-old boy with maxillary deficiency. Our system of treatment differs from conventional force applications, such as facemasks.

Previous studies [24,25] show that a significant amount of maxillary forward movement can be produced with maxillary protraction appliances. Recent reports indicate that some anteroposterior changes can be achieved up to the beginning of adolescence;4 however, these appliances may cause great discomfort for patients and are highly visible to wear, which leads to reduced patient cooperation. Another problem caused by extraoral appliances is that they can cause skin abrasions on the chin especially in hot climates. Therefore patients simply do not wear the appliance and lack of cooperation will lead to an unsatisfactory result. In addition if an extraoral force is applied against the chin, such as with protraction headgear or a chin cup then undesirable lingual tipping of the lower incisors can occur.[26]

In this case report, titanium miniscrews were used to overcome these various problems. Applying a force to the teeth in order to correct the skeletal discrepancy as was undertaken in this case will inevitably result in tooth movement; therefore, a full coverage upper removable appliance was used to cover all the maxillary dentition. The treatment using the miniscrew implants lasted for 8 months and tooth alignment was completed with fixed the completion of treatment and still has considerable residual growth he will be kept under careful review to monitor his continuing growth.[27]

The forces generated by elastics may be divided into two components. One force component is in a horizontal direction, moving the maxilla forwards, which is favourable in maxillary deficiency cases. The second component is in a vertical direction, moving the poster- ior maxillary dentition downwards. This might lead to unfavourable tooth movements when the vertical face height is increased, but is not a problem in patients with a low or average face height as in this case. Some changes to the appliance design may be considered in high angle cases such as the addition of a posterior biteplane. Otherwise, these mechanics should be avoided in high angle cases, as the force has a significant vertical component. Another shortcoming is that the miniscrews might loosen after insertion; therefore, we triedto increase stability by avoiding vibration and increasing the insertion depth. We did not use maxillary miniscrews since arguably they may be more unstable than mandibular ones because of the thinner, lessdense cortical plate.[28]

Summary

This case report demonstrates a novel method of using miniscrew implants to treat a 12-year-old boy with a skeletal Class III malocclusion due to maxillary deficiency. This is shown to be an acceptable alternative to the use of extra oral appliances such as facemasks.

Chapter 2

A NOVEL METHOD OF MAXILLARY DEFICIENCY TREATMENT BY TONGUE PLATE

Case History

A female patient, age 6 years, 6 months, was initially referred to a private orthodontic office for treatment of maxillary deficiency. She had no medical

problems and there were no signs of temporomandibular joint dysfunction.

Clinical examination revealed a Class III malocclusion with a mild maxillary deficiency. Facially, soft tissues masked the maxillary position (Figures 2, 1-2).

Intraoral examination showed an edge-to-edge incisor relationship of the upper incisors (Figures 2, 3-5).

Figures 2, 1-2 and Figures 2, 3-5: Pretreatment photographs

Cephalometric analysis confirmed the Class III skeletal pattern and normal mandibular position (Table 1) (Figures 6-7).

Table 1 - Cephalometric Analysis

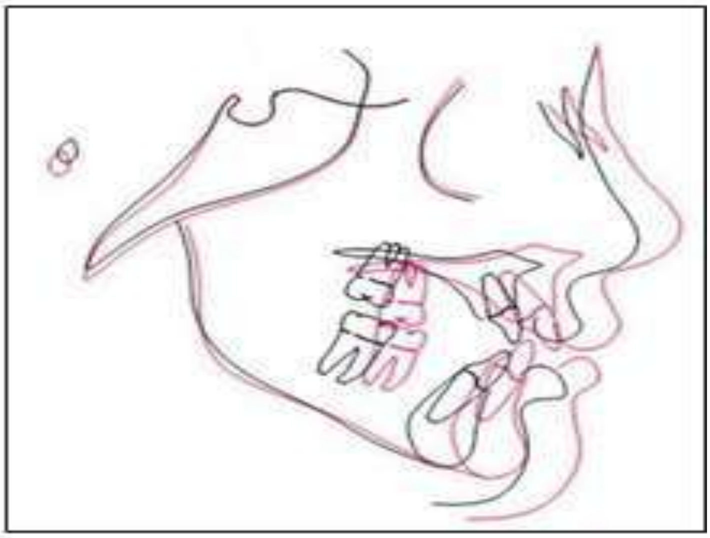
	Pretreatment	Post treatment
SNA (°)	77	81
SNB (°)	78	78.4
ANB (°)	-1	2.6
GoGn/SN (°)	35	33
1/SN (°)	102	110
IMPA (°)	96	85
Interincisal (°)	122	128

Figure 2- 6: Pretreatment lateral Cephalometric radiograph Figure 2-7: Pretreatment panoramic radiograph

Figures 2, 08-12: Posttreatment photographs

Figures 2- 13: Posttreatment lateral cephalometric

Figure 2-14: Posttreatment panoramic radiograph



Radiograph

Figure 2-15: Superimposition of pre (black) and post (red) treatment cephalometric analysis of the patient, on SN, registered at sella.

Treatment Objectives

The treatment objectives for this patient were to:

1. Correct the deficient maxillary arch, ideally by forward positioning of the maxilla

2. Obtain an ideal overjet and overbite

Treatment Alternatives

Extraoral appliances, such as a protraction facemask, a Class III functional appliance, any modified maxillary protraction devices, and a tongue appliance were considered as alternative treatments for correction of this Class III malocclusion. Orthognathic surgery at 18 years of age was also considered in case of unfavourable treatment results. However, the patient refused the use of extraoral appliances, and her parents rejected surgery; instead in this case, it was decided to use a tongue plate to protract the maxilla.

Treatment Progress

A tightly fitting and well-retained upper removable appliance was fabricated with Adams clasps on the upper first permanent molars and two C clasps were placed on the upper deciduous canines. An acrylic plate was mounted posterior to the upper incisors.

The patient was instructed to wear the appliance full- time except for eating, contact sports and tooth brushing. The active treatment time lasted for 24 months. The patient was examined, and the progress was observed after each monthly visit. The tongue plate was changed every 8 months.

Treatment Results

Positive overjet and overbite were achieved after 24 months of active treatment (Figures 2, 8-12). The post- treatment cephalometric radiograph tracing showed a favorable increase of 4° in the SNA angle (Figures 2-13, 2-14). The superimposition of pre- and post-treatment cephalometric tracings on the anterior cranial base are shown in Figure 2-15.

Discussion

This case illustrates the clinical application of a newly designed appliance named as “tongue plate” in the treatment of a 6-year-old girl with maxillary deficiency. An electronic review of the literature revealed no previous publication of clinical application of tongue plate for treatment of this malocclusion.[29]

This clinical approach differs from conventional applications, such as facemasks. Maxillary protraction appliances have been used for the treatment of maxillary deficiency.[30] These appliances may cause great discomfort for patients and are highly visible to wear, which leads to reduced patient cooperation. Another problem caused by extraoral appliances is that they can cause skin abrasions on the chin especially in hot climates. Therefore, patients simply do not wear the appliance and lack of cooperation might lead to an unsatisfactory result. Patients who wear glasses feel uncomfortable with these appliances. Another disadvantage is that use of a chin cup can lead to lingual tipping of the lower incisors as a result of the pressure of the chin cup component on the lower lip and dentition.18 In most cases, lingual tipping is an undesirable side effect and can cause crowding.[31]

In a recent study it was also reported that a tongue appliance can be used to treat maxillary deficiency, 8 A considerable pressure might be transmitted to the deficient maxilla when the tongue appliance is in the mouth and consequently move it in a forward position.[32] Mechanism of action of the tongue plate used in this study is very similar to the tongue appliance. The force of tongue during swallowing and resting posture is transferred through the tongue plate to the deficient nasomaxillary complex.

The considerable force of the tongue which is caged behind the acrylic plate moves the maxilla in a forward position. The rounded surface of the plate and its softened edges make it undamaging for the tongue. In addition, it is designed and adjusted in a way to avoid traumatizing the floor of the mouth. The tongue plate does not have any distinct advantage over the tongue appliance; however, the omission of the cribs which were used in the tongue appliance might give a better psychological feelingto the patients.

Nevertheless, the appliance used in this study has one disadvantage. It will lingualize the lower incisors due to elimination of tongue pressure on them. However, removal of the tongue plate will restore the pressure of the tongue on the lower incisors and will consequently.

result in increase of the IMPA. The treatment used in this study was for correction of a maxillary skeletal problem. Therefore, when the active treatment was finished, the patient was instructed to wear the appliance only at night to act as a retainer. This process is continued until arrival of the full permanent dentition. After eruption of the permanent dentition the tongue plate will be removed and further treatment will be continued by use of fixed appliances.[33, 34]

Summary

This case report demonstrates a newly designed appliance used to treat a 6-year-old girl with a skeletal Class III malocclusion and maxillary deficiency. This appliance is very similar to a tongue appliance and it has shown to be effective in treatment of maxillary deficiency and might be an alternative method to some extra-oral appliances such as facemasks.

Chapter 3

TREATMENT OF MAXILLARY DEFICIENCY BY MINIPLATES

Case History

The patient was an 11-year-old boy who was referred for treatment of maxillary deficiency. He had no medical problems, and there were no signs of temporomandibular joint dysfunction. The patient had a skeletal Class III malocclusion and maxillary deficiency. His parents had no Class III characteristics.

The facial photographs showed a Class III appearance with a concave profile because of maxillary deficiency. The pretreatment intraoral photographs and dental casts showed Class III relationship of the central incisors and anterior crossbite. The patient had a Class III molar relationship on the right and Class I on the left side (Figures 3-1 and 3-2). Cephalometric analysis confirmed the Class III skeletal pattern (Table 3-1) (Figure 3-3).

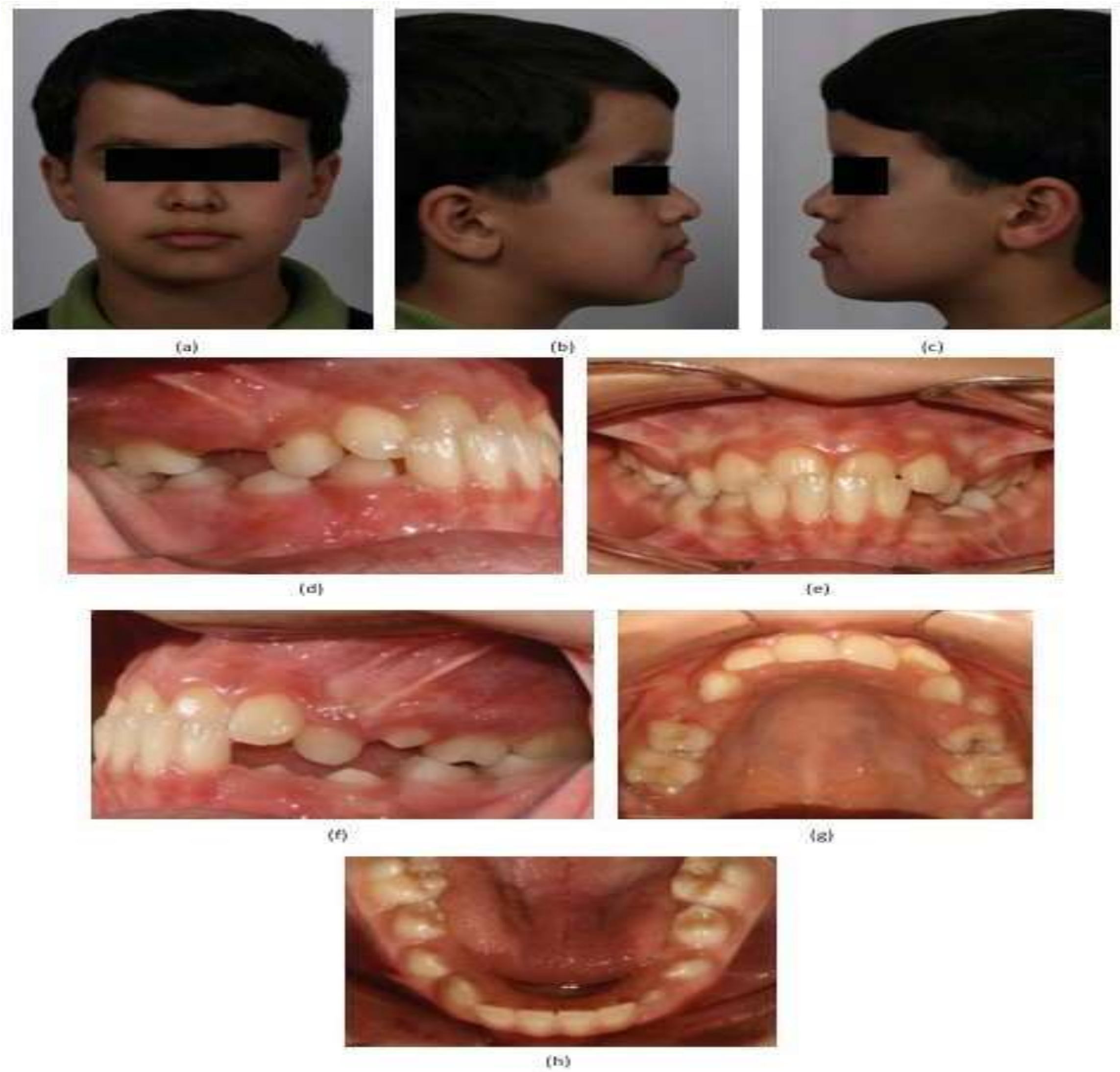


Figure 3- 1: Pretreatment photos of the patient.

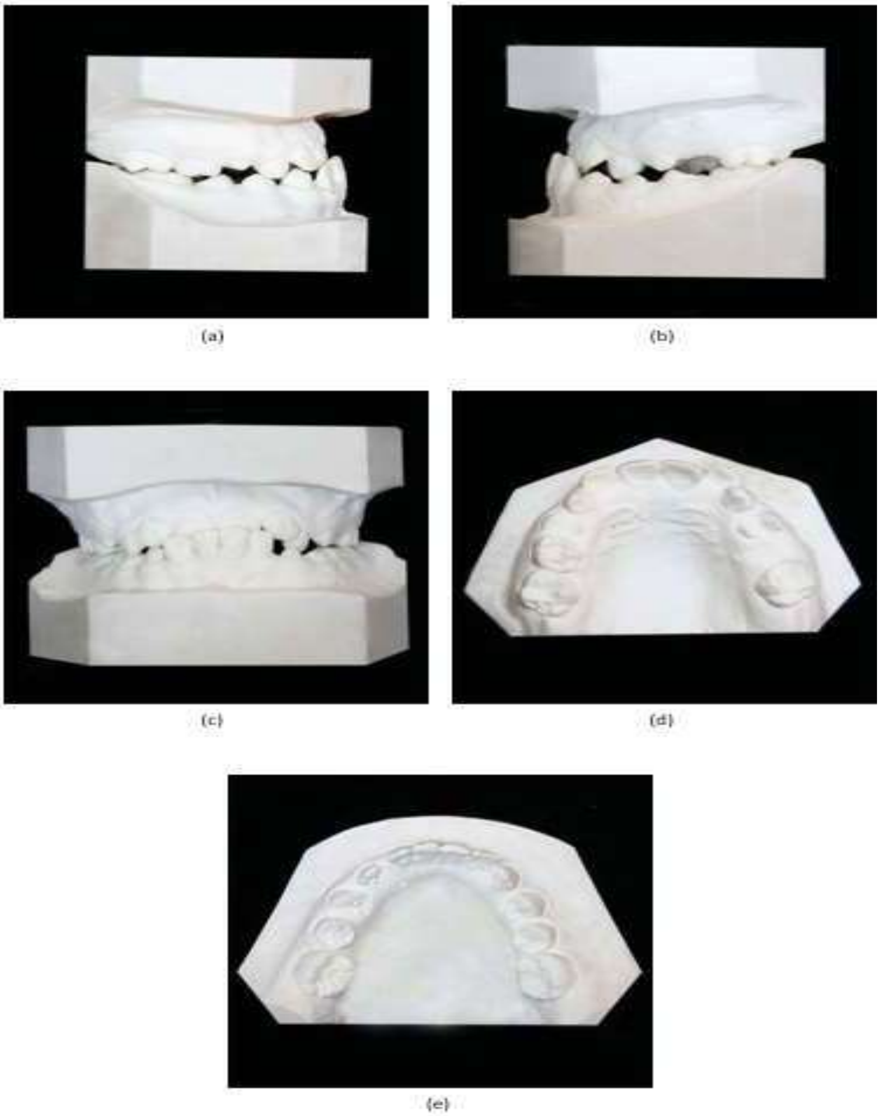


Figure 3-2: Pretreatment photos of the dental casts.

Table 3-1: Cephalometric analysis at pretreatment, posttreatment.

	Pretreatment	Posttreatment
SNA	77.1°	82.2°
SNB	79.9°	80.6°
ANB	□2.8°	1.6°
GO-GN to SN	27°	34°
U1 to Sn	116°	110°
MMPA	27.6°	32°
Facial proportion	64.3%	58%
SN to MxPl	8.7°	5.5°
U1 to MxPl	115°	112.9°
L1 to MnPl	90°	90°
Interincisal angle	127°	128.5°
L1 to A-Pog line	9 mm	5.2 mm

(a)

(b)

Figure 3-3: Pretreatment OPG and lateral cephalogram of the patient.

Treatment Alternatives

Extraoral appliances, such as protraction facemask, Class III functional appliance, any modified maxillary protrac- tion devices, and orthognathic surgery, were considered as alternative treatments for the correction of this Class III malocclusion. However, the patient refused the use of extraoral appliances and major surgery. Therefore, in this case, it was decided to use miniplates to protract the maxilla by application of Class III elastics.

Treatment Progress

Plates for Orthodontic Anchorage (Junji Sugawara, D.D.S., Ph.D.) (AP-YL-013) were placed under local anaesthesia in the canine areas of the mandible by a maxillofacial surgeon. The ideal position for miniplates insertion was evaluated by using a panoramic radiograph in order to avoid damage to the roots of the adjacent teeth and mental foramen. A tightly fitting and well-retained upper removable appliance was fabricated with two Adams clasps on the upper first permanent molars. Each of the Adams clasps had a loop which was used for retaining the elastics. A labial bow was also used on the anterior teeth for retention. A maxillary posterior bite plate was used to disclude the upper and lower jaws.

Orthodontic latex elastics (3/16" heavy size Unitek Elastics) were connected from the hooks of the miniplates to the Adams clasps of the removable appliance to generate approximately 500 g of anterior retraction. The patient was instructed to wear the appliance full-time except for eating, contact sports, and tooth brushing; he was also told to change the elastics every day. In order to retain these elastics, the Adams clasps on the molars were bent to form loops (Figure 3-4).

Figure 3-4: Removable appliance in the upper jaw.

Treatment Results

After 10 months of active treatment a positive overjet and Class I buccal segments were achieved and the anterior crossbite was corrected (Figures 3-5 and 3-6). The posttreatment cephalometric radiograph tracing showed a favourable increase of 5.1◦ and 4.4◦ in the SNA and ANB angles, respec- tively, (Figure

3-7). The pre- and posttreatment cephalometric superimposition on the anterior cranial base is shown in Figure 3-8.

Figure 3-5: Posttreatment photos of the patient.

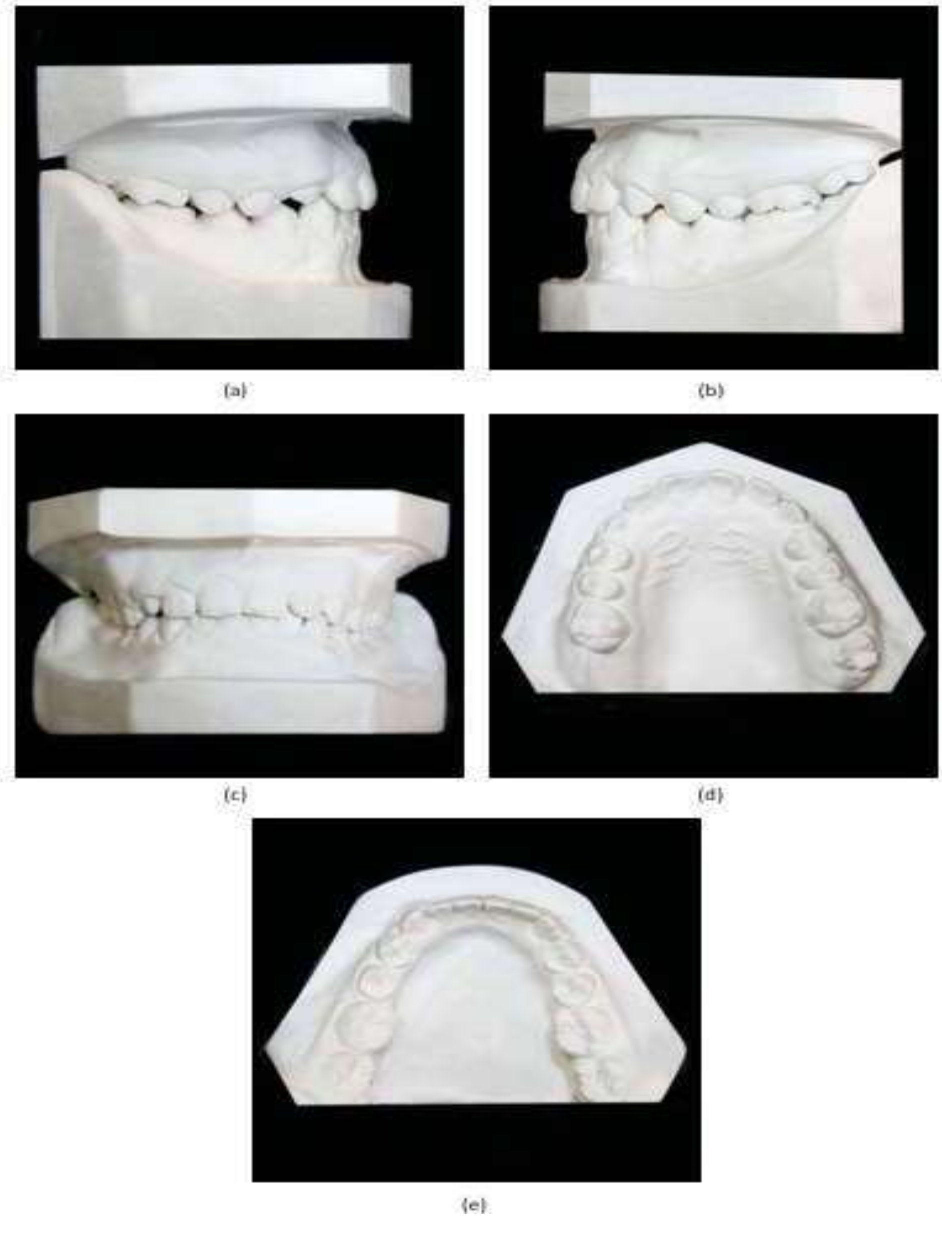


Figure 3- 6: Posttreatment photos of the dental casts.

Figure 3-7: Posttreatment OPG and lateral cephalogram of the patient.

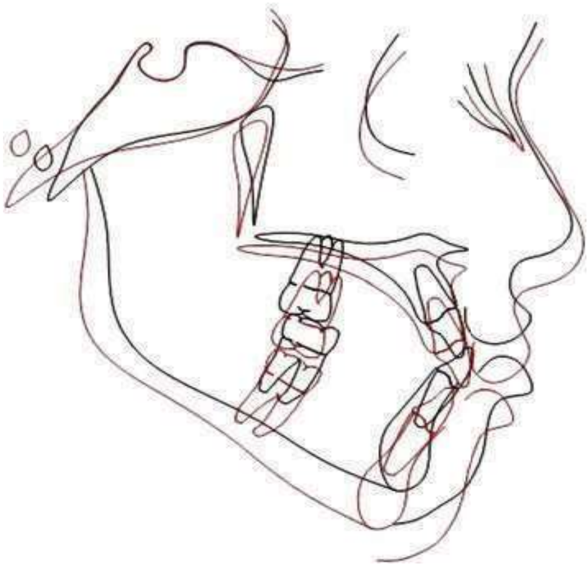


Figure 3-8: Superimposition in anterior cranial base at sella. Red: after treatment, black: before treatment.

Discussion

This case demonstrates the clinical application of miniplates in the treatment of an 11-year-old boy with maxillary defi- ciency. Our system of treatment differs from conventional force applications, such as facemasks. [35]

Previous studies [36, 37] show that a significant amount of maxillary forward movement can be produced with maxillary protraction appliances. Recent reports indicate that some anteroposterior changes can be achieved up to the beginning of adolescence; however, these appliances may cause great discomfort for patients and are highly visible to wear, which leads to reduced patient cooperation. Another problem caused by extraoral appliances is that they can cause skin abrasions on the chin especially in hot climates. Therefore patients may simply refrain from wearing the appliance, and the lack of cooperationmight lead to an unsatisfactory result.

One of the disadvantages of extraoral appliances is that, when extraoral force is applied against the chin, it is difficult to avoid tipping the lower incisors lingually. In other words, use of a chin cup can lead to lingual tipping of the lower incisors as a result of the pressure of the chin cup component on the lower lip and dentition [38]. In most cases, lingual tipping is an undesirable side effect and can cause crowding. In a case report miniscrews [39] have been used for treatment of maxillary deficiency. One of the limitations of miniscrew is their loosening, which can be distressing for the clinician and thepatient. In order to overcome this problem, wider diameter and deeper insertion of miniscrews must be used. De Clerck et al. [40] used the miniplates to protract the maxilla however; the design of current case report is different from that study. In a recent study bone-anchored maxillary protraction (BAMP) with miniplates was used in patients with Class III malocclusion, and significant improvements of over jet and molar relationship were recorded.[41]

In this case report, minor surgery and miniplates were used to overcome these various problems. As undertaken in this case, applying a force to the teeth in order to correct the skeletal discrepancy will inevitably result in tooth movement; therefore, a full coverage upper removable appliance was used to cover all the maxillary dentition. The treatment process lasted for 10 months. However, since the patient was only 11 years old and still had considerable residual growth, treatment was continued by fixed appliance.[42]

The forces generated by elastics may be divided into two components. One force component is in a horizontal direction, moving the maxilla forwards, which is favourable in maxillary deficiency cases. The second component is in a vertical direction, moving the posterior maxillary dentition downwards. This might lead to unfavourable tooth movements in high angle cases, but it is not a problem in patientswith a low or average face height. Maxillary posterior bite plate can overcome this problem in high angle cases by decreasing facial height.

Conclusion

This case report demonstrates a different method of using miniplates to treat an 11-year-old boy with a skeletal Class III malocclusion and maxillary deficiency. This treatment was found to be an acceptable alternative to the use of extraoral appliances such as facemasks and major surgery.

Chapter 4

TREATMENT OF MAXILLARY DEFICIENCY BY TONGUE APPLIANCE

Case History

A 10 year-old boy was initially referred for management of his dentofacial deformity. His medical history was clear and there were no signs or symptoms of temporomandibular joint dysfunction. Extra- and intra-oral examinations revealed a concave profile and underlying midface deficiency, resulting in an anterior crossbite (Figure 4-1). A cephalometric analysis confirmed the Class III skeletal pattern with maxillary deficiency and true mandibular prognathism (Table 4-I) (Figure 4-2). The diagnosis was a dental and skeletal Class III malocclusion created by a combination of maxillary deficiency and mandibular prognathism. The patient also had mild mandibular deviation to the right due to the occlusal disharmony but there was no evidence of a forward slide contributing to Class III.

Treatment objectives

The treatment objectives for this patient were to:

1. Correct the midface deficiency and the deficient maxillary arch, ideally by protracting the maxilla.

2. Establish an ideal overjet and overbite.

3. Correct the mandibular prognathism.

4. Correct the mandibular lateral shift.

Treatment alternatives

Postponing treatment until after the completion of skeletal growth was considered as a management possibility. Treatment at this time would require orthognathic procedures but this was unacceptable to the patient's parents who insisted on early intervention for psychological reasons. It was therefore decided to adopt an orthopaedic approach and attempt protraction of the maxilla by means of a tongue appliance.8 The use of other orthopaedic maxillary protraction devices such as the Delaire facemask,4 reverse chin cup,12 and miniscrew10 were also considered.

Figure 4-1. Pretreatment photographs. (a) Frontal view. (b) Lateral view. (c) Intra-oral.

Table 4-1 Pre and Post treatment cephalometric Analysis

Cephalometric index	Pretreatment	Post-treatment
SNA (degrees)	78	83
SNB (degrees)	80	81
ANB (degrees)	-2	2
U1 to MxPl (degrees)	120	120
L1 to MnPl (degrees)	85	79
Interincisal angle (degrees)	131	138
MMPA (degrees)	23	23
Facial Proportion (Per cent)	55	54
L1 to A-Pog Line (degrees)	0.7	0.1
SN to MxPl (degrees)	6	6.2

Treatment progress

A tightly fitting and well-retained upper removable appliance was fabricated with Adams clasps on the upper first permanent molars and two C clasps on the upper permanent central and lateral incisors. A long tongue crib was placed in the intercanine area to restrict the tongue (Figure 4-3). The patient was instructed to wear the appliance full-time except for eating, during contact sports and for tooth cleaning. The patient was examined and progress monitored monthly and the tongue appliance was replaced every 7 months for improved adaptation.

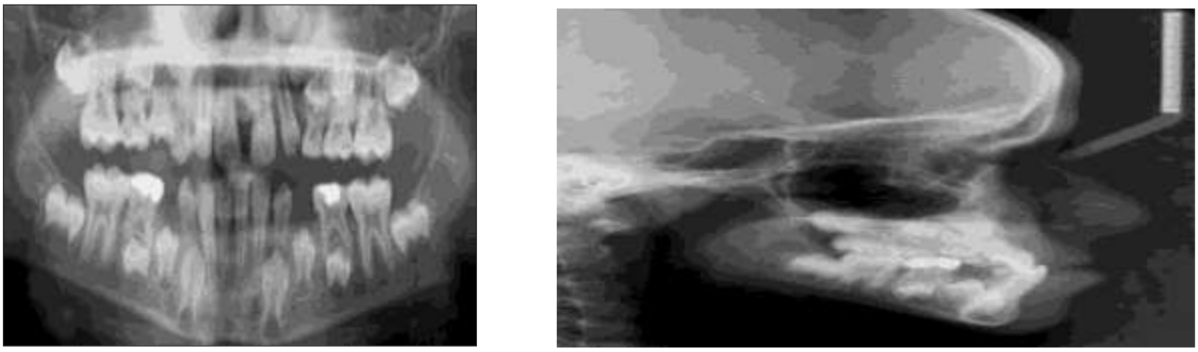


Figure 4-2. Pretreatment radiographs. (a) Panoramic radiograph. (b) Lateral cephalometric radiograph.

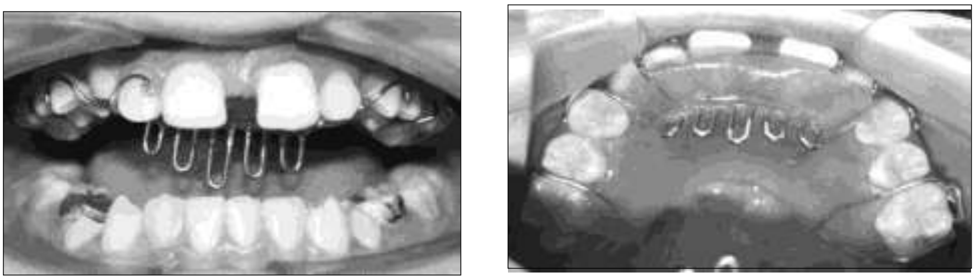


Figure 4-3. Tongue appliance in the mouth. (a) Frontal view. (b) Occlusal view.

Results

A positive overjet and overbite were achieved after 23 months of appliance wear. The maxillary deficiency was corrected which allowed the mandible to adopt a better position and resolve thefunctional lateral shift (Figure 4-4). The post-treatment cephalometric radio- graph tracing showed a favourable increase of 5 and 4 degrees in the SNA and ANB angles respectively (Table 4-I) (Figure 4-5). The superimposition of pre- and post-treatment cephalometric tracings on the anterior cranial base is shown in Figure 4-6.

Figure 4-4. Post-treatment photographs. (a) Frontal view. (b) Lateral view. (c) Intra-oral.

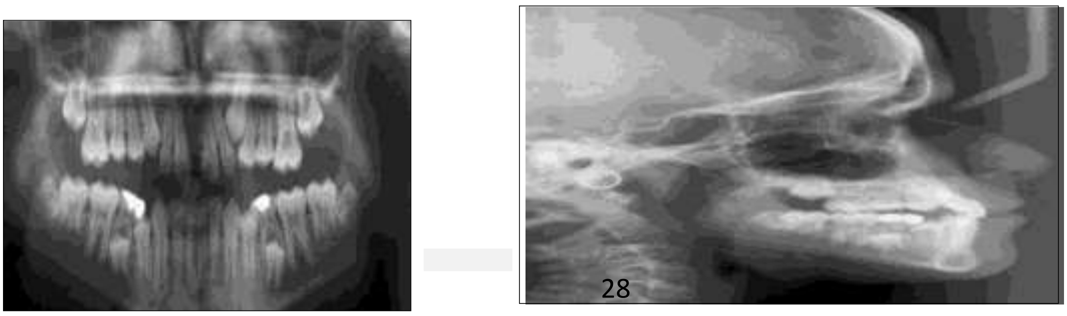


Figure 4-5. Post-treatment radiographs. (a) Panoramic. (b) Lateral cephalometric radiograph.

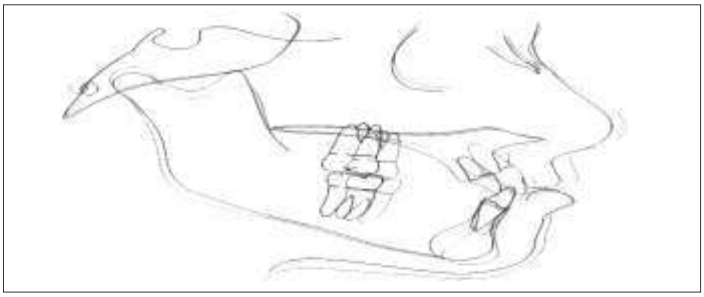


Figure 4- 6. Pre- and post-treatment tracings superimposed on S-N, at sella.

Discussion

The Class III malocclusion of the presented case was a combination of both maxillary deficiency and mandibular prognathism, which required a complex treatment plan. While the clinicians considered the use of orthopaedic traction in the form of a facemask,[43] reverse chin cup12 or the use of Bollard modified miniplates, the patient rejected the use of extra-oral appliances. A tongue appliance was used in this case which, when worn, placed considerable expansive pressure on the deficient maxilla. It is hypothesised that the mechanism of force application was generated in the following ways:

1. The pressure of the tongue in the act of swallowing could reach 2300 grams and the frequency of swallowing could be up to 1200 times in 24 hours. This heavy, intermittent force was possibly transferred through the tongue appliance to the deficient nasomaxillary complex.[44]
2. The resting posture of the tongue is altered by the caged restraint of the tongue appliance. Resting force may displace the maxilla into a more forward position by force transmission through the appliance to the underlying tissues.

An analysis of the results indicated that the maxillary deficiency was successfully corrected by the tongue appliance. However, despite the positive overjet achieved by the treatment, some mandibular prognathism is still reflected in the patient's profile view. It would be beneficial if treatment continued until the completion of growth and the patient reviewed periodically and assessed for the need for additional care.[45]

An alternative treatment approach was deferral until the cessation of skeletal growth. Even after successful treatment of the maxillary deficiency, an orthognathic surgical procedure may still be necessary. This could be considered unacceptable by many patients after an extended initial period of orthodontic treatment. In addition, deferring treatment and particularly in this case, if treatment had been deferred, the patient may have risked developing psychological problems.[46]

The possibility of oral dysfunction was also a treatment consideration as continuing growth could exaggerate the skeletal discrepancy and further complicate management.

Conclusion

The advantages and disadvantages of early or deferred treatment placed the clinicians in a treatment dilemma which was resolved by the patient's wishes. Nevertheless, the costs and benefits of each method remain unpredictable but are important factors.

Chapter 5

THE EFFECTS OF MINISCREW WITH CLASS III TRACTION IN GROWING PATIENTS WITH MAXILLARY DEFICIENCY

Materials and Methods

This retrospective study consisted of 20 patients who were randomly assigned to two equal groups. All subjects gave informed written consent and all met the following inclusion criteria:

1- SNA | 80°, SNB | 80°, ANB | 0°, at the initial lateral cephalograms;
2- No syndromic or medically compromised patients;
3- No previous surgical intervention;
4- No use of other appliances before or during the period of functional treatment.
5- A normal mandibular growth pattern; neither horizontal nor vertical growers. 6- No skeletal asymmetry.
7- Class III molar relationship with concave profile.

Pre-treatment and post-treatment photos and cephalometric records of 10 patients (7 girls, 3 boys) who were treated consecutively with facemask were obtained from a private orthodontic office. Their mean age was 10.5+1.5 years, and the average treatment time was 13+2 months. All patients had Uni-bar facemask and a tightly fitting removable appliance in the upper jaw with two hooks in upper molars, which was connected by two elastics (5/16 medium size) to facemask (Figure 5-1).

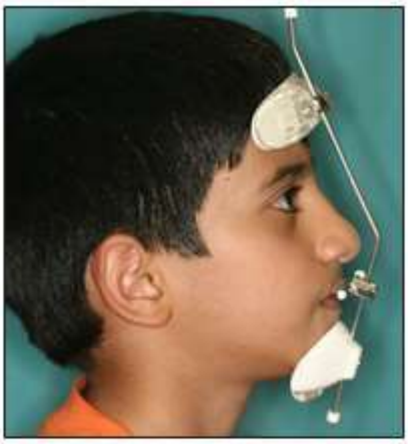
Ten patients (5 girls, 5 boys) with the mean age of 11.3±0.8 were treated by miniscrew (Figures 5,2-8). The treatment time was 11±3 months. Self-drilling Titanium Alloy JeilTM miniscrews (Jeil Medical Corp., Seoul, Korea; 1.6 mm diameter, 8 mm length) were placed under local anaesthesia into the buccal alveolar bone between the mandibular canine and first premolar roots on both sides. The ideal position for screw insertion was evaluated by using a panoramic radiograph in order to avoid damage to the roots of the adjacent teeth and mental foramen. A tightly fitting and well-retained upper removable appliance was fabricated with Adams clasps on the upper first permanent molars and premolars. C clasps were placed on the upper permanent canines and central incisors. If needed more C clasps and Adams clasps were added for better anchorage. Miniscrews were connected to the Adams clasps

of the removable appliance by orthodontic latex elastics (5/16 medium size) in order to generate ~350g of anterior retraction (Figures 5-9, 11). The patients were instructed to wear the appliances full-time except for eating, contact sports and tooth brushing. In order to retain these elastics, the Adams clasps on the molars were bent to form two loops. An expansion screw was placed in the mid palatal area of the upper removable appliance and the patients were instructed to turn the screw once a week in orderto correct the posterior cross-bites.

SNA, SNB, ANB, the Jarabak Ratio (the ratio between posterior and anterior face heights; S–Go/N– Me), U1 to SN (the angle between long axis upper central incisor and anterior cranial base), nasolabial angle (the angle between a line tangent to the base of the nose and a line tangent to the upper lip), palatal to SN (the angle between palatal plane and SN), U1 to palatal (the angle between long axisupper central incisor and palatal plane), inclination angle (the angle between the soft tissue nasion perpendicular line and the palatal plane), palatal to mandible (the angle between palatal plane and mandibular plane), SN –GoGn (the angle between SN and mandibular plane), and IMPA (the angle between the long axis of the lower central incisor and mandibular plane) were measured before and after treatment.

All measurements were carried out twice by one dentist trained by the co-authors. They were traced twice by the same trained dentist on two separate occasions after 1 month interval (the reliability of the measurements was determined by randomly selecting 5 cephalograms at the beginning and end of the treatment from each group). Paired t-test showed no statistically significant differences between the two measurements. The correlation analyses performed in two error studies between the first and second measurements consistently showed coefficients greater than 0.90.

Mann-Whitney U test was used in intra group and inter group evaluation. Statistical significance was set at $P<0.05$. The magnification factor of the cephalograms was standardized at 8%. The Statistical Package for Social Sciences, Version 16 (SPSS Inc. Chicago, Illinois, USA) was used to analyze the data.



Figures 5-1: Uni-bar facemask.

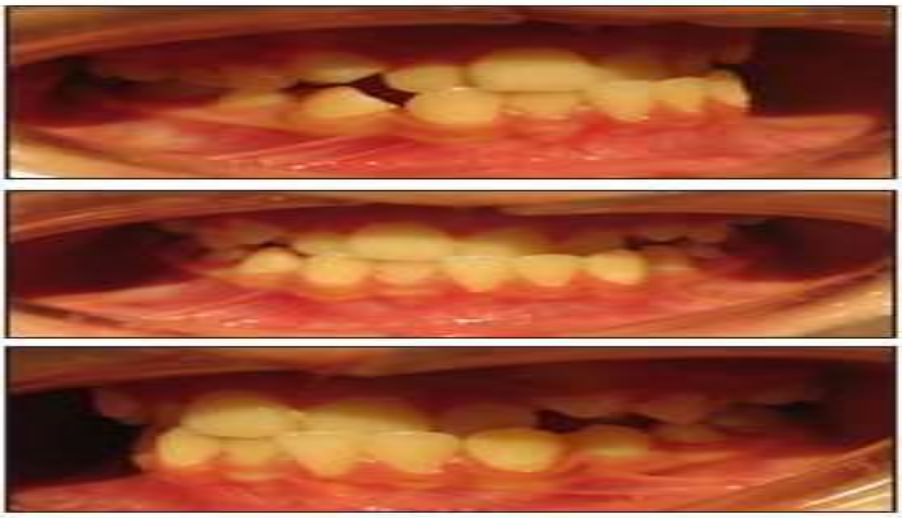
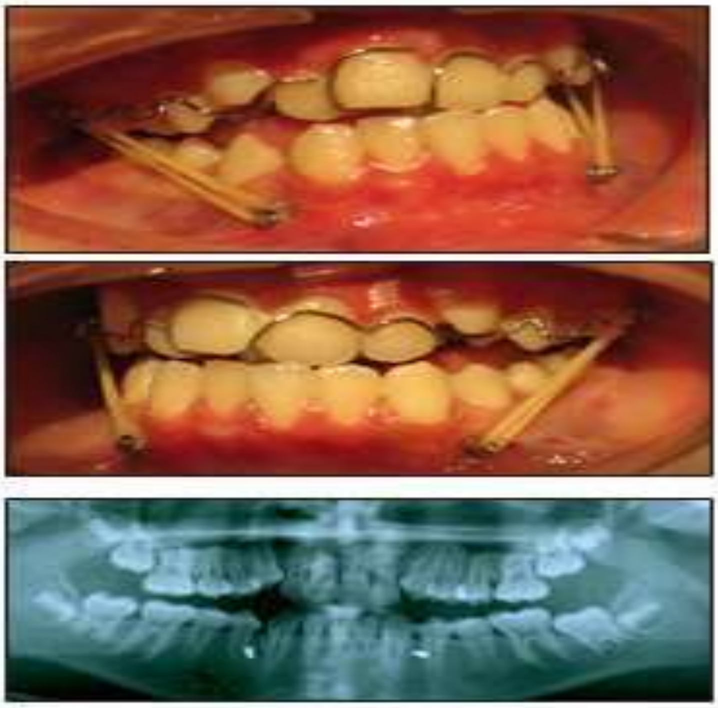


Figure 5, 2-6: Pretreatment photographs.



Figures 5-7: Pretreatment lateral

Figures 5-8: Pretreatment panoramic radiograph of the same patient cephalometric radiograph of the same patient.

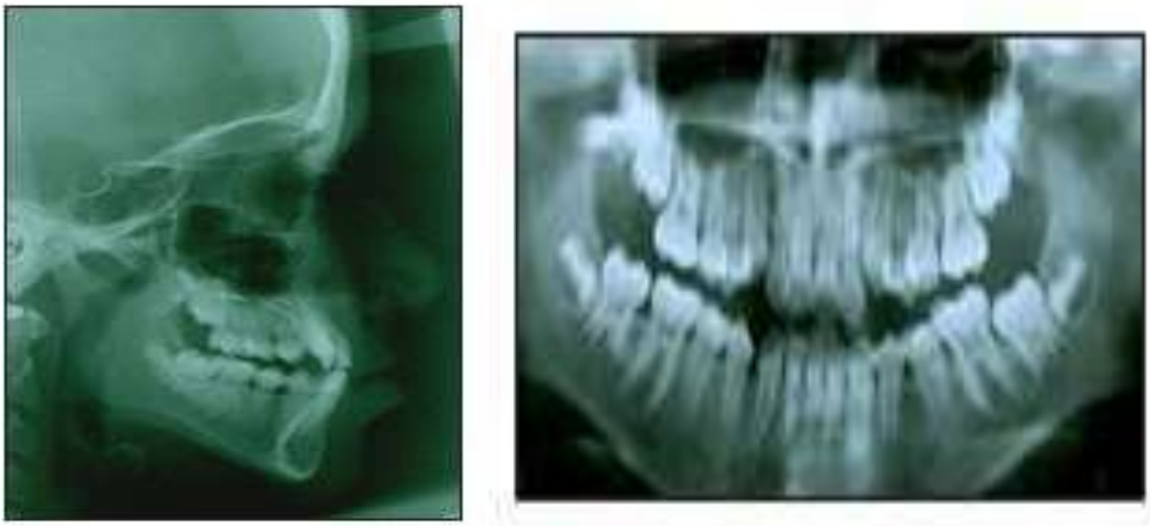


Figure 5, 9-11: Same patient after miniscrew insertion.

Figures 5, 12-16: Post-treatment photographs of the same patient.

Results

Mann-Whitney U test showed that the SNA in the face mask group increased by 1.5+1.4° from 77.9±1.8 to 79.4±1.4 (P<0.006) and ANB increased from -0.7±0.8 to 0.6±1 (P<0.004). The changes in SNB were not significant. IMPA showed a decrease of 6±7.1° from 90.3± 7.2 to 84.3± 5.1 (P<0.02) (Table 1, 2). In the miniscrew group, SNA increased by 1.8±1.1° from 77± 1.9 to 78.8± 1.5 (P<0.007), and ANB increased by 1.4±1.1° from -1.4±0.8 to 0±1.4 (P<0.006). SNB showed a non-significant change. IMPA was increased by 0.7±2.8° from 90.8± 4.6 to 91.5± 2.8 (P<0.3) (Figure 5-12-18) (Table 5-1, 5-2).

In inter group evaluation, Mann-Whitney U test showed no statistically significant difference between the cephalometric indexes of both groups except for IMPA. IMPA was decreased in face mask group while it showed an increase in the miniscrew group and this difference was statistically significant (P<0.004) (Table 5-2).

Table 5-1: Pre and Post treatment cephalometric analysis of face mask and miniscrew groups

Table 1: Pre and post treatment cephalometric analysis of face mask and miniscrew groups

Cephalometric Measurements	Groups	Pre-Treatment Mean ± SD	Post-Treatment Mean ± SD	P Value
SNA°	Face Mask	77.9±1.8	79.4±1.4	0.006
	Miniscrew	77±1.9	78.8±1.5	0.007
SNB°	Face Mask	78.6±1.3	78.8±1.1	1
	Miniscrew	78.3±2.1	78.8±2	0.09
ANB°	Face Mask	-0.7±0.8	0.6±1	0.004
	Miniscrew	-1.4±0.8	0±1.4	0.006
Jarabak Ratio %	Face Mask	64.4±3	64.9±2.5	0.5
	Miniscrew	63±1.9	63.1±2	0.7
U1 to SN°	Face Mask	98.1±12.7	104.8±5.7	0.08
	Miniscrew	100.8±7.2	106.9±5.5	0.008
Nasolabial Angle°	Face Mask	96.8±12.5	95.3±7.4	0.4
	Miniscrew	99.7±9.2	98±11	0.4
Palatal to SN°	Face Mask	8.4±2.8	7.8±3.7	0.6
	Miniscrew	8.9±3.7	7.6±2.6	0.03
U1 to Palatal°	Face Mask	106.3±11.2	113±5.7	0.07
	Miniscrew	109.4±6.4	113.8±5.6	0.02
Inclination Angle°	Face Mask	84.1±2.8	85±3.7	0.3
	Miniscrew	84±3.6	85.6±2.5	0.02
Palatal to mandible°	Face Mask	24.3±4.5	25.1±4.9	0.4
	Miniscrew	25.5±3.8	26.8±2.4	0.1
GoGn-SN°	Face Mask	32.4±3.3	32.2±2.5	0.8
	Miniscrew	34.2±2.6	34.2±2.5	0.9
IMPA°	Face Mask	90.3±7.2	84.3±5.1	0.02
	Miniscrew	90.8±4.6	91.5±2.8	0.3

Table 5-2: Pre and Post treatment changes in face mask and Miniscrew Groups

Table 2: Pre and post treatment changes in Face mask and Miniscrew groups.

Cephalometric Measurements	Face Mask Mean ± SD	Miniscrew Mean ± SD	P Value
SNA°	1.5±1.4	1.8±1.1	0.4
SNB°	0.2±1.5	0.5±1.8	0.2
ANB°	1.3±0.5	1.4±1.1	0.9
Jarabak Ratio %	0.5±2.1	0.1±1.4	0.8
U1 to SN°	6.7±11.2	6.1±3.8	0.9
Nasolabial Angle°	-1.5±7.7	-1.7±6.4	0.7
Palatal to SN°	-0.6±2.9	-1.3±1.4	0.2
U1 to Palatal°	6.7±10.5	4.4±3.4	0.4
Inclination Angle°	0.9±2.4	1.6±1.5	0.2
Palatal to mandible°	0.8±2.5	1.3±2.4	0.6
GoGn-SN°	-0.2±2.4	0±1.8	0.9
IMPA°	-6±7.1	0.7±2.8	0.004

Figures 5,-17: Post- treatment lateral cephalometric radiograph of the same patient.

Figure 5-18: Post-treatment panoramic radiograph of the same patient

Figure 5- 19: Same patient during fixed appliance application.

Discussion

The present study is the comparison of dentoskeletal changes of Class III patients treated by facemask and miniscrew combined with class III traction. The result of this study showed that both appliances were successful in forward movement of maxilla. Lower incisors had lingual tendency due to chin cup pressure in facemask group while IMPA increased in miniscrew group.

The magnitude and vector of force were different between the two groups. The force applied in miniscrew group was approximately 350g; while, the force in face mask group was approximately

500g. The latex elastics (5/16 medium size) were the same in both groups; however, they were stretched to a longer length in face mask group. Therefore, the face mask requires a smaller amount of hours per day during which the appliance is worn. However, the facial mask is more bulky and less easily tolerated than intraoral Class III elastics.47 Moreover face mask requires greater patient compliance. In addition, moderate continuous traction of miniscrew elastics rather than heavy interrupted traction of face mask elastics might have more favorable effects on maxillary protraction.

On the other hand, the direction of force application between the miniscrew and upper removable appliance was located below the center of resistance of the maxilla, which resulted in counterclockwise rotation of the palatal plane. The inclination angle increase in miniscrew group is suggestive of this fact. This finding was very similar to De Clerck et al.48 While in facemask the direction of force is not as oblique as that of miniscrew.

Facemask therapy is recommended to begin before the age of 8.15 However, miniscrew cannot be inserted before canine eruption. It is commonly believed that early treatment can be more effective in maxillary deficiency. Nevertheless, recent reports indicate that some anteroposterior changes can be produced up to the beginning of adolescence.[48] Based on these studies, there is no need for disappointment in delaying the treatment while waiting for canine eruption. However, due to many unanswered questions and doubts in this regard, if a patient is referred to an orthodontist at an early age, facemask therapy is preferred to delaying treatment for miniscrew.

One of the limitations of miniscrew is their loosening, which can be distressing for the clinician and the patient. In order to overcome this problem,[49] in this study miniscrews with wider diameter and deeper insertion were used. Moreover, maxillary miniscrews may be more unstable than mandibular ones because of the thinner, less dense cortical plate.[50]

The treatment used in this study was for correction of skeletal problem. Therefore, further treatment of both groups was continued by use of fixed appliances (Figure 5-19).

The results from this study are limited to a short-term observation period immediately after active treatment; long-term studies with larger sample sizes are needed for more precise evaluation.

Conclusions:

Both facemask and miniscrew class III traction were successful in correction of maxillary deficiency. Miniscrew is much smaller than bulky face mask and may increase patient’s compliance while its treatment cannot be started as early as face mask therapy.

Chapter 6

EFFECTS OF TONGUE PLATE ON THE NASOMAXILLARY COMPLEX OF PATIENTS WITH UNILATERAL CLEFT LIP AND CLEFT PALATE

Methods and Materials:

This study received ethical approval from the Local Research Ethics Committee of Shahid Beheshti University of Medical Sciences, and all participants or their legal guardians signed informed consent forms.

The inclusion criteria consisted of non-syndromic patients with unilateral cleft lip and cleft palate who showed growth potential based on the cervical vertebrae stage on lateral cephalograms,(18) whereas the patients with bilateral clefts, syndromic patients and those who had received alveolar grafts were excluded from the study. All the patients had class 3 malocclusion due to maxillary deficiency. The patients also had anterior and bilateral posterior crossbite prior to appliance therapy. No abnormal mandibular asymmetry was observed clinically. None of these subjects had a history of orthodontic treatment, and all of them were non-syndromic.

The sample size consisted of 24 growing patients with non-syndromic unilateral cleft lip and cleft palate (12 girls and 12 boys) between the ages of 6-12 years who had volunteered to participate in thisstudy. All patients had undergone the preliminary stages of lip and palate closure during infancy, but none of them had received bone grafts.

Tongue plate was constructed consisting of Adams clasps for first upper molars and C clasps for anterior teeth in order to increase the retention. A screw was mounted in the midpalatal area to correct the bilateral posterior crossbite. The screw was activated at weekly intervals by the patient. The tongue plate was incorporated in the palate, in the canine-to-canine area. The plate was long enough to cage thetongue and was adjusted in the clinic to avoid traumatizing the floor of the mouth. This appliance was used for 20 hours a day, and each patient was evaluated at monthly intervals. The duration of the treatment with tongue plate appliance was 18±3 months. Panoramic and lateral cephalometric radiographs, dental casts and photographs of the face were obtained from all subjects. Pre- and post- treatment lateral cephalograms were analyzed. These cephalograms had been taken with the teeth in occlusion. The magnification factor was recorded for each radiograph. All radiographs were traced on acetate paper by the same investigator. Figures6- 1 to 6-4 show pre-treatment intraoral and extraoral images of a patient with class 3 malocclusion.

Figure 6-1: Extra oral image before treatment

Figure 6-2: Intra oral image before treatment(latral view) Figure6-3: Intra oral image before treatment(latral view) Figure6-4: Intra oral image before treatment(frontal view) Figure6-5 :Tongue plate insitu

Data were analyzed by an orthodontist at the beginning and at the end of the treatment. The following variables were measured: Sella-Na- sion-Point A (SNA) angle, Sella-Nasion-Point B (SNB) angle,Point A-Nasion-Point B (ANB) angle, Anterior Nasal Spine to Posterior Nasal Spine (ANS-PNS) length, Gonion to Gnathion (GoGn) length, the angle formed by GoGn and Sella-Nasion lines (GoGn- SN or mandibular plane angle), inclination angle, the angle formed by upper incisor inclination and SN line (U1-SN) and Incisor Mandibular Plane Angle (IMPA).

The intra-examiner reliability was tested by randomly selecting 10 lateral cephalograms and having the examiner recalculate the measurements at a 4-week interval. The level of statistical significance was set at P<0.05. In order to compare the differences before and after the intervention, paired t-test was used for normally distributed data, while Wilcoxon test was applied when the distribution of data was not normal.

Results

In the present study, a total of 24 growing patients with non-syndromic unilateral cleft lip and cleft palate (12 girls and 12 boys) with the mean age of 10.4±4 years were treated with tongue plate appliance for 18±3 months.

Paired t-test showed that the SNA and ANB angles were respectively increased by 1±0.6 and 3.17±0.5 degrees (P<0.001).

No statistically significant differences were found with regard to the MPA and inclination angle before and after the treatment. The U1 increased significantly (P<0.001). No significant changes wereobserved in the inclination of lower incisors (L1). Figures 6 to 8 show extraoral and intraoral images of the same patient after treatment. Figures 6-9 and 6-10 show the pre- and post- treatment lateral cephalograms, respectively.

Figure 6-6: Extra oral image after treatment (frontalview)

Figure 6-7: Extra oral image before treatment (latral view)



Figure 6-8: Intra oral image after treatment (latral view) Figure 6-9:latral cephalometry before treatment

Figure 6- 10: latral cephalometry after treatment

Discussion

This study evaluated the effects of 18±3 months of treatment with tongue plate on 24 growing patients with non-syndromic unilateral cleft lip and cleft palate. This study showed that the SNA and ANB angles were increased significantly, which indicate the forward movement of the maxilla. In the current study, the U1 has also increased significantly, but no forward movements of the mandible or mandibularincisors were detected.

Maxillary protraction by means of face mask is one of the most common treatment methods for growing patients with cleft palate. This protocol has multiple variations and can be simultaneously usedwith different types of maxillary expansion de- vices. [112,113]

Face mask therapy has become a common technique for correction of the maxillary deficiency. However, this appliance is bulky, which makes it a discouraging choice for children. Patients who wearglasses experience more discomfort. This discomfort and the embarrassment caused by the large size ofthe device, especially at school, reduce patient’s compliance.

Due to the above-mentioned disadvantages, we decided to use the tongue plate intraoral appliance for treatment of this malocclusion. Placing the tongue plate in the mouth transmits considerable pressure to the deficient maxilla. This pressure is constant during rest position and intermit- tent during swallowing and functional activity.

Tongue plate is an intraoral device, which can be tolerated rather easily and therefore, can be used for longer durations. In terms of the point of force application, face mask directly exerts the force on both maxilla and mandible. In the mandible, the force vector leads to counterclockwise rotation, which can contribute to the improvement of the class 3 discrepancy, and also increases the vertical dimensions of the patient’s lower facial height. This effect, in theory, can be avoided by the use of tongue plate appliance since this device has no direct effect on the mandible.[114] However, since the rotation of the palatal plane can occur with tongue plate, this can, in turn, lead to clock- wise rotation of the mandible. However, this effect has been minimal and insignificant in the present study.

No significant changes were observed in the L1, which can be explained by the mechanism of tongue plate appliance, which only exerts direct force to the maxilla and maxillary dentition, and not on the mandible. The current study showed that tongue plate is successful in the treatment of growing pa- tients with class 3 malocclusion and maxillary deficiency due to the unilateral cleft lip and cleft palate. Similarly, in another study, it has been shown that tongue plate is effective in the treatment of class 3 malocclusion with maxillary deficiency.[115] The difference between the latter article and current studyis that the present study has been performed on patients with cleft palate. In both studies, for- ward movement of the maxilla and maxillary dentition was observed.

Forward movement of lower incisors was not detected in the present study. Tongue plate removes the tongue pressure on lower incisors, therefore the IMPA will be decreased. The reason behind the exclusion of patients with the bilateral cleft is that the premaxilla in these patients tends to be rather protruded. This can, in turn, distort the results of the study. We suggest recalling the patients after the retention period to determine which effects of the device have been stable. Also, de- signing a clinical trial to compare the results achieved by the use of tongue plate to the re- sults obtained by another appliance such as face mask is the next step.[116]

Conclusions

Tongue plate appliance has shown promising results related to maxillary protraction in patients with cleft lip and cleft palate. Due to the simple intraoral design of the appliance, we recommend tongue plate for maxillary protraction in patients presenting with cleft lip and cleft palate.

Chapter 7

TREATMENT OF MAXILLARY DEFICIENCY BY REVERSE CHIN CUP

Material and Methods

This retrospective study consisted of twenty patients (twelve males and eight females) with skeletal Class III malocclusion. The average age of the selected patients was 8.6±1.36 years. All subjects gave informed written consent, and all met the following inclusion criteria:

1) Negative overjet
2) Anterior crossbite
3) Class III molar relationship
4) No mandibular shift
5) No congenital disease or endocrine disorders
6) No previous orthodontic treatment and surgical intervention.

All patients and their parents did not accept orthognathic Surgery. All the patients were treated with the reverse chin cup. Lateral cephalograms, Panoramic radiographs, and photos were taken before and after treatment. The following variables were measured in each Lateral cephalogram of the patients:

1-SN-FH: The angle between the SN line and the Frankfurt plane

2-SNA: The angle at the intersection of the SN line and NA line

3-SNB: The angle at the intersection of the SN line and NB line

4-ANB: The angle at the intersection of the NA line and NB line

5- Wits appraisal: The distance between the AO line and the BO line

6- Facial angle: The angle at the intersection of the Frankfurt plane and N-Pog line

7-Y-axis: The angle at the intersection of the SN line and N-Gn line

8-Gonial angle: The angle at the intersection of GO-Gn and Go-Ar lines

9-GoGn-Sn: The angle at the intersection of Go-Gn and SN line

10-N-Me: The distance between the N point and the Me point (or posterior facial height)

11-S-Go: The distance between the S point and with Go point (or anterior facial height)

12- Jarabak index: The ratio of the anterior facial height to the posterior facial height

13- Inclination angle: The angle at the intersection of the N' line perpendicular to the palatal plane

14-U1-SN: The angle of upper incisors relative to SN line

15- U1-NA: The distance from upper incisors to NA line

16- U1-NA angle: The angle of upper incisors relative to NA line

17- L1-mand.: The angle of lower incisors relative to the mandibular plane

18-L1-NB: The distance between the lower incisors and the NB line

19-Interincisal angle: The angle between the maxillary and mandibular incisors

20- L1-NB angle: : The angle of lower incisors relative to NB line

21- Nasolabial angle: The angle between the line tangent to the nasal base and the line tangent to the upper lip

22- Upper lip to E-line: The distance between the upper lip to the Pn-Pog' or E-line

23-Lower lip to E-line: The distance between the lower lip to Pn-Pog' or E-line

All patients received a reverse chin cup and a removable palatal appliance. The upper removable appliance consists of two Adams clasps on the permanent first molars, two C-clasps on the permanent central incisors, two C-clasps on the permanent lateral incisors, and two C-clasps on the primary canines, and a porous acrylic chin cup with two arms which was bent to form a hook and two hooks was embedded on the palatal canine area of the upper removable appliance. Hooks on porous acrylic chin cup were connected to the hooks on the removable palatal appliance with heavy size,5/16" orthodontic latex elastics(figure3).

It was explained to the patients to use the appliance full time and to remove it only when eating, exercising, contact sports, and brushing their teeth.

The lateral cephalograms of each patient were traced before and after the treatment. The measurement accuracy was determined by tracing each lateral cephalogram twice by the same examiner. No difference between the two measurements was shown by Paired t-test.

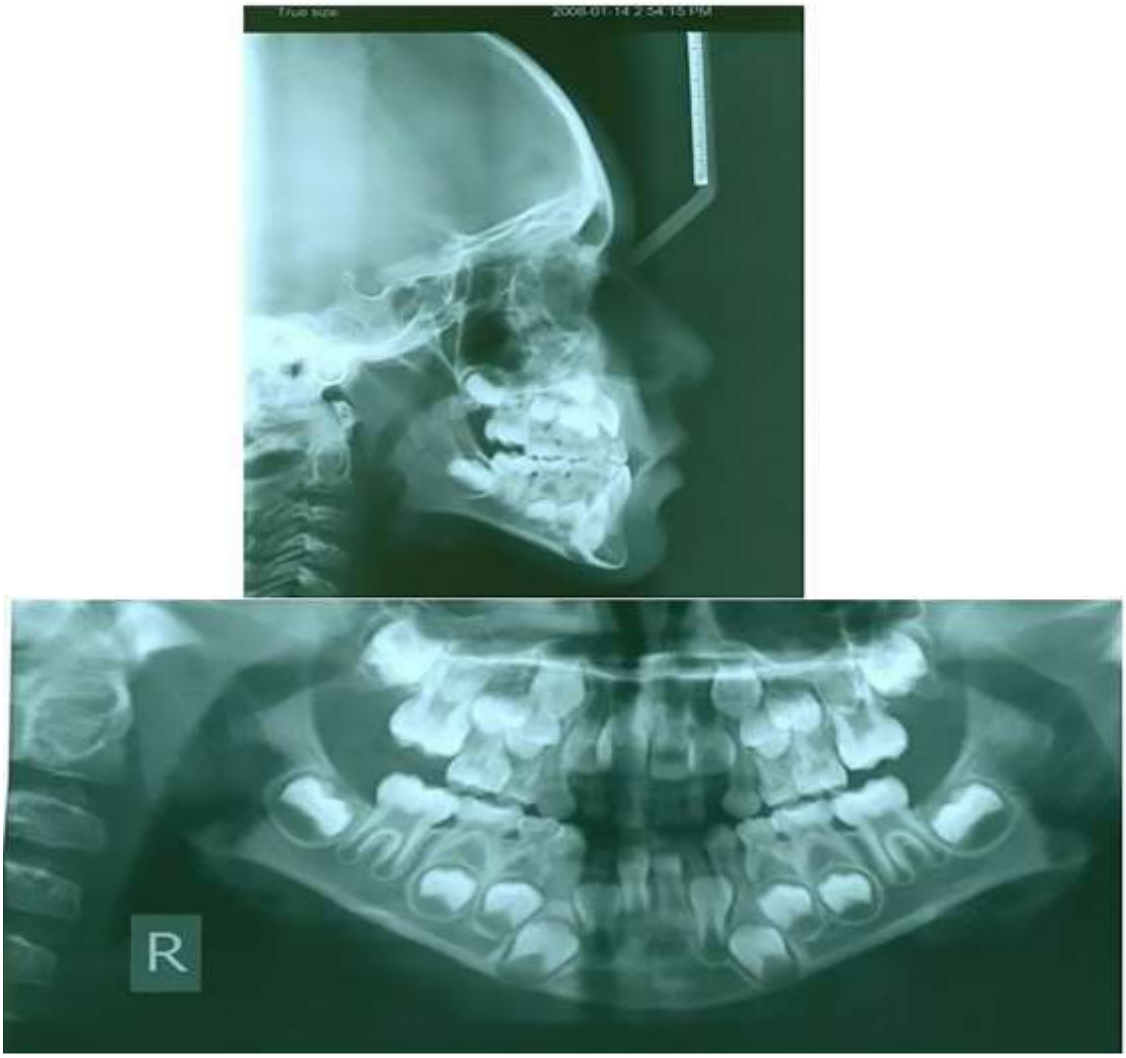


Figure 7-1: Lateral Cephalogram and OPG of a patient with skeletal Class III malocclusion beforetreatment

Figure 7-2: Intra-oral and extra-oral photos of the patient

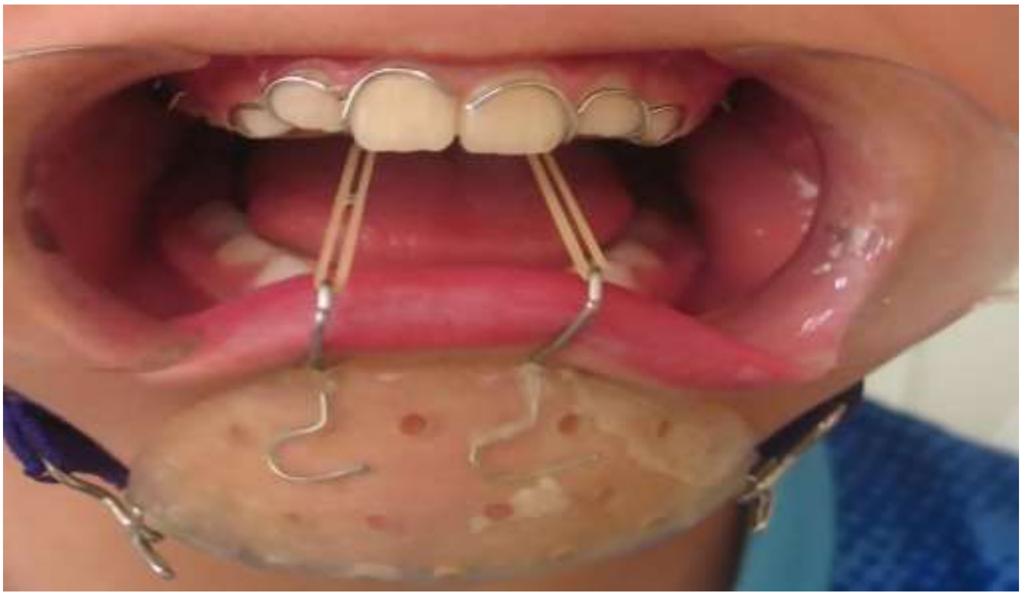


Figure 7-3: Palatal removable appliance with Six C-clasps (two on the permanent central incisors,

twoon the permanent lateral incisors, and two on the primary canines) connecting to reverse chin cup

Figure 7-4: Lateral and frontal view of the patient with reverse chin cup

Results

All the statistical analyses were performed using SPSS software version 25.0 (IBM, Chicago, Illinois, USA). Data are shown as mean ± standard deviation, respectively. The normality of data distribution was assessed using the Kolmogorov-Smirnov test. The Paired t-test or Wilcoxon test was also used to compare the mean outcome quantities before and after in each group. In this study, the value of a P-value less than 0.05 was considered statistically significant.

The mean treatment duration was 25±8 months. In the anterior-posterior dimension, a significant increase has been seen in ANB and Wits) P<001) by 2 degrees and 3.6mm, respectively, and SNA has increased from 78.68 degrees to 80.55 and in this variable p-value is 0.009 (Table 7-1).

The vertical dimension showed a significant increase in Inclination angle and N- ME by 2.8 degrees (p-value:0.015) and 4mm (p-value: 0.02), respectively. Furthermore, Y-axis, Gonial angle, and S-GO were raised by 0.25 degrees,5 degrees, and 2.25mm, respectively; however, these changes were not significant. Moreover, going sn decreased slightly from 33.05 degrees to 32.95 (Table 7-2). There wasa significant increase in U1-NA angle (P<001) by 6.7 degree and a considerable decrease in L1-NB angle (P<003) by 6.1 degree(Table3) none of the changes were significant in the soft tissue(Table 7-4).

Table 7-1: Cephalometric variables in anterior-posterior dimension

	Mean(SD) (before)	Mean(SD) (After)	Changes	P-value
SN-FH	9.55(4.19)	9.4(3.36)	+0.15	0.83
SNA	78.65(3.07)	80.55(2.04)	+1.9	0.009
SNB	81.8(2.46)	81.65(2.25)	-0.15	0.85
ANB	-3.1(2.36)	-1.1(2.13)	+2	<0.001
WITS	-5.7(3.66)	-2.1(2)	+3.6	<0.001
FA	88.75(4.87)	88.55(3.59)	-0.2	0.84

Table 7-2: Cephalometric Variables in vertical dimension

	Mean(SD) (before)	Mean(SD) (After)	Changes	P-value
Y-AXIS	58.6(3.33)	58.85(2.98)	+0.25	0.66
GONIAL Angle	118.4(5.49)	123.4(5.79)	+5	0.72
GOGN-SN	33.05(5.87)	32.95(5.45)	-0.1	0.88
N-ME	110.85(21.65)	114.85(22.55)	+4	0.02
S-GO	71.5(18.49)	73.75(16.15)	+2.25	0.1
JARABACK INDEX	63.95(4.36)	63.95(4.30)	0	0.83
INCLINATION Angle	88.2(6.44)	91(5.59)	+2.8	0.01

Table 7-3: Cephalometric Variable in dental analaysis

	Mean(SD) (before)	Mean(SD) (After)	Changes	P-value
U-SN	82.7(19.1)	72(18.5)	-10.7	0.08
U-NA Angle	28(11.07)	34.7(10.71)	+6.7	<.001
U-NA(MM)	-4.7(3.21)	-4.65(2.43)	+0.05	0.85
L-MAND	92.95(7.96)	87.5(8.27)	-5.45	0.93
L-NB Angle	27.65(7.15)	21.55(8.33)	-6.1	0.003
L-NB(MM)	-6.1(2.86)	-5.9(2.15)	+0.2	0.85
INTERINCISAL Angle	126.9(14.09)	125(13.62)	-1.9	0.4

Table7- 4: Cephalometric Variables in Soft Tissue

	Mean(SD) (before)	Mean(SD) (After)	Changes	P-value
NASOLABIAL Angle	109.95(13.8)	111.4(13.35)	+1.45	0.22
UPPER LIP TO E-LINE	-3.3(2.62)	-2.8(2.76)	+0.5	0.15
LOWER LIP TO E-LINE	0.15(2.16)	-0.55(2.74)	-0.7	0.12

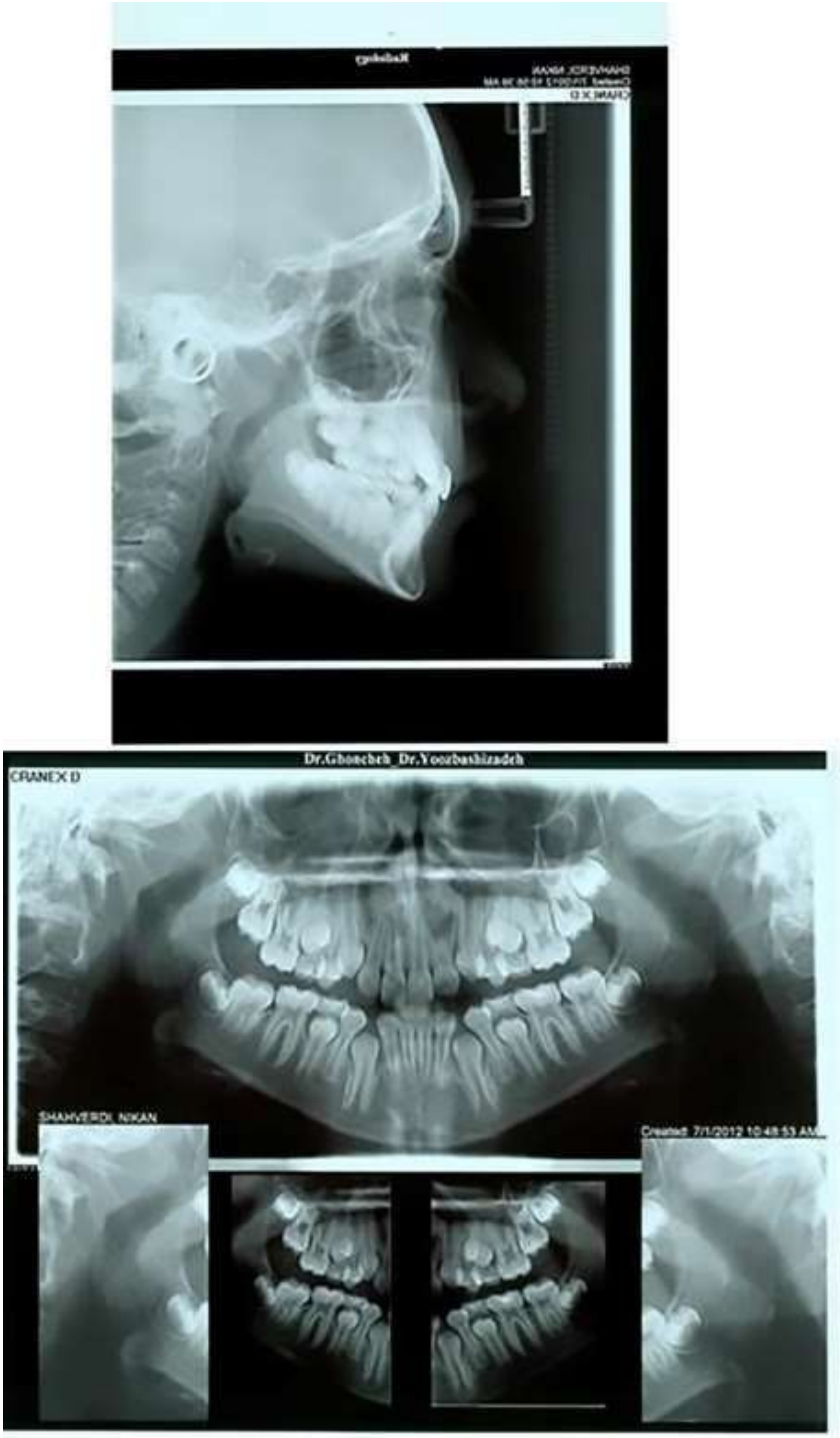


Figure 7-5: Lateral Cephalogram and OPG of the patient after completing the reverse chin cup treatment.

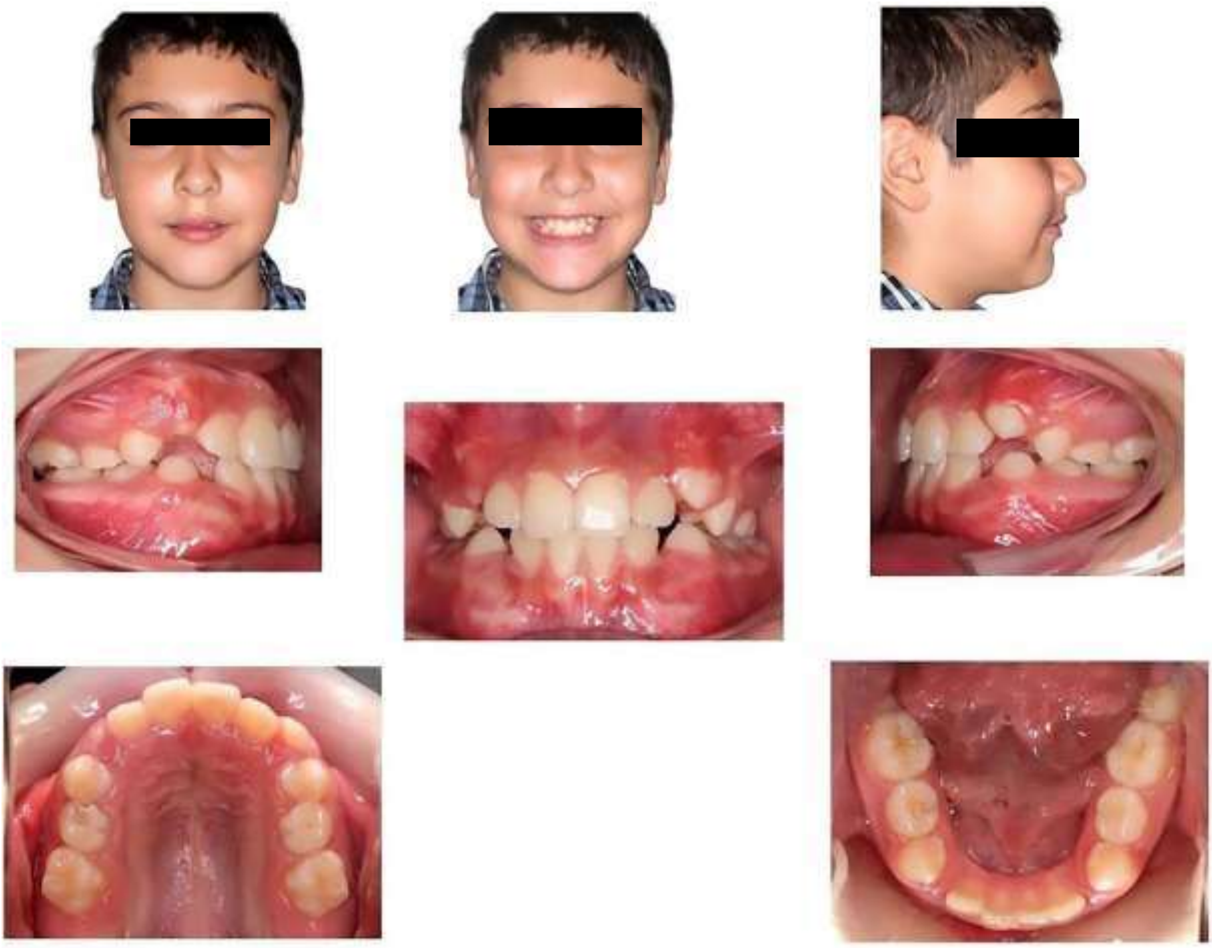


Figure 7-6: Intra-oral and extra-oral photos of the patient after completing the reverse chin cup treatment.

Discussion

With regard to the anterior-posterior dimension, positive overjet was achieved in all patients. Also, results have shown that the reverse chin cup has raised SNA, ANB, and Wits appraisal significantly, whereas SNB has decreased slightly; however, it was not significant. Since ANB has increased significantly, reverse chin cup can be used in the treatments in which the correction of the maxillomandibular discrepancies is needed. In the vertical dimension, A significant increase was seen in two variables (Inclination angle and N- ME) while three variables (Y-axis, Gonial angle, and S-GO) were raised, but their value was not significant. The non-changing number of the jaraback index shows that the patients did not have significant vertical facial growth. It has been reported that reverse chin cup can cause downward and backward movement of the mandible[123]. It has also been said that the main factor in the success of reverse chin cup treatment is its effect on the mandible. [124] In this study, the decrease of Gogn-sn and SNB is shown. However, These changes were not significant. If the force applies to the posterior maxilla, It causes the downward movement of the maxilla and the backward movement of the mandible. [125] For this reason, In the present study, the force of the reverse chin cup has applied on the anterior part of the maxilla, and The positive overjet of the patients was mostly achieved by the forward movement of the maxilla. Also, there was an increase in the inclination angle, which shows the counter-clockwise rotation of the maxilla. Due to the U1-NA angle increase in this research, it seems that the reverse chin cup has protruded the maxillary incisors. Also, considering the decrease of the L1-NB angle, the reverse chin cup has caused the retrusion of the mandibular incisors. In addition, the straps which connected the high pull cap to the chin cup was creating a force that operated as a posterior bite block, so posterior teeth were kept in contact with each other in order to achieve posterior impaction of the maxilla. It has been reported that maxillary forward movement can be done with different appliances, [126] Like the face mask, which is a standard treatment for Class III malocclusion. In the face mask, the applied force is spread between the chin and the forehead. Asa result, it creates fewer backward movements in the maxilla. On the other hand, In the reverse chin cup, the force is wholly transferred to the chin, which causes more backward movement in the mandible.[127] However, Large extra oral appliances reduce patient cooperation due to their appearance. Therefore, patients do not wear them regularly, and they may not have unsatisfactory results. Using the reverse chin cup is an acceptable method for most young children.[128, 129] In this study reverse chin cup used was similar to Chin support with cranial straps (Hickham), and A porous acrylic chin pad was used to provide a better air vent and reduce skin irritation. Reverse chin cup wasused to correct skeletal problems. Additional fixed appliance treatments have been usedto complete treatment and correct dental problems such as crowding(figure 7-4, 7-5). Since it is stated that after the treatment with the clockwise rotation, the maxilla may move backward and downward, it is essential to continue the use of orthodontic appliances until the growth stop.[130] Because there is limited research available on reverse chin cup, Further studies with larger sample sizes are required to validate our findings.

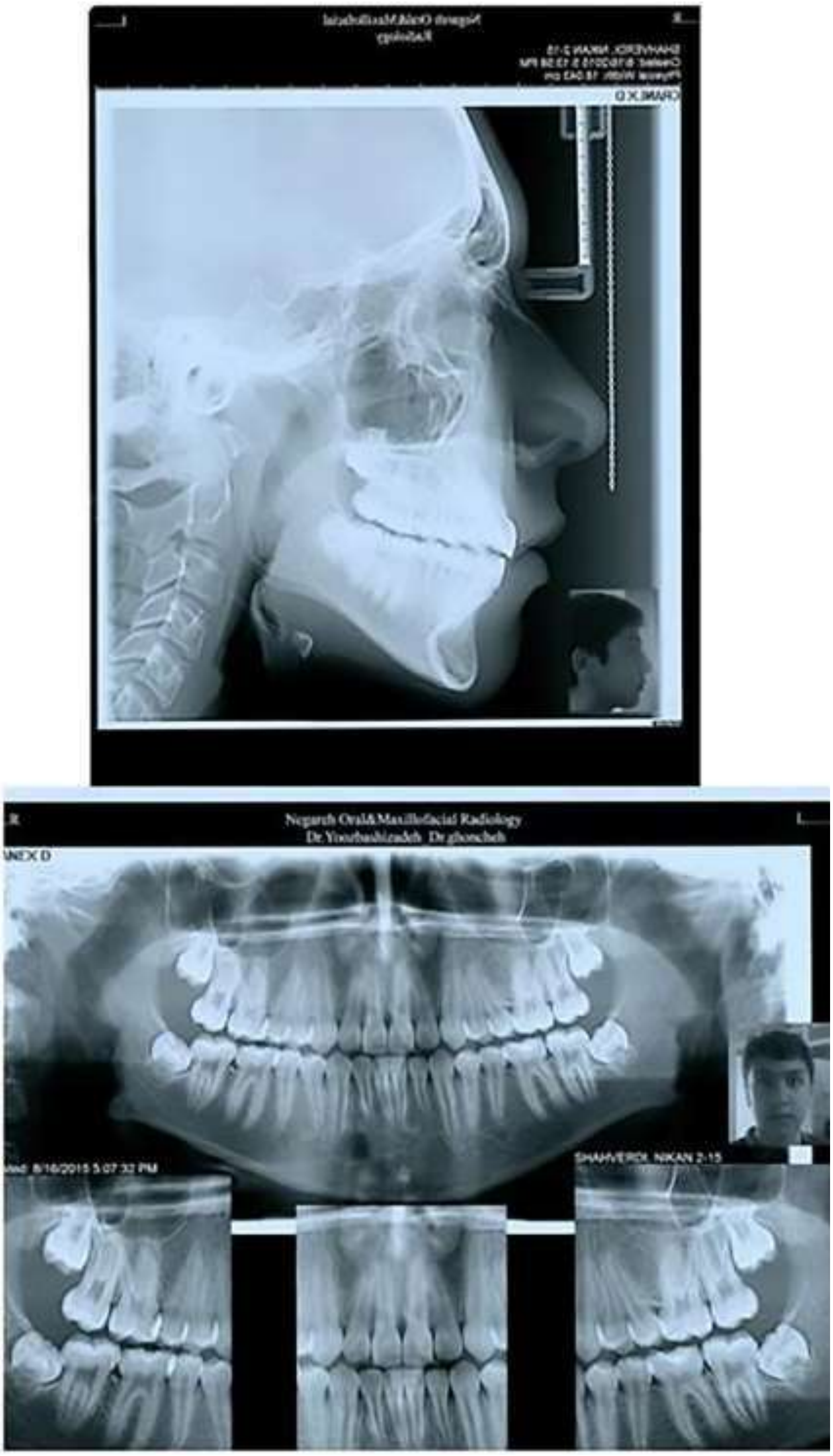


Figure 7-7: Lateral Cephalogram and OPG of the patient after completing treatment with fixed appliance.

Figure 7-8: Intra-oral and extra-oral photos of the patient after completing treatment with a Fixed appliance.

Conclusion

In this study, the Reverse chin cup has been effective in maxillary protraction and increasing SNA, wits, and ANB. Furthermore, Due to the smaller size compared with other large extraoral appliances, children have also accepted it well.

Materials and Methods

This retrospective study consisted of 10 consecutive patients (4 males, 6 females) with skeletal Class III malocclusion and maxillary deficiency. The mean age of the selected patients was 8.9±1.72 years. All subjects gave informed written consent and all met the following inclusion criteria:

1) Anterior crossbite

2) Class III molar relationship 3) No mandibular shift

4) Concave facial profile

5) Sella-Nasion-A (SNA) d" 80° , Sella-Nasion-B (SNB) d" 80°, A-Nasion-B (ANB) d" 0°

6) Negative overjet

7) No congenital disease or endocrine disorders

8) No previous orthodontic treatment and surgical intervention

All patients and their parents rejected orthognathic surgery. All the patients were treated with the reverse chin cup. The reverse chin cup included a fully anchoraged removable appliance in the upper jaw, two Adams clasps on permanent first molars, two C clasps on deciduous canines, and two other C clasps on the permanent central incisors for further anchorage. If necessary the number of C clasps could be increased for anchorage reinforcement. These hooks gave a very good retention to the removable appliance. If the hooks were loose, broken, or had lost their adaptability, they would have been replaced by a new one. Two hooks were mounted on the right and left canine areas of the palate (Figure 1). A porous acrylic chin cup with two vertical arms (1mm stainless steel) was fabricated foreach individual patient. The end of each arm was bent to form a hook. Two orthodontic Latex Elastics (7.95mm, each elastic 4.5 oz, G&H) connected the hooks of the canine area of the palate to the hooks of reverse chin cup in order to deliver 12 ounce each. A high pull head cap was used to hold the reverse chin cup. The patients were instructed to wear the appliance full-time except for eating, contact sports and tooth brushing. The reverse chincup in situ can be seen in Figure 7-9.(1-13) Lateral cephalograms, OPGs, photos, and study casts patients of both groups were taken before (T1) and after (T2) treatment. SNA, SNB, ANB, GoGn-Sn (mandibular plane angle), Upper 1 to SN (angle between long axis upper central incisor and anterior cranial base), IMPA (angle between the long axis of the lower central incisor and mandibular plane), Nasolabial angle (the angle formed between lines tangent to the columella and the upper lip vermillion and intersecting at the subnasale), Inclination angle (the angle formed between a perpendicular line to soft tissue nasion and palatal plane),ANS-PNS (anterior nasal spine-posterior nasal spine), GoGn (the distance between gonion and gnathion), and Jarabak ratio (the ratio between posterior and anterior face heights; S– Go/N–Me) of each patient were measured before and after treatment. The reliability of the measurements was determined by selecting four patients' records randomly, each of which was traced twice by the same practitioner on two separate occasions. Paired T-test showed no statistically significant difference between two measurements. A paired T-test was used to measure pre- and post- treatment cephalometric data.


Figure 1


Figure 2


Figure 3


Figure 4


Figure 5


Figure 6

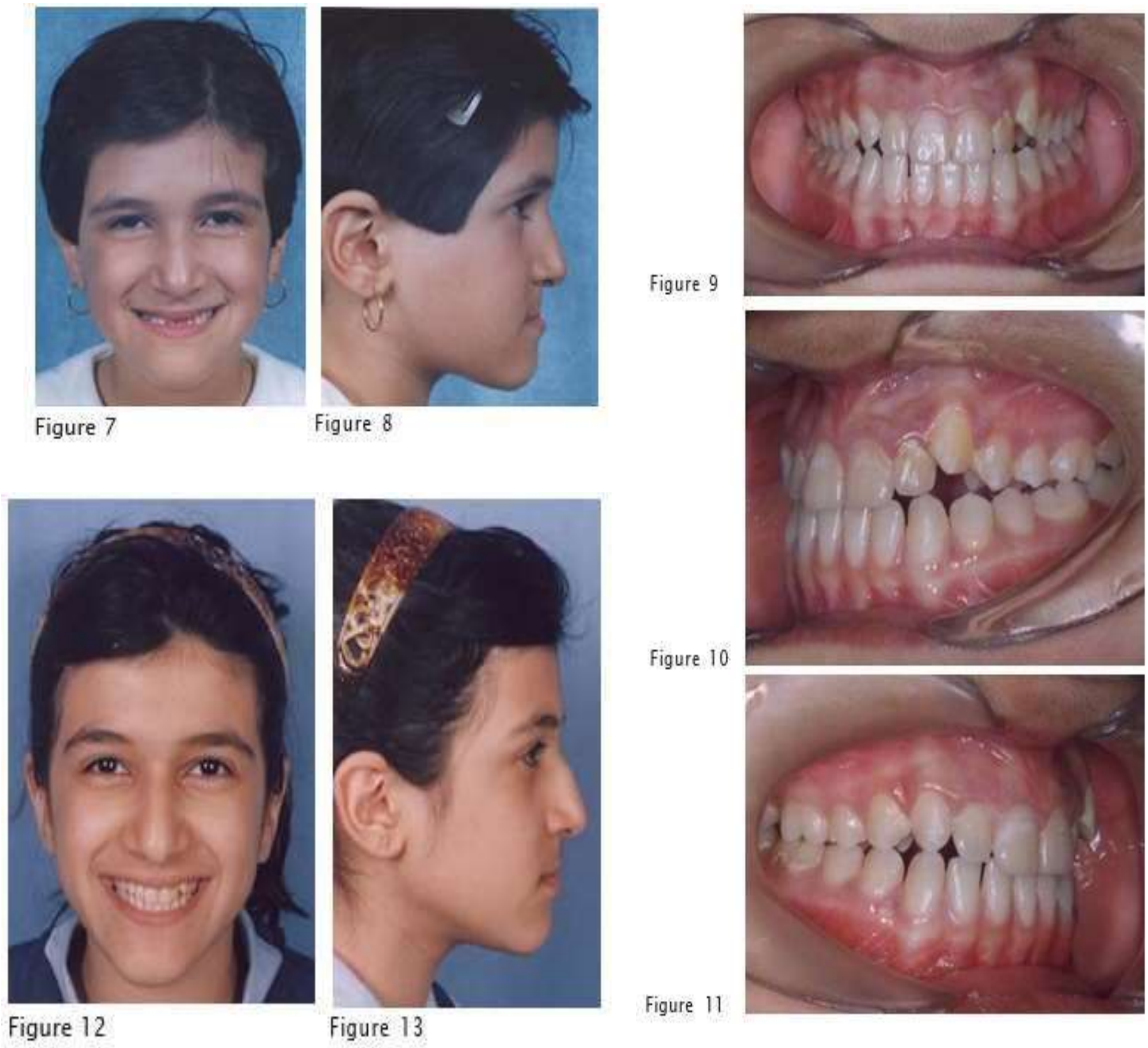


Figure 7-9(1-13). Lateral cephalograms, OPGs, photos, and study casts patients of both groups were taken before (T1) and after (T2) treatment

Results

In this study the mean treatment time was 24±9 months. After this time, SNA and ANB angles were significantly increased by 3.1°±1.6° ($P<0.001$) and 3.5°±1.7° ($P<0.001$), respectively. ANS-PNS was also increased by 3±1.8 mm ($P<0.0001$). SNB did not show any significant changes. IMPA and Nasolabial angles were decreased by - 5°±6.9° ($P<0.05$) and - 7.5°±6.3° ($P<0.004$), respectively (Table 7-5). Figures 7-4 to 7-8 show the pre-treatment images of one of the patients treated with the reverse chin cup. Figures 7-9 to 7-13 show the post-treatment images of the same patient.

	Mean + SD (Before)	Mean + SD (After)	Changes	P-value
SNA °	76.4 + 2.6	79.5 + 2.6	+3.1 + 1.6	0.001*
SNB°	77.8 + 1.9	77.4 + 2.9	-0.4 + 1.8	0.5
ANB°	-1.4 + 1.3	2.1 + 1.3	+3.5 + 1.7	0.001*
GOGN /SN°	37 + 7	35.3 + 5.6	-1.7 + 3.53	0.1
U1 / SN°	104.3 + 7.8	108.9 + 7.9	+4.5 + 4.4	0.01*
IMPA°	87.5 + 6.1	82.5 + 5.1	-5 + 6.9	0.05*
Nasolabial°	115 + 8.2	107.5 + 10.8	-7.5 + 6.3	0.004*
Inclination°	83.7 + 3.4	84.9 + 4.8	+1.2 + 3.9	0.3
ANS – PNS (mm)	48.1 + 2.5	51.1 + 2.6	+3 + 1.8	0.001*
Go Gn (mm)	73.5 + 3.9	75/3 + 4.2	+1.8 + 1.3	0.002*
Jarabak ratio (%)	61.4 + 6.6	63.2 + 4.8	+1.8 + 2.8	0.07
* The mean difference is significant at the P<0.05 level.				

Table 7-5: Pre and post treatment Cephalometric Measurements of reverse chin cup therapy

Discussion

The result of this study demonstrates that reverse chin cup was effective in correction of anteroposterior discrepancy. In other words, SNA and ANB showed a statistically significant increase. On the other hand, SNB showed some decrease; however, the change was non-significant. This lack of increase means that reverse chin cup has retarded the mandibular growth. Lower incisors were also lingualized due to pressure of the chin cup. Nasolabial angle decrease implies that the upper lip has moved forward. Moreover, increase of ANS- PNS shows that maxillary growth has been positively affected by the reverse chin cup. Oneof the advantages seen from the reverse chin cup was that not only GoGn-Sn did not increase,but also it showed a slight however, non-significant decrease. The force of the reverse chin cup was applied on the anterior part of the maxilla. However, if the force was applied on the posterior segment of the maxilla, the vertical direction of the force would have caused downward positioning of the posterior segment of maxilla and consequently unsatisfactory backward rotation of the mandible would have been resulted. [131] Jarabak ratio increase also confirms that anterior facial height did not increase, which is also the result of the area wherethe force was applied. Moreover, the force created form the straps which connected the high pull cap to the chin cup, acted as a posterior bite plate. In other words, it kept the posterior teeth in contact with each other, which resulted in posterior impaction of the maxilla.

Previous studiest[132-135] showed that maxillary forward movement was found with different maxillary protraction appliances. However, these appliances cause great discomfort for the patients due to their large size. Especially patients who wear glasses will be more susceptible to discomfort. This discomfort along with the embarrassment caused by the large size for children, especially at school in front of other peers, will reduce patient compliance. For most young children a protraction headgear is an acceptable method for treatment of maxillary deficiency. [136] The protraction headgear used in this study was named as reverse chin cup which is almost similar to Chin support with cranial straps (Hickham). A porous acrylic chin pad was used in order to allow better air vent to reduce skin irritation. It is noteworthy to mention that the current study was a preliminary one with 10 case series. The treatment used in this study was for correction of skeletal problem. After removal of the chin cup, further treatment to achieve interdigitation and decoding was done by use of fixed appliances.

Conclusion

In this preliminary study, reverse chin cup was effective in treatment of maxillary deficiency. Moreover, reverse chin cup seems more favourable for patients due to its smaller sizecompared with other large extraoral appliances.

Chapter 8

THE EFFECTS OF FIXED AND REMOVABLE FACE MASKS ON MAXILLARY DEFICIENCIES IN GROWING PATIENTS

METHODS

Forty-three patients (21 boys and 22 girls) with skeletal Class III malocclusions and maxillary deficiencies were selected. All subjects' parents or guardians gave informed writtenconsent, and the patients met the following inclusion criteria:

- SNA ≤ 80 degrees, SNB ≤ 80 degrees, and ANB ≤ 0 degrees
- Class III molar relationship
- No mandibular shift
- Concave facial profile
- Negative overjet
- No congenital disease or endocrine disorders
- No previous orthodontic treatment or surgical intervention

The patients were randomly assigned to two groups using a standard random number table. Twenty-one patients (10 boys and 11 girls) with the mean age of 8.9 ± 1.4 years were treated by means of a multi adjustable face mask (Ortho Technology) and a fully anchored removable appliance in the maxillary arch. The maxillary removable appliance had two Adams clasps on the permanent maxillary first molars, two C clasps on the primary canines, and two other C clasps on the permanent central incisors for further anchorage. If necessary, the number of C clasps and Adams clasps could be increased for anchorage reinforcement. Two hooks were mounted on the right and left buccal segments. Two orthodontic 5/16-inch, medium-sized latex elastics connected the hooks of the maxillary removable appliance to the horizontal crossbar of the face mask to deliver 450 to 550 g of force (Figs 8-1 to 8-3). Patients were instructed to wear the appliance full-time except while eating, playing contact sports, and brushing teeth. Treatment time was 17 ± 4 months.

Twenty-two patients (10 boys and 12 girls) with the mean age of 9.3 ± 1.2 years were treated with a multi adjustable face mask and a fixed standard 0.018- inch edgewise appliance. The maxillary first molars were banded. Afterward, the permanent central and lateral incisors and primary teeth were bonded. After the initial leveling and aligning phase, a 0.016-inch steel arch wire with two hooks on the mesial of molars was used. Two orthodontic 5/16-inch, medium-sized latex elastics connected the hooks of the wire to the horizontal crossbar of the face mask to deliver 450 to 550 g of force (Figs 8-4 and 8-5). Treatment time was 18 ± 3 months.

Lateral cephalograms, panoramic radiographs, photographs, and study casts of patients of both groups were taken before (T1) and after (T2) treatment. SNA, SNB, ANB, GoGn-Sn (mandibular plane angle), U1-SN (angle between the long axis of the maxillary central incisor and anterior cranial base), IMPA (angle between the long axis of the mandibular central incisor and mandibular plane), inclination angle (the angle formed between a perpendicular line to the soft tissue nasion and palatal plane), ANS-PNS (anterior nasal spine-posterior nasal spine), GoGn (the distance between gonion and gnathion), and Jarabak ratio (the ratio between posterior and anterior face heights—S-Go/N-Me) of each patient were measured at T1 and T2. The reliability of the measurements was determined by randomly selecting 15 cephalograms at T1 and T2 from each group. They were traced twice on two separate occasions after 1 month. The paired t test showed no statistically significant differences between the two measurements. Data were tested for normality, and the appropriate statis- tical tests were applied (Tables 8-1 and 8-2). Paired t tests were used for intragroup evaluation if the distribution was normal. Otherwise, the Wilcoxon test was used. The Mann-Whitney test was used to compare the data between the two groups.

Figure 8-1, Right intraoral view of a patient in removable face mask group

Figure 8-3,Frontal intraoral view of a patient in the the removable face mask group

Figure 8-2,Left view of a patient in the removable face mask group

Figure 8-4,Right intraoral view of a patient in the fixed face mask group

Figure 8-5,Frontal intraoral view of a patient in the fixed face mask group

Table 1 Normality test for the fixed face mask group

	Kolmogorov-Smirnov test[a]				Shapiro-Wilk test	Statistic
		df	Significance	Statistic	df	Significance
SNA before	.139	22	.200*	.952	22	.341
SNA after	.120	22	.200*	.963	22	.561
SNB before	.207	22	.015	.876	22	.010
SNB after	.170	22	.098	.923	22	.086
ANB before	.241	22	.002	.859	22	.005
ANB after	.184	22	.050	.925	22	.096
U1-SN before	.118	22	.200*	.975	22	.826
U1-SN after	.096	22	.200*	.971	22	.725
ANS-PNS before	.133	22	.200*	.962	22	.528
ANS-PNS after	.254	22	.001	.723	22	.000
GoGn before	.148	22	.200*	.960	22	.487
GoGn after	.124	22	.200*	.956	22	.410
Jarabak index before	.095	22	.200*	.986	22	.981
Jarabak index after	.096	22	.200*	.974	22	.811
Inclination angle before	.125	22	.200*	.972	22	.754
Inclination angle after	.191	22	.036	.931	22	.128
GoGn-SN before	.148	22	.200*	.979	22	.904
GoGn-SN after	.117	22	.200*	.975	22	.819
IMPA before	.122	22	.200*	.950	22	.323
IMPA after	.091	22	.200*	.969	22	.686

[a]Lilliefors significance correction.
*Lower bound of the true significance. *df*, degrees of freedom.

Table 8-1, Normality test for the fixed face mask group

Table 2 Normality test for the removable face mask group

	Kolmogorov-Smirnov test[a]				Shapiro-Wilk test	Statistic
		df	Significance	Statistic	df	Significance
SNA before	.216	21	.011	.896	21	.029
SNA after	.221	21	.009	.924	21	.105
SNB before	.225	21	.007	.830	21	.002
SNB after	.171	21	.112	.956	21	.446
ANB before	.252	21	.001	.757	21	.000
ANB after	.183	21	.066	.924	21	.106
U1-SN before	.110	21	.200*	.963	21	.587
U1-SN after	.170	21	.117	.933	21	.158
ANS-PNS before	.157	21	.192	.969	21	.715
ANS-PNS after	.134	21	.200*	.967	21	.670
GoGn before	.163	21	.148	.851	21	.004
GoGn after	.190	21	.047	.922	21	.097
Jarabak index before	.110	21	.200*	.974	21	.809
Jarabak index after	.099	21	.200*	.983	21	.957
Inclination angle before	.153	21	.200*	.962	21	.563
Inclination angle after	.111	21	.200*	.973	21	.788
GoGn-SN before	.164	21	.146	.959	21	.501
GoGn-SN after	.129	21	.200*	.979	21	.909
IMPA before	.105	21	.200*	.974	21	.810
IMPA after	.160	21	.172	.946	21	.281

Table 8-2, Normality test for the fixed face mask group

Results

The results of this study showed that SNA and ANB increased by 1.6 ± 1.9 de- grees (P < .01) and 1.8 ± 1.5 degrees (P < .001) in the fixed face mask group. SNA and ANB also increased in the removable face mask group by 1 ± 1.7 degrees (P < .003) and 1.6 ± 1.5 degrees (P < .001), respectively. SNB did not show any significant changes in either of the groups. U1-SN increased from 94.8 ± 6.0 degrees to 106.0 ± 6.5 degrees in the fixed face mask group (P < .001), and it increased from 98.1 ± 9.2 degrees to 104.3 ± 5.2 degrees in the removable face mask group (P < .001). The Mann-Whitney test showed that there were no statistically significant differences between the cephalometric data of two groups, except for the U1-SN (Tables 8-3 and 8-4).

Table 3 Pre - and posttreatment measurements of the fixed and removable face mask groups

Cephalometric measurement	Group	Pretreatment mean ± SD.	Posttreatment mean ± SD	*P* value
SNA (degrees)	Fixed face mask	75.6 ± 2.8	77.2 ± 3.0	.01*
	Removable face mask	76.6 ± 2.8	77.6 ± 3.2	.003*
SNB (degrees)	Fixed facemask	77.14 ± 2.7	77.1 ± 3.0	.6
	Removable face mask	77.8 ± 2.2	77.3 ± 2.6	.1
ANB (degrees)	Fixed face mask	-1.6 ± 1.5	0.2 ± 1.7	.001*
	Removable face mask	-1.1 ± 1.5	0.5 ± 2.4	.001*
U1-SN (degrees)	Fixed face mask	94.8 ± 6.0	106.0 ± 6.5	.001*
	Removable face mask	98.1 ± 9.2	104.3 ± 5.2	.001*
ANS-PNS (mm)	Fixed face mask	45.7 ± 3.6	49.0 ± 7.6	.003*
	Removable face mask	44.3 ± 3.0	46.3 ± 3.7	.02*
GoGn (mm)	Fixed face mask	63.2 ± 5.4	66.3 ± 4.0	.001*
	Removable face mask	62.9 ± 3.9	64.4 ± 3.5	.09*
Jarabak index (%)	Fixed face mask	62.1 ± 3.8	62.0 ± 3.3	.9
	Removable face mask	62.7 ± 5.2	63.6 ± 5.6	.07*
Inclination angle (degrees)	Fixed face mask	82.9 ± 3.2	83.2 ± 3.6	.1
	Removable face mask	83.1 ± 2.8	82.9 ± 3.6	.7
GoGn-SN (degrees)	Fixed face mask	35.3 ± 5.1	35.7 ± 4.2	.3
	Removable face mask	33.6 ± 5.5	33.3 ± 5.8	.4
IMPA (degrees)	Fixed face mask	89.9 ± 6.8	86.5 ± 7.4	.001*
	Removable face mask	91.1 ± 6.4	87.0 ± 5.6	.009*

Table 8-3, Pre and posttreatment measurements of the fixed and removable face mask groups.

Table 4 Comparison of cephalometric changes between the fixed and removable face mask groups

Cephalometric measurements	Fixed face mask mean ± SD	Removable face mask mean ± SD	*P* value
SNA (degrees)	1.6 ± 1.9	1 ± 1.7	.1
SNB (degrees)	−0.04 ± 1.8	−0.5 ± 1.2	.5
ANB (degrees)	1.8 ± 1.5	1.6 ± 1.5	.6
U1-SN (degrees)	11.1 ± 6.9	6.2 ± 7.1	.02*
ANS-PNS (mm)	3.3 ± 7.4	2.0 ± 3.5	.6
GoGn (mm)	3.1 ± 3.5	1.5 ± 2.1	.2
Jarabak index (%)	-0.1 ± 2.1	0.8 ± 2.1	.1
Inclination angle (degrees)	0.3 ± 2.3	−0.2 ± 2.7	.6
GoGn-SN (degrees)	0.4 ± 1.9	-0.3 ± 1.6	.2
IMPA (degrees)	−3.4 ± 3.5	−4.1 ± 6.5	.9

Table 8-4, Comparison of cephalometric changes between the fixed and removable face mask

Discussion

This study showed significant anterior movement in the maxilla with greater proclination of the maxillary incisors in the fixed face mask group than in the removable face mask group. There was mandibular incisal retroclination in both groups. The direction of force application in both groups was located below the center of resistance of the maxilla. This protraction force can be resolved into horizontal and vertical components. The horizontal component results in anterior movement of maxilla, and the vertical component results in counterclockwise rotation of the maxilla. In the fixed face mask group, it resulted in counterclockwise rotation of the palatal plane. The inclination angle increased in the fixed face mask group, which could be explained by more extrusive force on the molars. The extrusive force on the buccal segment in the removable group was less than the fixed group, which is why the inclination angle decreased in the removable group (see Table 8-3).

Various techniques and appliances are being used to treat the maxillary deficiency, including the modified protraction bow appliance, reverse pull head gear, face mask, Class III activator, and reverse chin cup. De Clerck et al used miniplates for orthopedic traction of the maxilla.15 Bone-anchored maxillary protraction was applied by Cevidanes et.al [64] for maxillary advancement. Mini-implants were also used for treatment of maxillary deficiencies.[65]

Face mask therapy has become a common technique used to correct developing Class III malocclusions. A search of the literature will reveal numerous studies about face masks and their effects on the nasomaxillary complex. In addition, the experimental studies constantly demonstrate pronounced forward movement of the maxilla due to heavy and continuous protraction forces of face masks.[66]

Enacar et al[67] proposed face mask therapy with rigid anchorage for a patient with a Class III skeletal relationship with maxillary hypoplasia and severe oligodontia. Various rigid anchors, including ankylosed canines, osseointegrated implants in the zygomatic buttress,6 lag screws in the posterior dentoalveolar area,[68] and onplants on the posterior palatal bone, have been used in the treatment of maxillary deficiencies. The usual effects of conventional face mask therapy on the dentition include extrusion and mesial movement of the maxillary molars, proclination of the maxillary incisors, and retroclination of the mandibular incisors.[69,70] Obviously, the major goal of orthopedic treatment is to correct the jaw discrepancy by achieving true skeletal alteration rather than just moving teeth to camouflage the problem.

The treatment duration of both groups was long because of a lack of patient cooperation. After the initial leveling and aligning phase, a 0.016-inch steel archwire with two hooks was applied on the mesial aspect of the maxillary molars. These two loops were applied to prevent mesialization of the maxillary molars during fixed appliance protraction.

In this study, both the removable and fixed face masks were successful in creating forward movement of the maxilla. However, since tooth movement is inevitable when force is applied via the dentition, U1-SN increased more in the fixed face mask group. This is because the removable face mask covers the entire maxilla and pressure is not exerted on just one point. With the fixed face mask, the pressure is exerted on the maxillary incisors, which results in a greater increase in U1-SN.

Chapter 9

THE EFFECTS OFF ACE MASK AND REVERSE CHIN CUP ON MAXILLARY DEFICIENT PATIENTS

Materials and Methods

Ethical approval was obtained from the IAU Local Research Ethics Committees (19014, October 2009). Informed written consent was obtained from each patient and a parent or guardian. A sample size calculation was carried out on the basis of the difference in means and standard deviation of the changes in SNA from previous studies, similar in nature to the current one,28–30 in which changes of SNA were 0.7u (SD: 0.6). For an alpha level of 0.05,a sample size of 20 per group was necessary to achieve a power of 0.90. Considering these studies, following published guidelines31 and considering prob- able drop outs, an optimal sample size of 42 patients was chosen for this study.

The following inclusion criteria were used:

• Sella–Nasion–A point (SNA) (80u; Sella–Nasion–B point (SNB) (80u; A point–Nasion–B point (ANB) (0u;

• class III molar relationship;

• no mandibular shift;

• negative overjet;

• no congenital disease or endocrine disorders;

• no previous orthodontic treatment and surgical intervention.

An unstratified subject allocation sequence was generated by computer program (Etcetra Version 2.59); random numbers were generated and assignment was carried out by one of the investigators, thus concealing allocation from the clinician until the time of the appointment at which the appliance was to be placed. The treating clinician was blinded from the randomization procedure, but because of clear differences in appliance design, blinding was not possible during the treatment period.

Participants were allocated to one of two groups:

•Group I: received a Multi-Adjustable face mask H (Ortho Technology Inc., Tampa, FL, USA) and a fully anchoraged removable appliance in the upper jaw. The upper removable appliance had two Adams clasps on the permanent first molars, two C clasps on the primary canines, and two C clasps on the permanent central incisors. If necessary, the number of C clasps and Adams clasps could be increased for anchorage reinforcement. Two hooks were mounted on the right and left buccal segments.

Two orthodontic latex elastics (5/160, medium size) connected the hooks of the upper removable appliance to the horizontal crossbar of the face mask in order to deliver approximately 500 g of force (Figures 9-1 and 9-2). The patients were instructed to wear the appliance full-time except for eating, contact sports and tooth brushing.

•Group II: received the reverse chin cup.[27] This upper removable appliance had two Adams clasps on the permanent first molars, two C clasps on the primary canines and two other C clasps on the permanent central incisors. If necessary, the number of C clasps and Adams clasps could be increased for anchorage reinforcement. A porous acrylic chin cup withtwo vertical arms (1 mm stainless steel) was fabricated for each individual patient. The end ofeach arm was bent to form a hook. Two orthodontic latex elastics (5/160, heavy size) connected the hooks of the palatal canine area of the upper removable appliance to the hooks of reverse chin cup in order to deliver approximately 500 g of force on each side. A high pull head cap was used to hold the reverse chin cup (Figures 9-3–9-4). The patients were instructed to wear the appliance full-time except for eating, contact sports and tooth brushing.

Lateral cephalograms, panoramic radiographs, photo- graphs and study casts of the patients in both groups were taken before (T1) and after (T2) treatment. SNA, SNB, ANB, Upper I to SN, ANS–PNS, to SN, Go–Gn, Jarabak ratio, Upper I to ANS–PNS, Go–Gn to Sn and IMPA were measured. The radiographs of each patient were measured before and after treatment by one trained clinician. The reliability of the measurements was determined by randomlyselecting 10 cephalograms at the beginning and end of treatment from each group.

Figure 9-1, Lateral intra-oral view of upper Removable appliance which connects to facemask

Figure 9-2, Frontal intra-oral view of upper removable appliance which connects to facemask

Figure 9-3, Lateral extra-oral view of reverse chin cup

Figure 9-4, Frontal extra-oral view of reverse chin cup

They were traced twice by the same trained clinician on two separate occasions after a 1- month interval. Paired t-test showed no statistically significant differences between the two measurements. An intra-class correlation coefficient was also calculated to assess test/re-test reliability, the results of which revealed a kappa value of 0.84, which is considered excellent. The level of statistical significance was set at P,0.05.

Data were tested for normality and appropriate statistical tests were applied (Table 9-1). Paired t-tests were used for intra group evaluation if the distribution was normal.

Results

A total of 42 patients (19 males and 23 females) were recruited to the study. A CONSORT diagram showing the flow of patients through the trial is provided in Figure 9-6. There were 21 patients (10 males and 11 females), with a mean age of 8.9 (SD: 1.4) years treated using the face mask. The active treatment time was 18 (SD: 2) months. There were 21 patients (nine males and 12 females), with a mean age of 9.2 (SD: 1.1) years treated using the reverse chin cup. The active treatment time was 19 (SD: 4) months.

The results of the cephalometric analysis are shown in Tables 2 and 3. Analysis using paired t-test and Wilcoxon test showed that the SNA in the face mask group increased by 1u (SD: 1.7) from 76.6u (SD: 2.8) to 77.6u (SD: 3.2) (P,0.003) and ANB increased from 21.1u (SD: 1.5) to 0.5u (SD: 2.4) (P,0.001). The changes in SNB were not significant. IMPA showed a decrease of 4.1u (SD: 6.5) from 91.1u (SD: 6.4) to 87u (SD: 5.6) (P,0.009)

(Table 2). In the reverse chin cup group, SNA increased by 1.8u (SD: 1.7) from 75.8u (SD: 2.6) to 77.6u (SD: 2.9) (P,0.001), and ANB increased by 1.4u (SD: 1.5) from 21.4u (SD: 1.9) to 0u (SD: 2.2) (P,0.001). SNB showed a non-significant change. IMPA was decreased by 3.1u (SD: 4.7) from 89.7u (SD: 6.2) to 86.6u (SD: 6.4) (P,0.008) (Table 9-2). In the inter-group evaluation, t-test and Mann–Whitney test showed no statistically significant differences between the cephalometric measurements of the two groups (Table 9-3).

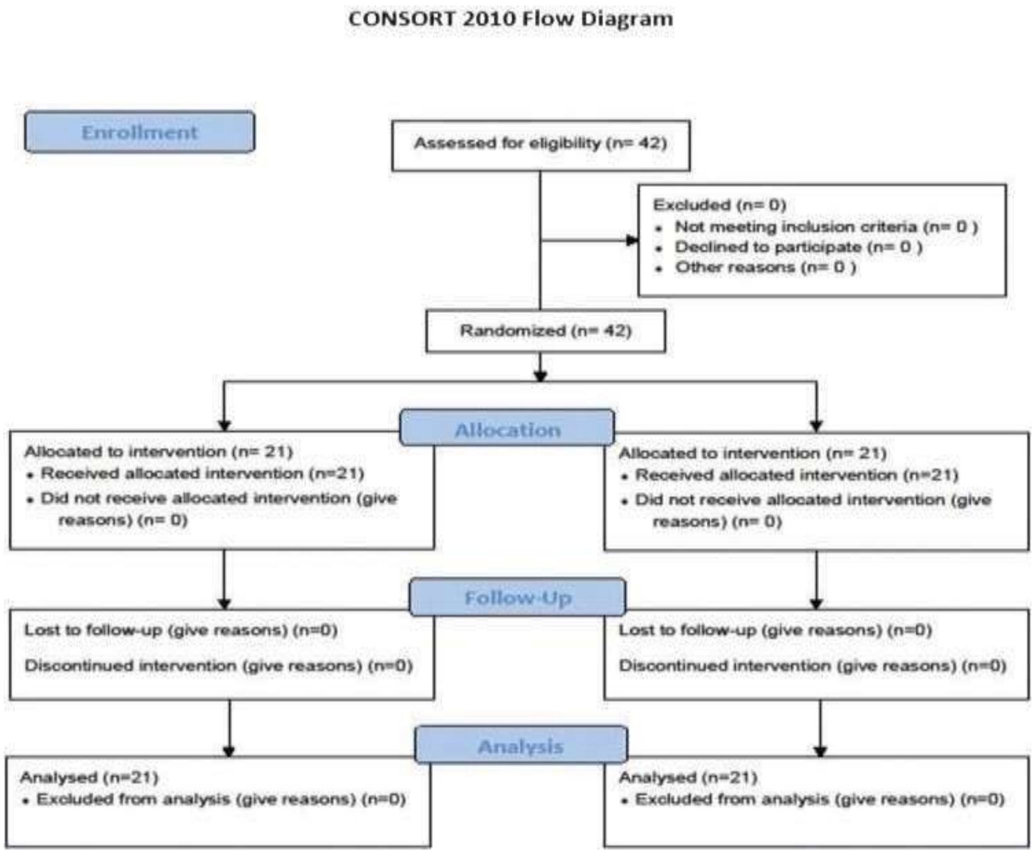


Figure 9-6 CONSORT flow diagram of subjects through each stage of the study

Cephalometric variables	Definition
SNA (u)	The angle between the anterior cranial base (sella to nasion) and NA (nasion to point A) line
SNB (u)	The angle between the anterior cranial base (sella to nasion) and NB (nasion to point B) line
ANB (u)	The angle between the NA and NB lines
U1 to SN (u)	The angle between long axis upper central incisor and anterior cranial base
ANS–PNS (mm)	Anterior nasal spine-posterior nasal spine
Palatal–SN (u)	The angle between palatal plane and SN
GoGn (mm)	The distance between gonion and gnathion
Jarabak ratio (%)	The ratio between posterior and anterior face heights; S–Go/N–Me
U1 to palatal (u)	The angle between long axis upper central incisors and palatal plane
Inclination angle	The angle formed between a perpendicular line to soft tissue
GoGn–SN	

Table 9- 1 Definition of the cephalometric variables.

Table 9-2 Pre- and post-treatment measurements of the Face mask and Reverse Chin Cup groups

Cephalometric measurement	Groups	Pre-treatment mean	SD	Post-treatment mean	SD	*P* value
SNA (u)	Face Mask	76.6	2.8	77.6	3.2	0.003
	R. Chin Cup	75.8	2.6	77.6	2.9	0.001
SNB (u)	Face Mask	77.8	2.2	77.3	2.6	0.100
	R. Chin Cup	77.2	2.3	77.5	2.5	0.300
ANB (u)	Face Mask	21.1	1.5	0.5	2.4	0.001
	R. Chin Cup	21.4	1.9	0	2.2	0.001
U1 to SN (u)	Face Mask	98.1	9.2	104.3	5.2	0.001
	R. Chin Cup	101	10.4	105.1	6.9	0.050
ANS–PNS (mm)	Face Mask	44.3	3	46.3	3.7	0.020
	R. Chin	45.9	3.	46.9	2.9	0.100

	Cup		6			
Palatal–SNu	Face Mask	9.8	2.8	10	3.8	0.800
	R. Chin Cup	10.3	4.4	10	3.3	0.600
GoGn (mm)	Face Mask	62.9	3.9	64.4	3.5	0.090
	R. Chin Cup	67.5	5.9	69.1	4.5	0.100
Jarabak ratio (%)	Face Mask	62.8	5.3	63.6	5.6	0.070
	R. Chin Cup	62.7	5.2	63.7	3.7	0.030
U1 to palatal (u)	Face Mask	107.7	10.1	114.7	5.9	0.003
	R. Chin Cup	111	11.1	115	7.1	0.050
Inclination angle	Face Mask	83.1	2.8	82.9	3.6	0.700
	R. Chin Cup	82.4	4.2	83.1	3.1	0.200
GoGn–SN (u)	Face Mask	33.6	5.5	33.3	5.8	0.400
	R. Chin Cup	35.5	5.5	34.2	5.2	0.009
IMPA (u)	Face Mask	91.1	6.4	87	5.6	0.009
	R. Chin Cup	89.7	6.2	86.6	6.4	0.008

Table 9-3 Comparison of cephalometric changes between Facemask and Reverse Chin Cup groups.

Cephalometric measurements	Facemask mean	SD	Reverse mean Chin Cup	SD	Confidence interval	*P* value
SNA (u)	1	1.7	1.8	1.7	. . .	0.07
SNB (u)	20.5	1.2	0.3	1.6	. . .	0.07
ANB (u)	1.6	1.5	1.4	1.5	. . .	0.30
U1 to SN (u)	6.2	7.1	4.1	8.8	27.2–2.8	0.10
ANS–PNS (mm)	2	3.5	1	2.5	. . .	0.40
Palatal–SN (u)	0.2	2.9	20.3	2.7	. . .	0.90
GoGn (mm)	1.5	2.1	1.6	4.5	22.6)–(2.9	0.90
Jarabak ratio (%)	0.8	2.1	1	1.8	. . .	0.60
U1 to palatal (u)	7	9.4	4	8.7	28.6–2.6	0.10
Inclination angle	20.2	2.7	0.7	2.7	. . .	0.40
GoGn–SN (u)	20.3	1.6	21.3	2.1	. . .	0.20
IMPA (u)	24.1	6.5	23.1	4.7	. . .	0.90

Discussion

The present study has indicated that treatment with a face mask or reverse chin cup appliance might have the following effects: (1) forward movement of the maxilla; and (2) forward movement of the maxillary dentition and lingual movement of the mandibular incisors.

In view of the high frequency of maxillary retrusion, maxillary advancement by reverse headgear has been considered a major treatment option in young patients. The aim of these orthopaedic approaches is to provide a more favourable environment for normal growth, as well as an improvement in the occlusal relationship.[71] Face mask therapy has become a common technique used to correct the developing class III malocclusion.[72,73] An electronic search in the literature reveals copious investigations relating to face masks and their effectson the nasomaxillary complex. In addition, experimental studies constantly demonstrate pronounced forward movement of the maxilla due to heavy and continuous protraction forces of via a face mask.[74–76] Face mask therapy is recommended to begin before the age of 8 years for maximal effect.[77] However, one of the problems with the face mask is the bulky size and shape, which make it a discouraging choice for children, which can be associated with discomfort. This discomfort, along with the embarrassment caused by the large size, especially at school in front of other peers, potentially reduces compliance. For most young children, protraction headgear is a more acceptable method for the treatment of maxillary deficiency.77 The protraction head- gear used in this study was a reverse chin cup, which is similar to a chin support with cranial straps.[78] A porous acrylic chin pad was used in order toallow better ventilation to reduce skin irritation. The reverse chin cup is not a small appliance by itself; however, it is smaller than the face mask. Moreover, it lacks the forehead rest of the face mask. The major goal of both treatment modalities was to correct the jaw discrepancy; however, tooth movement is inevitable when force is applied via the dentition. In addition, in both groups, the pressure of the chin cup caused a decrease in the IMPA. These findings are similar to other studies, which indicate that the usual effects of conventional face mask therapy on the dentition include proclination of the maxillary incisors, and retroclination of the mandibular incisors.[79-80] However, mini plates and mini-implants combined with class III elastics do not cause retroclination of the lower incisors. The reason for this differenceis that mini-plates and mini-implants combined with class III elastics utilise bone anchorage; thus, they do not exert any pressure on the lower incisors. The force applied on the face mask is not completely transferred to the chin, part of it being counteracted by forehead anchorage and resulting in less backward rotation of the maxilla. However, the force associated with the reverse chin cup is transferred completely to the chin and causes more backward rotation of the mandible. Although the origin of force application varies between the face mask and reverse chin cup, they are very similar because in both of them orthopaedic force is directed 30u downward and forward from the occlusal plane.

The treatment methods used in this study were for the correction of skeletal problems. Therefore, when the active treatment was finished, patients were instructed to wear the appliances only at nights to act as a retainer. The process will continue until the permanent dentition. Once in the permanent dentition, further treatment will be continued with the use of fixed appliances.

Conclusions

- Facemask and reverse chin cup therapy is able to produce forward movement of the maxilla in the growing child.
- Both appliances were also associated with lingual tipping of the lower incisors and labial tipping of the uppers.

Chapter :10

THE EFFECTS OF FACE MASK AND TONGUE APPLIANCE ON MAXILLARY DEFICIENCY IN GROWING PATIENTS: A RANDOMIZED CLINICAL TRIAL

Materials and Methods

Ethical approval was obtained from Islamic Azad University Local Research Ethics Committees and the study was conducted at Islamic Azad University. The study was carried out in accordance with the ethical standards set forth in the 1964 Declaration of Helsinki. Informed written consent was obtained from the patient and a parent or guardian.

45 patients (22 males, 23 females) with skeletal Class III malocclusion and maxillary deficiency were selected. This study was approved by the orthodontic department of dental school and all participants signed an informed consent. The power of the study was calculated on the basis of the difference in means and standard deviation of the changes in SNA in previous studies which were similar in nature to our study,23–25 the resulting power was 0.90. Considering these studies and following the guidelines provided by Petrie et al.26 an optimal sample size of 45 patients was chosen for this study. All patients were in prepubertal (CS1, CS2, and CS3), according to the recently improved version of cervical vertebral maturation (CVM) method described by Franchi et al27 and Baccetti et al.28 All subjects gave informed written consent, and all met the following inclusion criteria:

1) Sella-Nasion-A (SNA) ≤ 80◦, Sella-Nasion-B (SNB) ≤ 80◦, A-Nasion-B (ANB) ≤ 0◦.

2) Class III molar relationship.

3) No mandibular shift.

4) Concave facial profile.

5) Negative overjet.

6) No congenital disease or endocrine disorders.

7) No previous orthodontic treatment and surgical intervention.

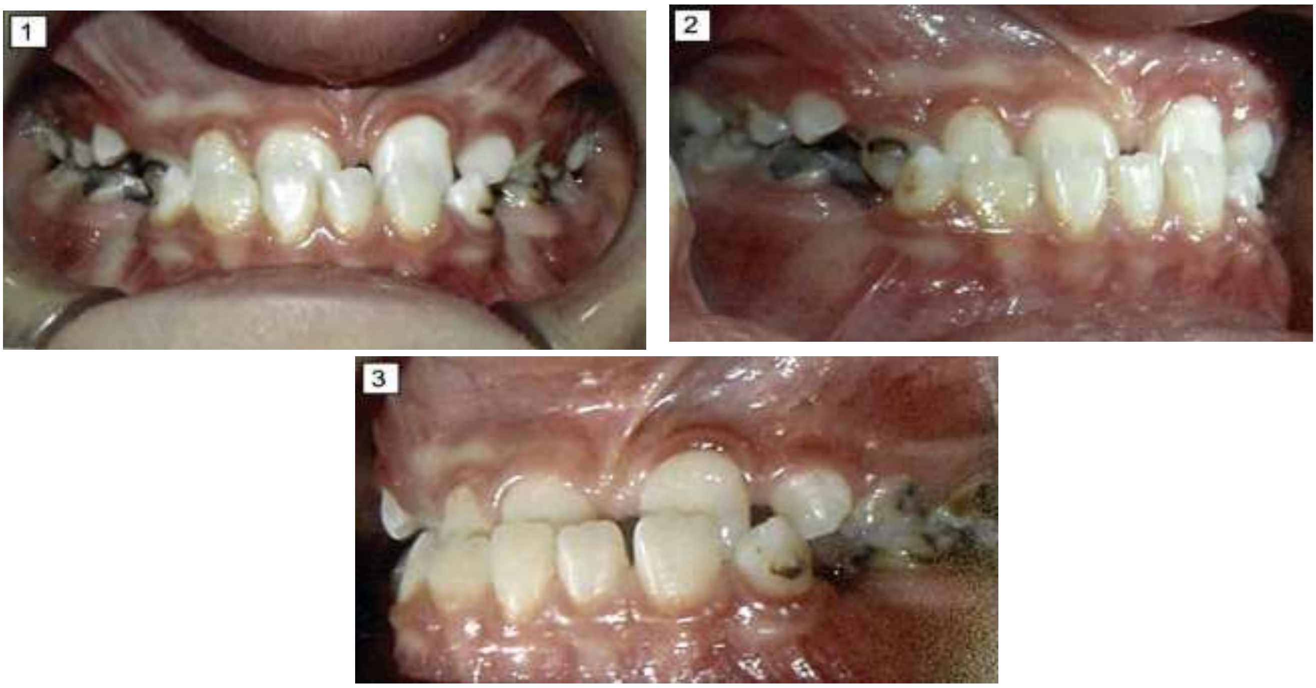
The patients were randomly assigned to two groups using a standard random number table. 22 patients (10 boys, 12 girls) with the mean age of 9.3 years ± 1.2 years were treated by a Multi-Adjustable Facemask® (Ortho Technology, Inc., Tampa, Florida, USA®) and a fixed standard .018-inch slot edgewise appliance. First maxillary molars were banded. After- wards, permanent centrals and laterals and primary teeth were bonded. After the initialleveling and aligning phase, .016-inch stainless steel archwire with two hooks on the mesialof molars was used. Two orthodontic latex elastics (5/16 inch, medium size) connected the hooks of the wire to the horizontal crossbar of the face mask in order to deliver 500 g force. The treatment time was 18 months ± 3 months.

23 patients (12 boys, 11 girls) with the mean age of 10.1 years ± 0.7 years were treated by tongue appliance. (Figs.10-1-5). A tightly fitting and well retained upper removable appliance was fabricated with Adams clasps on the upper first permanent molars and two C clasps were

placed on the upper permanent central and lateral incisors. Long tongue cribs were placed in the intercanine area in an effort to restrict the tongue. These cribs were long enough to cage the tongue and were adjusted to avoid traumatizing the floor of the mouth. (Figs. 10-6 and10- 7)

The patients were instructed to wear the appliance full- time except for eating, contact sports and tooth brushing. The active treatment time lasted for 17 months ± 3 months. The patients were examined and the progress was observed after each monthly visit.

Lateral cephalograms, panoramic radiographs, photos, and study casts of patients of both groups were taken before (T1) and after (T2) treatment. Lateral cephalograms of both groups at T1 and T2 were standardized as to magnification factor (8%). SNA, SNB, ANB, GoGn-Sn (mandibular plane angle), Upper 1 to SN (angle between long axis upper central incisor and anterior cranial base), IMPA (angle between the long axis of the lower central incisor and mandibular plane), Nasolabial angle (the angle formed between lines tangent to the columella and the upper lip vermillion and intersecting at the subnasale), Inclination angle (the angle between the perpendicular drawn from N' on Se-N' line "entry of sella-soft tissue nasion" and the palatal plane), and Jarabak ratio (the ratio between pos- terior and anterior face heights; S–Go/N–Me) of each patient were measured before and after treatment. The measure- ments were done by a clinician (T.T.) who was blinded to the type treatment. The reliability of the measurements was determined by randomly selecting 12 cephalograms at thebeginning and end of the treatment from each group. They were traced twice on two separate occasions after 1 month interval. Paired t-test showed no statistically significant differences between the two measurements. Paired T-tests were used for intra group evaluation if the distribution was normal; otherwise, Wilcoxon test was used. Mann-Whitney test was used to compare the data between the two groups.



Figs. 10, 1-3 – Pretreatment intraoral photographs of a tongue appliance patient.

Figs. 10, 4-5 – Pretreatment radiographs of the same patient.

Figs. 10, 6-7 – Tongue appliance in situ.

Results

The results of this study showed that SNA and ANB increased by 1.6◦ ± 1.9◦ ($P < 0.01$) and 1.8◦ ± 1.5◦ ($P < 0.001$) in fixed face mask group. SNA and ANB also increased in tongue appliance group by 1.4◦ ± 1.4◦ ($P < 0.001$) and 1.6◦ ± 1.6◦ ($P < 0.001$), respectively. The SNB did not show any significant changes SNA, SNB, ANB, GoGn-Sn (mandibular planeangle), Upper 1 to SN (angle between long axis upper central incisor and anterior cranial base), IMPA (angle between the long axis of the lower central incisor and mandibular plane), Nasolabial angle (the angle formed between lines tangent to the columella and the upper lip vermillion and intersecting at the subnasale), Inclination angle (the angle between the perpendicular drawn from N' on Se-N' line "entry of sella-soft tissue nasion" and the palatal plane), and Jarabak ratio (the ratio between pos- terior and anterior face heights; S–Go/N– Me) of each patient were measured before and after treatment. The measurements were done by a clinician (T.T.) who was blinded to the type of treatment. The reliability of the measurements was determined by randomly selecting 12 cephalograms at the beginning and end of the treatment from each group. They were traced twice on two separate occasions after1 month interval. Paired t-test showed no statistically significant differences between the two measurements. Paired T-tests were used for intra group evaluation if the distribution was in either of the groups. U1 to SN increased from 94.8◦ ± 6.0◦ to 106.0◦ ± 6.5◦ in fixed face mask group ($P < 0.001$) and it increased from 96.6◦ ± 7.9◦ to 99.1◦ ± 7.1◦ in tongue appliance group ($P < 0.06$). Linear measurements show that ANS-PNS increased significantly in both groups. It increased from 45.7 mm ± 3.6 mm to 49.0 mm ± 7.6 mm in fixed face mask group ($P < 0.001$) and it increased from 45.0 mm ± 3.6 mm to 45.7 mm ± 3.3 mm in tongue appliance group ($P < 0.003$). Go-Gn also showed statistically significant changes in both groups.

Mann-Whitney test showed that there were no statistically significant differences between the cephalometric data of two groups; except for the Jarabak ratio and U1 to SN. U1 to SN increased by 11.1◦ ± 6.9◦ in fixed face mask group, while it increased by 2.5◦ ± 6.1◦ in tongue appliance group ($P < 0.001$). Jarabak ratio decreased by -0.1 ± 2.1 in facemask group; while it increased by 0.6 ± 3.0 I in tongue appliance group ($P < 0.04$). ANS-PNS increased 3.3 mm ± 7.4 mm in face- mask group and it increased 0.7 mm ± 0.9 mm in tongue appliance group ($P < 0.1$). GoGn increased 3.1 mm ± 3.5 mm in facemask group andincreased 1.8 mm ± 2.2 mm in Tongue appliance group. (Tables 10-1 and 10-2) It is noteworthy to mention that none of the patients dropped out during this clinical trial. The intra oral improvement in tongue appliance group can be seen in Figs. 10,8-12.

Table 10-1 – Pre and post treatment measurements of the facemask and Tongueappliance groups.

Cephalometric measurement	Grou ps	PretreatmentMean ±SD	Post treatment Mean ± SD	P value
SNA°	Fixed FM	75.6 ± 2.8	77.2 ± 3.0	0.01*
	Tongue Appliance	75.9 ± 2.6	77.3 ± 2.6	0.001
SNB	Fixed FM	77.14 ± 2.7	77.1 ± 3.0	0.6
	Tongue Appliance	77.2 ± 2.8	77.1 ± 2.8	0.9
ANB	Fixed FM	−1.6 ± 1.5	0.2 ± 1.7	0.001
	Tongue Appliance	−1.3 ± 1.7	0.3 ± 1.4	0.001
U1 to SN	Fixed FM	94.8 ± 6.0	106.0 ± 6.5	0.001
	Tongue Appliance	96.6 ± 7.9	99.1 ± 7.1	0.06
Nasolabial Angle	Fixed FM	103.7 ± 12.5	98.8 ± 10.3	0.01
	Tongue Appliance	105.5 ± 12.5	103.4 ± 14.6	0.2
Jarabak R. (%)	Fixed FM	62.1 ± 3.8	62.0 ± 3.3	0.9
	Tongue Appliance	61.8 ± 2.9	62.4 ± 4.4	0.4
Inclination Angle	Fixed FM	82.9 ± 3.2	83.2 ± 3.6	0.1
	Tongue Appliance	83.5 ± 3.2	85.7 ± 5.5	0.03
GoGn-SN	Fixed FM	35.3 ± 5.1	35.7 ± 4.2	0.3
	Tongue Appliance	35.3 ± 4.6	34.3 ± 6.4	0.3
IMPA	Fixed FM	89.9 ± 6.8	86.5 ± 7.4	0.001
	Tongue Appliance	87.3 ± 6.4	82.5 ± 5.6	0.001
ANS-PNS (mm)	Fixed FM	45.7 ± 3.6	49.0 ± 7.6	0.001
	Tongue Appliance	45.0 ± 3.6	45.7 ± 3.3	
	Fixed FM	63.2 ± 5.4	66.3 ± 4.0	
	Tongue Appliance	63.8 ± 4.3	65.6 ± 5.5	

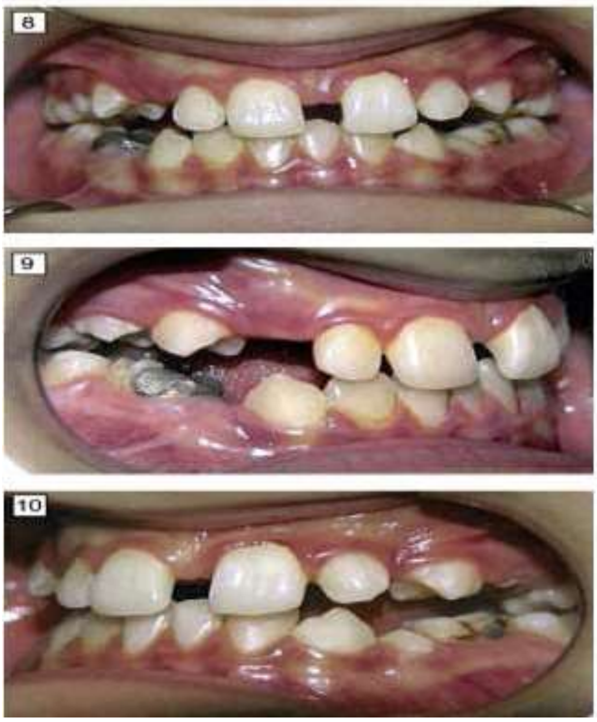
	Tongue Appliance	0.003*
Go-Gn (mm)	Fixed FM	0.001*
	Tongue Appliance	0.001*

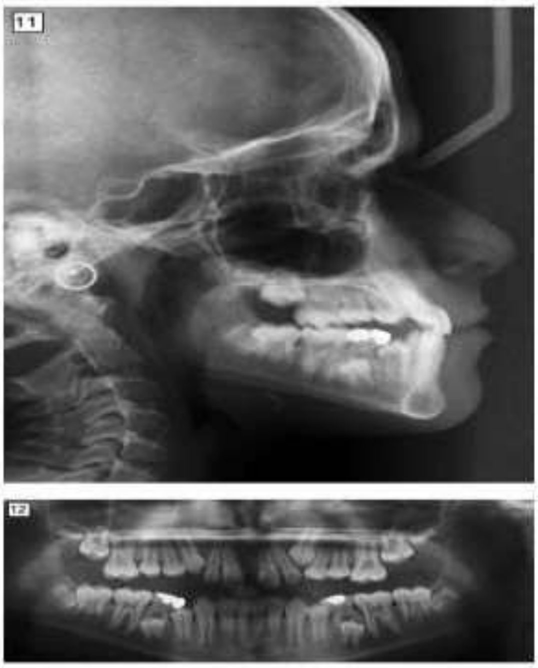
* Statistical significance was set at P < 0.05.

Table 1 0 - 2 – Comparison of Cephalometric changes between facemask and Tongueappliance groups.

Cephalometric Measurements	Fixed F Mean ± SD	Tongue Appliance Mean ± SD	P Value
SNA (˚)	1.6 ± 1.9	1.4 ± 1.4	0.6
SNB ( )	−0.04 ± 1.8	−0.1 ± 1.8	0.8
ANB ( )	1.8 ± 1.5	1.6 ± 1.6	0.4
U1 to SN ( )	11.1 ± 6.9	2.5 ± 6.1	0.001
Nasolabial Angle( )	−4.9 ± 8.2	−2.1 ± 6.8	0.4
Jarabak R. (%)	−0.1 ± 2.1	0.6 ± 3.0	0.04
Inclination Angle( )	0.3 ± 2.3	2.2 ± 5.1	0.2
GoGn-SN ( )	0.4 ± 1.9	−1.0 ± 4.1	0.2
IMPA ( )	−3.4 ± 3.5	−4.8 ± 3.8	0.2
ANS-PNS (mm)	3.3 ± 7.4	0.7 ± 0.9	0.1
Go-Gn (mm)	3.1 ± 3.5	1.8 ± 2.2	0.1

* Statistical significance was set at P < 0.05.





Figs. 10, 8-10 – Posttreatment intraoral photographs of the same patient.

Figs. 10, 11-12 – Posttreatment radiographs of the same patient.

Discussion

Various techniques and appliances are being used to treat the maxillary deficiency including modified protraction appliance, reverse-pull headgear, facemask, Class III activator, and reverse chin cup. De Clerck et al.[110] used miniplates for orthopedic traction of the Maxilla. Recently, bone-anchored maxillary protraction was applied by Cevidanes et al.81 for maxillary advancement. In a recent study, miniscrews were used for treatment of maxillary deficiency.

Face mask therapy has become a common technique used to correct the developing Class III malocclusion.[82] A search in literature will reveal copious researches about face masks and their effects on nasomaxillary complex. In addition, the experimental studies constantly demonstrate pronounced forward movement of the maxilla due to heavy and continuous protraction forces of face masks.83 However, one of the problems with face masks is their bulky size and shape, which make it a discouraging choice for children. Especially patients who wear glasses will be more susceptible to discomfort. This discomfort along with the embarrassment caused by the large size for children, especially at school in front of other peers, might reduce patient compliance.

Fig. 10-13 – The mark of the cribs on the tongue.

Due to the above mentioned disadvantages, we decided to use an intraoral appliance for treatment of this malocclusion. The intraoral appliance used in this study was a habit breaker; however, in this study it was used for a different purpose other than its common application. Here, it was used as a tongue appliance. When the tongue appliance is in the mouth, a considerable pressure might be transmitted to the deficient maxilla. The mechanism of this force is provided by the following ways:

1. The pressure of the Tongue during swallowing might be 5 pounds in each swallowing. The frequency of swallowing might be 500 to 1200 times in 24 hours. This force as an intermittent force was transferred through the tongue appliance to the deficient nasomaxillary complex.

2. There is a considerable force of tongue in the rest position because the tongue is caged behind the cribs. This force pushes the maxilla into a forward position as a continuous force of the tongue.

Physiological position and functional activity of the tongue generate these available forces. These forces are transmitted by the tongue through the palatal cribs and finally to the nasomaxillary complex. The more anterior the tongue is, the greater the force will be. The more posterior the crib is, the greater the force will be. The mark of the cribs on the tongue inFigure 10-13 show good compliance of the patient.

Application of face masks might cause unfavorable effects on the mandible. In other words, backward and downward rotation of the mandible is one of the unfavorable effects of such extra oral appliances. These effects are very unsatisfactory in vertical growing patients. However, the tongue appliance used in this study had no adverse effects on the mandible. This can be seen in the Jarabak ratio of the two groups, where it decreased due to backward rotation of the mandible in facemask group; while, it showed an increase in Tongue appliance group. Another advantage of Tongue appliance over the other extra oral appliances is that it's less conspicuous and needs less patient compliance.[83]

Both the Tongue appliance and facemask lingualize the lower incisors by two different mechanisms. The Tongue appliance will lingualize the lower incisors due to elimination of tongue pressure on them. And the facemask lingualizes the lower incisors due to chin cup pressure. After discontinuing the Tongue appliance and facemask the IMPA will be increased and the overjet will be decreased.[84]

In this study, both the fixed facemask and tongue appliance were successful in forward movement of the maxilla. However, since tooth movement is inevitable when force is applied via the dentition, U1 to SN increased in both groups. The reason for higher increase of U1 to SN in fixed face mask group is the greater direct pressure exerted on upper incisors. ANS- PNS increased significantly in both groups due to the intervention of the appliances. However, the pressure of facemask is exerted more on upper incisors which might be the reason for greater advancement of ANS resulting in a greater increase in ANS-PNS length. GoGn also increased in both groups. This increase is due to the growth of the patients during treatment time.[85]

The main difference between these two groups was the direction of the force. Facemask pulls the maxilla out; while tongue appliance pushes the maxilla outwards. However, further studies should be done to clarify the effects of the tongue on the maxilla.

The treatment used in this study was for correction of skeletal problem as part of growth modification and further treatment was done by use of fixed appliances.[86]

Conclusions

•Both fixed face mask and tongue appliance were successful in treatment of Class III patients with maxillary deficiency.

•In both groups the maxilla was moved to a forward position.

•Inevitable dental movement in both groups included lingual movement of lower incisors and labial movement of upper incisors.

Chapter 11

THE EFFECTS OF FACE MASK AND TONGUE PLATE ON MAXILLARY DEFICIENCY IN GROWING PATIENTS: A RANDOMIZED CLINICAL TRIAL

Participants and Methods

Ethical approval was obtained from the SB Local Research Ethics Committee and. informed written consent was obtained from each patient and a parent or guardian.

The sample size for the present study was calculated based on a significance level of 0.05 and a power of 90% to detect a minimum clinically significant change of 1.3u in SNA. Using a two-tailed paired t-test (PASS 2011; NCSS Software, Kaysville, UT, USA), 22 samples were required in each group. To compensate for possible dropouts during the trial, we elected to allocate 25 patients in each group for the present study.

All subjects met the following inclusion criteria:

1. SNA#80u, SNB#80u, ANB#0u according to the initial lateral cephalograms;
2. No syndromic or medically compromised patients;
3. No previous surgical intervention.
4. No use of other appliances before or during the period of functional treatment;
5. No skeletal asymmetry;
6. Class III molar relationship;
7. Classified as pre-pubertal (CS1, CS2 and CS3) according to a recently improved version of the cervical vertebral maturation (CVM) method.22,23

An unstratified subject allocation sequence was generated by computer program (Etcetra Version 2.59, Copyright J. H. Abramson 2006-11) with random numbers generated and assignment concealed from the clinician until the time of appliance placement. The treating clinician was blinded from the randomization procedure; however, because of clear differences in appliance design, blinding was not possible during the actual treatment. At the time of data collection, the clinician carrying out the measurements was blinded to the treatment allocation. Participants were allocated to one of two groups:

Group I: Received a Multi-Adjustable FacemaskH

(Ortho Technology, Inc., Tampa, FL, USA) and a full anchorage removable appliance in the upper jaw. The upper removable appliance had two Adams clasps on the permanent upper first molars, two C clasps on the primary canines and two other C clasps on the permanent central incisors. If necessary, the number of C clasps and Adams clasps could be increased for anchorage reinforcement. Two hooks were mounted on the right and left buccal segments. Two orthodontic latex elastics (5/160, medium size) connected the hooks of the upper removable appliance to the horizontal crossbar of the facemask in order to deliver 500 g of force. The patients were instructed to wear the appliance full-time except for eating, contact sports and tooth brushing.

Group II: Received the tongue plate appliance (Figure 11- 1). A tightly fitting and well-retained upper removable appliance was fabricated with Adams clasps on the upper first permanent molars and C clasps placed on the upper primary canines. Additional C clasps were added if more retention was needed. An acrylic plate was mounted posterior to the upper incisors. The patients were instructed to wear the appliance full-time except for eating, contact sports and tooth brushing. The patients were examined and progress was observed after each monthly visit. The tongue plate was changed every 6 months.

Cephalometric lateral skull radiographs, orthopantomograms (OPG), clinical photographs and study casts of patients in both groups were taken before (T1) and after (T2) treatment. SNA, SNB, ANB, upper incisor to SN, nasolabial angle, inclination angle (the angle formed between a perpendicular line to soft tissue nasion and the palatal plane), GoGn–SN (mandibular plane to anterior cranial base), Lower incisor to mandibular plane angle(IMPA), ANS–PNS length and GoGn length of each patient were measured before and after treatment (Table 11-1). The reliability of the measurements was determined by randomly selecting 10 cephalograms at the beginning and end of the treatment from each group. The same clinician traced these twice, on two separate occasions, after an interval of 1 month. Theinternal consistency of SNA was calculated by Cronbach’s alpha and was 0.95, which is excellent. The level of statistical significance was set at P,05. Data were tested for normality and paired t-tests were used for intra-group evaluation if the distribution was normal; otherwise, a Wilcoxon test was used. The Mann–Whitney test was used to compare data between the two groups. Hotelling’s T2 multivariate statistic was used to test forsignificant differences for concurrent comparison of indexes.

Figure 11-1 Tongue plate appliance in situ

Results

A total of 50 patients (24 males, 26 females) were recruited to the study. A CONSORT diagram showing the flow of patients through the study is provided in Figure 2. It can be seenthat three patients dropped out before final assessment. A total of 24 patients (12 males, 12 females) with a mean age of 9 (SD 1.2) years were treated using the facemask. The active treatment time was 18 (SD 3) months. In the tongue plate group, 23 patients (10 males, 13 females) with mean age of 9.1 (SD 0.9) years were treated. The active treatment time was 16 (SD 2) months.

The results of this study show that SNA increased from a mean of 76.6u (SD 2.8u) to 77.7u (SD 3u) (P,0.001) and ANB increased from 21u (SD 1.6u) to 0.2u (SD 2.4u) (P,0.001) in the facemask group. SNA and ANB also increased in tongue plate group with SNA increasing from 76.7u (SD 2.5u) to 78.9u (SD 2.1u) (P,0.001) and ANB increasing from 21u (SD 1u) to 0.8u (SD 1.8u) (P,0.001). Change in SNB was not significant in either experimental group. U1 to SN increased from 98.5u (SD 8.5u) to 105.0u (SD 6.8u) in the facemask group (P,0.001) and from 100.2u (SD 6.3u) to 105.1u (SD 4.4u) in the tongue plate group (P,0.001). Linear measurements showed that ANS–PNS increased significantly in both groups; from 43.1 mm (SD 2.3 mm) to 45.5 mm (SD 3 mm) in the facemask group (P,0.001) and from 45.8 mm (SD 2.5 mm) to 47.4 mm (SD 2.4 mm) in the tongue plate group (P,0.001). GoGn showed a statistically significant change in the tongue plate group; however, its change was non-significant in the facemask group. Mann– Whitney testing showed that there were no statistically significant differences between cephalometric data derived from the two groups; except for SNA and GoGn. SNA increased by 1u (SD 1.5u) in the facemask group, while it increased by 2.2u (SD 1.5u) in the tongue plate group (P,0.001). GoGn increased 0.4 mm (SD 2.6 mm) in the facemask group and 3 mm (SD 6.6 mm) in the tongue plate group (P,0.001) (Tables 1 1 - 2 and 1 1 - 3).

Hotelling's T2 multivariate test showed a significant difference between the two groups (T25 4.053, P50.001). This multivariate test in addition to the descriptive statistics tells usthat the mean differences of the described indexes were significantly higher in the tongue plate group compared to the facemask. Before and after treatment, photos and cephalometric images of a patient treated with the tongue plate can be seen in Figure 11-3.

Cephalometric variables	Definition
SNA (u)	The angle between the anterior cranial base (sella to nasion) and NA (nasion to point A) line
SNB (u)	The angle between the anterior cranial base (sella to nasion) and NB (nasion to point B) line
ANB (u)	The angle between the NA and NB lines
U1 to SN (u)	The angle between long axis upper central incisor and anterior cranial base
Nasolabial angle	The angle formed between lines tangent to the columella and the upper lip vermillion and intersecting at the subnasale
Inclination angle	The angle formed between a perpendicular line to soft tissue nasion and palatal plane
GoGn–SN (u)	Mandibular plane angle
IMPA (u)	The angle between the long axis of the lower central incisor and mandibular plane
ANS–PNS (mm)	Anterior nasal spine–posterior nasal spine
GoGn (mm)	The distance between gonion and gnathion

Table 11-1 Definition of the cephalometric variables.

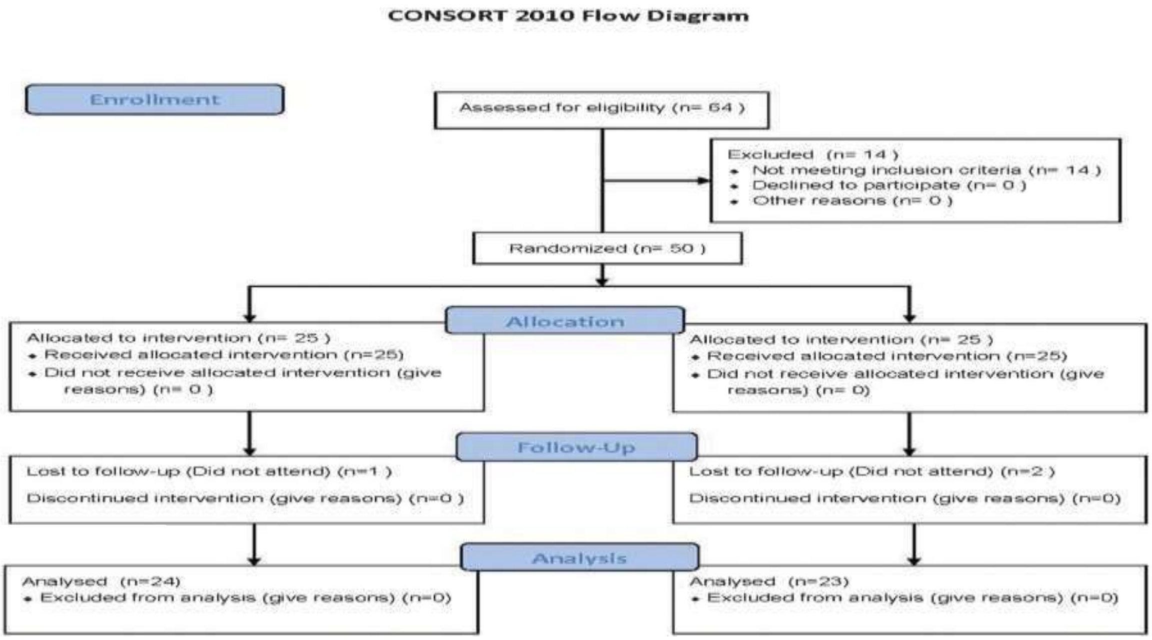


Figure 11-2 Consort flow diagram

Cephalometric measurement	Groups	Pre-treatment Mean (SD)	Post-treatment Mean (SD)	*P* value
SNA (u)	Facemask	76.7 (2.8)	77.7 (3)	0.001*
	Tongue plate	76.7 (2.5)	78.9 (2.1)	0.001*
SNB (u)	Facemask	77.7 (2.1)	77.5 (2.5)	0.4
	Tongue plate	77.7 (2.8)	78.1 (2.4)	0.2
ANB (u)	Facemask	21 (1.6)	0.2 (2.4)	0.001*
	Tongue plate	21 (1)	0.8 (1.8)	0.001*
U1 to SN (u)	Facemask	98.5 (8.5)	105 (6.8)	0.001*
	Tongue plate	100.2 (6.3)	105.1 (4.4)	0.001*
Nasolabial angle (u)	Facemask	100.5 (12.8)	96 (12.7)	0.001*
	Tongue plate	110.3 (11.9)	106.3 (11.6)	0.03*
Inclination angle (u)	Facemask	83 (3.2)	83.04 (3.6)	0.9
	Tongue plate	81.7 (3.4)	82.7 (3.9)	0.1
GoGn–SN (u)	Facemask	34 (5.7)	33.6 (5.8)	0.2
	Tongue plate	35.6 (5.3)	36 (4.8)	0.3
IMPA (u)	Facemask	92.6 (6.6)	86.6 (7.2)	0.001*
	Tongue plate	92.1 (6.3)	87.3 (6)	0.001*
ANS–PNS (mm)	Facemask	43.1 (2.3)	45.5 (3)	0.001*
	Tongue plate	45.8 ± 2.5	47.4 ± 2.4	0.001*
GoGn (mm)	Facemask	62.8 (3.7)	63.2 (2.9)	0.4
	Tongue plate	64.8 (3.6)	67.8 (7.6)	0.001*

Table 11- 2 Pre- and post-treatment measurements of the removable facemask and tongue plate groups.

Cephalometric measurements	Facemask Mean (SD)	Tongue plate Mean (SD)	*P* value
SNA (u)	1 (1.5)	2.2 (1.5)	0.001*
SNB (u)	20.2 (1.4)	0.4 (1.5)	0.07
ANB (u)	1.2 (1.6)	1.8 (1.2)	0.1
U1 to SN (u)	6.5 (6)	4.9 (4.5)	0.3
Nasolabial angle (u)	24.5 (3.3)	24 (7.8)	0.4
Inclination angle (u)	0.04 (2.7)	1 (3.5)	0.2
GoGn–SN (u)	20.4 (1.6)	0.4 (1.8)	0.1
IMPA (u)	26	24.8 (2.7)	0.8

	(5.4)		
ANS–PNS (mm)	2.4 (2.1)	1.6 (1)	0.2
GoGn (mm)	0.4 (2.6)	3 (6.6)	0.001*

Table 11-3, Comparison of Cephalometric Measurements with Facemask and Tangue Plate treatment

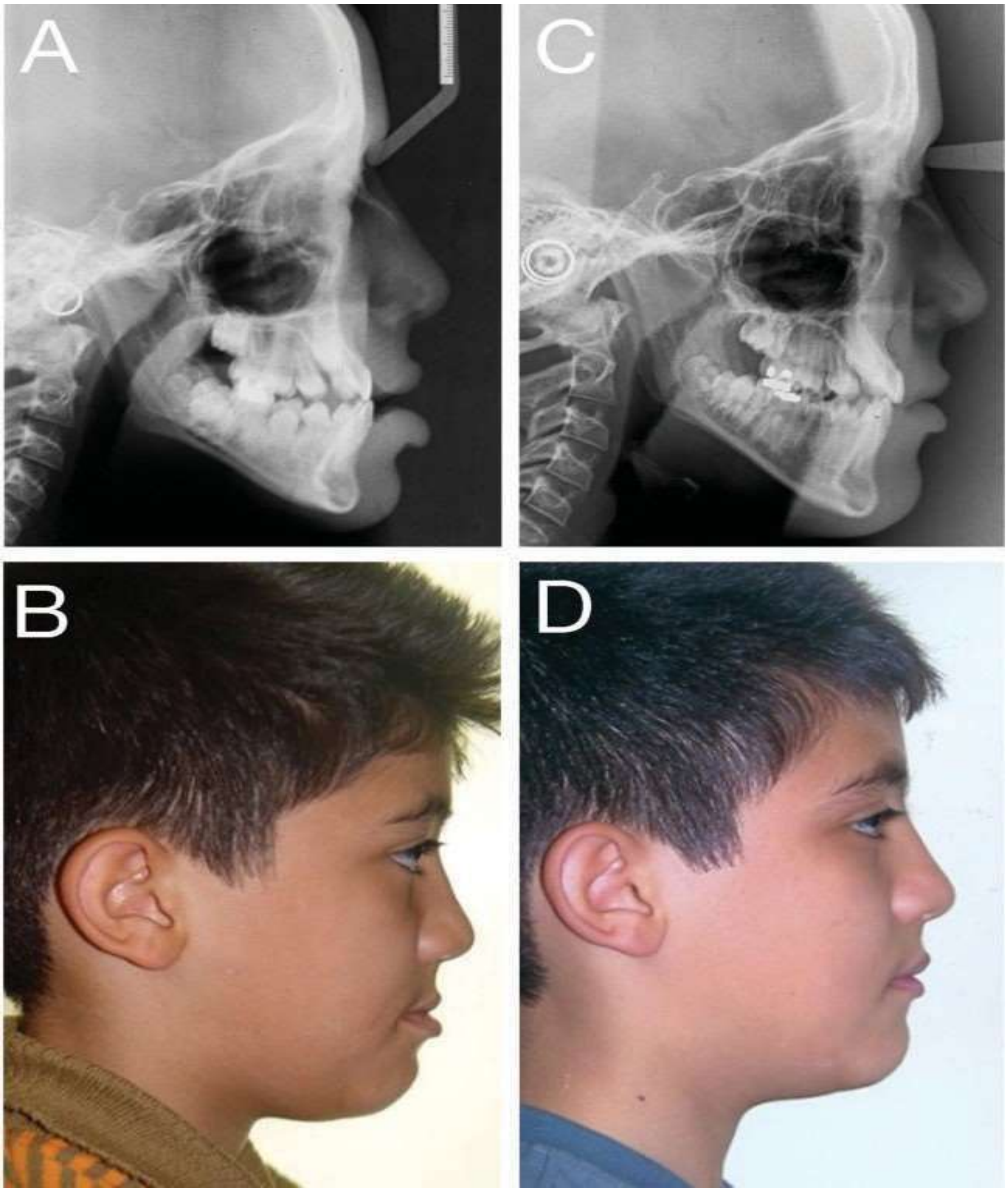


Figure 11- 3 Treatment with the tongue plate. (A) Pre-treatment cephalometric radiograph; (B) pre-treatment profile; (C) post-treatment cephalometric radiograph; (D) post-treatment profile.

Discussion

The present study has found evidence that treatment with a facemask or tongue plate in a growing individual with maxillary deficiency can have the following effects:

(1) forward movement of the maxilla, (2) forward movement of the maxillary incisors and (3) lingual movement of the mandibular incisors.

Facemask therapy has become a common technique used to intercept a developing class III malocclusion,[84] having the ability to produce pronounced forward movement of the maxilla due to heavy and continuous protraction force, particularly when used before the age of 8 years.[87-89] However, one of the problems associated with the use of facemasks is their bulky size and shape, and associated discomfort, which can make compliance an issue for some children. Because of these disadvantages, we have investigated the use of a simpler intra-oral appliance for treatment of this type of malocclusion. The tongue plate transmits considerable pressure to the deficient maxilla, which is continuous in the rest position and intermittent during swallowing and other functional activity. The mechanism of this force is provided by the intermittent pressure and frequency associated with the tongue during swallowing, which is transferred through the tongue plate to the nasomaxillary complex. The tongue also transmits considerable pressure to the plate, while it is in the rest position. This continuous force pushes the maxilla into a forward position. The physiological position and functional activity of the tongue generate these available forces, which are transmitted by the tongue plate to the nasomaxillary complex. The tongue plate proved effective in improving the facialprofile of patients affected by maxillary deficiency (Figure 11-3).

Previous studies have shown that intra-oral devices are able to move the maxilla into a more forward position. Maxillary advancement induced by bone-anchored maxil- lary protraction has also been previously investigated.[90] The results of these studies has shown that bone-anchored maxillary protraction is able to induce significantly larger maxillary advancement than a face mask. de Clerck et al.[91] reported that there may be a more favourable maxillary growth response under the moderate continuous traction of intra-oral appliances rather than under heavy forces that are interrupted during the day. Similarly, miniplates in combination with class III elastics have also been used for maxillary advancement.[91] Jamilian et al.[92] also used miniscrews in combination with class III elastics as an alternative to extra-oral appliances. The advantage of the tongue plate over these appliances is that these intra-oral appliances require minor surgery; however, insertion of the tongue plate is extremely easy and patients feel very comfortable with it.

In this study, both the facemask and tongue plate were found to retrocline the mandibular incisors, but by two different mechanisms. The tongue plate achieved this retroclination through the elimination of tongue pressure on these teeth, while the facemask retroclined them through the pressure of the chin cup. After the completion of tongue pate or facemask therapy, the IMPA is likely to be increased and the overjet decreased. One potential weaknesses of the tongue plate is that after discontinuation, the mandibular incisor teethmight be expected to move into a more forward position through the resumption of normal tongue pressure.[93]

Both the facemask and tongue pate were also successful in achieving forward movement of the maxilla. However, since tooth movement is inevitable when force is applied via the dentition, the U1 to SN also increased in both groups. The reason for a higher increase of U1 to SN in the facemask group is almost certainly the greater direct pressure exerted on the upper incisors by this appliance. GoGn increased in both groups due to the underlying mandibular growth of these patients during treatment. Nevertheless, GoGn increased much more significantly in the tongue plate group. This significant difference is likely because the facemask restricts the mandible while there is no restricting force against the mandible from the tongue plate. Thus, these two appliances work through two different mechanisms, with a major difference being the direction of the force; the facemask pulls the maxilla out, while the tongue plate pushes it. This study is a preliminary one and further studies are needed to examine in detail the treatment effects of the tongue plate in comparison to other extra oral and intra-oral appliances.[94]

Conclusion

• Both the facemask and tongue plate were effective in achieving forward movement of the maxilla and improving the facial profile of patients in this study

• Inevitable dental tipping movement occurred in both groups, which included retroclination of the mandibular incisors and proclination of the maxillary incisors.

Chapter 12

THE EFFECT OF TONGUE APPLIANCE ON THE NASOMAXILLARY COMPLEX IN GROWING CLEFT LIP AND PALATE PATIENTS

Materials and Methods

Ten complete bilateral cleft lip and palate patients who had undergone orthodontic treatment were selected from private practice. There were six females and four males. Their age ranged from 7.6 to 9.8 years.

The surgical procedure for cleft lip closure had been done in the first 10 to 20 weeks by utilizing the Millard procedure and for cleft palate had been performed in the first 18 to 24 months by the V-Y 'push back' method. All the patients had CL III malocclusion due to maxillary deficiency. Each patient had anterior and bilateral posterior crossbite prior toappliance therapy. No abnormal mandibular asymmetry was observed clinically. None of these subjects had a history of orthodontic treatment and all of them were nonsyndromic. Tongue appliance was constructed by Adams clasp for first upper molars and C clasps in the anterior teeth in order to increase the retention. A screw was mounted in midpalatal area to correct bilateral posterior crossbite. The tongue appliance is shown in Figure 1. It was activated at weekly intervals by the patient. Three to five separate tongue cribs were incorporated in the plate, between canine to canine area. These cribs were long enough to cage the tongue and were adjusted in the clinic to avoid traumatizing the floor of the mouth. This appliance was used for 22 hrs a day and each patient was evaluated at monthly intervals.The mean observation time was 13 ± 2 months till positive overjet was achieved.

OPG, lateral cephalometric radiographs, dental casts and photographs of the face were taken for all subjects. For the purpose of this study, pre- and post-operative lateral cephalograms were analyzed. These cephalograms had been taken with the teeth in occlusion. The magnification factor was recorded for each radiograph. All radiographs were traced on acetate paper by one investigator. Since the 'A' point is not clear in cleft lip and palate patients, it was substituted by ANS. The following angular measurements were calculated. In this study, SN-ANS angle, SNB, IMPA, inclination angle, nasolabial, mentolabial, 1 to SN, mandibular plane angle, angle of convexity were recorded and angle of convexity was traced by the intersection of a line from nasion to point ANS with a line from point ANS to pogonion. The cephalometric data was collected before and after treatment and these findingswere then compared with paired t-test.

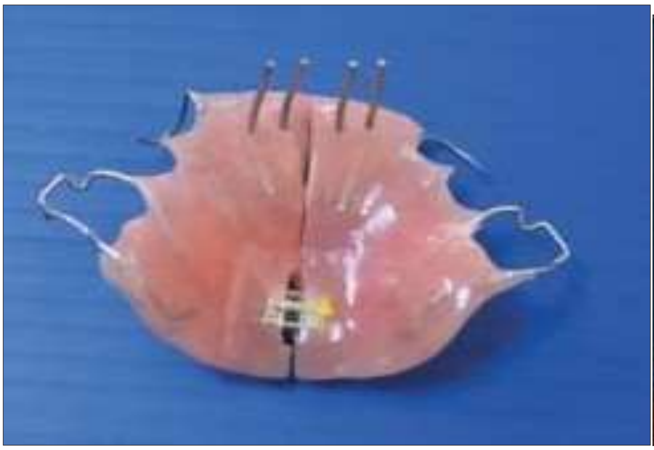


Figure 12- 1: Tongue appliance with expansion screw Figure 11- 2: Patient's photograph before treatment.

Figure 12-3: Patient's Figure photograph after treatment Figure 12-4: Initial cephalogram Figure12-5: Post-treatment cephalogram

Results

Table 12-1 shows the changes that occurred during the 13 ± 2 months of treatment observation period.

In all cases, the maxilla had advanced. The SN-ANS angle increased 1.9 ± 1.8 - P < 0.05; and the nasolabial angle decreased 10.3 ± 10.8 - P < 0.03. The angle of convexity had improved 2.78 ± 3.1 - P < 0.05. IMPA reduced 2.6 ± 4.9 - P < 0.2.

The profiles of patients before and after the application of tongue appliance are shown in Figures 12-2 and 12-3 respectively. The cephalograms of patients before and after appliance therapyare shown in Figures 12-4 and 12-5 respectively.

Table 12-1: Cephalometric measurements before and after the treatment observation period with complete bilateral cleft lip and palate at mixed dentition

Subjects cephalometric indexes	Before treatment x±SD	After treatment x±SD	Changes x±SD	Changes percent	*P* value
SN-ANS angle	82.5±6.6	84.4±5.9	+1.9±1.8	12.3	0.05
Inclination angle	87.3±4	87.9±5.7	+0.6±5.5	0.7	0.8
IMPA	9.04±6.6	87.8±4.9	-2.6±4.9	3	0.2
SNB	75.4±4.6	74.4±3.8	-1±2.3	1.3	0.3
Angle of convexity	5.13±12.05	8±11.6	+2.78±3.1	5.4	0.05
Nasolabial angle	107±19.9	96.8±19.4	-10.3±10.8	9.6	0.03
Mento labial angle	133.2±14.6	140±10.8	+6.5±12.7	+5	02
1 to SN	82.6±14.7	81.6±13.6	-1±1.9	1.1	0.05
Mandibular plane angle	35.4±5.2	37.1±5.4	+1.8±2.4	5.1	0.07

Discussion

Maxillary advancement with tongue appliance improved the facial profile by moving the nasomaxillary complex in a forward position, resulting in improving the facial concavity, increasing the angle of convexity, normalizing the nasolabial angle, moving the upper lip forward, balancing lip posture, improving the intermaxillary basal relationship andeliminating dysfunction.

Cleft lip and palate patients with maxillary deficiency are treated traditionally by maxillary protraction appliances.[95] reverse pull headgear,[96,97] endosseous implants, surgically assisted orthopedic protraction,[4] ankylosed teeth and distraction osteogenesis.[98]

Majority of children with cleft lip and palate show features of severe malocclusion at an early age due to scar tissue of the lip and palate closure procedure.[99] Early treatment reduced severe underlying skeletal discrepancy.[100] Growth modification definitely influences facial appearance. Proffit stated that patients with maxillary deficiency might be treated at the age of 8 years, although treatment should be continued till growth ceased.

The findings of this study are similar with respect to other extraoral appliances that are mentioned above. Tongue appliance and extraoral protraction appliances increase the profile convexity and push the nasomaxillary complex into the forward position. The results showed that protraction treatment improved the sagittal jaw relationship (SN-ANS angle by 12.3%) [Table 12- 1].

Angle of convexity was increased 2.7° due to forward movement of ANS and backward rotation of mandible. In this study, nasolabial angle was decreased; this angle showed concurrent forward movement with the underlying skeletal structures and therefore the profile was improved.

Such dental movement must be borne in mind by clinicians who use this appliance.

As reported in other studies, habit-breaking application to prevent the tongue thrust can move the maxilla in the forward position. When the tongue appliance is in the mouth, there is considerable pressure that might be transmitted to the deficient maxilla. The mechanism of this force is provided in the following two ways.

1. The pressure of the tongue during swallowing might be 5 pounds in each swallowing. The frequency of swallowing might be 500 to 1,200 times in 24 h. This force is intermittent and transferred through the tongue appliance to the deficient nasomaxillary complex.
2. There is considerable continuous force of tongue in the rest position because the tongue is caged behind the cribs. This force pushes the maxilla into a forward position.

Physiological position and functional activity of tongue generate these forces that are transmitted by tongue through the palatal cribs and finally to the nasomaxillary complex. The more anterior the tongue, the greater will be the force. The more posterior the crib, the greater will be the force. There is more concern about the imbalance of neuromuscular system and nasomaxillary complex in the patients when the tongue position moves inferiorly and anteriorly. In this study, inclination angle was increased. This finding showed that the anterior part of palatal plane moved superiorly (anteinclination) and posterior part of palatal plane moved inferiorly. In other words, the maxillary posterior teeth were extruded and therefore the mandible rotated in a clockwise direction. These changes led to a more successful and pronounced correction of the overjet and decreasing of SNB and enhancing of mandibular plane angle, although some of these changes might be related to growth.

The reverse chin cup application to improve the deficient nasomaxillary complex might have an unfavorable effect on the normal mandible, but the tongue appliance doesn't have this effect. This appliance is very simple and comfortable. It will be accepted better than other appliances as, it is less conspicuous. This appliance is relatively inexpensive and easy to construct. Cleft lip and palate patients have suffered right from birth and they can't stand more stress, this appliance is more acceptable as it generates the least stress to patients in comparison with other extraoral appliances.

In spite of the many advantages of the tongue appliance, this appliance has one disadvantage. Lower incisors are lingualized due to elimination of the pressure of tongue and acting force of orbicularis oris.

Therefore, IMPA was decreased by 2.6° and mentolabial angle was increased by 6.5° during the use of this appliance. After discontinuing the use of appliance, the IMPA is increased and the overjet is decreased.

In this research, all the patients had upper arch expansion to correct bilateral posteriorcrossbite. Expansion will open all maxillary sutures like pterygomaxillary, zygomaxillary thus, maxilla will move more in forward position.[101]

The 13-2 months of tongue appliance therapy produced statistically significant skeletal changes in sagittal plane during the mixed dentition stage in patients with complete bilateral cleft lip and palate. This study showed that tongue appliance treatment might be an effective method for normalizing the maxillomandibular discrepancy by improving the sagittal jaw relationship. The overjet correction was mainly a result of skeletal change due to moving of nasomaxillary complex in forward position.

Chapter 13

THE SHORT-TERM EFFECTS OF FACE MASK AND FIXED TONGUE APPLIANCE ON MAXILLARY DEFICIENCY IN GROWING PATIENTS – A RANDOMIZED CLINICAL TRIAL

Materials and Methods

Ethical approval was obtained for this prospective, single bind, parallel randomized clinical trial from SB Local Research Ethics Committees. The study was carried out in accordance with the ethical standards set forth in the 1964 Declaration of Helsinki. Informed written consent was obtained from each patient and a parent or guardian.

In order to calculate the required sample size a pilot study was done on 10 patients (5 in each group, and the SNA was IJO VOL. 26 NO| 1 SPRING 2015 chosen as the primary outcome. The sample size was calculated based on a significance level of .05 and a power of 90% to detect a minimum clinically significant difference of 3.1±0.8°. Using a two-tailed paired t-test (PASS 2011, NCSS software, Kaysville, Utah) 26 samples were required in each group. To compensate for possible dropouts during the trial and to increase the power even more we decided to select 30 patients for each group.

All patients were in prepubertal (CS1, CS2, and CS3), according to the recently improved version of cervical vertebral maturation (CVM) method described by Franchi et al 18 and Baccetti et al. 19

All subjects met the following inclusion criteria:

1. SNA | 80°, SNB | 80°, ANB | 0°, Wits | -1°, at the initial lateral cephalograms;

2. No syndromic or medically compromised patients;

3. No previous surgical intervention;

4. No use of other appliances before or during the period of functional treatment.

5. A normal mandibular growth pattern by assessment of Jarabak ratio.

6. No skeletal asymmetry

7. Moderate Class III molar relationship with concave profile.

8. Occlusal evaluation was done in centric relation. Any attempt to move the mandible in backward position was not possible.

H. Abramson 2006-11); random numbers were generated and assignment by a trained dentist and was concealed from the clinician until the time of the appointment at which the appliance was to be placed. The samples were divided into two equal groups. In order to do so an unstratified subject allocation sequence was generated by a computer program (Etcetra Version 2.59 Copyright J.

Group one included 30 patients (13 males, 17 female) with the mean age of 8.5 (SD 1.4) years who received a Multi- Adjustable Face mask (Ortho Technology, Inc., Tampa, Florida, USA®) and a fully anchoraged removable appliance in the upper jaw. The upper removable appliance had two Adams clasps on permanent upper first molars, two C clasps on the primary canines, and two other C clasps on the permanent central incisors for further anchorage. If necessary the number of C clasps and Adams clasps could be increased for anchorage reinforcement. Two hooks were mounted on the right and left buccal segments. Two orthodontic Latex Elastics (5/16", medium size) connected the hooks of the upper removable appliance to the horizontal crossbar of the face mask in orderto deliver 500 g force (Figure 13-1). A screw was mounted in the upper removable appliance andthe patients were instructed to open the screw by making ¼ of a turn at the beginning of each week for 3 months. The patients were instructed to wear the appliance full-time except for eating, contact sports and tooth brushing. The active treatment time was 18 (SD 4) months.

Group two included 30 patients, however, 4 of the patients dropped out due to personal reasons none of which was related to treatment. The 26 remaining patients were 13 males and13 females with the mean age of 8.9 (SD 1.7) years. In group two a hyrax® (Dentaurum, ref 602-805, Inpringer, Germany) was mounted on first maxillary molars and premolars or on first maxillary molars and deciduous first molars to loosen the maxillary sutures in order to facilitate the forward movement of the maxilla. Forward movement of maxilla was achieved by a fixed tongue appliance comprising of a few curved cribs (width=1.2 mm) which were soldered to the anterior side of the hyrax® (Figure 13-2). The patients were instructed to activate the screw of the hyrax® by making 1/4 turn at the beginning of each week for 3 months. A complete turn of the screw would create 1mm of horizontal distance. The patients were examined and the progress was observed after each monthly visit. The active treatment time was 14 (SD 2) months.

The growth modification of both groups was continued until a positive overjet was achieved and the treatment continued with fixed appliances. Lateral cephalograms, OPGs, photos, and study casts of patients of both groups were taken before (T1) and after (T2) treatment. SNA, SNB, ANB, Wits appraisal, Inclination angle, ANS-PNS, GoGn, Gonial Angle, Jarabak ratio, GoGn- Sn, Upper 1 to SN and IMPA of each patient were measured before and after treatment (Table 13-1). The reliability of the measurements was determined by randomly selecting 10 cephalograms at the beginning and end of the treatment from each group. They were traced twice by the same trained clinician on two separate occasions after 1 month interval. The internal consistency of the SNA was calculated by Cronbach's alpha and it was 0.95 which is excellent. The level of statistical significance was set at $P<0.05$. Data were tested for normality and Paired T-test and two sample T-test were used if the distribution was normal; otherwise, Wilcoxon and Mann-Whitney tests were used to compare the data.

Cephalometric measurement	Groups	Pre-treatment Mean (SD)	Post-treatment Mean (SD)	P value
SNA°	Facemask	76.4 (2.6)	77.7 (2.6)	0.001*
	Fixed Tongue Appliance	76 (3.1)	77.8 (2.8)	0.001*
SNB°	Facemask	77.3 (2.2)	77.2 (2.4)	0.573
	Fixed Tongue Appliance	76.7 (3)	77.3 (3.5)	0.054*
ANB°	Facemask	-0.9 (1.4)	0.5 (2)	0.001*
	Fixed Tongue Appliance	-0.6 (1.3)	0.5 (1.4)	0.001*
Wits Appraisal (mm)	Facemask	-4.4 (1.7)	-3.4 (2)	0.001
	Fixed Tongue Appliance	-5.2 (2.3)	-3.3 (2.1)	0.001*
Inclination angle	Facemask	83 (3.1)	83.3 (3.6)	0.482
	Fixed Tongue Appliance	82.5 (4)	82.7 (4.1)	0.483
ANS-PNS (mm)	Facemask	43.4 (2.5)	45.7 (2.7)	0.001*
	Fixed Tongue Appliance	44.5 (2.1)	46.5 (2.2)	0.001*
GoGn (mm)	Facemask	62.1 (4)	63.4 (3.8)	0.012*
	Fixed Tongue Appliance	64.1 (4.7)	66.3 (4.5)	0.001*
Gonial angle	Facemask	131.1 (5.8)	131 (6)	0.951
	Fixed Tongue Appliance	131.7 (5.4)	131 (5.7)	0.153
Jarabak Ratio (%)	Facemask	62.2 (4.7)	63 (5)	0.035*
	Fixed Tongue Appliance	61.9 (4.9)	62.7 (5.3)	0.108
GoGn-Sn°	Facemask	35 (5.6)	34.8 (6)	0.368
	Fixed Tongue Appliance	36.2 (5.5)	35.4 (5.6)	0.056*
U1 to SN°	Facemask	98.8 (8.2)	103.7 (5.5)	0.001*
	Fixed Tongue Appliance	98.5 (8.4)	102.8 (7.2)	0.001*
IMPA°	Facemask	92.4 (6.1)	86.8 (6.5)	0.001*
	Fixed Tongue Appliance	90.3 (8.1)	85.7 (8.8)	0.001*

Table 13- 1: Definition of the cephalometric variables

Cephalometri cVariables	**Definition**
SNA°	The angle between the anterior cranial base (sella to nasion) and NA (nasion to point A) line
SNB°	The angle between the anterior cranial base (sella to nasion) and NB (nasion to point B) line
ANB°	The angle between the NA and NB lines
Wits appraisal (mm)	the distance between perpendiculars drawn from the occlusal plane to Points A and B
Inclination Angle	The angle formed between a perpendicular line to soft tissue nasion and palatal plane
ANS-PNS (mm)	Anterior nasal spine-posterior nasal spine
GoGn (mm)	The distance between gonion and gnathion
Gonial Angle	angle formed by the posterior border of the ramus of the mandible and the mandibular plane
Jarabak Ratio (%)	The ratio between posterior and anterior face heights (S–Go/N–Me)
GoGn-SN°	Mandibular plane angle
U1 to SN°	The angle between long axis upper central incisor and anterior cranial base
IMPA°	The angle between the long axis of the lower central incisor and mandibular plan

Table 13-2: Pre and post treatment measurements of the removable facemask and fixed tongue appliance groups.

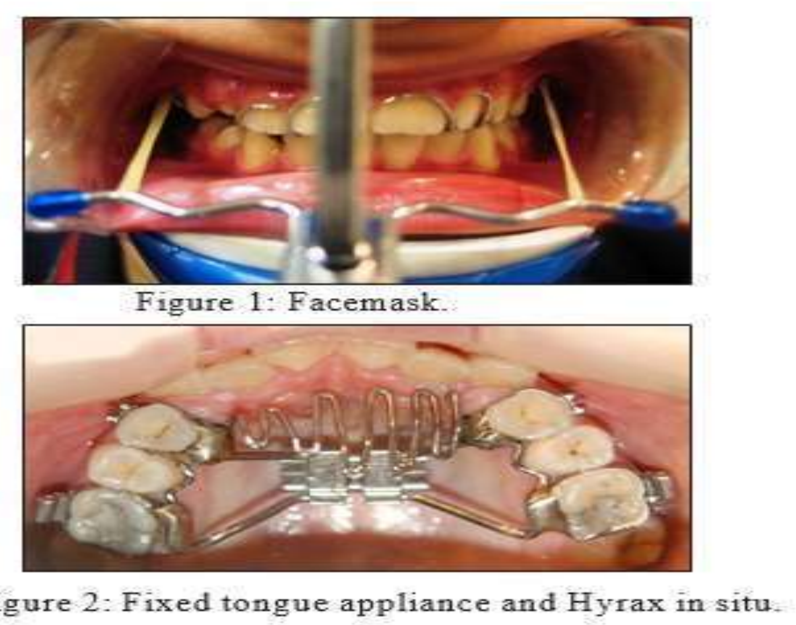
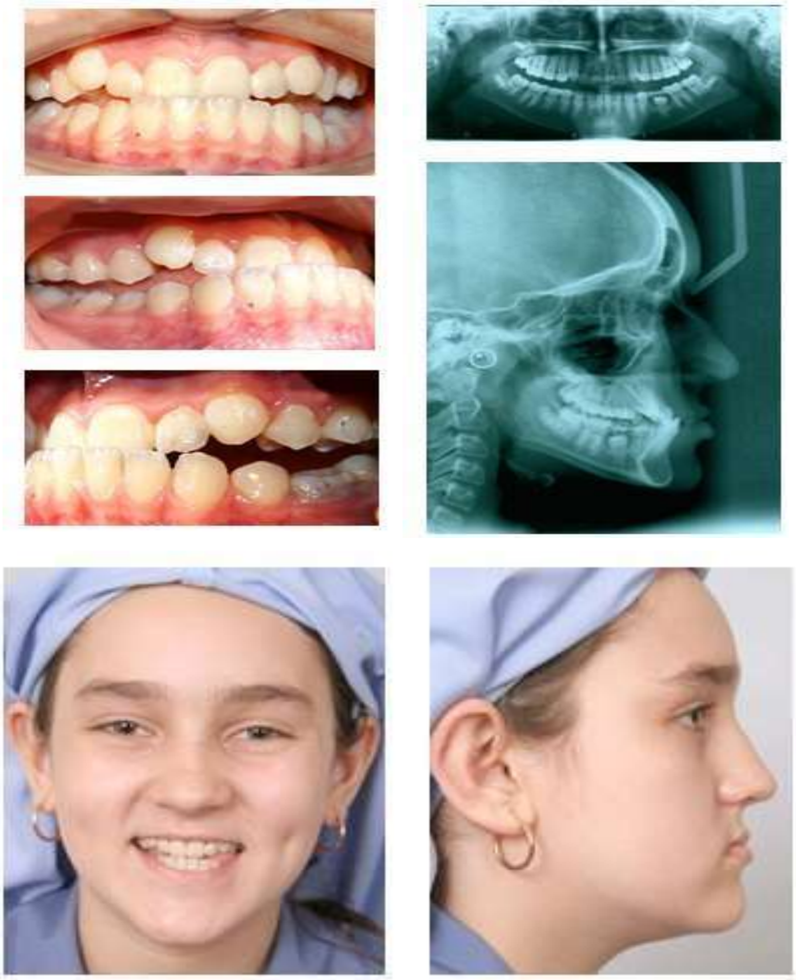


Figure 13-1: Face Mask, Figure 13-2: Fixed tongue appliance and Hyrax in situ



Figures 13, 4-10: Before treatment records a fixed tongue appliance patient.

Results

A total of 60 patients (29 males, 31 females) were recruited to the study. A CONSORT diagram showing the flow of patients through the trial is provided in Figure 13-3. Four of the patients dropped out before final assessment. 30 patients (13 males, 17 females), with a mean age of 8.5 (SD 1.4) years were treated using the Multi-Adjustable face mask® (OrthoTechnology®), and 26 patients (13 males, 13 females), with the mean age of 8.9 (SD 1.7) years were treated using the fixed tongue appliance. Both treatment modalities were successful in treatment of Class III malocclusion and maxillary deficiency. As can be seen in table 13-2 both treatments caused lingual tipping of the lower incisors. The results were as following:

In the face mask group, SNA increased from 76.4° (SD 2.6°) to 77.7° (SD 2.6°) (P<0.001), ANB increased from -0.9° (SD 1.4°) to 0.5° (SD 2°) (P<0.001), ANS-PNS increased from 43.4 mm (SD 2.5) to 45.7 mm (SD 2.7) (P<0.001) and IMPA

decreased significantly from 92.4° (SD 6.1) to 86.8° (SD 6.5). The molar relationships were also in class I (Table 13-2).

In fixed tongue appliance group, SNA increased from 76° (SD 3.1°) to 77.8° (SD 2.8°) (P<0.001), ANB increased from -0.6° (SD 1.3°) to 0.5° (SD 1.4°) (P<0.001), ANS-PNS

significantly increased from 44.5 mm (SD 2.1) to 46.5 mm (SD 2.2), and IMPA decreased significantly from 90.3° (SD 8.1) to 85.7° (8.8) (Table 2). The molars changed to class I relationship.

Figures 4 to 15 show the pre and post treatment records of one of the patients treated with fixed tongue appliance. Superimposition of the same patient can be seen in Figure 16.

Inter group evaluations showed that there were no statistically significant differences between the cephalometric data of two groups; except for the SNB. SNB decreased by 0.1° (SD 1.2°) in face mask group, while it increased by 0.6° (SD 1.6°) in fixed tongue appliance group (P<0.05) (Table 13-3).

Table 13-4 shows the cervical vertebral maturation (CVM) stages of the patients at the beginningand completion of their treatment.

Table 13-3: Comparison of Cephalometric changes between removable facemask and fixed tongue appliance groups by two sample t-test.

Cephalometric Measurements	Facemask	Fixed Tongue Appliance	P Value
	Mean (SD)	Mean (SD)	
SNA°	1.3 (1.1)	1.8 (0.9)	0. 095
SNB°	-0.1 (1.2)	0.6 (1.6)	0.049*
ANB°	1.4 (1.4)	1.1 (1.7)	0.446
Wits appraisal (mm)	1 (1.9)	1.8 (2.6)	0.190
Inclination Angle	0.3 (2.8)	0.2 (2.5)	0.806
ANS-PNS (mm)	2.3 (1.5)	2 (1.7)	0.487
GoGn (mm)	1.3 (3.6)	2.2 (2.5)	0.283
Gonial Angle	-0.1 (2.9)	-0.7 (2.3)	0.366
Jarabak Ratio (%)	0.7 (1.8)	0.7 (2.2)	0.996
GoGn-SN°	-0.2 (1.5)	-0.9 (2.4)	0.207
U1 to SN°	5.7 (5)	4.3 (7.4)	0.411
IMPA°	-5.6 (5)	-4.5 (6)	0.467

CVM Stage	Face Mask		Tongue Appliance	
	Before	After	Before	After
CS1	24	14	22	11
CS2	4	6	1	8
CS3	2	8	3	3
CS4	0	2	0	4

Table 13-4: Cervical vertebral maturation (CVM) stages of patients.

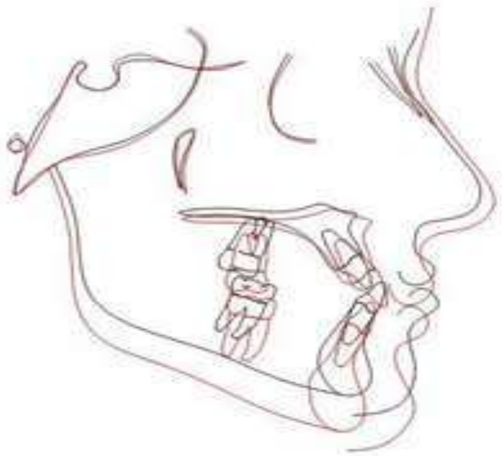


Figure 13- 16: Superimposition of pre and post treatment cephalometric records of the same patient

Figure 13, 11-15: After treatment records of the same patient

Discussion

The present study clearly indicated that treatment with face mask and fixed tongue appliance had the following effects:

(1) Forward movement of the maxilla, (2) Forward movement of maxillary teeth, and lingual movement of the lower incisors.

Face mask therapy has become a common technique used to correct the developing Class III malocclusion.102 An electronic search in literature will reveal copious research about face masks 104 and their effects on maxillary deficiency. Face masks can be used with either a rapid palatal expansion (RPE) or a removable expansion appliance. Both are effective in expanding the upper arch however controversy exists in literature about the efficacy of each.Vaughn et al [105] suggested that the indication for palatal expansion should be based on clinical criteria other than assisting the Class III correction.

In current study, removable expansion appliance was used because the cases did not have severe maxillary constriction; otherwise, RPE would have been used. Face mask is a large extra oral appliance and may cause great discomfort for patients and is highly visible to wear,which leads to reduced patient cooperation. Another problem caused by face masks is that they can cause skin abrasions on the chin especially in hot climates. Therefore, patientssimply do not wear the appliance and lack of cooperation might lead to an unsatisfactory result. Patients who wear glasses may also feel uncomfortable. Another disadvantage is that, use of a chin cup can lead to lingual tipping of the lower incisors as a result of the pressure of the chin cup component on the lower lip and dentition.[106] In most cases, lingual tipping is anundesirable side effect and can cause crowding.[107]

Recently, In order to overcome the above mentioned disadvantages, various intra oral appliances have been introduced for treatment of maxillary deficiency.[108] Showkatbakhsh etal have designed two intra oral appliances named “tongue plate” and “tongue appliance”. They compared these appliances with facemask in two different studies and found that they were both effective in anterior movement of the maxilla. Nevertheless, both of these appliances were removable while the appliance used in this study was fixed and required less patient cooperation.

Fixed tongue appliance is a habit breaker; however, in this study it was used in conjunction with Hyrax for a different purpose other than its common application. When the fixed tongue appliance is in the mouth, a considerable pressure is transmitted to the deficient maxilla through the cribs of the appliance. The mechanism of this force is provided by the following ways:

1. The pressure of the tongue during swallowing is estimated to be about 5 pounds in each swallowing. The frequency of swallowing is about 500 to 1200 times in 24 hours. This intermittent force is transferred through the fixed tongue appliance to the deficient nasomaxillary complex.

2. Tongue transmits considerable pressure to the appliance while it is in the rest position. This continuous force of the tongue pushes the maxilla into a forward position.

Hyrax® screw is for the purpose of loosening the maxillary sutures and extending the width of the maxillary arch and thus creating a better intermaxillary relationship. This expansion facilitates anterior displacement of the maxilla. One of the advantages of fixed tongue appliance is that patient’s cooperation is not needed. The vertical length of the cribs should be designed and adjusted in a way to avoid traumatizing the floor of the mouth. The main advantage of fixed tongue appliance over facemask is that fixed tongue appliance does not cause backward rotation of the mandible; thus, it can be used in long face patients. While, the cup of facemask results in backward rotation of the mandible and can have unfavorable effects of long face patients.

Nevertheless, fixed tongue appliance has one disadvantage.

It will lingualize the lower incisors due to elimination of tongue pressure on them. However, removal of the fixed tongue appliance will restore the pressure of the tongue on the lower incisors and will consequently result in increase of IMPA. This study was limited by the short time evaluation of the patients and further studies to evaluate the long term effects oftreatment is needed.

Conclusion

In this study, both the face mask and fixed tongue appliance were effective in treatment of maxillary deficiency. However, both of them lingualized the lower incisors by two different mechanisms. The fixed tongue appliance lingualized the lower incisors due to elimination of tongue pressure on them but face mask lingualized the lower incisors due to chin cuppressure.

After discontinuing the appliances, the IMPA will be increased and the overjet will be decreased.

Chapter 14

THE EFFECTS OF TONGUE PLATE AND TONGUE APPLIANCE ON MAXILLARY DEFICIENCY IN GROWING PATIENTS

Materials and Methods

In this retrospective study, the patient data were handled according to the requirements and recommendations of the Declaration of Helsinki. The ethical approval was obtained from SBUMS Local Research Ethics Committees. The informed written consent was obtained from the patient and a parent or guardian. A CONSORT diagram showing the flow of patients through the trial is provided in Fig 14-1. Sixty-eight patients were enrolled in this research. 23 patients were excluded due to not meeting the inclusion criteria. Three of the patients in the tongue plate and 2 patients in the tongue appliance dropped out before final assessment. 40 patients (19 males, 21 females) with skeletal Class III malocclusion due to maxillary deficiency were selected. Considering the previous studies, a sample size of 40 patients was chosen for this study. All subjects gave their informed written consent and met the following inclusion criteria: 1) Sella-Nasion-A (SNA) ≤ 80°, Sella-Nasion-B (SNB) ≤ 80°, A-Nasion-B (ANB) ≤ 0° 2) Class III molar relationship 3) No mandibular shift 4) Concave facial profile 5) Negative overjet 6) No congenital disease or endocrine disorders 7) No previous orthodontic treatment and surgical intervention. An unstratified subject allocation sequence was generated by a computer program; random numbers were generated and their assignment was concealed from the clinician until the time of the appointment at which the appliance was to be placed. The treating clinician was blinded from the randomization procedure, but because of clear differences in appliance design, blinding was not possible during the treatment period. A table of random numbers was used to divide the patients into two equal groups. A CONSORT diagram showing the flow of patients through the trial is provided in Fig. 14-1. The patients were randomly assigned to two equal groups using a standardrandom number table. The tongue appliance has some C clasps on the upper permanent central or lateral incisors or deciduous canines. An acrylic plate was mounted posterior to the upper incisors. The patient was instructed to wear the appliance full-time except for eating, contact sports and tooth brushing. The active treatment time lasted for 24 months. The patientwas examined and progress was observed after each monthly visit. Pre and post photographs and cephalometric images of one of the tongue plate patients can be seen in Figs. 14-2-8. 20 patients (10 boys, 10 girls) with the mean age of 10.1±0.7 were treated by tongue appliance.

A tightly fitting and well retained upper removable appliance was fabricated with Adams clasps on the upper first permanent molars and two C clasps were placed on the upper permanent central or lateral incisors or deciduous canines. Long tongue cribs were placed in the inter-canine area in an effort to restrict the tongue. These cribs were long enough to cage the tongue and were adjusted to avoid traumatizing the floor of the mouth. The patients were instructed to wear the appliance full-time except for eating, contact sports and tooth brushing.The active treatment time lasted for 17±3 months. The patients were examined and progress was observed after each monthly visit. Pre and post photographs and cephalometric images of one of the tongue appliance patients can be seen in Figs. 14- 9-14. Lateral cephalograms, OPGs, photos, and study casts of patients of both groups were taken before (T1) and after (T2) treatment. SNA, SNB, ANB, GoGn-Sn (mandibular plane angle), Upper 1 to SN (angle between long axis upper central incisor and anterior cranial base), IMPA (angle between the long axis of the lower central incisor and mandibular plane), Nasolabial angle (the angle formed between the lines tangent to the columella and the upper lip vermillion and intersecting at the subnasale), inclination angle (the angle formed between a perpendicular line to soft tissue nasion and the palatal plane), and Jarabak ratio (the ratio between the posterior and anterior face heights; S–Go/N–Me) of each patient were measured before and after treatment. The reliability of the measurements was determined by randomly selecting 16 cephalograms at the beginning and end of the treatment from each group. They were traced twice on two separate occasions.

Cephalometric measurement	Groups	Pre treatment Mean ± SD	Post treatment Mean ± SD	p value
SNA°	Tongue Plate	76.0±1.7	78.4±1.7	0.001*
	Tongue Appliance	75.9±2.8	77.4±2.7	0.001*
SNB°	Tongue Plate	76.9±1.8	77.5±1.4	0.08
	Tongue Appliance	77.2±2.9	77.2±2.9	1
ANB°	Tongue Plate	-0.9±1.1	0.7±1.6	0.001*
	Tongue Appliance	-1.4±1.7	0.2±1.4	0.001*
U1 to SN°	Tongue Plate	99.9±6.1	103.7±5.3	0.02*
	Tongue Appliance	98.6±6	99.9±7.2	0.3
ANS-PNS (mm)	Tongue Plate	45.7±3.1	47±3	0.001*
	Tongue Appliance	45.1±3.9	45.7±3.5	0.007*
Palatal-SN°	Tongue Plate	10.9±3.4	10.4±4.1	0.2
	Tongue Appliance	9.2±3	8.4±2.8	0.2
GoGn (mm)	Tongue Plate	65±4	66.9±3.8	0.001*
	Tongue Appliance	66.4±7.4	67.5±8	0.1
Jarabak R. (%)	Tongue Plate	61.7±3.7	61.3±3.8	0.3
	Tongue Appliance	61.7±3	62.3±4.4	0.5
U1 to Palatal°	Tongue Plate	108.7±11.4	111.8±11.4	0.03*
	Tongue Appliance	107.8±6.3	108.8±7.8	0.6
Inclination Angle	Tongue Plate	81.4±3.4	83±4.3	0.05*
	Tongue Appliance	83.6±3.2	85.9±5.8	0.07
GoGn-SN°	Tongue Plate	35.9±5.4	36.4±4.9	0.3
	Tongue Appliance	35.4±4.7	34.4±6.3	0.3
IMPA°	Tongue Plate	92.3±6.2	87±6.5	0.001*
	Tongue Appliance	88.2±6.6	83±5.5	0.001*

Table 14-1. Pre and post treatment measurements of the tongue plate and tongue appliance

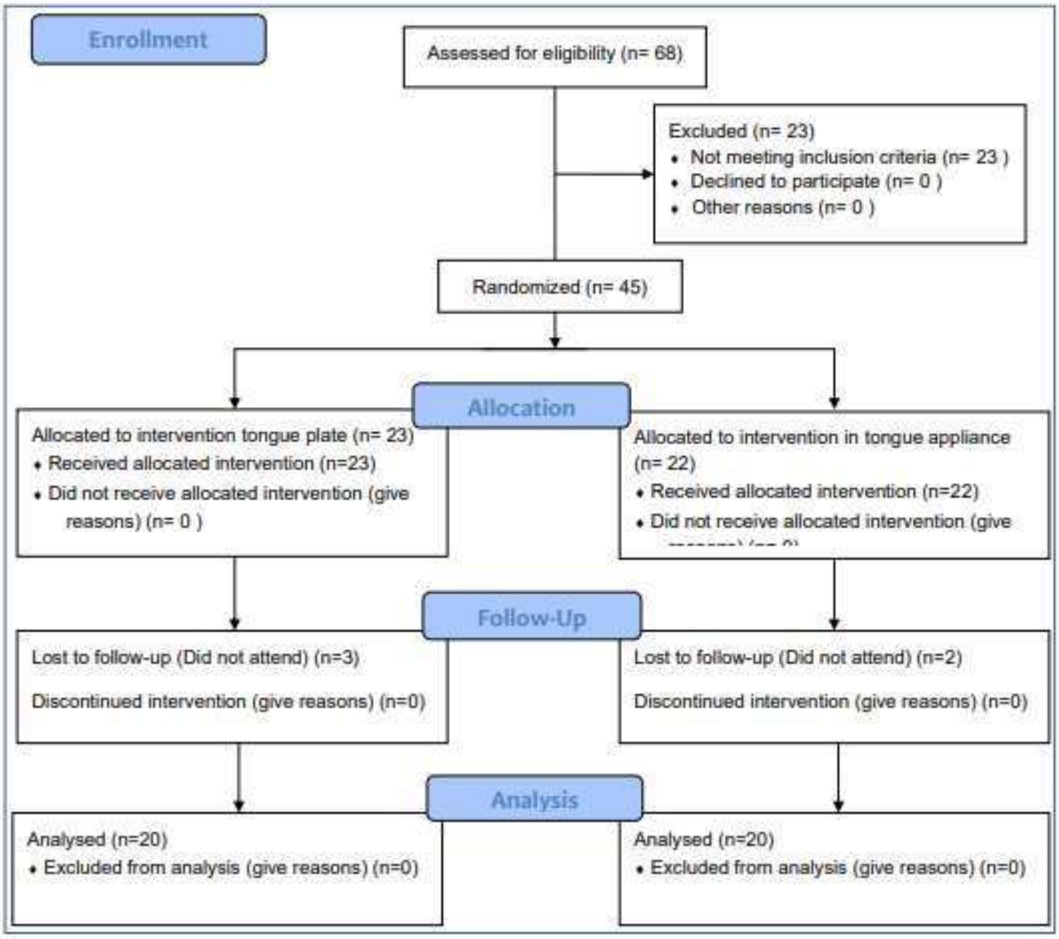


Figure 14- 1 Consort

Figure 14-2. Right view of pretreatment of a tongue plate patient. Figure 13-3. Left view of pretreatment of a tongue plate patient.

Cephalometric measurement	Tongue Plate X±SD	Tongue Appliance X±SD	p Value
SNA (°)	2.4±1.5	1.5±1.4	0.2
SNB (°)	0.6±1.4	0±2	0.8
ANB (°)	1.6±1	1.6±1.6	0.6
U1 to SN (°)	3.8±6.3	1.3±5.5	0.2
ANS-PNS (mm)	1.3±1.3	0.6±0.9	0.1
Palatal-SN (°)	-0.5±3.4	-0.8±2.9	0.6
GoGn (mm)	1.9±1.3	1.1±1.5	0.09
Jarabak R. (%)	-0.4±1.6	0.6±3.2	0.03
U1 to Palatal (°)	3.1±5.5	1±7.6	0.3
Inclination Angle	1.6±4.1	2.3±5.4	0.8
GoGn-SN (°)	0.5±1.8	-1±4.2	0.09
IMPA (°)	-5.3±3	-5.2±7.2	0.7

*Statistical significance was set at $p<0.05$

Table 14-2. Comparison of cephalometric changes between tongue plate and tongue appliance

Figure 14-4. Pretreatment cephalometric of a patient with tongue plate.

Figure 14-5. Tongue plate in situe


Figure 14-6. Right view of posttreatment of the same tongue plate patient

Figure 14-7. Left view of posttreatment of the same tongue plate patient.

Figure 14-8. Posttreatment cephalometric of the same patient with tongue plate.

Figure 14-9. Frontal view of pretreatment of a tongue app liance patient Figure 14-10. Pretreatment cephalometric of a patient with tongue appliance.




Figure 14-11. Frontal view of the tongue appliance Figure 14-12. Palatal view of the tongue appliance

Figure 14-13. Frontal view of posttreatment of the same tongue appliance patient.

Figure 14-14 Pretreatment cephalometric of the same patient with tongue appliance
Figure 14-15. The markof the tongue appliance on the tongue.

Results

The results of this study showed that SNA and ANB increased by 2.4±1.5° ($p<0.001$) and 1.6±1° ($p<0.001$) in the tongue plate group. SNA and ANB also increased in the tongue appliance group by 1.5±1.4° ($p<0.001$) and 1.6±1.6° ($p<0.001$), respectively. The SNB did not show any significant changes in either of the groups. U1 to SN increased from 99.9±6.1°

to 103.7±5.3° in the tongue plate group ($p<0.02$) and it increased from 98.6 ±6° to 99.9 ±7.2° in the tongue appliance group ($p<0.3$). The Mann-Whitney test showed that there were no statistically significant differences between the cephalometric data of the two groups; except for the Jarabak ratio. The Jarabak ratio decreased by -0.4±1.6 in the tongue plate group; yet, it increased by 0.6±3.2 in the tongue appliance group ($p<0.03$).

Discussion

Various techniques and appliances are being used to treat the maxillary deficiency including modified protraction appliance, reverse-pull headgear, facemask, Class III activator, and reverse chin cup [117]. The face mask therapy has become a common technique used to correct the developing Class III malocclusion 118. A search in literature will reveal ample research about the face masks and their effects on the nasomaxillary complex. In addition, the experimental studies constantly demonstrate pronounced forward movement of the maxilla due to the heavy and continuous protraction forces of the face masks [119, 120] However, one of the problems with the face masks is their bulky size and shape, which makes it a discouraging choice for children. Especially patients who wear glasses will be more susceptible to discomfort. This discomfort along with the embarrassment caused by the large size for children, especially at school in front of other peers, might reduce patient compliance. The chin part of the face mask will result in the backward rotation of the mandible and increase inthe anterior facial height. Recently, tongue plate and tongue appliance were used to overcome the abovementioned disadvantages. In both appliances a considerable pressure will be transmitted to the deficient maxilla. The mechanism of the force is provided in the following ways: 1. The pressure of the Tongue during swallowing might reach 5 pounds in each swallowing. The frequency of swallowing is about 500 to 1200 times in 24 hours. This intermittent force is transferred through the tongue appliance to the deficient nasomaxillary complex. 2. The tongue generates a considerable force in its rest position while caged behind the cribs or plate. These forces are transmitted by the tongue to the palatal cribs or plate and finally to the nasomaxillary complex consequently pushing the maxilla to a forward position. The more anterior function and position of the tongue, the greater the force will be. The more posterior the crib or plate, the greater the force will be. The application of face masks might cause unfavorable effects on the mandible.[121]

In other words, backward and downward rotation of the mandible is one of the unfavorable effects of such extra oral appliances. These effects are very unsatisfactory in vertically growing patients. However, the tongue appliance and tongue plate used in this study had no adverse effects on the mandible. Another advantage of the tongue appliance and tongue plate over the other extra oral appliances is that it is less conspicuous and needs less patient compliance. The tongue appliance, tongue plate and facemask lingualize the lower incisors by different mechanisms. The tongue appliance and tongue plate lingualize the lower incisorsdue to the elimination of the tongue pressure on them. However, the facemask lingualizes the lower incisors due to chin cup pressure. The neutral zone is the area where the displacing forces of the lips and tongue are in balance. The presence of the tongue appliance and tongue plate in the mouth alters the neutral zone. In other words, since the tongue is caged by thecrib or plate it does not exert any forces on the lower incisors thus, they are retroclined due to the pressure of the lips. After the appliances are removed, the tongue pressure on the lower incisors will result in their proclination. The force of the tongue transfers to the nasomaxillary complex and that is why the inclination angle is increased in both groups. In this study, both appliances were successful in forward movement of the maxilla. One of the advantages of the tongue plate is that unlike the tongue appliance it does not leave any marks on the tongue of the patient. The tongue appliance might bother the tongue and consequently parents are complaining about minor inflammation of the tongue. As can be seen in Fig. 15, the tongue appliance has left marks on the patient's tongue. It seems that the cooperation of the patient with the tongue plate is better than with the tongue appliance due to the smooth surface area of the tongue plate and lack of irritation of the cribs. The treatment used in this study was meant to correct a skeletal problem as part of growth modification and further treatment was done by using fixed appliances. [122]

Conclusion

Both treatment modalities were successful in moving the maxilla forward. The crib of the tongue appliance might bother the tongue and consequently parents are complaining about minor inflammation of the tongue. The smooth surface of the tongue plate might therefore confer some advantages to this system as compared to the tongue plate.

CHAPTER 15

METHODOLOGICAL QUALITY AND OUTCOME OF SYSTEMATIC REVIEWS REPORTING ON ORTHOPAEDIC TREATMENT FOR CLASS III MALOCCLUSION

Materials and Methods

Due to the similarities between the designs of current study with SRs, this study was performed according to guidelines published in the PRISMA statement (Moher et al., 2010) and Cochrane Handbook for Systematic Reviews of Interventions (Higgins and Green, 2011).Two reviewers (AJ and RC) independently carried out the study inclusion and data extraction.

Search strategy

A systematic search was carried out using the following online databases: Medline (PubMed, www.ncbi.nlm.nih. gov), Google Scholar (https://scholar.google.com/), Cochrane Library (www.cochranelibrary.com), Embase (http://www.elsevier.com/online-tools/embase), LILACS (http://lilacs.bvsalud.org) and SciELO (http://www. scielo.org). Manual searching was also performed for the following journals published in paper after 1995: American Journal of Orthodontics and Dentofacial Orthopaedics, Angle Orthodontist, European Journal of Orthodontics and Journal of Orthodontics. Conference abstracts and 'Grey literature' (unpublished or informally published studies) were also included in the search. No restrictions were set on language or date of publication. The search encompassed the starting date of the databases until 30 April 2015. The search encompassed MeSH terms and free- text terms including: 'mal- occlusion', 'Angle class III', 'orthodontic appliances', 'functional', 'facemask', 'review' and meta-analysis. The search strategies used for each database are shown in Table 15-1. The data were extracted separately by AJ and RC in two different countries. Since the extraction was done at the SR level, only one discrepancy was found between the results obtained by the two researchers, which was resolved with further discussion.

Inclusion criteria included SRs or meta-analyses, studies analysing the effectiveness of functional orthopaedic appliances on skeletal class III malocclusion and growing patients. Exclusion criteria included animal studies, those involving syndromic patients and surgical procedures or systematic review of SRs.

Quality assessment of SRs

AMSTAR (A Measurement Tool to Assess Systematic Reviews) is a reliable and valid measurement tool to assess the methodological quality of individual SRs (Shea et al., 2007, 2009). The instrument consists of 11 questions, which ask reviewers to answer 'yes', 'no', 'can't answer' or 'not applicable'. Each 'Yes' answer is scored 1 point and the other answers are scored 0 point. The Canadian Agency for Drugs and Technologies in Health categorizes the quality of SRs as following: low (scores 0–3), medium (scores 4–7) and high (scores 8– 11) (Rogante et al., 2015). In 2010, another group of researchers adapted AMSTAR to includea 4-point scale and named it as R-AMSTAR (Kung et al., 2010). Comparison of the AMSTAR and R-AMSTAR tools in assessing SRs has found that R-AMSTAR provides greater guidance in the assessment of domains and produced quantitative results. However, problems exist with construction of the R-AMSTER criteria and AMSTAR is much easier to apply consistently (Popovich et al., 2012); therefore, in the current study AMSTAR was used for evaluation of the SRs.

Both investigators assessed the methodological quality of the SRs. Kappa analysis was used to test inter examiner reliability for the AMSTAR score. The results showed that there was perfect agreement (0.94) between the two reviewers (Blackman and Koval, 2000).

Results

Study selection and characteristics

A total of 222 citations were identified through electronic and manual searching. Eligibility criteria used in this study are shown in Supplementary Table S1. After removing 8 duplicates, 196 more references were also excluded because the topics were not relevant. Eighteen studies were considered eligible and full texts were retrieved after screening titles and abstracts. After reading the remaining articles, two of them were excluded because they were narrative literature reviews (Kanas et al., 2008; Solano Mendoza et al., 2012). One article was removed because cases were treated by surgical procedures, which was not mentioned in the title (Minami-Sugaya et al., 2012). The last article was removed because it was only a commentary (Turley, 2002). Finally, 14 reviews and meta-analyses were included in the qualitative synthesis (Kim et al., 1999; Jager et al., 2001; Toffol et al., 2008; Fudalej et al., 2011; Liu et al., 2011; Feng et al., 2012; Freire et al., 2012; Major et al., 2012; Morales-Fernandez et al., 2013; Watkinson et al., 2013; Chatzoudi et al., 2014; Cordasco et al., 2014; Yang et al., 2014; Yepes et al., 2014) (Figure 1; Table 1). Articles excluded on the basis of full-text examination and the reason for exclusion are shown in Supplementary TableS2. The data extracted from the 14 studies is shown in Table 2. The number of subjects included in the SRs ranged from 90 (Major et al., 2012) to 1676 (Toffol et al., 2008). Three ofthe SRs did not report the number of samples they had reviewed (Jager et al., 2001; Freire et al., 2012; Morales-Fernandez et al., 2013). The appliances studied in the SRs and meta- analyses were as follows: face mask, chin cup, temporary anchorage device, reverse headgear, maxillary protraction, FR3, bionator 3 and rapid maxillary expansion.

Quality of the SRs

The AMSTAR score ranged from a minimum of three to a maximum of ten with a mean score of 7.7. Table 3 shows the detailed AMSTAR score for each paper. According to AMSTAR, one paper was rated as ‘low quality’ (Jager et al., 2001), three papers were rated as ‘medium quality’ (Kim et al., 1999; Fudalej et al., 2011; Freire et al., 2012) and 10 papers were rated as ‘high quality’ (Toffol et al., 2008; Liu et al., 2011; Feng et al., 2012; Major et al., 2012; Morales-Fernandez et al., 2013; Watkinson et al., 2013; Chatzoudi et al., 2014; Cordasco et al., 2014; Yang et al., 2014; Yepes et al., 2014). Only two SRs did not mention the characteristics of the included studies; whilst 13 of the articles did not include any conflicts of interest. Surprisingly, 10 of the articles did not provide a complete list of included and excluded studies. Moreover, in the study carried out by Kim et al. (1999) we could not identify how many people were involved in extracting the data.

Design of the studies included in the SRs

The SRs conducted by Kim et al. (1999) and Jager et al. (2001) did not mention the inclusion criteria of their studies. The SR conducted by Toffol et al. was the only SR mentioning retrospective studies in its inclusion criteria; however, no retrospective studies were found eligible to be included in their SR. And the SR conducted by Major et al. (2012) was the only one including non-randomized clinical trials and three studies were found to be eligible. In a study con- ducted by Papageorgiou et al. (2015), it was found that based on existing empirical evidence, intervention effects in orthodontic research seem to be inflated in non-randomized clinical trials compared with randomized clinical trials and in retrospective non-randomized clinical trials compared with prospective non-randomized clinical trials.

Maxillary and mandibular effects of orthodontic/ orthopaedic appliances Facemask

Five SRs analysed solely the effects of face mask on treat- ment of class III subjects (Kim et al., 1999; Jager et al., 2001; Freire et al., 2012; Cordasco et al., 2014; Yepes et al., 2014). One of them just focused on optimal magnitude, duration and direction that should be used in maxillary protraction facemask therapy and reported that there was no scientific evidence that would allow for the definition of these parameters in class III patients (Yepes et al., 2014). All four other SRs found that face mask therapy can successfully stimulate forward move- ment of maxilla (as demonstrated by an increase in SNA and ANB angles) and also confirmed backward rotation of mandible and increase in facial height (Kim et al., 1999; Jager et al., 2001; Freire et al., 2012; Cordasco et al., 2014).

Skeletal and dental anchored devices

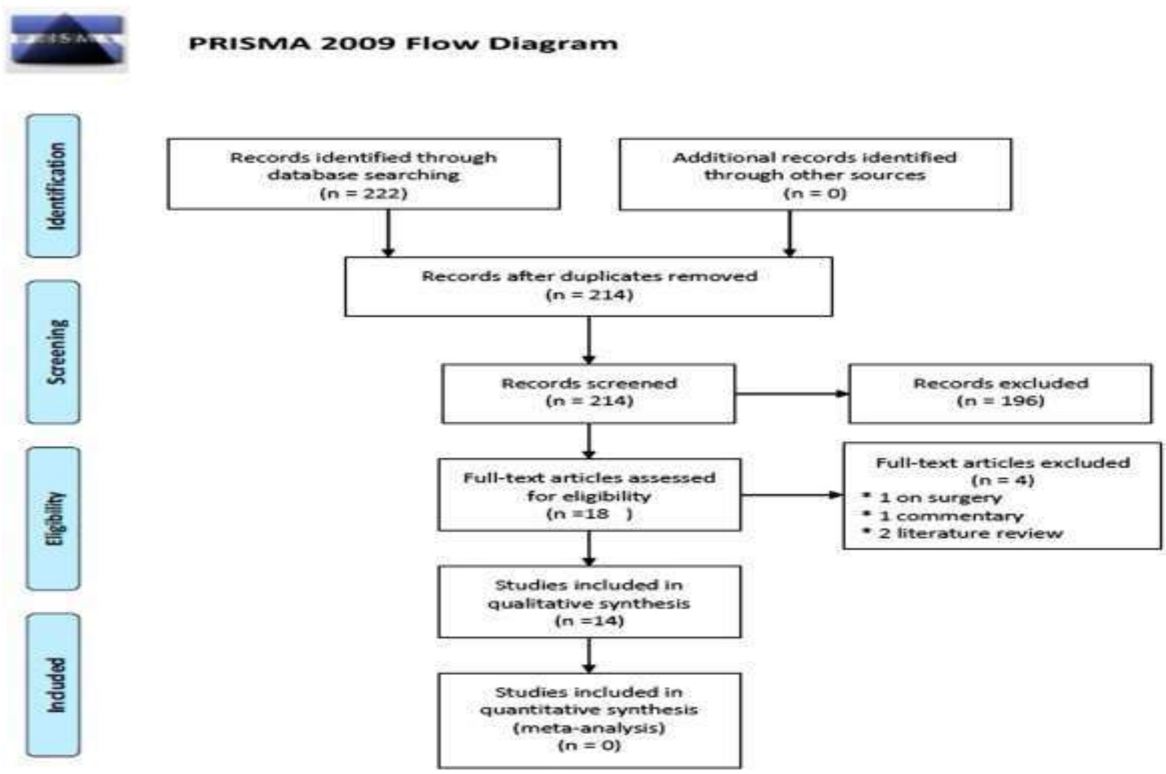
Two SRs evaluated the effects of skeletally anchored devices versus dentally anchoreddevices and both reported that greater horizontal maxillary movement is achieved withskeletally anchored devices, possibly with no dental changes and a reduced clockwise rotation of the mandible (Feng et al., 2012; Major et al., 2012).

Chin cup

Two studies reviewed the literature relating to the efficacy of chin cup treatment on retardation of mandibular growth in class III malocclusion (Liu et al., 2011; Chat- zoudi etal., 2014). Both confirmed a reduction of SNB. However, there were some disagreements concerning e effect on the gonial angle. One reported a reduction (Chatzoudi et al., 2014) whilst the other one reported an increase (Liu et al., 2011).

Database	Search strategy	Retrieved articles	Excluded (Duplicates)	Excluded (Other reasons)	Full text retrieved	Final selection
PubMed	(Malocclusion, Angle Class III [MeSH Major Topic] OR Orthodontic Appliances, Functional [MeSH Major Topic] OR facemask [Title]) AND (Review* OR Meta-Analys*)	197	–	181	16	12
Cochrane library		2	1	1	0	0
Google Scholar	Malocclusion Angle Class III [Search Limit: Review]	18	7	10	1	1
LILACS	allintitle: Class III 'systematic review'	3	–	2	1	1
SciELO	tw:((tw:(malocclusion angle class iii)) AND (tw:(review))) AND (la:('en'))	2	–	2	0	0
Embase	Angle Class III Malocclusion AND (Review ORMeta-Analys*)	0	–	–	0	0
	Malocclusion Angle Class IIITotal	222	8	196	18	14

Table 15-1



Discussion

In this study we performed an overview of published SRs and meta-analyses to investigate and summarize orthopaedic treatment of class III malocclusion. The evidence presented is largely inconclusive, due to a variety of factors. The methodological quality of many of the included trials was low, thereby reducing the validity of reported results. [109]

The methodological quality of the SRs and meta-ana- lyses were assessed with AMSTAR (Shea et al., 2007; 2009). One point was given for each affirmative answer; however, not all questions carry the same weight. For example, question 1 of the AMSTAR tool evaluates whether the research question and inclusion criteria are established before conducting the review or not; whilst, question 11 assesses whether potential sources of support were clearly acknowledged in both the SRs and included studies. As can be seen in Table 3, only one of the studies mentioned any conflicts of interest. A point would be given only to the studies that mentioned the source of support for both the SR and the included studies; therefore, no points were given to the studies con- ducted by Liu et al. (2011) and Yepes et al. (2014), who highlighted their own conflict of interest but not that of the included studies. Most of the studies lost points for not performing a grey literature search and not mention- ing a list of excluded studies (Questions 4 and 5). There- fore, AMSTAR scores should be carefully interpreted, since each item will have different weights in contributing to the overall qualityof the SR (List and Axelsson, 2010). The difficulties encountered in the current study were due to heterogeneity, of samples and the large variety of appliances used. The most frequentlyreported flaws in the studies included low quality articles, small or inadequate sample sizes, lack of control group, high risk of bias, no previous power calculation and no long- term follow-up in the studies.[110]

The treatment outcomes discussed in the SRs was for short-term effects of orthodontic /orthopaedic appliances. Although most of the SRs had included investigation of both the short and long-term effects in their aims; however, due to the limited data provided from their included articles, only the short-term effects were examined. More high-quality evidence-based clinical trials with proper design and adequate sample size are needed in the future in order to reach more reliable results concerning the use of orthodontic/orthopaedic appliances in treatment of Class III malocclusion in the short and the long term.

In addition, all the SRs only evaluated the cephalon metric outcomes of orthodontic /orthopaedic appliances and further studies are required to elucidate the quality of life outcomes of these appliances in the short and long terms.[111]

Conclusions

The evidence from current SRs of orthopaedic treatment for class III malocclusion demonstrates that orthopaedic appliances can significantly improve a class III malocclusion-in growing patients over the short-term; however, each appliance has certain drawbacks:

●Face mask can protrude the maxilla and cause back- ward rotation of the mandible; thus, increasing anterior facial height;

●Greater horizontal maxillary movement with less dental changes can be achieved by skeletally anchored devices in comparison to dentally anchored devices;

●Chin cup can cause retardation of mandibular growth; and FR-3 may restrict mandibular growth but cannot stimulate forward movement of maxilla.

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