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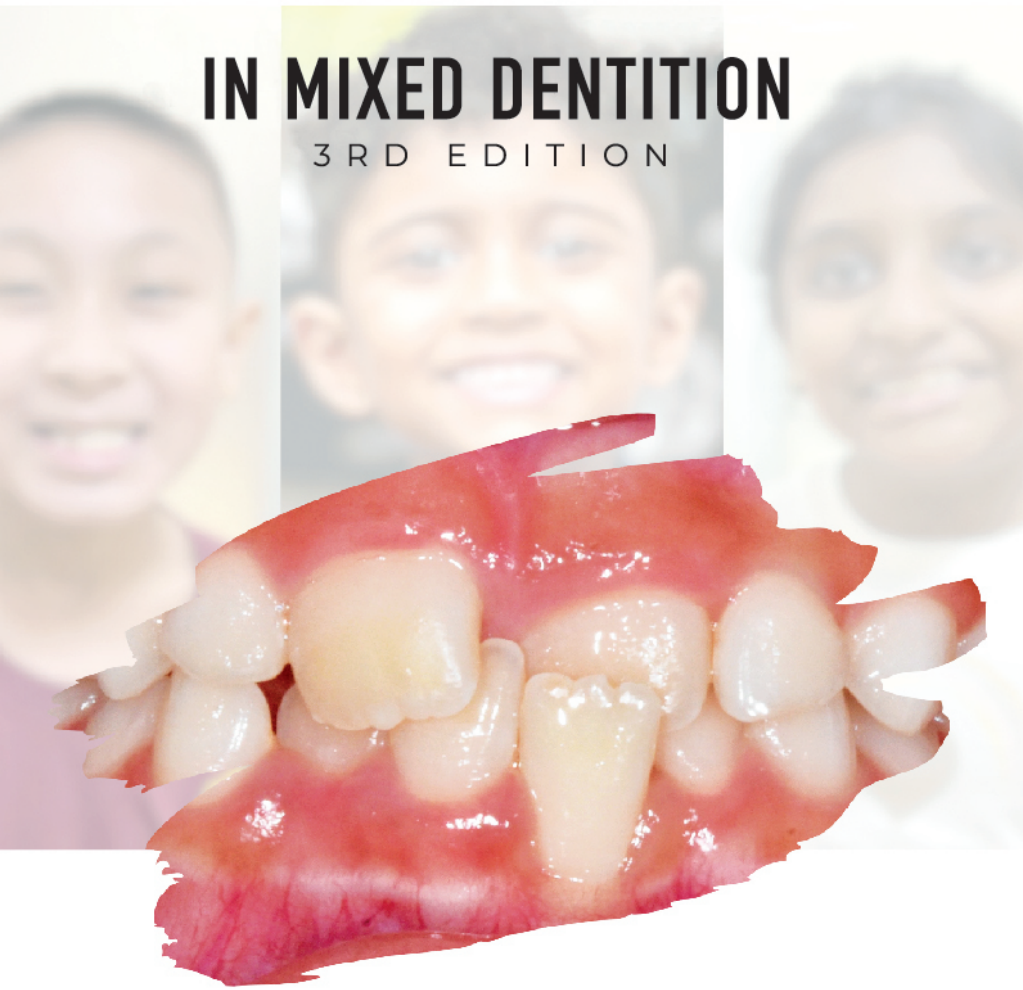
CLINICAL PRACTICE GUIDELINES

MANAGEMENT OF ANTERIOR CROSSBITE IN MIXED DENTITION

3RD EDITION



MINISTRY OF HEALTH MALAYSIA
ORAL HEALTH PROGRAMME

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STATEMENT OF INTENT
These guidelines update and supplant the previous guidelines developed in 2013 and are based on the best available contemporary evidence. They are intended as a guide for the best clinical practice in the management of anterior crossbite in the mixed dentition presently. However, it must be noted that adherence to these guidelines do not necessarily lead to the best clinical outcome in individual patient care, as every health care provider is responsible for the management of his/her unique patient based on the clinical presentation and management options available locally.

REVIEW OF THE GUIDELINES
These guidelines were issued in November 2023 and will be reviewed in 2028 or earlier if important new evidence becomes available. When it is due for updating, the head of the related specialty will be informed about it. A multidisciplinary team will be formed and discussion will be done on the need for a revision including the scope of the revised CPG. The systematic review methodology used by the Malaysia Health Technology Assessment Section (MaHTAS) will be employed in reviewing the guidelines.

Every care is taken to ensure that this publication is correct in every detail at the time of publication. However, in the event of errors or omissions, corrections will be published in the web version of this document, which is the definitive version at all times.

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LEVELS OF EVIDENCE

Level	Study design
I	Evidence obtained from at least one properly designed randomised controlled trial.
II-1	Evidence obtained from well-designed controlled trials without randomisation.
II-2	Evidence obtained from well-designed cohort or case-control analytic studies, preferably from more than one center or research group.
II-3	Evidence obtained from multiple time series studies, with or without intervention. Dramatic results in uncontrolled experiments (such as the results of the introduction of penicillin treatment in the 1940s) could also be regarded as this type of evidence.
III	Opinions or respected authorities, based on clinical experience; descriptive studies and case reports; or reports of expert committees.

Source: Adapted from Harris RP, Helfand M, Woolf SH, Lohr KN, Mulrow CD, Teutsch SM, Atkins D. Current Methods of the U.S. Preventive Services Task Force: A Review of the Process. Am J Prev Med. 2001;20 (suppl 3):21-35.

FORMULATION OF RECOMMENDATION

- In line with the new development in CPG methodology, the **Grading Recommendations, Assessment, Development and Evaluation (GRADE)** was adapted in its work process. The quality of body of evidence and related effect size are carefully assessed /reviewed by the CPG Development Group (DG).
- In formulating the recommendations, overall balances of the following aspects are considered in determining the strength of the recommendations which includes:
  - overall quality and level of the evidence
  - balance of benefits and harms of the options
  - patient's preference and values
  - resource implications
  - equity, feasibility and acceptability to the local target population
- The more criteria being fulfilled, the more certain is the evidence leading to strong recommendations using the word "**should**" being considered. Otherwise, weak recommendations use the word "**may**" in proposing an action to be made.
- In the CPG, a yellow box ☐ highlights important message(s) in the management while a blue box ☐ contains evidence-based recommendation(s) for the particular condition.

LIST OF KEY MESSAGES

Key Message 1
Important signs to look for when patients present with anterior crossbite:
- Enamel wear - attrition of the upper or lower incisors
- Periodontal problems (labial gingival recession associated with traumatic occlusion, probing depth and bone dehiscence)
- Tooth mobility due to traumatic occlusion
- Presence of mandibular displacement that may occur when closing in the retruded contact position (RCP) into the intercuspal position (ICP) due to premature contact
- Patient's ability to achieve an edge-to-edge incisor relationship

Key Message 2
- Comprehensive history taking, clinical examination, and radiographs are important to determine the nature of the crossbite, whether dental, functional or skeletal in origin.

Key Message 3
- The management of anterior crossbite requires a proper diagnosis.
- Record taking is crucial for evaluation, monitoring treatment progress and medico-legal purposes.

Key Message 4
The criteria for achieving successful treatment of anterior crossbite:
- Overall oral health
- Age and timing of treatment
- Patient's growth potential, i.e. magnitude and direction of mandibular growth
- Severity of malocclusion
- Adequate space in the arch to align the tooth/ to correct anterior crossbite
- Sufficient overbite to hold the tooth in position following correction
- Incisors inclination before treatment
- Patient's compliance
- Clinician's skill and experience
- Cost
- Safety

Key Message 5

- Protraction facemask (PFM) alone is sufficient to be used in the correction of anterior crossbite in mild Class III skeletal patterns with maxillary hypoplasia among growing patients in mixed dentition.
- If there is a problem with maxillary constriction or if the maxillary arch needs to be expanded, PFM can be utilised with RME.
- PFM treatment need to be carried out by an orthodontist.
- PFM bulkiness and soft tissue irritation can compromise patient's compliance.
- The assessment of treatment stability is usually done after the patient has completed their growth spurt.

Key Message 6

The factors that determine good outcome of functional appliance treatment in anterior crossbite correction:

- Growing patients with Class III skeletal pattern
- Cases with no or minimal dentoalveolar compensation
- Good patient motivation

Key Message 7

- Functional appliance may be provided by an orthodontist for correction of skeletal anterior crossbite in mixed dentition.

LIST OF KEY RECOMMENDATIONS

Recommendation 1
- Anterior crossbite among patients in mixed dentition should be corrected early to prevent unwanted implications.

Recommendation 2
- An upper removable appliance, a lower inclined bite plane and cemented bite pads may be used to correct dental anterior crossbite in patients with mixed dentition based on the clinician's skill, preferences and patient's compliance.

Recommendation 3
- Correction of anterior crossbite using fixed appliances should be carried out by orthodontist.

Recommendation 4
- Protraction facemask therapy may be used to correct skeletal anterior crossbite in growing patients with Class III malocclusion.

GUIDELINES DEVELOPMENT

These clinical practice guidelines (CPG) were developed by a multidisciplinary expert committee consisting of Orthodontists, a Paediatric Dental Specialist, Dental Public Health Specialists and Dental Officers from the Ministry of Health.

The previous edition of the CPG on Management of Anterior Crossbite in the Mixed Dentition (2013) was used as the basis for the development of these guidelines. The recommendations were formulated taking into consideration the best available evidence and local practices. Several improvements have been introduced in this edition. The scope has been expanded to include new and updated information. In addition, clinical audit indicators have also been identified for the purpose of monitoring and evaluating outcomes.

Literature search was carried out using the following electronic databases: Medline, PubMed, Cochrane Database of Systematic Reviews (CDSR) and Embase while full text journal articles were retrieved from these databases. The literature search was limited to human study, English language and published articles from 2012 to April 2023. In addition, the reference lists of all retrieved literature and guidelines were searched to further identify relevant studies. Future CPG updates will consider evidence published after this cut-off date. An example of the search strategy used can be found in **Appendix 1**. Details of the search strategy can be obtained upon request from the CPG Secretariat.

There were five (5) clinical questions which were assigned to members of the development group. The group members met a total of 13 times throughout the development of these guidelines. All retrieved articles were appraised using the Critical Appraisal Skill Programme (CASP) checklist by at least two (2) members, presented in the form of evidence tables and discussed during group meetings. All statements and recommendations formulated were agreed upon by both the development group and reviewers. This CPG is based on the findings of systematic reviews, randomised controlled trials, observational studies and case reports, with local practices taken into consideration. However, when there was lack of evidence, recommendations were based on consensus of group members. Although ideally patients' views and preferences need to be considered in the development of CPGs, in this instance, it was not feasible.

The literature used in these guidelines were graded using the US / Canadian Preventive Services Task Force Level of Evidence (2001), while the formulation of recommendation was done using the principles

of GRADE. The writing of the CPG strictly follows the requirements of Appraisal of Guidelines Research and Evaluation (AGREE II).

The draft was reviewed by a panel of internal and external reviewers. Recommendations were presented to the Technical Advisory Committee for CPGs, and finally to the HTA and CPG Council, Ministry of Health, Malaysia for approval.

GENERAL OBJECTIVE

To provide evidence-based recommendations for the best management practices of anterior crossbite among patients in mixed dentition.

SPECIFIC OBJECTIVES

The objectives of the CPG are to provide recommendations on the management of anterior crossbite among patients in mixed dentition on following aspects:

- early detection and referral
- assessment and diagnosis
- treatment modalities and stability

CLINICAL QUESTIONS

The clinical questions addressed by these guidelines can be found in **Appendix 2**.

TARGET POPULATION

The primary target group is mixed dentition with anterior crossbite which affects one or more permanent teeth.

Inclusion criteria
Children with anterior crossbite in the mixed dentition

Exclusion criteria
Children with anterior crossbite who have cleft lip and palate or other cranio-facial deformity

TARGET GROUP / USER

This document is intended to guide those involved in the management of anterior crossbite at any healthcare level including:

- Dental practitioners
- Medical practitioners
- Dental and medical students
- Patients and their advocates
- Professional societies

SETTINGS

Primary and specialist healthcare settings.

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The draft guidelines were reviewed by a panel of experts. They were asked to comment primarily on the comprehensiveness and accuracy of the interpretation of evidence supporting the recommendations in the guidelines.

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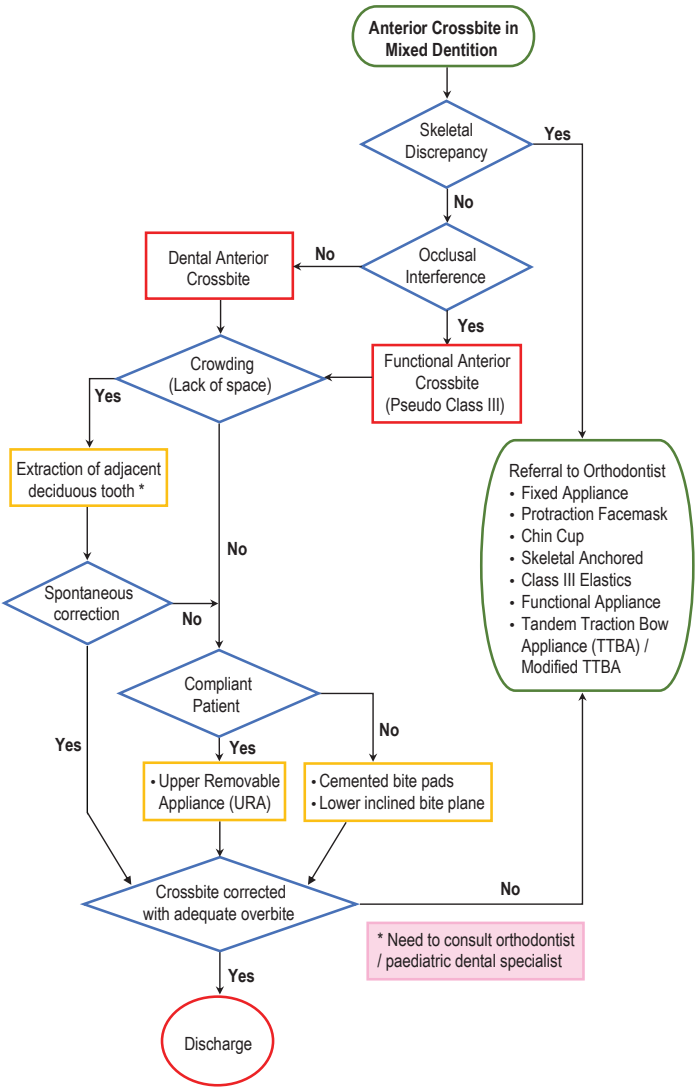
ALGORITHM ON MANAGEMENT OF ANTERIOR CROSSBITE IN THE MIXED DENTITION



1.0 INTRODUCTION

An anterior crossbite is defined as the misalignment of the upper and lower front teeth, with the lower teeth overlapping the upper teeth. This may involve one or more anterior teeth and can occur during primary or mixed dentition phase, when the child has a combination of deciduous and permanent teeth. It is common for children with Class III skeletal pattern to have anterior crossbite, especially crossbite of all the incisors.[1] Anterior crossbite in the primary dentition is rare but when it occurs, it is an indication that the child will develop a more severe Class III skeletal pattern as the child grows. Rarely this problem will need to be corrected at the primary dentition stage; rather the child's jaw growth and anterior bite will have to be monitored during the onset of early permanent dentition stage.

The prevalence of anterior crossbite differs among regions and ethnicities. Between 2.2 and 11.0% of people in the European region are experiencing anterior crossbite. A study conducted in Shanghai found that 10.5% of children between the ages of 7 and 9 had anterior crossbite.[2] According to a cross-sectional study in Malaysia, 7.7% of 12-year-old Malay students had an anterior crossbite.[3]

Anterior crossbite in mixed dentition can lead to several functional and aesthetic issues that can impact a child's oral health and overall well-being. It can affect the child's ability to bite and chew food properly. In addition to functional challenges, the abnormal tooth alignment can cause tooth wear and enamel damage. Gingival recession and loss of periodontal attachment may also occur due to the improper forces exerted on the gingiva as a result of the malpositioned teeth. Furthermore, anterior crossbite can contribute to mandibular displacement, where the lower jaw shifts to accommodate the malalignment. An anterior crossbite also may reveal an underlying jaw problem that is best addressed at a young age, while the face and jaws are still developing.[4] Therefore, anterior crossbite should be treated early in order to avoid a more complex and complicated treatment for the patient in the future.

Early intervention can address anterior crossbite in mixed dentition. Depending on the severity of the anterior crossbite, the child's age, and other factors, various orthodontic appliances may be used, including removable appliances, fixed appliances, or protraction facemasks and others. These appliances gradually shift the misaligned teeth into their proper positions, promoting improved function and aesthetics.

With new developments in the management of patients with anterior crossbite in mixed dentition, this CPG is updated to include latest evidence on the management of anterior crossbite of dental origin in mixed dentition using different treatment modalities such as lower

inclined bite plane and cemented bite pads. This CPG also includes documented evidence for the treatment of anterior crossbites of skeletal origin, including class III malocclusions using protraction masks with or without RME and skeletal anchored Class III elastics.

This CPG aims to provide evidence-based recommendations to help healthcare providers at all levels of care make appropriate clinical judgments in the management of patients with anterior crossbite in the mixed dentition. It is to provide a valuable resource for the effective management of patients with this condition.

2.0 AETIOLOGY

According to Littlewood and Mitchell (2019), an anterior crossbite occurs when one or more of the upper incisors are in linguo-occlusion position compared to the lower arch.[6] The aetiology of the anterior crossbite can be divided as below:

2.1 Dental and Local Factors

Dental anterior crossbite is solely due to displacement of teeth. It could be due to:

- crowding of teeth that can cause the maxillary incisors to be displaced lingually[1, 5]
- presence of supernumerary teeth that interferes with the eruption of maxillary tooth[1, 5]
- traumatic injuries to the primary dentition can cause lingual displacement of the maxillary permanent tooth bud.[5]
- trauma to permanent teeth can cause them to be displaced, resulting in anterior crossbite[5]
- over-retained primary incisors can cause the permanent teeth to erupt lingually, leading to anterior crossbite[1, 5]

2.2 Functional

A change in anterior function during closure from centric relation to centric occlusion due to habit of placing the mandible forward can lead to an anterior crossbite. It may be the result of premature occlusal interference that forces the lower jaw to move forward or laterally to achieve maximum occlusion.[5]

2.3 Skeletal

Skeletal anterior crossbite usually results from retarded maxillary growth or excessive mandibular growth or the combination of both. Generally, the more anterior teeth in crossbite, the more severe the underlying skeletal problem.[6]

It can be associated with the following factors:

- strong familial inheritance contributes to the development of a Class III skeletal pattern, which can lead to anterior crossbite[5]
- scar tissue from cleft lip and palate repair can restrain the growth of the maxilla, resulting in a narrow maxilla and anterior crossbite[5]
- overdevelopment of mandible in craniofacial dysostosis, cleidocranial dysplasia and hormonal disturbances such as acromegaly and gigantism[5]
- trauma or fractures to the jaws can cause skeletal abnormalities and anterior crossbite

3.0 TYPES OF ANTERIOR CROSSBITE

According to aetiological factors, anterior crossbite can be classified into three types;[5]

3.1 Dental Anterior Crossbite

Dental anterior crossbite are generally localised in nature, involving lingually displaced maxillary central or lateral incisors. It does not have underlying skeletal problems.[1, 5]

3.2 Functional Anterior Crossbite (Pseudo Class III)

This is a type of anterior crossbite caused by occlusal interferences between upper and lower incisor(s) which leads to forward displacement of the mandible in order to achieve maximum intercuspation.

3.3 Skeletal Anterior Crossbite

This is an anterior crossbite as a result of skeletal discrepancies due to retrognathic maxilla or the prognathic mandible or combination of both. The greater the number of teeth in crossbite, the greater the skeletal component of the aetiology.[6] Early treatment may not be successful in all patient with Class III skeletal problem due to the unpredictability of the growth patterns, hence consultation with a specialist is required.

4.0 EARLY INTERVENTION

Anterior crossbite may potentially have a detrimental effect on the development of skeletal and dentoalveolar structures. Therefore, early correction around 6-10 years old is important to prevent the problem from worsening and becoming more difficult to manage. Early intervention typically starts when the permanent incisor(s) are erupting in a crossbite position (7-8 years old).

The rationale for early intervention are:
- a crossbite has little possibility of self-correction
- a crossbite in the primary dentition may lead to development of crossbite in the permanent dentition[7]
- postponing treatment may result in prolonged treatment of greater complexity[7]
- a functional crossbite can develop from cuspal interference, resulting in a mandibular shift[7]
- to improve maxillary lip posture and facial appearance[7]

4.1 Implications of delayed or no treatment

If left untreated, anterior crossbite may lead to:[7]
- damage to the teeth in crossbite through attrition.
- mobility of the lower incisor due to labial displacement of this tooth accompanied by loss of gingival attachment labially.
- gingival recession and loss of alveolar bone support to the opposing lower incisor.
- the potential adverse growth influences on the mandible and anterior portion of the maxilla.
- constant protrusion of the mandibular condyle from the fossa may stimulate growth of the mandible.

4.2 Consideration before embarking on early intervention (interceptive treatment) :

The following factors need to be considered before early intervention of anterior crossbite in mixed dentition:[7]
- oral hygiene status
- the severity of the underlying skeletal discrepancy
- the amount of dentoalveolar compensation that has taken place (proclined upper incisors and retroclined lower incisors)
- the amount of overbite present
- patient's compliance
- patient's overall health condition

Recommendation 1
Anterior crossbite among patients in mixed dentition should be corrected early to prevent unwanted complications

5.0 EXAMINATION AND DIAGNOSIS

Early recognition and correct diagnosis of anterior crossbite are essential to determine suitable treatment and subsequently achieve a successful outcome. It is crucial for the clinician to be able to differentiate between the different types of anterior crossbite as management depends on the aetiology and severity of the condition. For example, dental anterior crossbite can be managed by using simple orthodontic appliances while functional and skeletal anterior crossbite require more complex treatment modalities. Crossbite can be diagnosed through appropriate case history, clinical examination and cephalometric analysis to develop an appropriate treatment plan for patients.

5.1 History Taking

Patient's assessment starts with addressing the patient's complaint, thorough history taking, comprehensive physical examination and radiographic investigations.

History taking should include:
- patient's complaint or parents' concern
- medical history - any relevant medical illness / syndrome
- dental history - any history of trauma to teeth / jaw, age when trauma occur
- family history - any family member with mandibular prognathism or Class III skeletal pattern
- social history to access patient motivation and compliance to treatment
- habit

5.2 Extra-oral and Intra-oral Examination

Diagnosis of anterior crossbite can be done from routine clinical examination as summarised below:

1. EXTRA-ORAL EXAMINATION	
Skeletal pattern	• In three planes i.e. anterior-posterior (A-P), vertical and transverse
Temporomandibular joint (TMJ)	• Clicking / crepitus • Tenderness • Deviation and displacement upon mouth opening and closing
Soft tissue	• Facial profile - straight / convex / concave • Lip competency

2. INTRA-ORAL EXAMINATION	
General condition	• Oral hygiene and DMF status • Gingival health • Gingival recession • Tooth mobility • Tooth attrition
Assessment of the arches	• Severity of crowding • Spacing availability for alignment • Upper and lower incisors inclination
In occlusion	• Number of teeth involved in crossbite • Overjet and overbite • Able to achieve edge-to-edge incisor relationship • Any mandibular displacement in closure • Centreline discrepancy • Buccal segment relationship

Key Message 1

Important signs to look for when patients present with anterior crossbite:

- Enamel wear - attrition of the upper or lower incisors
- Periodontal problems (labial gingival recession associate with traumatic occlusion, probing depth and bone dehiscence)
- Tooth mobility due to traumatic occlusion
- Presence of mandibular displacement that may occur when closing in the retruded contact position (RCP) into the intercuspal position (ICP) due to premature contact
- Patient's ability to achieve an edge-to-edge incisor relationship

5.3 Radiographic Examination

Orthopantomogram (OPG)	• to confirm the presence / absence of teeth • to assess general condition of teeth and supporting tissues
Lateral Cephalogram	• to assess skeletal relationship • to measure the inclination for the upper and lower incisors • Deviation and displacement upon mouth opening and • to determine the aetiology of the malocclusion
Standard Upper Anterior Occlusal *(if necessary)*	• to detect any supernumerary teeth or other pathology in the anterior region

Features To Differentiate Types of Anterior Crossbite

	 **Figure 1**: Dental Anterior Crossbite and Functional Anterior Crossbite (Pseudo Class III)	 **Figure 2:** Skeletal Anterior crossbite
Aetiology	• Lack of space / crowding in the dental arches • No size discrepancy between maxilla and mandible	• Genetic or hereditary in most cases • Size discrepancy between maxilla and mandible
	 **Figure 1**: Dental Anterior Crossbite and Functional Anterior Crossbite (Pseudo Class III)	 **Figure 2:** Skeletal Anterior crossbite
Maxillary incisors inclination	• Upright or retroclined	• Proclined
Mandibular incisors inclination	• Proclined or upright	• Retroclined
Transverse discrepancy	• Not present • If present, may be associated with mandibular displacement (Functional crossbite / Pseudo Class III)	• Can be associated with posterior crossbite
Mandibular growth pattern	• Normal	• Unfavourable growth pattern
Number of teeth in crossbite	• One or more teeth	• Segmental crossbite

Key Message 2
Comprehensive history taking, clinical examination, and radiographs are important to determine the nature of the crossbite, whether it is dental, functional, or skeletal in origin.

5.4 Study Model

Study model and wax bite registration is taken for diagnosis and treatment planning. It is also for medicolegal and research purposes.[7]

With the advance of technology, digital models are gaining acceptance as an alternative to traditional study models. The advantages of the digital models eliminate problems of storage, easier communication between specialists, significant time saving in performing necessary occlusal measurement.[8]

5.5 Clinical Photographs

Clinical photographs taken both extraorally and intraorally with standardised settings for pre- and post-treatment records are advisable. An example of clinical photograph is shown in **Figure 4a and 4b.**

Figure 4a: Extraoral photos

Figure 4b: Intraoral photos

Key Message 3

- The management of anterior crossbite requires a proper diagnosis.
- Record taking is crucial for evaluation, monitoring treatment progress and medico-legal purposes.

6.0 TREATMENT

The main aim of anterior crossbite treatment is to correct the relationship between the affected maxillary tooth or teeth to a point of a stable overbite relationship to prevent relapse. Simple interceptive treatment, such as extraction of adjacent primary teeth (under specialist advice) can sometimes help to prevent the development of a crossbite, if treated early. A detailed examination and diagnosis should be carried out to establish a tailored treatment plan for the patient.

Positive outcome for the correction of anterior crossbite is achieved through the following:

- dentoalveolar compensation i.e. proclination of upper teeth alone or combination of proclination of upper teeth and retroclination of lower teeth
- forward maxillary protraction
- backward rotation of the mandible

Key Message 4

The criteria for achieving successful treatment of anterior crossbite:

- Overall oral health
- Age and timing of treatment
- Patient's growth potential, i.e. magnitude and direction of mandibular growth
- Severity of malocclusion
- Adequate space in the arch to align the tooth/ to correct anterior crossbite
- Sufficient overbite to hold the tooth in position following correction
- Incisors inclination before treatment
- Patients' compliance
- Clinician's skill and experience
- Cost
- Safety

Treatment modalities should be considered carefully by taking into account the underlying aetiology of crossbite, clinician's skill and preference, the availability of technical support and patient's motivation and compliance.

6.1 Treatment Modalities for Dental Anterior Crossbite

Dental anterior crossbite can be corrected by using simple treatment modalities such as upper removable appliance (URA), fixed appliance, lower inclined bite plane and cemented bite pad. (Refer **Appendix 3** for summary). Apart from achieving a correct diagnosis, it is also important

to assess the patient's compliance and motivation before deciding the treatment that best suits the patient.

6.1.1 Upper Removable Appliance (URA)

Removable appliance is an appliance that is not attached to the teeth and can be removed by the patient for the purpose of cleaning. It is usually used to move teeth and correct the problem. The appliance is typically fitted in the upper arch and consists of an acrylic (plastic) plate, wire components for tooth movement, as well as retention of the appliance in the mouth (examples in **Figure 5a** and **Figure 5b**). The fabrication of this appliance is done in a laboratory using the Appliance Fabrication Laboratory Form (Refer **Appendix 4**). Advantages and disadvantages are summarised in **Table 3**.

Figure 5a: Frontal view with URA

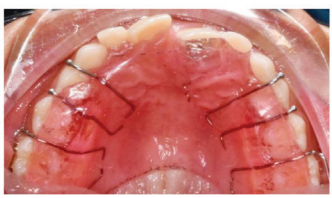


Figure 5b: Occlusal view with URA

Table 3: Advantages and disadvantages of URA in correcting anterior crossbite

ADVANTAGES	DISADVANTAGES
Simple	Highly dependent on patient's compliance
Can be removed for oral hygiene purposes	Need good laboratory support
Reduce chairside time	Slurring of speech
Efficient at tipping movement	Inefficient at rotation and bodily tooth movement

i Designing Removable Appliance

Designing a successful removable appliance requires a simple and functional design. It consists of four important components:

COMPONENTS	FUNCTION
Active component	• Provide forces to move teeth. Mainly by applying tipping force to the tooth / teeth forward. • Eg: Z spring, recurved spring, expansion screw etc
Retentive component	• Ensure the appliance is retentive and comfortable to wear • Facilitate the active component(s) stay in place to function efficiently • Eg: Adam's clasp, Southend clasp, Ball-ended clasp etc
Anchorage component	• A source of resistance to the reaction from the active components • Eg: Baseplate, retentive components
Baseplate	• Hold together the other components of the appliance. • Can be incorporated with a posterior bite plane to free the occlusion and allow the tooth in crossbite to move forward effectively.

To date, there is no evidence suggesting any particular design is more effective than the other in treating anterior crossbite in the mixed dentition. Thus, the design of the URA should be customised according to the patient's malocclusion, clinicians' preferences and technicians' skills.

ii Management of Removable Appliance

Removable appliance management involves monitoring and maintaining removable appliance throughout the patient's treatment period. This includes all responsibilities and processes necessary to ensure proper care and handling of the appliance.

a. Fitting of Removable Appliance

During the appliance fitting appointment, the clinician should ensure the appliance fits properly and is comfortable for the patient to wear. In addition, clear instructions for inserting, removing and care of the appliance should be explained and demonstrated to the patient and parents.

1. Before placing a removable appliance in the patient's mouth, ensure that it is the correct appliance for the patient and the design is followed.
2. Explain to the patient how the appliance works.

3. Ensure there is no roughness on the fitting surfaces.
4. Ensure free movement of the active component, i.e. no restriction from acrylic.
5. Demonstrate to the patient how to insert and remove the appliance and get the patient to practice doing it.
6. Give clear instructions to the patient and parents/guardian, stressing on the importance of full-time wear. (refer **Appendix 5**)
7. Arrange for review appointment.

b. Review appointment

Ideally, patients with removable appliance should be seen every 4-6 weeks. During the review appointment, the most important aspect is to assess the patient's compliance. The signs for the lack of compliance include:

- presence of lisping
- pooling of saliva
- absence of appliance looks very new and absence of wear and tear marks
- no appliance imprint in the mouth
- frequent breakages
- inability to insert and remove the appliance unaided
- active component is still active

If the patient's compliance is good, examine for:

- oral hygiene status, presence of caries or gingivitis
- overjet and overbite
- correction/ improvement of the crossbite

If the crossbite is not fully corrected, the clinician needs to continue activation of the active components. Successful correction of anterior crossbite should be achieved within 6-9 months. If there is no improvement after 9 months, referral to a specialist for further management is needed. Positive overbite is essential to maintain stable results. No retainer is required if sufficient overbite is achieved to maintain the correction.[7]

Figure 6: Pre-treatment frontal photo

Figure 7: Post-treatment frontal photo showing corrected anterior crossbite with sufficient overbite

6.1.2 Lower Inclined Bite Plane

Lower inclined bite plane is an appliance uses natural forces which creates a slight lingual movement in the mandibular teeth, while generating labial movement in the maxillary teeth.[9, 10] It can be removed or cemented to the mandibular incisors with luting glass ionomer cement or composite [Refer **Figure 8**[11]]. This can be used in patients who are unable to tolerate or have poor compliance to URA. One of the commonly used lower inclined bite planes is Catlan's appliance.

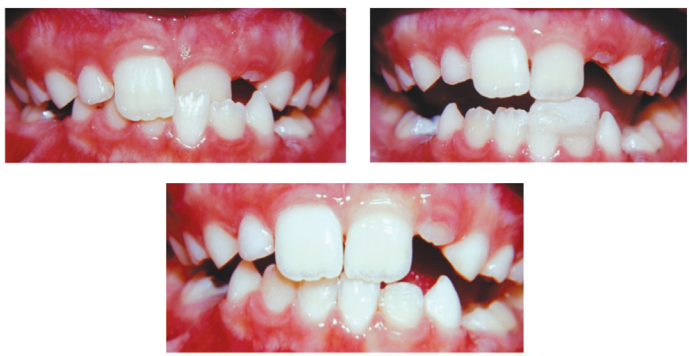


Figure 8: Correction of anterior crossbite using lower inclined bite plane

In a systematic review, one RCT reported that the Catlan's appliance had the longest treatment duration (21 days) compared with the URA (15 days) and fixed appliances (11 days).[12] Patients with Catlan's appliances also had communication problems during treatment.[13), level I] However, this RCT had unclear methods for generating random sequences, as well as blinding and allocation concealment.

6.1.3 Cemented Bite Pads

Cemented bite pads, also known as bite risers which are resin-reinforced glass ionomer cement that are placed on lower first molars to disengage the occlusion. [refer **Figure 9**[14]] It disengages the anterior teeth in crossbite to allow them to move freely over the bite by tongue pressure. It is a simple treatment option that is effective in the correction of anterior crossbite. It may be used especially for those patients who cannot tolerate wearing a removable appliance, uncooperative when wearing a removable appliance, have inadequate oral hygiene or are susceptible to removable appliance-induced stomatitis.

Figure 9a: Pre-treatment frontal photo

Figure 9b: Occlusal view with cemented bite pads on mandibular 1st molars

Figure 9c: Frontal view with bite opening

In a systematic review, an RCT showed that cemented bite planes using resin-reinforced glass ionomer cement equally effective in treating anterior dental crossbite with and without functional shift, compared to URA. No significant difference between the two groups in terms of increased overjet, mandibular intercanine width, maxillary intercanine width and upper incisor inclination. By using the Brazilian version of the Child Perception Questionnaire (CPQ), the quality of life at the end of treatment improved with cemented bite pad group.[13], level I However, this RCT was of moderate quality due to the unclear risk of bias.

Recommendation 2
An upper removable appliance, a lower inclined bite plane and cemented bite pads may be used to correct dental anterior crossbite in patients with mixed dentition based on the clinician's skill, preferences and patient's compliance.

6.1.4 Fixed Appliance

Fixed appliance (refer **Figure 10**) are orthodontic device / braces which are attached onto the surfaces of teeth and cannot be removed by the patient. In treating anterior crossbite, a simple sectional fixed appliance is preferred when three-dimensional tooth movement including bodily movement, root torquing, derotation and movement of multiple teeth is needed.(15)

Figure 10: Fixed appliances on anterior crossbite

In a recent systematic review, an RCT on treatment of anterior crossbite with functional shift in mixed dentition using 8 bonded-brackets fixed appliance and removable appliance, found that treatment time for fixed appliance (5.5 months) was significantly shorter compared to removable appliance (6.9 months). Furthermore, fixed appliance produces significantly greater effectiveness in terms of increased overjet ($p<0.05$) and arch length measurements ($p<0.01$) (arch length to incisal edge and arch length gingival) compared to removable appliance. Both appliances cause a low to moderate pain intensity, but generally were well tolerated. No significant difference was found in 2-years treatment stability with both fixed and removable appliances.(13) level I However, included primary studies were of low to moderate quality.

A small RCT from a recent systematic review, estimating treatment duration and comfort equation between fixed, removable and functional appliances to correct a developing single tooth crossbite showed shortest treatment duration with fixed appliance (11 days) compared to functional appliance (21 days) and removable appliance (15 days). Comfort equation (communication, mastication, oral hygiene, pain and discomfort) was also better with fixed appliances.(13) level I

Recommendation 3
Correction of anterior crossbite using fixed appliances should be carried out by orthodontists.

6.2 Treatment Modalities for Functional Anterior Crossbite (Pseudo Class III)

The treatment modalities for functional anterior crossbite are similar as treatment modalities for dental anterior crossbite.

6.3 Treatment Modalities for Skeletal Anterior Crossbite

Treatment of skeletal anterior crossbite during growth period aims to encourage maxillary growth and/or restrain or redirect mandibular growth.[6] The treatment of anterior crossbites due to skeletal origin is more complicated, so the treatment of these cases must be performed by an orthodontist. The choice of treatment depends on the clinician's assessment and expertise. (Refer **Appendix 3** for summary)

6.3.1 Protraction Facemask

Protraction facemask (PFM), also known as reverse-pull headgear is an interceptive orthopaedic device used to treat young children in early mixed dentition with maxillary deficiency preferably around the age 8 to 9 years old.[16-18] Facemask can be used either as a stand-alone treatment or in conjunction with other maxillary arch expansion appliances. Alternate rapid maxillary expansion and constriction combined with protraction facemask (Alt-RAMEC/PFM) is a treatment approach that involves using a device to gradually widen the upper jaw, followed by a period of constriction to stabilise the expansion. [refer **Figure 11b** and **11c**[19]]

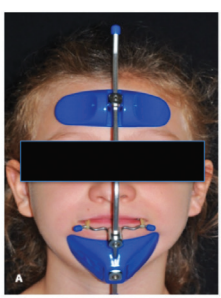


Figure 11a: Protraction Facemask

Figure 11b: Bonded Maxillary Expander

Figure 11c: Hyrax Maxillary Expansion Appliance

i Skeletal effect

PFM applies extraoral force that induces skeletal modifications by forward displacement of maxilla, backward displacement of mandible, clockwise rotation of the mandibular plane and counter-clockwise rotation of the maxillary plane.

A Cochrane Review of seven RCTs between PFM treatment and control group demonstrated a significant improvement of skeletal parameters in terms of increased ANB angle (MD= 3.93º, 95% CI 3.46 to 4.39) and Wits (MD= -3.84mm, 95% CI -5.31 to -2.37) after one year review. The ANB angle showed some relapse after three years follow up (MD= 1.4º, 95% CI 0.43 to 2.37).(20) level I

A later meta-analysis consisting of three good to moderate quality RCTs showed PFM without RME group have significant improvement in ANB (MD = 4.42º, 95% CI 3.30 to 5.94), SNA (MD = 2.57º, 95% CI 1.60 to 3.54) and SNB (MD = -1.82º, 95% CI -2.77 to -0.87) as compared to untreated patients.(21) level I

In the same meta-analysis, when group that used PFM in conjunction with rapid maxillary expander compared to the untreated group, similar significant improvements were seen in both ANB (MD = 2.97º 95% CI 1.84 to 4.09) and SNB (MD = -1.28º, 95% CI -1.88 to -0.68).(21), level I

Both studies concluded that the preliminary use of RME in the facemask therapy did not improve the effectiveness of facemask.(20), level I; (21), level I

The effect of Alt-RAMEC/PFM was compared with RME/PFM in a meta-analysis with four RCTs. At minimum of ten months follow up, Alt-RAMEC/PFM group showed significant improvement in SNA angle (1.16°; 95% CI 0.65 to 1.66), SNB angle (0.67°; 95% CI 0.32 to 1.02) and ANB angle (0.66°; 95% CI 0.08 to 1.25) when compared with RME/PFM.(22) level I

ii Dentoalveolar effect

PFM can facilitate the correction of the overjet (OJ) in Class III growing patients. When compared with untreated group, the patients who have had PFM demonstrated significant OJ improvement (MD= 4.1mm, 95% CI 3.04 to 5.16).[20] level I Another meta-analysis also showed similar OJ improvement of 3.94mm (95% CI 2.17 to 5.71).[23] level I

Only one RCT from a meta-analysis showed significant OJ changes in both Alt-RAMEC/PFM and RME/PFM groups respectively. This significance was in favor of Alt-RAMEC/PFM group (p<0.001). However, it need to be interpreted with caution due to the high risk of bias.[22] level I

iii Psychological benefit

An RCT comparing early Class III PFM treatment with a control group using Pier-Harris Questionnaire, measured self-esteem and Oral Aesthetic Subjective Impact Score (OASIS) which assessed the impact of concern on the appearance of teeth showing no significant difference between both groups. Thus, it does not seem to confer a clinically significant psychosocial benefit in early treatment.[24] level I

iv Temporomandibular joint

Effect of morphology changes in the temporomandibular joint (TMJ) following short term wear (6 to 15 months) of PFM was reported in a systematic review with 13 moderate to good quality studies. They found that there were significant morphological changes in the condylar growth (p<0.001), bone remodelling (p<0.05) and significant condylar displacement in the posterior (1.13 mm ±1.46 mm, p=0.007) and superior (−0.97 mm ± 0.96 mm, p=0.001) direction in the PFM group. The occurrence of TMJ dysfunction was not significant between the PFM and the control group. This could be due to the patient's adaptive ability to achieve centric relation (CR) and maximum intercuspation (MI) positions.[25] level I

v Stability and Relapse

The stability of Class III skeletal pattern correction using PFM is highly dependent on the growth pattern, particularly the late mandibular growth.

A systematic review of five studies assessing the mid-term stability at six years follow-up of PFM therapy showed skeletal relapse with:[26], level I

- SNB value increased between 1.3° to 2.0°
- ANB value reduced between 2.0° to 2.6°

Another meta-analysis with four studies evaluated the stability of treatment effects of maxillary protraction therapy in Class III children demonstrated skeletal relapse after 2 to 3.5 years with:[23] level I

- SNA (MD= -0.75°, 95% CI -1.38 to -0.11)
- ANB (MD= -0.80°, 95% CI -1.45 to -0.15)
- SNB (MD= -0.06°, 95% CI -0.71 to 0.60)

Dentoalveolar relapse can be seen in terms of OJ (MD= -0.69mm; 95% CI -1.28 to -0.09)[23] level I and another study showed 40% subjects in the treatment group did not maintain a positive OJ.[26] level I

Key message 5

- Protraction facemask (PFM) alone is sufficient to be used in the correction of anterior crossbite in mild Class III skeletal patterns with maxillary hypoplasia among growing patients in mixed dentition.
- If there is a problem with maxillary constriction or if the maxillary arch needs to be expanded, PFM can be utilised with RME.
- PFM treatment need to be carried out by an orthodontist.
- PFM bulkiness and soft-tissue irritation can compromise patient's compliance.
- The assessment of treatment stability is usually done after the patient has completed their growth spurt.

Recommendation 4

Protraction facemask therapy may be used to correct skeletal anterior crossbite in growing patients with Class III malocclusion.

6.3.2 Chin Cup

Orthodontic chin cup appliance is a device outside of the mouth (extra oral appliance) that covers the chin and is attached to elastic bands that usually fit over the head. (refer **Appendix 6**). It is used to help reduce or correct mandibular prognathism in growing children. It is mainly used to restrict the forward and downward growth of the mandible by placing force on the lower jaw.(27)

Two meta-analyses assessing the effectiveness chin cup treatment in pre-pubertal Class III malocclusion patients compared with no treatment at short-term showed improvement in:

a. Skeletal:

- ANB (MD=1.96°, 95% CI 1.58 to 2.34)[20], level I
- Wits appraisal (MD=3.62 mm, 95% CI 1.32 to 5.92)[28], level II-1
  (MD=4.96 mm, 95% CI 4.45 to 5.42)[20], level I
- Gonial angle (MD= -0.799°, 95% CI -1.523 to -0.075)[28],level II-1

b. Dental:
- Overjet (SMD=2.623 mm, 95% CI 1.061 to 4.185)[28], level II-1

Although chin cup therapy showed a general improvement in the facial profile, skeletal and dentoalveolar changes but various responses can occur depending on the facial skeletal pattern and growth of the patients.

As for stability, not all effects from chin cup will be sustainable in the long term until patient growth completion.

The role of chin cup therapy in the retardation of mandibular growth in the long term is not conclusive. There are insufficient articles reported for the long-term effect of chin cup therapy and it is difficult to obtain long term cooperation from patients to wear chin cup until the growth is complete. In addition, chin cup therapy is not suitable for patients with open bite or significant reverse OJ.

6.3.3 Skeletal Anchored Class III Elastics

Skeletal anchored Class III elastics involves class III elastics applied from infra-zygomatic mini-plates / mini-screws in the maxilla to symphyseal mini-plates / mini-screws in the mandible.[1] (refer **Appendix 6**)

A meta-analysis, with 9 moderate quality studies (8 case-control studies and 1 controlled clinical study), reported that skeletal anchorage group, when compared to no treatment control groups showed significantly increased in Wits values effect size (WDM= 7.8mm, 95% CI 7.19 to 8.14), overjet effect size (WDM= 6.52mm, 95% CI 6.17 to 6.88), ANB (WDM= 6.07°, 95% CI 5.56 to 6.58) and SNA (WDM= 2.70°, 95% CI 2.16 to 3.24). The SNB was reported to decrease in skeletal anchorage group (WDM= 3.07° , 95% CI -3.52 to -2.62).[29] level I

From another similar meta-analysis, skeletal anchorage when compared with more traditional treatment methods, i.e. expander and face mask, there was no significant difference between two groups in terms of overjet, ANB or SNB effect size. However, there was a slight increment in Wits values effect size (WDM= 1.28mm, 95% CI 0.28 to 2.28, p=0.012) and SNA (WDM=0.60°, 95% CI 0.13 to 1.07).[29] level I

A non-randomised clinical trial comparing skeletal and facemask treatment among 7 to 12 years old patients reported that there was no significant difference in terms of overjet, SNA, ANB and Wits values. However, the median time of treatment was significantly shorter in the mini-implant group (12.5 months vs 16 months, p=0.025). The failure rate of mini-implant was reported as 16.7%. More implant failure reported in 11-12 year old group compared to 9-10 year old group

(4.2% vs 29.2%, p= 0.048) There was no association between site of insertion or sex with the implant failure.[30] level I

In conclusion, skeletal anchored Class III elastic can be an effective treatment modality in improving skeletal class III malocclusion. However, the precautions need to be taken while inserting the miniplates especially for patients below the 10 years old considering the developing mandibular canine germ.[1]

6.3.4 Functional Appliance

Functional appliance was a classic method of treatment used in a Class III skeletal pattern growing patients, primarily to enhance the growth of the maxilla and restrict the growth of the mandible. The two functional appliances used for Class III correction are Fränkel Functional Regulator III Appliance (FR III) and Reverse Twin Block Appliance. (refer **Appendix 6**)

i Fränkel Functional Regulator III Appliance

Fränkel Functional Regulator III appliance (FR III) (refer **Appendix 6**) has been used for correction of anterior crossbite in skeletall Class III patients. A meta-analysis with 7 moderate cohort studies showed FR III therapy produced significant short-term (two to three years follow-up) skeletal effects among patients with anterior crossbite[31] level II-2. Participants wearing the FR III demonstrated significant difference in terms of SNA (MD = 1.02°; 95% CI, 0.53 to 1.51), SNB (MD = 1.62°; 95% CI, 2.62 to 0.62), ANB (MD =1.84° ; 95% CI, 0.96 to 2.71) and Wits appraisal (MD = 2.70 mm; 95% CI, 1.88 to 3.52). Apart from that, FR III also cause dentoalveolar effect as seen on the significant increase in the overjet (MD = 3.47 mm; 95% CI, 2.93 to 4.01). However, these changes only can be maintained long term (eight to nine years) in the SNB value (MD = 1.50°; 95% CI, 2.12 to 0.88) and overjet (MD = 4.56 mm; 95% CI, 3.78 to 5.35). No significant changes in the overbite were observed in both short- and long-term among the participants.

ii Reverse Twin Block Appliance

Reverse Twin Block appliance (RTB) is also used in crossbite correction in Class III skeletal pattern patients. An RCT with 13 patients aged between 6 to 12 years old demonstrated that when use in conjunction with rapid maxillary expander (RME) for 9 months, RTB with RME patients showed significant improvement in ANB angle and Wits appraisal compared to the control group.[32] level I

Key message 6
The factors that determine good outcome of functional appliance treatment in anterior crossbite correction:
- growing patients with Class III skeletal pattern
- cases with no or minimal dentoalveolar compensation
- good patient motivation

Early correction of anterior crossbite in skeletal Class III patients with functional appliance was found to be effective for short-term. However, the long-term stability is highly dependent on favourable growth and excellent compliance by the patients. Other factors to take in consideration are the fabrication cost and the patient's motivation.

Key message 7
Functional appliance may be provided by an orthodontist for correction of skeletal anterior crossbite in mixed dentition.

6.3.5 Tandem traction bow appliance

Tandem traction bow appliance (TTBA) is an intraoral appliance with upper splint attached to RME and lower splint with headgear tubes connected by traction bow and elastic. The elastic wear is attached intraorally.

A small *in vivo* study to support the use of intra oral TTBA in early treatment of skeletal Class III malocclusion for patients (6 to 12 years old) with mild maxillary deficiency found that there were significant improvements in terms of:[33] level II-3
- Skeletal: point A moved forward (MD=2.2 mm; p=0.005), SNA moved forward (MD=2.8°; p<0.005), SNB moved backwards (MD= 0.4°; p<0.005), ANB increased (MD=3.2°; p value <0.005)
- Dental: upper incisal angulations decreased (MD= 8.3°; p<0.005) and lower incisal angulation decreased (MD=3.6°; p value =0.007)

However, this study was conducted in small sample size, and there is no consideration on growth related changes in post treatment follow-up.

TTBA can also be used in combination with extra oral headgear and extra oral elastic (Modified TTBA). In a Cochrane Systematic Review published in 2013, a small RCT found that children and adolescents with prominent lower front teeth treated with modified TTBA had shown effective improvement in the overjet (MD=3.30 mm, 95% CI 2.46 to

4.14) and ANB (MD=1.70°, 95% CI 1.09 to 2.31) when compared to the untreated.[20] level I

In a meta-analysis, an RCT showed that PFM (Petit-type) therapy was significantly effective compared to modified tandem appliance (Modified TTBA) (p=0.04) in improving OJ among patients with skeletal class III malocclusion (7 to 10 years old).[18] level I

Furthermore, the construction and method of wearing of modified TTBA is more complicated for operator and patient. Hence, PFM treatment is more convenient and effective than modified TTBA.

7.0 IMPLEMENTING THE GUIDELINES

The management of anterior crossbite in mixed dentition should be guided by an evidence-based approach in order to provide quality care. Clinicians are required to keep abreast with current knowledge through continuing professional education as well as understanding patients' expectations.

Therefore, it is important for these guidelines to be disseminated to all healthcare professionals in primary and secondary healthcare facilities. This can be facilitated through the development of appropriate training modules and quick references. Several factors may affect the implementation of the recommendations of the CPG.

7.1 Facilitating and Limiting Factors

Existing facilitators for application of the recommendations in the CPG include:

- wide dissemination of the CPG to healthcare professionals and teaching institutions via printed and electronic copies
- continuing professional education on the management of anterior crossbite in mixed dentition for healthcare professionals
- adequate facilities at primary and secondary care level for diagnosing and treating anterior crossbite in mixed dentition.
- Existing barriers for application of the recommendations of the CPG include:
- lack of understanding or limited knowledge on the management of anterior crossbite in mixed dentition.
- variation in skills and treatment practices.
- constraints in equipment and facilities

7.2 Potential Resource Implications

This CPG recommends early detection and referral, comprehensive assessment and treatment of anterior crossbite in mixed dentition. This requires increased awareness among healthcare providers and the public to establish early diagnosis and uninterrupted various forms of treatment as well as support to the patients and their caregivers.

To implement the CPG, there must be strong commitment to:

- ensure widespread distribution of the CPG in hard and soft copy to healthcare professionals in primary and secondary healthcare facilities
- strengthen training of healthcare professionals to ensure knowledge and information is up to date

7.3 Proposed Clinical Audit Indicators

To assist in the implementation of the CPG, the following are proposed as clinical audit indicators for quality management of anterior crossbite in mixed dentition.

Early referral of anterior crossbite	=	Number of referred cases in mixed dentition with anterior crossbite / Total number of referred cases with anterior crossbite	X 100%

X	=	Number of referred cases in mixed dentition (6-10 years old) with anterior crossbite
Y	=	Total number of referred cases with anterior crossbite
X/Y	x	100%
Target	≥	70%

Appendix 1

SEARCH STRATEGY

Literature search was carried out using the following electronic databases: Medline, Pubmed, Cochrane Database of Systematic Reviews (CDSR) and Embase while full text journal articles were retrieved from these databases. The following Medical Subject Heading terms of free text terms were used either singly or in combination. The literature search was limited to human study, English language and published articles from inception of databases from 2012 to April 2023

Clinical Question:
Is fixed appliance safe and effective in treating anterior crossbite among mixed dentition?

Ovid MEDLINE(R) ALL <1946 to July 18, 2023>

1. (bite, cross or bites, cross or cross bite or cross bites).mp. **616**
2. (anterior adj1 crossbite).tw. **584**
3. Malocclusion, Angle Class III/ **4102**
4. 1 or 2 or 3 **5099**
5. Dentition, Mixed/ **2174**
6. 4 and 5 **190**
7. Orthodontic Appliances, Fixed/ **461**
8. (appliance, fixed or appliance, fixed functional or appliance, fixed orthodontic or appliances, fixed or appliances, fixed functional or appliances, fixed orthodontic or bonded retainer or bonded retainers or fixed appliance or fixed appliances or fixed functional appliance or fixed functional appliances or fixed orthodontic appliance or fixed retainer or fixed retainers or functional appliance, fixed or functional appliances, fixed or orthodontic appliance, fixed or orthodontic appliances, fixed or permanent retainer or permanent retainers or retainer, bonded or retainer, fixed or retainer, permanent or retainers, bonded or retainers, fixed or retainers, permanent).mp. **3179**
9. 7 or 8 **3179**
10. 6 and 9 **18**
11. limit 10 to (English language and humans and yr=”2012 - 2023”) **13**

Appendix 2

CLINICAL QUESTIONS

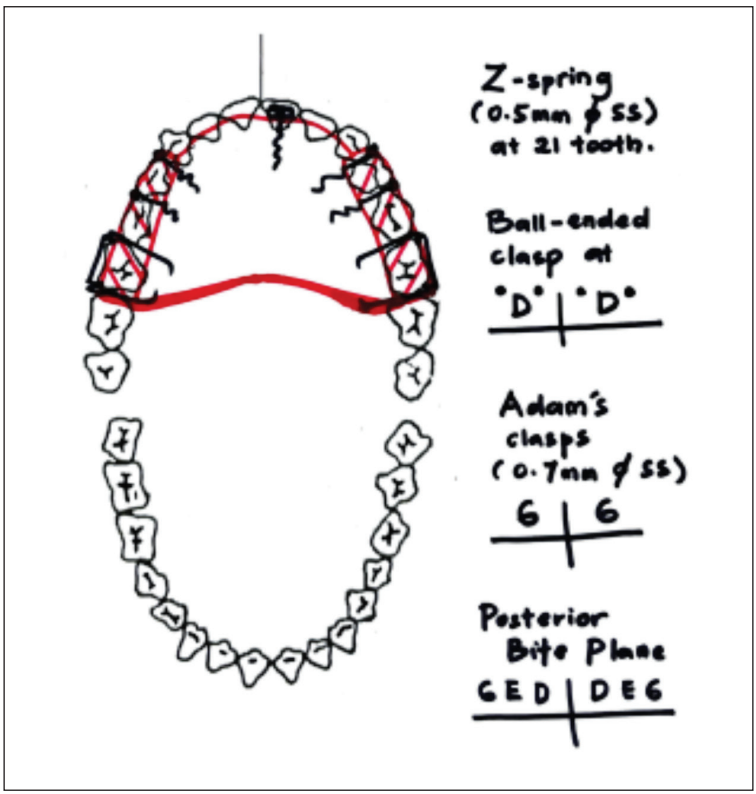
1. What is the aetiology/predisposing factors of anterior crossbite in mixed dentition?
2. What are the classifications of anterior crossbite in mixed dentition?
3. What are the accurate methods to diagnose anterior crossbite in mixed dentition?
4. What are the effective and safe treatment modalities for anterior crossbite in mixed dentition?
    a. Fixed appliance
    b. Upper Removable Appliance
    c. Inclined Bite Plane (Catlan's Appliance)
    d. Cemented Bite Pads
    e. Protraction Facemask
    f. Chin cup
    g. Mini implant / miniscrew / TAD/ miniplate
    h. Tandem traction bow appliance (TTBA)
    i. Functional appliance

SUMMARY OF TREATMENT MODALITIES OF ANTERIOR CROSSBITE

TREATMENT MODALITIES FOR DENTAL ANTERIOR CROSSBITE	Upper Removable Appliance (URA)	An appliance that is not attached to the teeth and can be removed by the patient. The active component can be Z spring, recurved spring or expansion screw.
	Lower Inclined Bite Plane	Inclined plane either removable or cemented can be placed at the lower incisors for non-compliant patients
	Cemented Bite Pads	It is a bite riser that are placed on lower first molars to disengage the occlusion.
	Fixed Appliance	Orthodontic devices / braces which are attached onto the surface of teeth and cannot be removed by the patient. It is used for cases that need three-dimensional tooth movement.
TREATMENT MODALITIES FOR FUNCTIONAL ANTERIOR CROSSBITE (PSEUDO CLASS III)	Similar with treatment modalities for dental anterior crossbite	
TREATMENT MODALITIES FOR SKELETAL ANTERIOR CROSSBITE	Protraction facemask	It is an orthopaedic device used in early mixed dentition to protract the maxilla. It can be stand-alone treatment or in conjunction with other maxillary arch expansion appliances.
	Chin Cup	It is a device outside of the mouth (extra oral appliance) that covers the chin and is attached to elastic bands that usually fit over the head. It is used to restrict the forward and downward growth of the mandible.
	Skeletal Anchored Class III Elastics	It is Class III elastics applied from infra-zygomatic mini-plates / mini-screws in the maxilla to symphyseal mini-plates / mini-screws in the mandible.
	Functional Appliance	Removable appliance used in a Class III skeletal pattern growing patients.
	Tandem Traction Bow Appliance	It is an intraoral appliance with upper splint attached to a RME and a lower splint with headgear tubes connected by a traction bow and intraoral elastics.

Appendix 4

APPLIANCE FABRICATION LABORATORY FORM
(Example of URA design)*



* This is an example of the URA design. The design of URA needs to be tailored according to patient's malocclusion

Appendix 5

INSTRUCTIONS FOR REMOVABLE APPLIANCE

1. The appliance should be worn at all times, including meals and in bed at night.

2. The appliance should only be removed during tooth brushing and playing contact sports. It must then be replaced in the mouth at the earliest opportunity.

3. It is very common to feel discomfort, pooling of saliva and altered speech initially, but it should pass in a few days once you get used to the appliance.

4. It is important to take care of oral hygiene during the treatment.

5. Avoid hard, sticky, sweet foods and carbonated/ higher sugar contained drinks.

6. If there be any problem with the appliance, please contact the Orthodontic Department as soon as possible. The contact number is …….

Appendix 6

PHOTOS OF TREATMENT MODALITIES FOR ANTERIOR CROSSBITE OF SKELETAL ORIGIN

Chip Cup[34]

Skeletal Anchored Class III Elastics[35]

Fränkel Functional Regulator III Appliance[36]

Tandem Traction Bow Appliance (TTBA)[37]

LIST OF ABBREVIATIONS

AGREE	Appraisal of Guidelines Research and Evaluation
Alt-RAMEC	Alternate Rapid Maxillary Expansion and Constriction
ANB	Angle between the line A point to Nasion and B point to Nasion on a lateral cephalogram
A-P	Anteroposterior
CASP	Critical Appraisal Skill Programme
CDSR	Cochrane Database of Systematic Reviews
CI	Confidence Interval
CPG	Clinical Practice Guidelines
CPQ	Child Perception Questionnaire
CR	Centric Relation
DMF	Decay Missing Filling
FM	Facemask
FR III	Fränkel Functional Regulator III Appliance
GRADE	Grading Recommendations, Assessment, Development and Evaluation
HTA	Health Technology Assessment
MD	Mean Difference
MI	Maximum Intercuspation
mm	millimeter
MyMAHTAS	Malaysia Health Technology Assessment Section
OASIS	Oral Aesthetic Subjective Impact Score
OB	Overbite
OH	Oral Hygiene
OHP	Oral Health Program
OJ	Overjet
OPG	Orthopantomogram
PFM	Protraction Face Mask
RCT(s)	Randomised Control Trial
RME	Rapid Maxillary Expander
RTB	Reverse Twin Block appliance
SMD	Standard Mean Difference
SNA	Angle between the line Sella to Nasion and A point to Nasion on a lateral cephalogram
SNB	Angle between the line Sella to Nasion and B point to Nasion on a lateral cephalogram
TAD(s)	Temporary Anchorage Device
TMD	Temporomandibular disorder
TMJ	Temporomandibular joint
TTBA	Tandem Traction Bow Appliance
URA	Upper Removable Appliance
WDM	Weighted Mean Difference

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