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Growth Modification Approach for Class III Malocclusion in a 9-Year-Old Female: A Nonsurgical Case Report

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ABSTRACT

A 9-year-old growing female patient presented with a concave facial profile, anterior cross bite with an associated anterior open bite, and misaligned maxillary incisors, indicative of a Class III malocclusion. Early diagnosis and comprehensive treatment planning allowed for timely intervention using orthopedic and orthodontic approaches. Treatment involved maxillary expansion combined with protraction therapy, followed by fixed orthodontic appliances to achieve optimal dental alignment and occlusal stability. This nonsurgical approach resulted in significant improvement in facial profile, smile esthetics, and functional occlusion. Early growth modification successfully eliminated the need for future surgical intervention, highlighting the importance of interceptive treatment in growing patients. The treatment plan, progress, and outcomes were thoroughly discussed with the patient and her guardian throughout the course of care.

Keyword

Class III malocclusion, Growth modification, Rapid maxillary expansion, Facemask therapy, Fixed orthodontic appliance (MBT system).

Introduction and Literature Review

Class III malocclusion represents one of the most complex orthodontic problems, with treatment outcomes largely dependent on the patient's growth status. In growing patients, early orthopedic intervention can modify jaw growth and correct the underlying skeletal discrepancy. In contrast, once growth has ceased, ideal correction often necessitates a combination of orthodontic treatment and orthognathic surgery to achieve optimal functional and aesthetic results.

Definition and Characteristics

According to Angle's classification, a defining feature of Class III malocclusion is the mesial positioning of the mandibular first molar relative to the maxillary first molar [1,2]. Clinically, Class III malocclusion—commonly referred to as an under bite or reverse overjet—is characterized by a forward-positioned mandible relative to the maxilla. This discrepancy may be skeletal in nature, resulting from mandibular prognathism, maxillary retrusion, or a combination of both, or it may be purely dental, where the malocclusion arises from tooth positioning rather than jaw disharmony. These variations can lead to significant functional impairment and aesthetic concerns.

Diagnostic Advances

The introduction of cone-beam computed tomography (CBCT) has significantly enhanced the diagnostic accuracy of Class III malocclusion by providing detailed three-dimensional imaging. CBCT allows clinicians to distinguish more precisely between skeletal and dental components of the malocclusion, thereby facilitating more accurate diagnosis and individualized treatment planning. Despite ongoing concerns regarding radiation exposure—particularly in pediatric patients—advancements such as improved detector sensitivity and adjustable collimation have contributed to safer and more efficient CBCT imaging protocols [3].

Treatment Considerations Based on Growth Status

Successful management of Class III malocclusion relies heavily

on an accurate assessment of the patient's growth potential. Treatment strategies are customized based on age, severity of the malocclusion, and whether the etiology is skeletal or dental. For patients who are still growing, treatment primarily aims to modify jaw development. Common modalities include:

Orthopedic appliances, such as reverse-pull facemasks, which encourage forward growth of the maxilla or restrict mandibular growth.

Functional appliances, which including the Frankel III regulator; that guides muscular function and promote favorable skeletal adaptation in cases of mild discrepancies.

Expansion and protraction protocols, most notably rapid maxillary expansion (RME) combined with facemask therapy, which addresses both transverse maxillary deficiency and sagittal maxillary retrusion.

Nikia et al. described orthodontic camouflage as an alternative management approach for Class III malocclusion, involving proclination of the maxillary incisors and retroclination of the mandibular incisors to achieve acceptable dental relationships. While this approach improves dental alignment and facial appearance, it does not correct the underlying skeletal discrepancy. Nevertheless, with careful case selection and planning, particularly in younger patients, camouflage treatment can yield satisfactory aesthetic outcomes [4].

Westwood et al. emphasized the importance of overcorrection when using RME and facemask therapy, recommending a slight shift toward a Class II molar relationship to enhance long-term stability and reduce the risk of relapse [5]. However, a 2020 study by Huynh et al. highlighted a significant limitation of RME/facemask therapy, demonstrating that although initial maxillary advancement is often achieved, these skeletal improvements may not be fully maintained over time due to relapse. This finding underscores that while early intervention is beneficial, its long-term stability cannot always be guaranteed [6].

More recently, Yuyao et al. reported that a modified expansion protocol, the Alternate Rapid Maxillary Expansion and Constriction (Alt-RAMEC) technique combined with facemask therapy, produces superior outcomes in early Class III treatment. Compared with conventional approaches, this method resulted in greater maxillary advancement, improved skeletal overjet correction, and fewer undesirable mandibular changes [7].

Etiology and Epidemiology

The etiology of Class III malocclusion is multifactorial, involving both genetic and environmental influences. A strong hereditary component has been well documented, with classic examples including the Habsburg royal family. Environmental factors such as mouth breathing, functional anterior mandibular shifts and Parafunctional habits may also contribute. In addition, systemic conditions, such as pituitary tumors leading to acromegaly, are recognized etiological factors [8,9].

The skeletal and dental characteristics of Class III malocclusion are highly variable and often deviate from established craniofacial norms. The condition may present as mandibular prognathism, maxillary deficiency, a combination of both, or, in some cases, without a significant anteroposterior skeletal discrepancy [10].

A systematic review and meta-analysis by Daniel et al. demonstrated that the global prevalence of Angle Class III malocclusion is highly heterogeneous. The highest prevalence rates were observed in Chinese and Malaysian populations, whereas Indian populations exhibited significantly lower prevalence compared with other ethnic groups [11]. Additional studies report prevalence rates of approximately 1–4% in White populations, 5–8% in Black populations, and 4–14% in Asian populations [12-14]. These variations highlight the significant clinical and epidemiological challenges associated with managing Class III malocclusion.

Treatment in Adults

Treatment planning for Class III malocclusion must consider patient age, malocclusion pattern, and severity. In growing patients, growth modification remains the primary objective. In adults, however, treatment options are limited to orthodontic camouflage or combined orthodontic–surgical approaches. Severe skeletal discrepancies typically require orthognathic surgery to achieve optimal functional and aesthetic outcomes.

Orthodontic camouflage is a well-established non-surgical option for mild to moderate Class III malocclusions [15-17]. This approach, as described by Nikia et al., focuses on proclining maxillary incisors and retroclining mandibular incisors to establish a functional occlusion [18]. Despite its limitations in correcting skeletal disharmony or significantly improving facial profile, camouflage treatment can produce notable dental and soft-tissue improvements in carefully selected patients. Successful outcomes depend on accurate diagnosis, realistic treatment goals, and thorough patient counseling to avoid undesirable effects [18].

Achieving non-surgical correction is particularly challenging in adults due to the absence of growth potential. Nevertheless, many adult patients prefer non-surgical options because of their reluctance to undergo orthognathic surgery.

This case report describes the management of a 9-year-old growing female patient with a concave facial profile, anterior crossbite accompanied by an anterior open bite, and misaligned maxillary incisors, consistent with skeletal Class III malocclusion treated using growth modification in combination with fixed orthodontic appliances.

Case Report

A 9-year-old female patient reported to the orthodontic clinic with the chief complaint of a protruded lower jaw and a deficient upper

jaw, accompanied by an anterior open bite and reverse overjet.

Extraoral examination

Extraoral evaluation revealed an oval facial form with a concave profile. The patient exhibited competent lips, a deficient chin, maxillary deficiency, a thin upper lip, and protruded lower lip (Figure 1).

Comment

The concave profile is indicative of an underlying skeletal Class III pattern, predominantly due to maxillary deficiency rather than mandibular prognathism.

Figure 1: Pretreatment extraoral photographs showing an oval facial form, concave profile, deficient chin and maxilla, thin upper lip, protruded lower lip, competent lips, and an normal nasolabial angle.

Intraoral examination

The patient was in the early mixed dentition stage. Sagittal assessment revealed a Class III incisor relationship with a negative overjet of −1 mm. The overbite was also negative (−1 mm) in relation to teeth 11 and 21, indicating a mild anterior open bite. There was no midline deviation in either the maxillary or mandibular arches.

Early extraction of tooth 64 had resulted in premature eruption of its successor, tooth 24. The maxillary incisors were in anterior crossbite. The upper arch showed spacing and flaring of the incisors consistent with the “ugly duckling” stage.

In the mandibular arch, all permanent incisors and both permanent first molars were present. Teeth 84, 85, and 75 had permanent restorations, and both deciduous canines were retained (Figure 2)

Comment

The presence of anterior crossbite and negative overjet at this age emphasizes the need for early orthopedic intervention to prevent worsening of the skeletal discrepancy during growth.

Radiographic findings

The orthopantomograph (OPG) confirmed early mixed dentition with the presence of all permanent teeth except the third molars. Early eruption of tooth 24 was evident due to the premature extraction of tooth 64.

Lateral cephalometric analysis revealed a skeletal Class III relationship (ANB:-0.5°) with a mild skeletal open bite tendency (maxillary–mandibular plane angle: (23°), slightly increased gonial angle (128°), proclined upper incisors (U1–NA: 27°), proclined lower incisors (L1–NB: 35°), and a normal nasolabial angle (NLA 112°) (Figure 3).

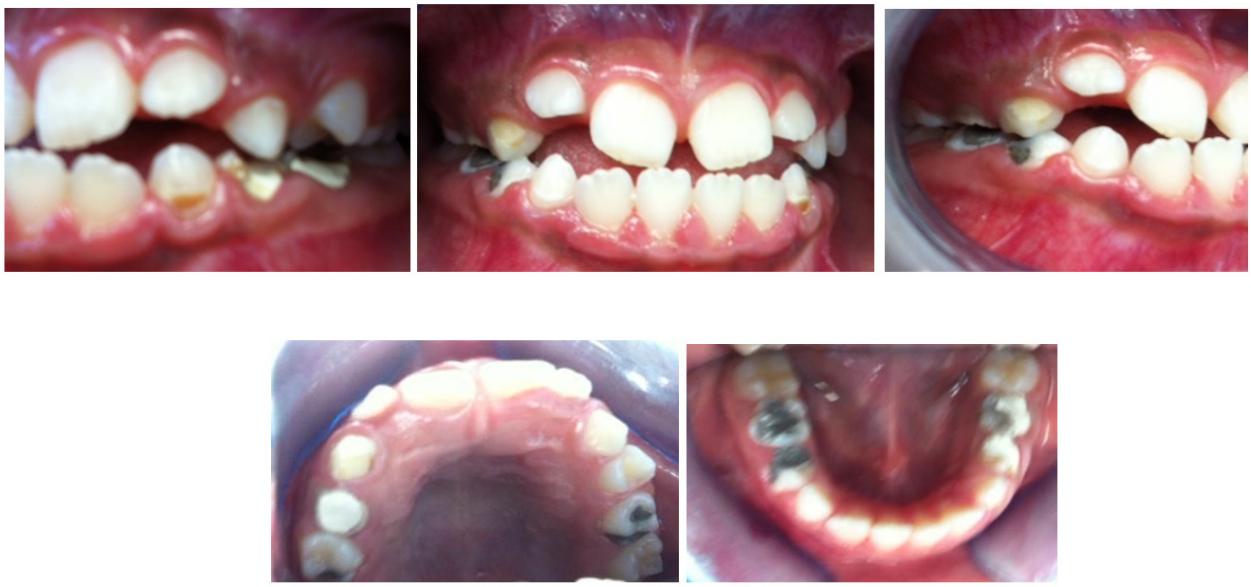

Figure 2: Pretreatment intraoral photographs show a Class III incisor relationship with negative overjet and overbite. The maxillary arch is in mixed dentition with spaced and flared incisors.

Comment

The skeletal maturity stage and maxillary deficiency supported the decision for early orthopedic correction to harness remaining growth potential.

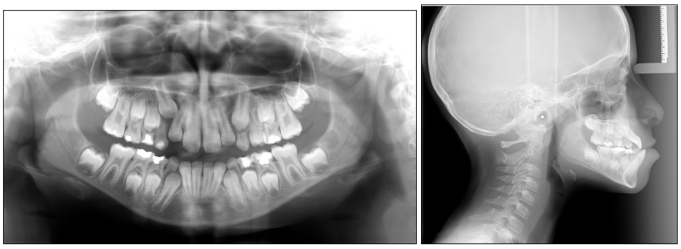

Figure 3: Pretreatment OPG, lateral cephalogram show early mixed dentition and skeletal Class III pattern.

Treatment objective

The orthodontic treatment objectives were to:

1. Correct the anterior crossbite.
2. Achieve Class I molar and canine relationships.
3. Establish normal overjet and overbite.
4. Align and level both dental arches.

Treatment

Phase I Treatment: Orthopedic Intervention

Treatment Procedure

1. Impressions and Appliance Fabrication

After band selection and adaptation on the maxillary first molars, alginate impressions of both arches were taken. A Hyrax-type fixed rapid maxillary expansion (RME) appliance was fabricated.

2. Appliance Placement and Activation

The Hyrax appliance was cemented, and the patient was instructed to activate the expansion screw by one-quarter turn (0.25 mm) twice daily—once in the morning and once in the evening.

3. Monitoring and Diastema Stabilization

The activation protocol continued for ten days. At the follow-up visit, the presence of a midline diastema was clinically confirmed, indicating successful maxillary expansion. Flowable composite resin was placed to stabilize the expansion and minimize relapse, allowing for bone formation at the mid-palatal suture.

4. Observation Period

Following active expansion, the patient was placed under observation to allow spontaneous eruption of the remaining permanent teeth.

Comment

Early maxillary expansion at this stage not only corrects transverse deficiency but also facilitates favorable sagittal changes in growing Class III patients.

Phase II Treatment: Comprehensive Fixed Orthodontic Therapy

Once the remaining permanent teeth had erupted, comprehensive orthodontic treatment was initiated using a pre-adjusted edgewise appliance with a 0.022 × 0.025-inch MBT prescription.

Treatment Progression

Upper Arch

- **Leveling and Alignment:** 0.014-inch and 0.016-inch Nickel–Titanium (NiTi) archwires
- **Space Closure and Tooth Movement:** 0.016 × 0.022-inch Stainless Steel archwire
- **Torque Expression and Finishing:** 0.017 × 0.025-inch NiTi followed by 0.019 × 0.025-inch NiTi archwire

Lower Arch

- **Leveling and Alignment:** 0.014-inch and 0.016-inch NiTi archwires
- **Space Closure and Alignment:** 0.016-inch and 0.016 × 0.022-inch Stainless Steel archwires
- **Finishing:** 0.017 × 0.022-inch NiTi followed by 0.019 × 0.022-inch NiTi and SS arch wire

Finishing and Occlusal Detailing

A final 0.018-inch Stainless Steel arch wire was placed in both arches for re-leveling and detailed finishing. Class III and vertical elastics (5/16-inch, 4.5 oz) were used to achieve optimal intercuspation.

Treatment Outcome

All treatment objectives were successfully achieved, including correction of the anterior crossbite, establishment of Class I molar and canine relationships, normalization of overjet, overbite, and satisfactory occlusal intercuspation. Hence, both arches were debonded.

Retention

Post-treatment records were obtained. Retention protocol included:

- Upper and lower vacuum-formed retainers.
- A fixed modified figure-of-eight retainer extending from teeth 33 to 43 in the mandibular arch.

Comment

Long-term retention is essential in Class III cases due to the potential for residual mandibular growth and relapse.

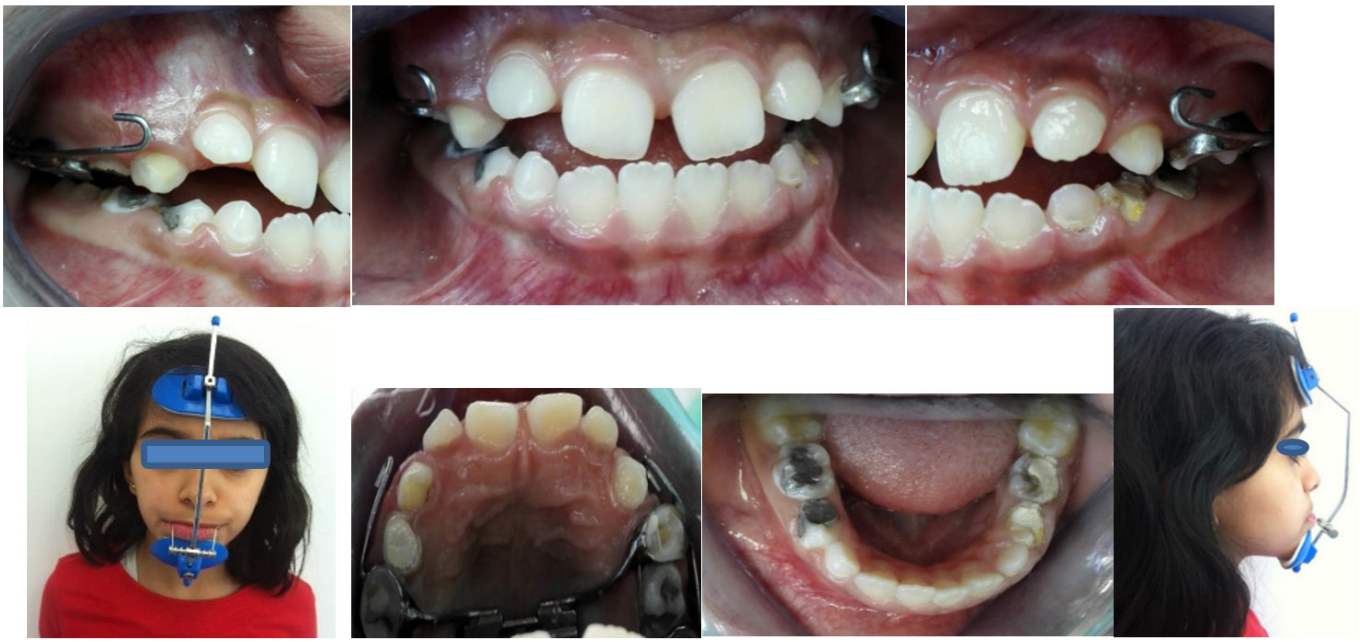

Figure 4 Phase 1: Treatment: cementation of rapid maxillary expander with Face Mask.

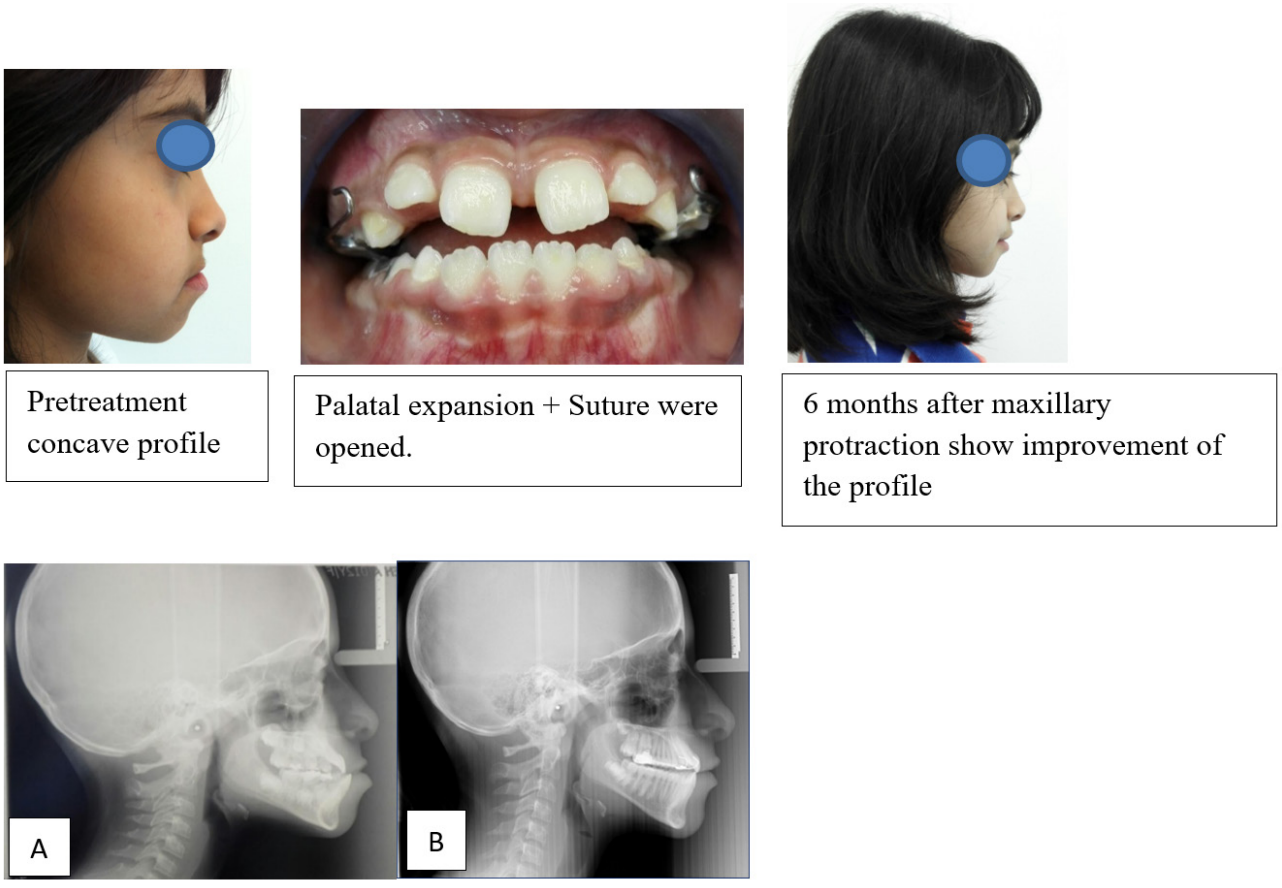

Figure 5: Three months after palatal expansion and maxillary protraction. (A) Pretreatment radiograph and (B) the result after 6 months using RME and Face mask.

Figure 6: Phase 2 treatments: Upper photos show patient profile was improved, and lower photos Show all permanent teeth erupted with positive overjet and overbite.

Figure 7: Phase 2 during orthodontic treatment: bonding upper and lower arches (MBT system 0,022 slot) + Class III elastics 5/16, 4.5 OZ + 12 OZ Elastic face mask.

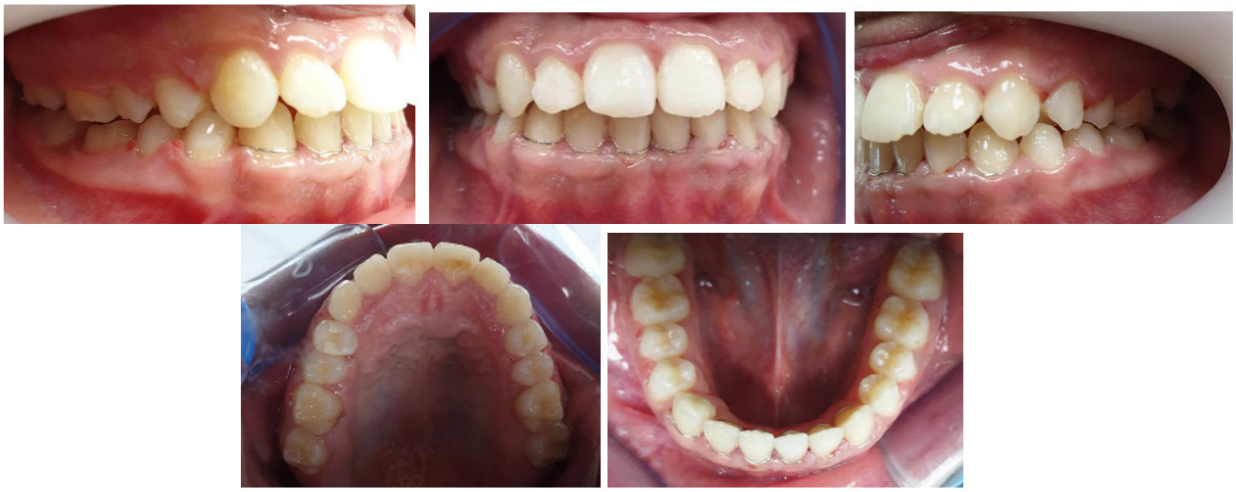

Figure 8: Intra oral views after debonding with Figure 8 long ligature wire set around the lower anterior segment in addition to the lower and upper vacuum retainers.

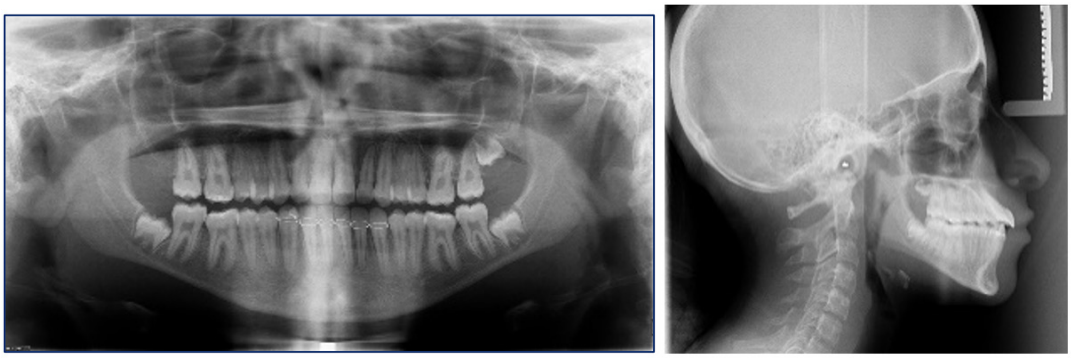

Figure 9: OPG and Lateral skull radiograph after debonding. OPG showed eruption and alignment of all teeth except third molars. 28 was congenitally absent??.

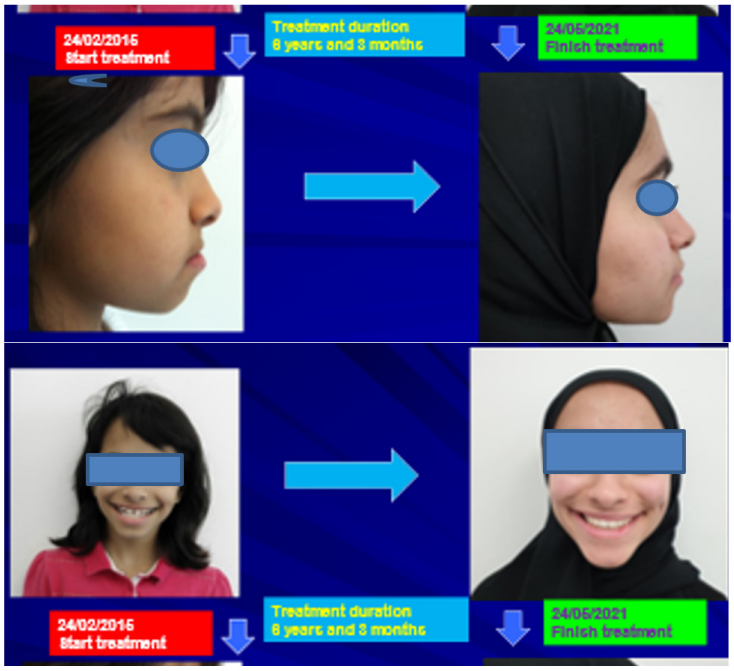

Figure 10: Extraoral view of patient profile before and after treatment (top) as well as front view before and after treatment (below).

Figure 11: Extraoral photos showed profile improvement from start of treatment to end of treatment.

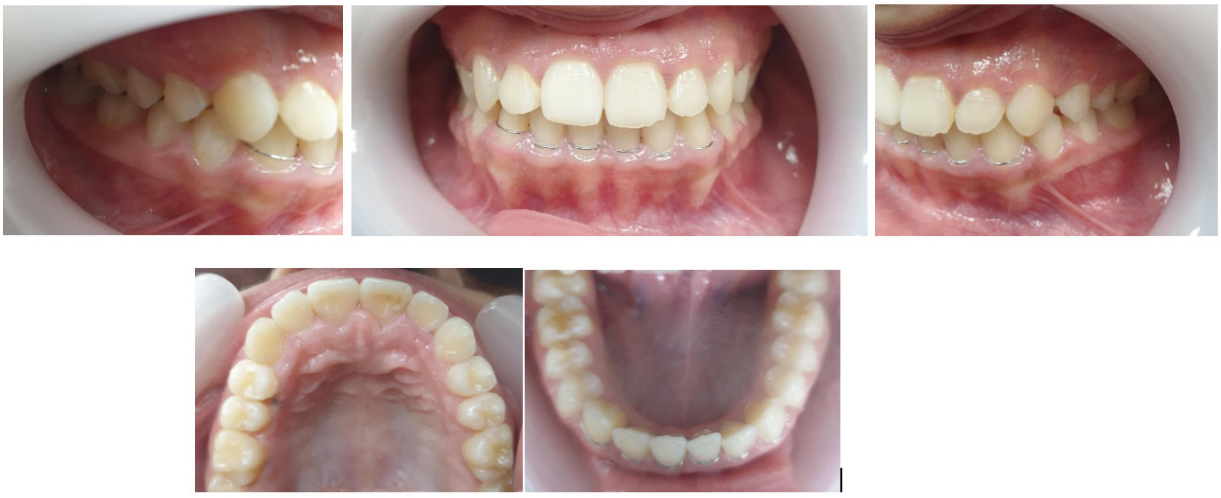

Figure 12: Intraoral view after seventeen months post-treatment, showed stable result.

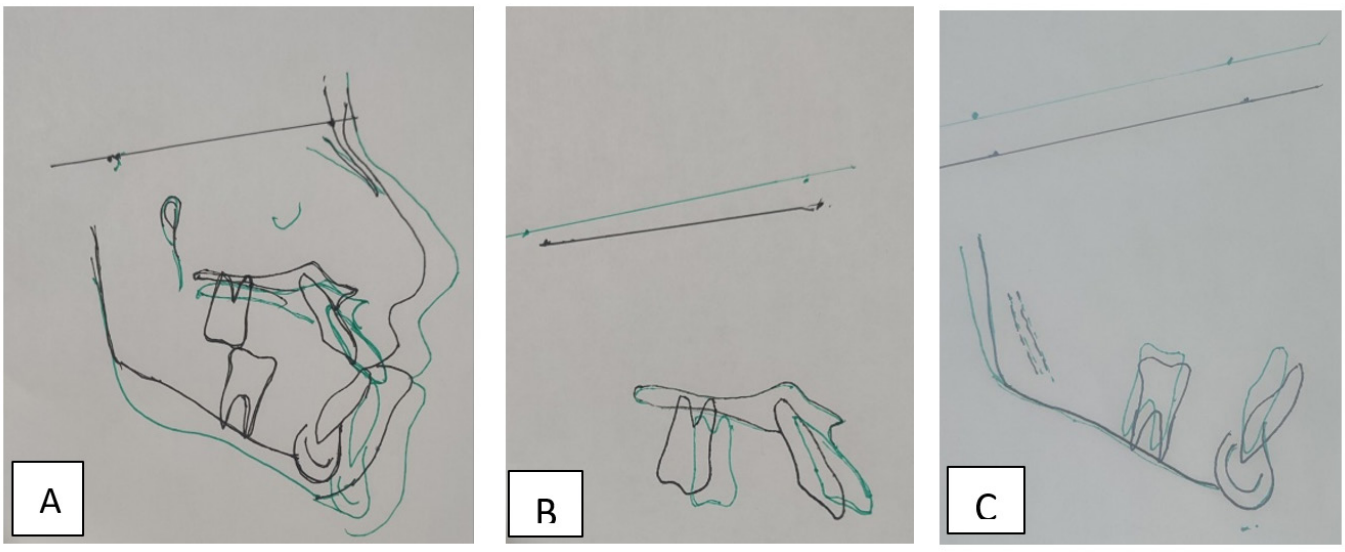

Figure 13: Superimpositions of overall changes (A), Upper dental changes (B) and lower dental changes (C).

Table 1: Cephalometric pre-treatment, post-treatment and post-retention value.

Variable	Pretreatment	Post-treatment
SNA	84.5	85
SNB	85	84
ANB	-0.5	1
SN-Pog	85	84
N-Sella-Ba	128	132
Ar-Go-Me	128	128
NL-SNL	18	15
ML-SNL	41	37
ML-NL	23	22
UI-LI	117	127
UI-NA	27	30
UI-NA mm	+6mm	+8mm
LI-NB	35	22
LI-NB mm	9mm	4mm
Facial index	86.3	84.2
Upper lip-E line	0 mm	-2mm
Lower lip –E line	+3mm	+1mm
Nasolabial angle	112	105

Cephalometric Summary, pre-treatment and post-treatment

Pretreatment cephalogram revealed a mild skeletal Class III tendency with increased mandibular plane angle. Superimposition showed a stable cranial base and maxilla, confirming absence of significant skeletal jaw displacement. The mandible demonstrated counterclockwise rotation with reduction of the mandibular plane angle, leading to improvement in sagittal jaw relationship. Upper incisors were proclined and advanced, while lower incisors were retroclined and repositioned posteriorly, indicating effective dental camouflage. The ANB angle improved toward a Class I relationship. Soft tissue profile showed improved lip balance and facial harmony post-treatment. Hence, no major skeletal jaw displacement, effective dental movements, mandibular rotation, vertical correction and successful Class III camouflage treatment with improved facial esthetics

Discussion

Skeletal Class III malocclusion often results from antero-posterior and vertical maxillary deficiency, either due to a small or retrusive maxilla or indirectly via insufficient vertical maxillary growth, which can lead to upward and forward mandibular rotation, creating apparent mandibular prognathism [19]. Because maxillary deficiency is common in Class III cases, treatment strategies primarily focus on stimulating maxillary growth, although high-quality randomized clinical trial data remain limited [19]. In growing children, growth modification can be achieved by restraining mandibular forward growth or promoting maxillary advancement, improving both skeletal and dental relationships [20].

Management of maxillary deficiency typically involves three approaches: Frankel's FR-III functional appliance, reverse-pull facemask, and Class III elastics anchored to skeletal structures [19]. The FR-III appliance repositions the mandible posteriorly and incorporates lip pads to stretch the upper lip, stimulating forward maxillary growth via periosteal stretching. Long-term studies demonstrate that sustained use can significantly improve maxillary size and position, mandibular position, incisor inclination, and overjet, with stability observed for up to six years [21]. Facemask therapy applies protraction forces to the peri-maxillary sutures and is often combined with rapid palatal expansion to enhance skeletal effects [22]. Evidence indicates that maxillary protraction is most effective when initiated before 8 years of age, with long-term studies showing greatest skeletal benefit when started before age 10, as the potential for forward maxillary repositioning diminishes after puberty.

In the present case report, a Petit facemask was selected for its comfort during sleep, ease of adjustment, and reduced bulk compared with the Delaire facemask, minimizing interference with daily activities [19]. A banded rapid maxillary expander (Hyrax) was used to open the mid-palatal suture, activated twice daily for 10 days. The appearance of a diastema between the maxillary central incisors confirmed successful suture loosening. Recommended protraction forces of 350–450 g per side were applied for 12–14 hours per day, initiated after eruption of the permanent incisors and first molars to optimize anchorage control and minimize dental compensation [19,23].

Following the planned expansion, the screw was stabilized using a ligature wire to prevent relapse, and the appliance was maintained passively to allow consolidation of the expanded maxillary segments through new bone formation at the mid-palatal suture [24-26]. This stabilization preserved transverse correction and provided a solid orthopedic foundation for facemask protraction, ensuring that forces were directed to skeletal structures rather than dentition [27,28].

Orthodontic camouflage was achieved without compromising facial esthetics. The combined orthopedic and orthodontic approach in this present case report patient produced forward displacement of the maxilla, improved the maxillo-mandibular relationship, and reduced the skeletal Class III discrepancy. Mandibular incisor retraction, often associated with increased chin prominence, was controlled, while maxillary incisor advancement occurred in concert with underlying skeletal protraction rather than excessive proclination. These coordinated changes resulted in improved dental intercuspation, normal overjet and overbite, and preservation of facial harmony. The favorable skeletal and dento-alveolar adaptations highlight the efficacy of early orthopedic intervention in enhancing Class III camouflage treatment outcomes [23,26].

The patient's pre-adolescent status (CVM I–II) provided an ideal biological window for growth modification, allowing achievement of a stable, functional Class I occlusion and harmonious facial profile without orthognathic surgery [29,30]. Subsequent transition to the MBT fixed appliance system facilitated precise final alignment, occlusal interdigitation, and root parallelism, while

maintaining light, continuous forces to manage dento-alveolar compensations effectively [31,32].

The cephalometric findings of the present case demonstrated a mild skeletal Class III pattern managed primarily through orthodontic camouflage. Superimposition confirmed cranial base and maxillary stability, with sagittal improvement achieved mainly by counterclockwise mandibular rotation and reduction of the mandibular plane angle. Dental compensation involved upper incisor proclination and lower incisor retroclination, effectively correcting the sagittal discrepancy. These changes resulted in improved ANB values, enhanced vertical control, and a more harmonious soft tissue profile.

This case report demonstrates that comprehensive, sequential treatment combining expansion, facemask protraction, and fixed appliance finishing can successfully camouflage skeletal Class III malocclusion in growing patients, avoiding surgical intervention while achieving long-term esthetic and functional stability. Early timing, careful appliance selection, and controlled mechanics were critical to the favorable outcome observed in this patient.

Conclusion

Skeletal Class III malocclusion is a complex condition characterized by an anterior positioning of the mandible relative to the maxilla, influenced by both genetic and environmental factors. Comprehensive diagnosis requires careful assessment of skeletal and dental components, including molar relationships, craniofacial morphology, and incisor positioning.

The patient of this case report demonstrates that early, growth-modification treatment—initiated in the pre-adolescent stage—can effectively address maxillary deficiency, redirect mandibular growth, and achieve a functional and esthetically pleasing Class I occlusion without orthognathic surgery. Sequential treatment combining rapid maxillary expansion, facemask protraction as well as fixed MBT appliance finishing; enables controlled skeletal and dento-alveolar correction, ensuring proper occlusal interdigitation, alignment, and long-term stability.

Early intervention maximizes skeletal response, reduces the need for extensive dental compensation, and provides a viable non-surgical alternative for selected growing patients. This approach not only achieves favorable esthetic and functional outcomes but also mitigates the psychological, financial, and medical burdens associated with surgical treatment. Timely, well-planned, and carefully executed orthodontic treatment is therefore critical in managing growing Class III patients effectively.

References

1. Proffit WR, Fields HW, Sarver DM, et al. Contemporary Orthodontics. 4th ed. St. Louis: Mosby. 2007; 71: 1599-1600.
2. Angle EH. Classification of malocclusion. Dent Cosmos. 1899; 41: 248-264.
3. Bora P, Agrawal P, Bagga DK, et al. Applications of cone beam computed tomography in orthodontics: an overview. Biosci Biotechnol Res Commun. 2020; 13: 168-172.
4. Burns NR, Musich DR, Martin C, et al. Class III camouflage treatment: what are the limits? Am J Orthod Dentofacial Orthop. 2010; 137: 1-13.
5. Liu Y, Hou R, Jin H, et al. Relative effectiveness of facemask therapy with alternate maxillary expansion and constriction in early treatment of Class III malocclusion. Am J Orthod Dentofacial Orthop. 2021; 159: 321-332.
6. Westwood PV, McNamara JA Jr, Baccetti T, et al. Long-term effects of rapid maxillary expansion and facemask therapy in Class III patients. Am J Orthod Dentofacial Orthop. 2003; 123: 306-320.
7. Huynh Le BN, Goonewardene M, Duigou C, et al. Long-term efficacy of rapid maxillary expansion and facemask therapy in Class III malocclusion. Aust Orthod J. 2020; 36: 27-37.
8. Daher W, Caron J, Wechsler MH. Nonsurgical treatment of an adult with a Class III malocclusion. Am J Orthod Dentofacial Orthop. 2007; 132: 243-251.
9. Hannuksela A, Väänänen A. Predisposing factors for malocclusion in 7-year-old children with special reference to atopic disease. Am J Orthod Dentofacial Orthop. 1987; 92: 299-303.
10. Graber TM, Vanarsdall RL, Vig KWL, et al. Orthodontics: Current Principles and Techniques. St Louis: Mosby. 2005.
11. Hardy DK, Cubas YP, Orellana MF. Prevalence of Angle Class III malocclusion: a systematic review and meta-analysis. Open J Epidemiol. 2012; 2: 75-82.
12. Ngan P. Treatment of Class III malocclusion in the primary and mixed dentitions. In: Bishara SE, editor. Textbook of Orthodontics. Philadelphia: WB Saunders. 2001; 375.
13. Altemus LA. Frequency of the incidence of malocclusion in American Negro children aged twelve to sixteen. Angle Orthod. 1959; 29: 189-200.
14. Garner LD, Butt MH. Malocclusion in black American and Nyeri Kenyans. Angle Orthod. 1985; 55: 139-146.
15. Moullas AT, Palomo JM, Gass JR, et al. Nonsurgical treatment of a patient with a Class III malocclusion. Am J Orthod Dentofacial Orthop. 2006; 129: 111-118.
16. Sugawara Y, Kuroda S, Tamamura N, et al. Adult patient with mandibular protrusion and unstable occlusion treated with titanium screw anchorage. Am J Orthod Dentofacial Orthop. 2008; 133: 102-111.
17. Kuroda S, Tanaka E. Application of temporary anchorage devices for the treatment of adult Class III malocclusions. Semin Orthod. 2011; 17: 91-97.
18. Burns NR, Musich DR, Martin C, et al. Class III camouflage treatment: what are the limits? Am J Orthod Dentofacial Orthop. 2010; 137: 1-13.
19. Harvold EP. The Activator in Interceptive Orthodontics. St Louis: CV Mosby. 1974.

20. Al Khalifa HN. Orthopedic correction of Class III malocclusions during mixed dentition. Open J Stomatol. 2014; 4: 372-380.
21. Levin AS, McNamara JA Jr, Franchi L, et al. Short-term and long-term treatment outcomes with the FR-3 appliance of Fränkel. Am J Orthod Dentofacial Orthop. 2008; 134: 513-524.
22. Maino G, Turci Y, Arreghini A, et al. Skeletal and dentoalveolar effects of hybrid rapid palatal expansion and facemask therapy in growing skeletal Class III patients. Am J Orthod Dentofacial Orthop. 2018; 153: 262-268.
23. McNamara JA Jr, Lione R, Franchi L, et al. The role of rapid maxillary expansion in the promotion of oral and general health. Prog Orthod. 2015; 16: 33.
24. Haas AJ. Rapid expansion of the maxillary dental arch and nasal cavity by opening the midpalatal suture. Angle Orthod. 1961; 31: 73-90.
25. Haas AJ. The treatment of maxillary deficiency by opening the midpalatal suture. Angle Orthod. 1965; 35: 200-217.
26. Baccetti T, Franchi L, Cameron CG, et al. Treatment timing for rapid maxillary expansion. Angle Orthod. 2001; 71: 343-350.
27. Nartallo Turley P, Turley PK. Cephalometric effects of combined palatal expansion and facemask therapy on Class III malocclusion. Angle Orthod. 1998; 68: 217-224.
28. Baccetti T, McGill JS, Franchi L, et al. Skeletal effects of early treatment of Class III malocclusion with maxillary expansion and facemask therapy. Am J Orthod Dentofacial Orthop. 1998; 113: 333-343.
29. Mandall NA, Cousley R, DiBiase AT, et al. Is early Class III protraction facemask treatment effective? A multicentre randomized controlled trial: 3-year follow-up. J Orthod. 2010; 37: 149-161.
30. Mandall N, Cousley R, Di Biase A, et al. Early Class III protraction facemask treatment reduces the need for orthognathic surgery: a multicentre randomized controlled trial. J Orthod. 2016; 43: 164-175.
31. McLaughlin RP, Bennett JC, Trevisi HJ. Systemized Orthodontic Treatment Mechanics. Edinburgh Mosby. 2001.
32. Bennett JC, McLaughlin RP. Orthodontic treatment mechanics and the preadjusted appliance. J Clin Orthod. 1990; 24: 251-260.

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