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Class III malocclusion treated with a 3D-printed hybrid hyrax distalizer combined with mentoplate using Alt-RAMEC protocol: A case report

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Abstract

Introduction: The aim of this report was to assess the skeletal, dental and soft tissue changes in a juvenile patient with a severe class III malocclusion. This case report describes a novel method of class III treatment using skeletal anchorage for maxillary protraction and Alt-RAMEC protocol.

Patient concerns: The patient did not have any subjective complaints before treatment and there was no family history of class III malocclusion.

Clinical findings and primary diagnoses: Extra-orally, the patient had a concave profile with a retrusive mid-face and prominent lower lip. The intra-oral examination revealed angle class III malocclusion with a −3-mm overjet. There was no anterior displacement on closure when the patient was assessed clinically. According to the cephalometric analysis, the sagittal jaw relation and Wits appraisal were reduced due to a retrognathic maxilla and prognathic mandible.

Interventions: The treatment plan involved maxillary protraction, Alt-RAMEC protocol for 10 weeks and upper molar distalisation with a hybrid hyrax distalizer in combination with a mentoplate. The active treatment time was estimated to 18 months followed by 6 months retention with the appliance.

Outcomes: The sagittal jaw relationship was increased by approximately 9°, mainly due to maxillary advancement of 8 mm and a positional change of the mandible anteroposteriorly. Natural decompensation of the lower incisors was also observed. In addition, both the facial profile and the smile became more harmonious after treatment. The treatment analysis revealed that the changes achieved were mainly skeletal and it was possible to avoid adverse effects on the dentition.

Conclusion: In conclusion, treatment with a hybrid hyrax distalizer combined with mentoplate using the Alt-RAMEC protocol is effective in correcting the anteroposterior discrepancy in a juvenile class III patient and it is possible to achieve maxillary advancement of 8 mm.

Keywords

Angle class III, maxillary protraction with skeletal anchorage, mentoplate, Alt-RAMEC, case report

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Introduction

The prevalence of class III malocclusion is in the range of 1%–20% in different countries (Alhammadi et al., 2018); in Denmark, it is estimated to be 1.8% (Helm, 1968).

The aetiology of reverse overjet can be attributed to environmental or genetic factors (Battagel, 1993; Ellis and

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McNamara, 1984). The craniofacial morphology is most often characterised by a retrognathic maxilla, a prognathic mandible or both. About half of the patients with a class III skeletal relationship are reported to have maxillary retrognathism (Ellis and McNamara, 1984), hence maxillary protraction is essential.

Different treatment options exist in order to correct the skeletal deficiency, including maxillary protraction with facemask or bone plates according to De Clerck et al. (2010). The use of temporary anchorage devices (TADs) provides absolute anchorage for tooth movement in order to avoid dental adverse effects (Rutili et al., 2023; Wang et al., 2022) in terms of mesialisation of the maxillary dentition, proclination of upper incisors and dental crowding with the risk of impaction of permanent teeth, especially the maxillary canines.

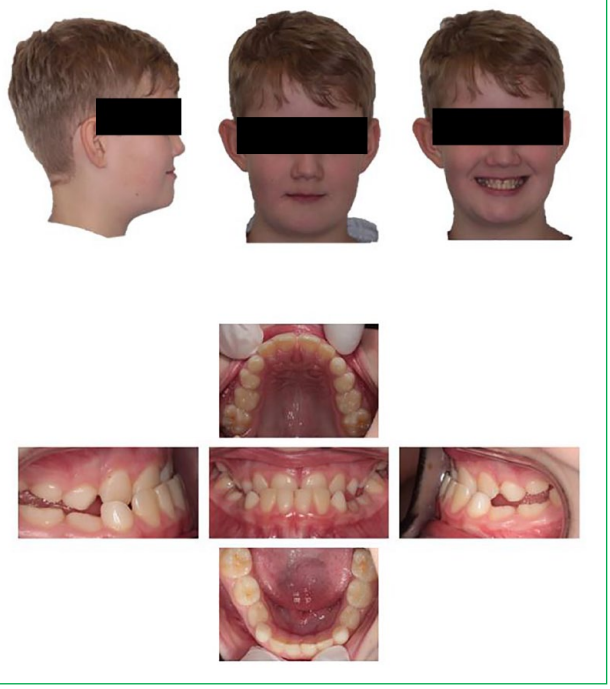
Correction of class III malocclusion in growing patients using a mentoplate combined with a hybrid hyrax distalizer was introduced by Wilmes et al. (2011, 2014). This treatment modality has several advantages, including distalisation of the upper first molars and transverse expansion simultaneously with maxillary advancement. Another significant advantage is that it is an intra-oral device, which makes it easier for the patient to wear full-time compared to a face mask, for instance. The symphyseal placement of the mentoplate allows early onset of treatment without waiting for the eruption of permanent teeth. The combination of the hybrid hyrax appliance in the upper jaw and mentoplate in the lower jaw transfers the orthopaedic forces to the skeletal structures resulting in a mainly skeletal effect.

Performing Alternate Rapid Maxillary Expansion and Constriction (Alt-RAMEC) protocol simultaneously with maxillary protraction was introduced by Liou in 2005 (Liou and Tsai, 2005). The aim of this protocol is to disarticulate the circumferential maxillary sutures to gain greater maxillary advancement. According to Liou et al., the protocol consists of 9 weeks of alternate rapid maxillary expansion and constriction with an activation rate of 1 mm/day corresponding to 7 mm/week followed by approximately 3 months of maxillary protraction in class III patients. Daily activation of the weekly expansion or constriction results in a significantly greater anterior displacement of the maxilla compared to rapid maxillary expansion (RME). With Alt-RAMEC, the center of rotation is opened at the level of the posterior nasal spine and the tuber maxillae moves more forward whereby mobilisation of the sutures are more evident and resistance structures are weakened (Büyükçavuş, 2019; Liou and Tsai, 2005).

History

This case report includes a 10-year-old male patient with a class III malocclusion who received treatment with a hybrid hyrax distalizer and mentoplate for Alt-RAMEC, maxillary protraction and upper molar distalisation at the Department of Oral and Maxillofacial Surgery, University Hospital of Southern Denmark during the period between 10 December 2019 and 19 November 2021.

Figure 1. Pre-treatment facial and intra-oral photographs.



Informed consent was obtained from the parents. In addition, permission was given to use photographs in publications.

In general, shortly after the class III diagnosis had been made by the Municipality Clinic of Orthodontics, the patient was referred to the Department of Oral and Maxillofacial Surgery, where the same orthodontist throughout the treatment period evaluated the patient clinically and radiographically.

Patient information: The patient did not have any subjective complaints and there was no family history of class III malocclusion. The patient had not received orthodontic treatment previously.

Assessment

Extra-oral assessment

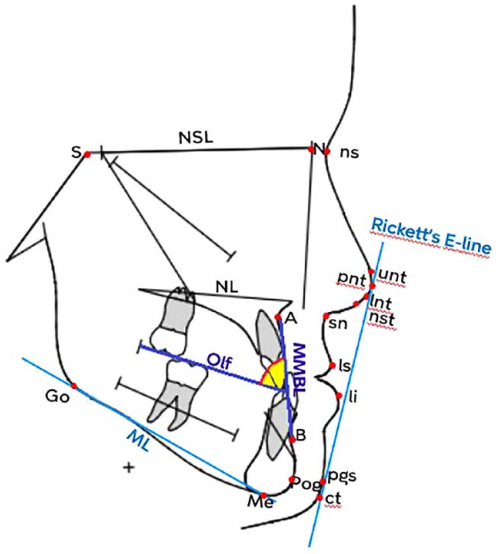
The patient had a concave profile with hypoplasia of the mid-face, increased tension of the mentalis muscle and a prominent lower lip (Figure 1). The maxillary midline was coincident with the facial midline while the mandibular midline was shifted 2 mm towards right due to posterior occlusal interferences.

Intra-oral assessment

Clinical evaluation revealed an angle class III malocclusion characterised by an anterior crossbite involving all incisors

Figure 2. Pre-treatment radiographs: panorama and lateral cephalogram.

Figure 3. Cephalometric measurements.



and a half cusp mesial molar relation on both sides. Molar occlusion was evaluated based on plaster models. The overjet was −3 mm and overbite was 4 mm. The posterior crossbite in the primary teeth was accompanied by a mandibular shift producing a lower midline deviation by 2 mm to the right. There was no anterior displacement on closure when the patient was assessed clinically.

Diagnostic assessment

Radiographic assessment

A cephalometric radiograph in the lateral projection was obtained with the patient's head in a natural head position with maximum intercuspation and the lips at rest (Figure 2). Identification of landmarks and measurements of the cephalometric images were carried out by the same investigator using TIOPS software (www.Tiops.com; Roskilde, Denmark). Anatomic landmarks and reference planes were defined based on the existing literature (Björk, 1971; Ingerslev and Solow, 1975; Kreiborg, 1981; Riolo and Moyers, 1974) (Figure 3, Tables 1 and 2). In case of double contour, the mid-point between the two sides was marked. Superimposition was performed on the stable structures in the anterior cranial base. The cephalometric radiograph revealed a reduced sagittal jaw relation and Wits appraisal due to a retrognathic maxilla and a prognathic mandible. The maxilla was retrognathic in relation to the cranial base and mandible, respectively. Furthermore, the vertical jaw relation was relatively normal before treatment with a relatively normal inclination of the maxilla in relation to the anterior cranial base. In addition, the patient had an almost normal inclination of the upper incisors and an extreme retroclination of the lower incisors as an expression of dentoalveolar compensation to the altered sagittal jaw relation.

An orthopantomographic radiograph was obtained under standardised conditions. The panoramic radiograph revealed that maxillary third molar was erupting occlusally to the second molar on the left side.

Therapeutic intervention

Aim of treatment

The treatment objective involved elimination of the class III malocclusion by maxillary advancement and avoiding adverse effects on the dentition.

Treatment plan

The chosen treatment involved a hybrid hyrax distalizer combined with a mentoplate to correct the skeletal discrepancy. As an alternative, a hybrid hyrax combined with facemask was considered but the patient did not want to wear an extra-oral appliance. Proclining the upper incisors with removable or fixed appliances were not in accordance with the aim of the treatment, which was to correct the skeletal discrepancy and improve the facial appearance while avoiding side effects on the dentition.

Table 1. Cephalometric measurements before and after treatment (the cephalometric analysis is based on Caucasian norms).

Cephalometric analysis	Norm	Pre treatment (T0)	Post treatment (T1)
Anteroposterior changes			
SNA	81.5	77.4	82.4
SNB	77.2	84.2	80.5
ANB	2	−6.7	1.9
Angular Wits (MMBL/OLf)	85.2	67.0	84.5
Linear Wits (mm)	−1	−11	−4
Vertical relations			
Vertical jaw relation (ML/NL)	23.9	24.8	26.5
Maxilla inclination (NSL/NL)	6.5	5.8	4.2
Mandible inclination (NSL/ML)	30.4	30.6	30.7
Occlusalplane inclination (NSL/OLf)	21.9	18.3	18.1
Dento-alveolar relations			
Upper incisor inclination (ILs/NL)	111.0	108,9	100.9
Lower incisor inclination (ILi/ML)	98.0	72.2	90.2
Interincisal angle (ILs/ILi)	128.0	154.1	142.4
Soft tissue			
Convexity (ns-sn-pgs)	163.0	178.8	165.5
Nasolabial angle (nst-sn-ls)	109.0	101.5	98.4
Upper lip position to E-line (mm)	−2.8	−3.4	−0.5
Lower lip position to E-line (mm)	−2.7	−4.4	0.2

Treatment progress

The surgical insertion of the mentoplate in the lower jaw and temporary anchorage devices (TADS) in the upper jaw was performed under general anaesthesia by a maxillofacial surgeon. The protocol of insertion was inspired by Wilmes et al. (2011). Two mini-implants 2.0 × 9 mm from the Benefit system were placed paramedian in the line of force in the anterior palate distal to the third rugae. The distance between the mini-implants was approximately 7 mm. A mucoperiosteal flap was raised and a mentoplate with four holes and 11 mm bar from PSM system (Benefit PSM Medical Solutions, Guningen, Germany; www.psm.ms) was used (Figure 4) and hooks were bent buccally to the mandibular canines during surgery. The mentoplate was fixed with four mini-implants 2.0 × 9 mm from the Benefit system. The mentoplate emerged at the mucogingival junction. Postoperatively, the patient was instructed in cleaning the hooks of the mentoplate twice daily with chlorhexidine applied on a cotton swab for 1 week. Furthermore, the patient was advised to brush the palatal mini-implants 3–4 times daily in order to keep the palatal mucosa away and avoid gingival overgrowth, which might increase the risk of mini-implant failure.

A digital impression of the maxilla using 3Shape scanner (model 3 basic; www.3shape.com) was taken in order to manufacture a 3D-printed hybrid hyrax distalizer (lab Roskilde Orto-Teknik ApS; www.rot.dk) (Figure 4). The design is according to Wilmes et al. (2014). The hyrax (10 mm from PSM) and distalizer screws (12 mm from PSM) produce an expansion of 0.2 mm per quarter turn. The hybrid hyrax distalizer was cemented using Unitek Multi-Cure GI orthodontic band cement and locked to the palatal TADS by fixation screws and composite flow (Figure 4). Despite the lack of a transversal discrepancy on the level of the upper first molars, a hyrax screw was added to the appliance to perform the Alt-RAMEC protocol. The protocol consisted of rapid expansion for 1 week with an expansion rate of 0.4 mm per day followed by turning the screw in the opposite direction for another week and continuing this procedure for a 10-week period.

Table 2. Explanation of the cephalometric variables.

Cephalometric analysis	Norm
Anteroposterior changes	
SNA	Sella nasion A-point
SNB	Sella nasion B-point
ANB	A-point nasion B-point
Angular Wits (MMBL/OLf)	The angle between the maxilla-mandibular base line (MMBL) and the functional occlusal plane. Reflects the degree of adaptation of the occlusal plane to the actual jaw base relations. A larger angle is equal to an increased sagittal jaw base relation and v.v
Linear Wits	Measurement of the distance between perpendiculars from A-point and B-point to the occlusal plane
Vertical relations	
Vertical jaw relation (ML/NL)	Mandibular line/Nasal line
Maxilla inclination (NSL/NL)	Nasion sella line/ Nasal line
Mandible inclination (NSL/ML)	Nasion sella line/ mandibular line
Occlusalplane inclination (NSL/OLf)	Nasion sella line/ functional occlusal plane
Dento-alveolar relations	
Upper incisor inclination (ILs/NL)	Upper incisor axis to nasal line
Lower incisor inclination (ILi/ML)	Lower incisor axis to mandibular line
Interincisal angle (ILs/ILi)	Angle subtended by the long axes of the maxillary and mandibular central incisors
Soft tissue	
Convexity (ns-sn-pgs)	Soft tissue Nasion – sub-nasale – soft tissue pogonion
Nasolabial angle (nst-sn-ls)	Nasal septum tangent – subnasale – labrale superius
Upper lip position to E-line (mm)	Labrale superius – Ricketts E-line
Lower lip position to E-line (mm)	Labrale inferius – Ricketts E-line

A protraction force of 130 g (Bear elastics, Ormco) were applied on each side initially followed by 170 g/side (Ram elastics, Ormco) and finally 230 g/side (Cougar elastics, Ormco). The time interval between the increase of force of the elastics was 6–8 weeks in order to give the patient sufficient time to adapt to the new force level. The patient was instructed in using intra-oral elastics from the hooks on the bands of the upper first molars directly to the mentoplate fulltime. As the patient started to develop distal molar relation, the patient was instructed in activating the distalizer screw once a week bilaterally for 5 months, yielding a distalisation of 4 mm in total.

After 1.5 years of full-time wear of intra-oral elastics, a retention period was planned, where the patient only had to use the Cougar elastics (230 g/side) at night. A 6-month retention period was necessary in order to evaluate the stability of the treatment, particularly in relation to the potential for differential mandibular growth after completion of active treatment. Debonding of the hybrid hyrax distalizer was performed after retention. Surgical removal of the mentoplate was performed shortly after debonding under general anaesthesia.

Treatment results

After the interceptive treatment, the patient experienced clinical improvement in his facial appearance, going from a concave profile to a more harmonious facial profile with an improved smile and ideal lip relation. Intra-orally, the patient had a class I molar occlusion and class II canine relation on both sides with a slightly overcorrected overjet, increased overbite and coincident midlines (Figures 5 and 6).

The cephalometric analysis revealed a normalisation of the angular Wits, an improvement in the sagittal

Figure 4. (a) A 3D printed PSM Hybrid Hyrax Distalizer, (b) mentoplate and (c) appliance in situ.

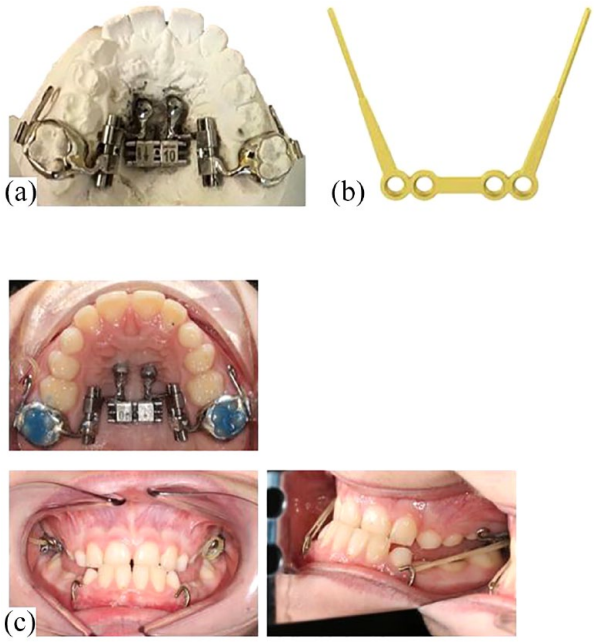
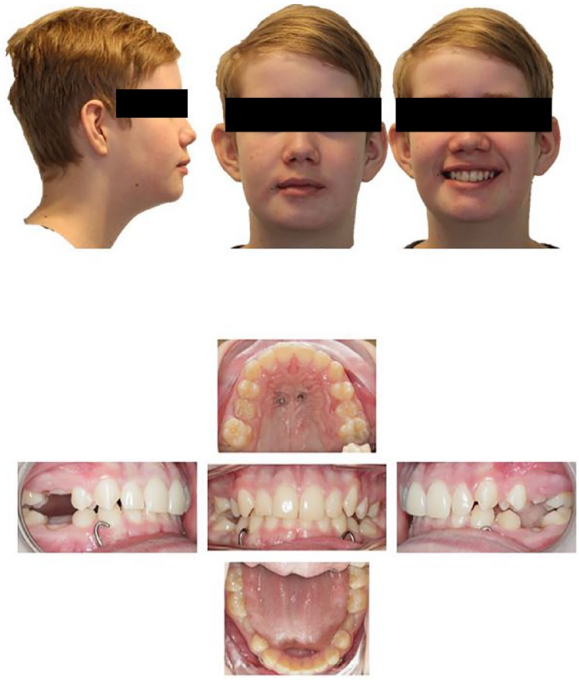
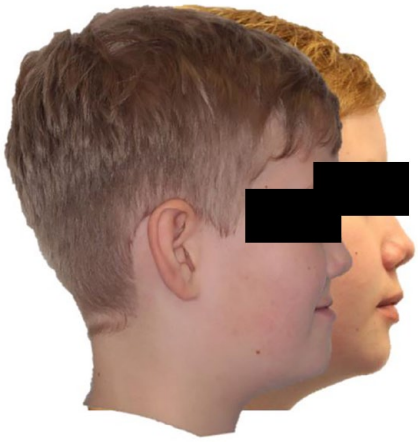


Figure 5. Post-treatment facial and intra-oral photographs.



jaw relation and 8 mm maxillary advancement. The upper incisors became more retroclined while the lower incisors became more upright (Figures 7 and 8).

Figure 6. Soft tissue changes.



The vertical jaw relation was increased (NL/ML = 26.5°) mainly due to anterior rotation of the maxilla, which is probably caused by the direction of force of the maxillary protraction; inferior to the maxillary center of resistance (Figure 7).

Figure 8 and Table 1 depict the cephalometric changes between before and after treatment.

The panoramic radiograph revealed that the maxillary second molar managed to erupt further despite the displacement of tooth 28. The patient was referred to the general dentist for further treatment and follow-up.

Limitations/complications

The patient did not experience any complications with the hybrid hyrax during treatment. The hooks of the mentoplate were adjusted regularly with a weingart as they bent in response to the elastic traction producing pressure on the lower canines. The palatal miniscrews and mentoplate were stable during treatment and did not experience loosening.

A mild extrusion of the upper molars was experienced probably due to flexibility in the appliance especially after distalisation since the distalisation screws become more bendable.

The patient did not come to any of his follow-up appointments, why it was not possible to obtain longer-term post-treatment follow-up records.

The treatment time taken into consideration might have been too long for a 10-year-old patient, but this interceptive intervention may reduce the risk of orthognathic surgery in adulthood, which is a far more complicated and invasive procedure. Furthermore, the interceptive treatment has improved oral function during growth and minimised the risk of further attrition on the upper incisors, which was due to the previous anterior crossbite. In addition, the profile became more harmonious after treatment. In general, the

Figure 7. Post-treatment radiographs: panorama and lateral cephalogram. CRmax: center of resistance of the maxilla.

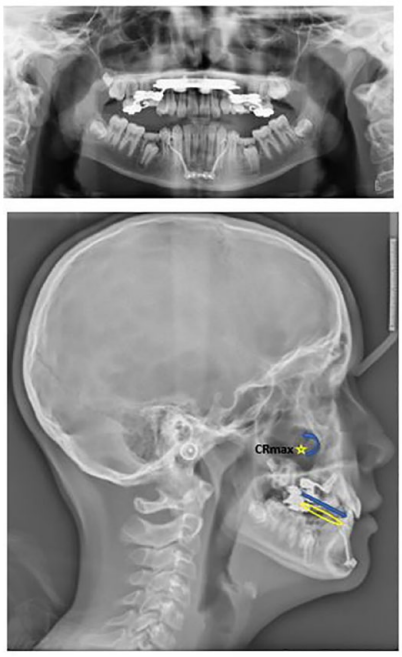
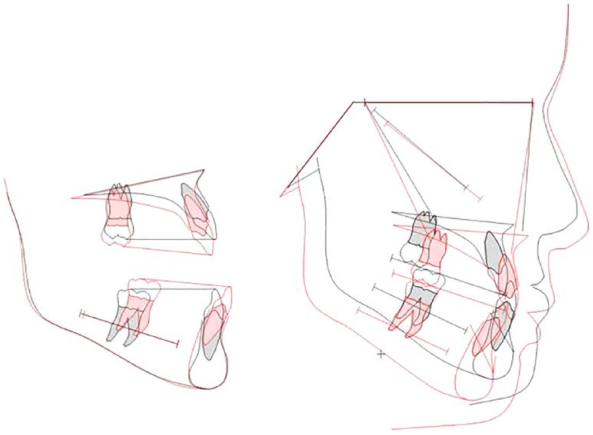


Figure 8. Cephalometric superimposition. Black: before treatment; red: after treatment.



treatment might have a positive impact on the psychosocial well-being and quality of life of the patient.

Discussion

The present case report illustrates treatment of a class III malocclusion with skeletal anchorage using a hybrid hyrax distalizer combined with mentoplate. The patient's age before treatment was 10 years, which is an appropriate age to initiate class III treatment according to the literature (Katyal et al., 2016). The subapical placement of the mentoplate made it possible to start the treatment before the eruption of the lower permanent canines.

The treatment analysis revealed that the changes achieved with the employed treatment modality was mainly skeletal and it was possible to avoid adverse effects to the dentition. Overall, the sagittal jaw relationship was increased by approximately 9°, mainly due to maxillary advancement and a positional change of the mandible anteroposteriorly due to a backward rotation of the mandible. Lowering of the maxilla after transversal expansion might have induced a backward rotation of the mandible. The line of force was inferior to the center of resistance of the maxilla whereby maxillary protraction may have induced forward rotation of the upper jaw (Figure 7) increasing the vertical jaw relation.

The angular Wits experienced a considerable increase by almost 17° thereby normalising the Wits while the linear Wits was increased by 7 mm.

Dental changes include retroclination of the upper incisors probably owing to the increased soft tissue pressure from the upper lip. The lower incisors, on the other hand, became more upright, probably due to the reduced tension from the lower lip and increased tongue pressure after the anterior crossbite was resolved. The changes in the upper and lower incisor angulation improved the interincisal angle.

Facial features were characterised by improvement in the facial profile in terms of a harmonious middle face, straight lip line and relaxed lower lip.

Different treatment options to correct the class III malocclusion exist in the current literature and will be discussed in the following section.

Treatment alternatives

Rapid maxillary expansion with face mask (RME-FM)

RME-FM reduces the projection of the mandible and improves the sagittal jaw relation relatively. In addition, face mask therapy may affect lower incisor inclination (Watkinson et al., 2013). Unfavourable side effects in terms of mesialisation of the maxillary dentition and thereby greater dental than skeletal effect have been reduced with the use of skeletal anchorage. Tarraf et al. (2023) proved threefold increase in the SNA angle and thereby a significantly higher maxillary advancement in patients treated with mandibular miniplates compared to RME-FM. The use of skeletal anchorage reduces dental side effects and maximises the skeletal effect (Seiryu et al., 2020), which is why RME-FM is not the treatment of choice.

Skeletally anchored face mask

A skeletally anchored face mask is a less invasive treatment alternative to the mentoplate since it eliminates the need for surgical intervention under general anesthesia depending

on the chosen approach. The disadvantage of face mask therapy is the extra-oral appliance, which is why some patients find it challenging to wear. Another drawback is the bite opening effect. Since the line of force is inferior to the center of rotation of the mandible, the mandible will inevitably rotate posteriorly and worsen the vertical dimension in high angle patients.

Facio-Umaña et al. (2021) compared miniscrew-assisted rapid palatal expansion (MARPE) with face mask and MARPE combined with mandibular miniplates (MM), concluding that both treatments resulted in a significant forward movement of the A-point though greater maxillary advancement was obtained with mandibular miniplates. This could be explained by the full-time effect of the elastics.

Willmann et al. (2018) compared the hybrid hyrax (HH) with face mask and HH with mentoplate. Patients treated with mentoplate experienced greater vertical control and it might be the treatment of choice in high angle patients. In our case, the patient experienced posterior rotation of the mandible despite the use of mentoplate, which could be explained by the bite opening effect of distalisation. The distalisation force was superior to the centre of resistance (Cres) of the upper molars due to anatomic limitations instead of being on the level of Cres and parallel to the occlusal plane.

Bone anchored maxillary protraction (BAMP)

De Clerk introduced BAMP (Cevidanes et al., 2010).

There are certain limitations with the BAMP protocol. First, delaying the treatment until the eruption of the lower canines in order to be able to place the miniplates means that the treatment cannot be initiated before the age of 11–12 years on average. This will result in a lower amount of maxillary advancement compared to treatment in younger patients. Second, zygomatic miniplates are associated with a high risk of failure owing to low bone density in young patients (De Clerck and Swennen, 2011), while placing miniscrews in the anterior palate has a success rate of 98.4% and thereby offers greater stability (Hourfar et al., 2017). Third, it is not possible to perform simultaneous transversal expansion.

Miniscrew anchored maxillary protraction (MAMP)

MAMP is a less invasive and more cost-effective alternative to mentoplate treatment though it requires sufficient space to place buccal miniscrews interradicularly and that is not always possible to obtain in the mixed dentition. Besides the risk of damaging roots and surrounding periodontal structures during insertion, buccal interradicular miniscrews are associated with a higher rate of failure in young patients, especially if using small diameters. This is why the mentoplate serves as a more stable choice as it is placed subapically away from the roots.

RME or Alt-RAMEC

Rapid maxillary expansion disarticulates the circumaxillary sutures enhancing forward movement of the maxilla before maxillary protraction. Repetitive weekly alternate rapid maxillary expansion and constriction (Alt-RAMEC) disarticulates the maxilla without overexpansion. Liou (Liou, 2005) postulated a difference between Alt-RAMEC and RME, the former leading to approximately twice the amount of maxillary advancement. This finding is supported by a number of studies (Masucci et al., 2014; Wu et al., 2020) including a systematic review and meta-analysis according to Almuzian et al. (2018).

Summary

In conclusion, treatment of class III malocclusion with a hybrid hyrax distalizer in the upper jaw combined with a mentoplate in the lower jaw makes it possible to expand the maxilla concurrently with molar distalisation in order to create space for the eruption of permanent teeth while avoiding dental side effects. Symphyseal placement of the mentoplate allows early treatment of class III patients.

The Alt-RAMEC protocol performed simultaneously with maxillary protraction produced a substantial improvement in the sagittal jaw relation by approximately 9°, mainly due to the maxillary advancement of 8 mm. On level of the occlusal plane, the angular Wits increased by approximately 17° and the linear Wits by 7 mm. Natural decompensation of the lower incisors was also evident. In addition, both the facial profile and the smile became more harmonious after treatment.

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