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Case 1

Non-extraction Treatment for Adolescent Patients with Skeletal Class II Mandibular Retrognathia

01.Case summary

A 14-year-old female came to the clinic with a chief complaint of protrusion of maxillary incisors. Extra-oral examination showed an asymmetrical appearance with chin shifts to right, height of lower facial 1/3 decreased. The lateral view showed a convex facial profile with mandibular retrognathia. Intra-oral examination revealed a deep overjet of 8mm, a deep overbite of 6mm, Class III molar relationship on the left side, Class II molar relationship on the right side, 3mm of mandibular dental midline deviation to the right in relation to the midfacial plane, space on the upper anterior segment and light crowding and rotations on the lower anterior segment.

Radiographic evaluation showed a skeletal class II relationship (pre-ANB: 6.9°) with mandibular retrognathia (pre-SNB: 75.6°, pre-0-Meridian to Pog': -5.3mm) and a normodivergent mandibular plane angle (pre-MP-SN: 21.9°). The temporomandibular joint showed no symptoms and had normal function and structure. There were no signs of active periodontal disease. She had no contributory medical history.

Pre-treatment photos

Pre-treatment X-ray

02.Diagnosis and treatment objectives

The patient was diagnosed with Skeletal Class II malocclusion with mandibular hypoplasia, facial asymmetry, Angle's Class II malocclusion with deep overjet and overbite, misaligned midline and anterior teeth spacing.

The treatment objectives are improving the condition of mandibular retrognathia, resolving the condition of misaligned midline, deep OB, deep OJ and anterior teeth spacing. The patient and her parents were informed that the condition of facial asymmetry cannot be resolved through orthodontic treatment.

03.Treatment options

Phase I: mandibular advancement through Herbst appliances.

Phase II: follow up and choose orthodontic treatment or joint treatment of orthodontics and orthognathic surgery according to the profile. The patient and parents were satisfied with the facial profile after orthopedic treatment and treatment plan for this stage included extraction of 18, 28, 38, 48, using clear aligners for lower molar distalization, 33-43 intrusion and retrusion, TADs assisted 13-23 intrusion and retrusion, 34, 35, 44, 45 extrusion for obtaining stable occlusion, and establishing Class I canine and molar relationship.

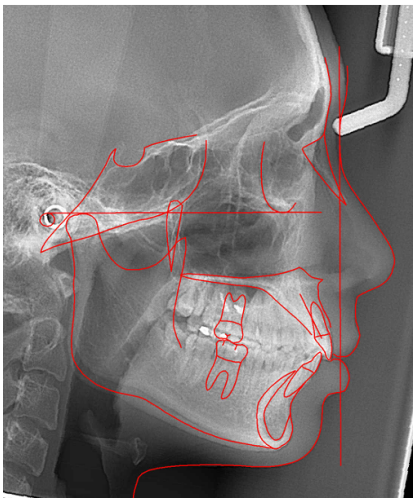
04.Processing and evaluation

After 36 months of therapy with Herbst and clear aligners, the following treatment outcomes have been achieved. Resolution of mandibular retrognathia, resolution of spacing in the upper arch and crowding in the lower arch, bilateral molar and canine Class I, correction of overjet and overbite, and coincidence of dental midlines.

Post treatment cephalometric analysis showed that ANB value was reduced from 6.9° to 4.9°. 0-Meridian to Pog' was reduced from -5.3mm to -2.4mm.

Post-treatment photos

Post-treatment X-ray



05.Discussion and learning

Growth and development of Jaw

Both endochondral and periosteal activity are important in the growth of the mandible. As viewed from the perspective of a stable cranial base, the chin moves downward and forward. On the other hand, as viewed from the perspective of vital staining studies, which reveal minimal changes in the body and chin area, while there is exceptional growth and modeling of the posterior surface of the ramus, the condylar and coronoid processes. Taken together, the mandible translated downward and forward, while increasing in size by growing upward and backward[1].

Growth and development of the mandible lies in the three dimensions of length, width and height. The body of the mandible grows longer as the ramus moves away from the chin. Meanwhile, removal of bone from the anterior surface of the ramus and deposition of bone on the posterior surface makes the mandible longer. The width increase of the mandible can be attributed to the removal of bone from the interior surface of the ramus and deposition of bone on the lateral surface. As for the growth of height, ramus grows upward and backward. The increase of the height of alveolar bone also contributes to the growth of height[2].

As for orthopedic treatment of the mandible, condyle, coronoid process, the anterior surface of the ramus, mandibular angle, alveolar bone, and chin are the areas easier to be modified through orthopedic treatment. These are also the reconstruction areas of Class II malocclusion after orthopedic treatment. The mechanism of growth modification in Class II can be attributed to growth of mandible, especially the condyle, advancement of mandible, anterior movement of the mandibular dentition, and restraining the maxilla and maxillary teeth[3].

CVM assessment based on deep learning

The assessment of growth and development helps determining the treatment timing of adolescents with Skeletal Class II mandibular retrognathia. The combination of bone age, sexual maturity and dental age is usually used in the clinical practice. Among them, bone age is most used. Baccetti et al. described the Cervical Vertebral Maturation method (CVM) based on cephalometric analysis for determining the stage of development[4]. Many scholars have proven that CVM method can predict the growth and development as well as assist in choosing the best time for treatment. However, assessing CVM is a complex process. The experience and seniority of the clinicians have an enormous impact on judgment[5]. With the wide application of the deep learning model of artificial intelligence in medical imaging, Professor Fang Bing's research conducted the following research to establish a fully automated, high-accuracy CVM assessment system called the psc-CVM assessment system based on deep learning, to provide valuable reference information for the growth period determination[6].

This study used 10200 lateral cephalograms as the data set to train the system. The psc-CVM assessment system is designed as three parts with different roles, each operating in a specific order. 1) Position Network for locating the position of cervical vertebrae; 2) Shape Recognition Network for recognizing and extracting the shapes of cervical vertebrae; and 3) CVM Assessment Network for assessing CVM according to the shapes of cervical vertebrae. Statistical analysis was conducted to detect the performance of the system and the agreement of CVM assessment between the system and the expert panel.

The system has achieved good performance for CVM assessment with total accuracy of 70.42%. Heatmaps were analyzed to understand better what the system had learned. The area of the third (C3), fourth (C4) cervical vertebrae and the lower edge of second (C2) cervical vertebrae were activated when the system was assessing the images. The results showed that the psc-CVM assessment system achieved high accuracy in CVM assessment. The system in this study was significantly consistent with expert panels in CVM assessment, indicating that the system can be used as an efficient, accurate, and stable diagnostic aid to provide a clinical aid for determining growth and developmental stages by CVM.

Dentoalveolar and TMJ changes after Herbst

Dentoalveolar changes after Herbst lies in proclination and anterior movement of the lower incisors, overjet reduction, and improvement of first molar relationship thorough mesial movement of the first molars, reduction of ANB angle, and an increase in the mandibular plane angle. There were mixed findings as to mandibular sagittal length and position and increases in lower face height, both anteriorly and posteriorly. No statistically significant changes were noted in the sagittal length or position of the skeletal maxilla[7]. Approximately 40-50% of the patient sample exceeded condylar growth by > 1.5 mm compared to untreated controls ($p < 0.05$)[8].

In addition, considering TMJ changes after Herbst treatment, it is suggested that during the 12-month period of Herbst appliance treatment, mild changes in the position of the disc occurred in patients whose articular discs were within normal limits at T1. These changes were within normal physiological limits when evaluated in the short term[9]. Also, The Herbst group showed anterior remodeling on the postero-superior aspect of glenoid fossa. Herbst appliance treatment also induced growth at the condylar head, thereby improving the maxilla-mandibular relationship in growing skeletal Class II patients[10].

Stress and movement trend of lower anterior teeth intruded by clear aligner

In recent years, clear aligners are favored by teenagers and parents for superior comfort and aesthetics. During the intrusion of lower anterior teeth with clear aligners, it often happens that the root disengages from the alveolar bone, resulting in serious complications11. This study by Prof Fang's team aimed to find the potential force mechanism of the mandibular anterior teeth under the pressure of CA, providing theoretical data for clinical practice12.

3D finite element (FE) model was established, including CA, periodontal ligament (PDL), and mandibular dentition. Incisor mandibular plane angles (IMPA) were set as 5 groups: 90°, 95°, 100°, 105° and 110°. The 4 mandibular incisors were intruded by 0.2mm while the canines were the anchorage teeth. The stress, the force systems and potential movement trends of mandibular anterior teeth were obtained.

It was found that with the increase of the initial IMPA, the force direction reversed. However, the root of mandibular anterior teeth always moved labially, which indicated the trend of fenestration and dehiscence.

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Case 2

A Case of Two-stage Treatment of Skeletal Class III Malocclusion in Adolescents

General situation

The patient, male, 10 years old, his chief complain is anterior teeth crossbite for 4 years. The parents said that the tendency gradually worsen after replacement of tooth. Denial of family history, orthodontic treatment and bad oral habits.

Clinical examination

1.Facial examination Frontal View: Facial asymmetry, Chin shifts to right. The Upper midline coincides with midline of the face. The exposure of Maxillary teeth is Inadequate. Lateral Profile: Concave, Nasolabial angle is acute, Normodivergent.

2. Intra-oral Exam Mixed dentition, Class III molar relationship in both sides, Overjet -3.5mm, Overbite -3mm, Lower midline shifts to left about 2mm, Narrowed maxillary arch, the First primary molars loosed I-II° .

Pre-treatment facial and intraoral views

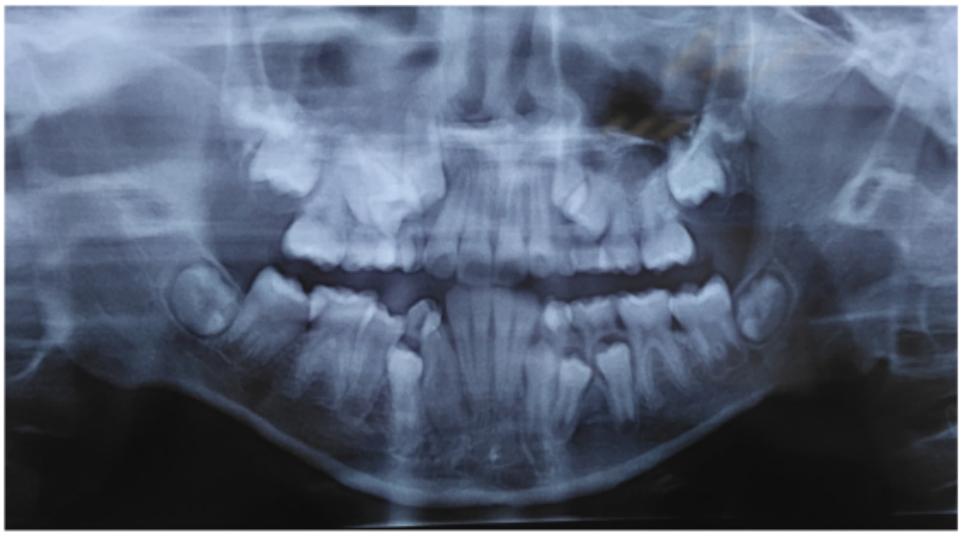
Imaging examination

1. Pre-treatment Panoramic: we can see the Insufficient eruption spaces for premolars , 25 is missing， all third molars existed

2. Cephalometric Analysis: cvms2 stage, Skeletal class III, Maxillary hypoplasia, Mandibular hyperplasia, Normodivergent, inclination of Upper incisor is normal and lower incisor is lingual. Soft tissue subnasal point is retracted. Chin protrusion

3. CBCT Exam indicated Thin alveolar bone on labial side of lower incisors

Pre-treatment X-ray



Diagnosis

1.Bone: Skeletal Class III malocclusion with maxillary hypoplasia, and mandibular hyperplasia and deviation

2.Teeth: Angle Class III malocclusion, anterior teeth crossbite, crowding of mixed dentition

3.Soft tissue: Concave profile, facial asymmetry

4.Others: 25 missing, Thin alveolar bone on labial side of lower incisors

Treatment aims

1. Aesthetic: align teeth to establish normal occlusal relationship, improve smile aesthetics and lateral profile, rebuild maxillofacial beauty.

2. Function: Restore the normal shape of the upper and lower dental arch, correct the crossbite of teeth, establish the normal molar relationship, overjet and overbite.

3. Stable health: maintain periodontal health and bite balance; And try to keep the correction result stable.

Treatment plan

Two-stage treatment should be adopted. Stage I: Firstly, the maxillary molar was distal zed through headgear to extend the maxillary arch length, which was conducive to the eruption of premolar teeth; Then, the maxillary protraction with face mask was used to promote the development of the maxilla and correct the crossbite of anterior teeth. Stage II: After the growth and development of the jaw, the stage II treatment could begin, and the treatment plan will be evaluated and determined according to the degree of crowding and occlusal status.

Treatment progress

1.Stage I (1-10 months) : Headgear with neck band low traction, 300g on each side, 12-14 hours a day.

2.Stage I (11-25 months) : maxillary Hyrax expansion device, maxillary rapid expansion, 0.25mm per week, 4 times expansion and 4 times contraction alternately; Facemask (9.5mm, 8oz per side)， 12-14 hours each day

3.After the end of stage I treatment, the jaw growth and development were observed for 24 months.

4. Stage II (1-22 months): Invisible appliance and Class III traction were used to achieve mandibular teeth distalization, and establish normal overbite and overjet.

5. Retaintion.

Facial and intraoral views after stage I treatment

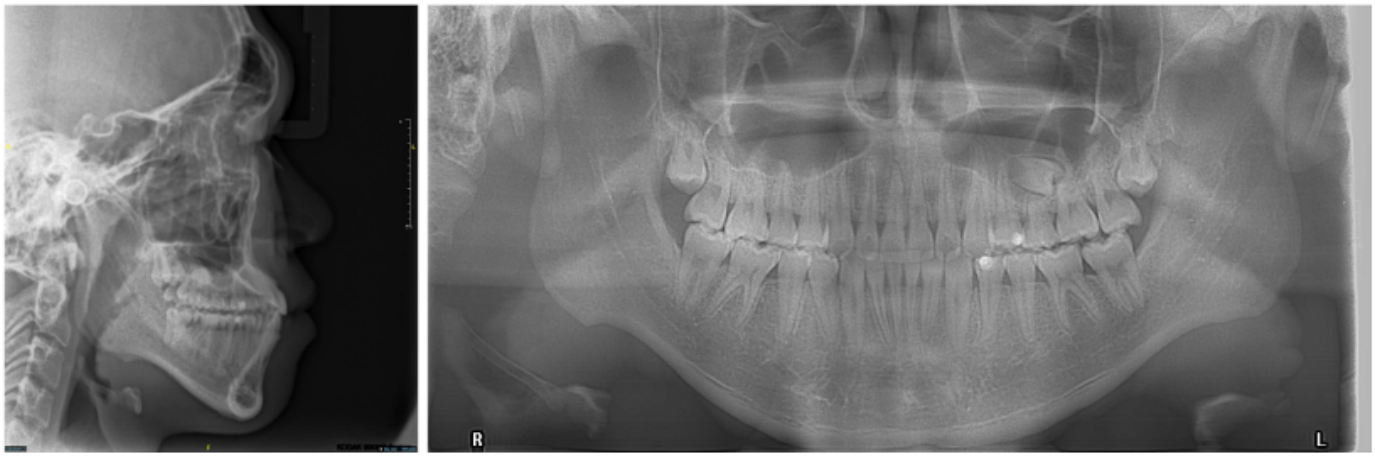
X-ray after stage I treatment

Results

After stage I treatment, the crossbite of anterior teeth were corrected and, and the concave profile and nasal depression were improved. After the treatment of stage II, the upper and lower teeth orderly aligned, normal overjet and overbite, and class I molar relationship, without congestion or space. The maxillary midline is consistent with the facial midline, and the mandibular midline is 0.5mm to the right. The appearance of the profile was obviously improved, the smile was obviously improved, and the relationship between lips and teeth was normal. The panoramic radiograph showed that the root of the tooth was basically parallel, and no obvious abnormality was found in the root and alveolar bone. The Cephalometric analysis revealed skeletal class III, upper and lower anterior teeth labial and lingual inclined.

Facial and intraoral views after stage II treatment

X-ray after stage II treatment



Cephalometric analysis

Measurement	Before Treatment	Phase I (After)	Phase II (Before)	Phase II (After)
SNA (°)	74.7	79.1	84.9	85.2
SNB (°)	77.3	78.8	85.2	85.1
ANB (°)	-2.6	0.4	-0.3	0.1
Wits appraisal (mm)	-5.8	-3.0	-2.6	-2.5
MP-FH (°)	23.2	25.9	29.8	28.8
ALFH/PLFH	151.0	152.3	161.0	160.2
UI-SN (°)	101.6	115.6	125.9	117.6
UI to N-A (°)	26.9	36.5	41.0	32.5
UI to N-A (mm)	4.5	7.8	9.5	7.9
LI-MP (°)	82.8	74.9	76.3	75.1
LI to N-B (°)	19.1	14.8	14.0	14.2
LI to N-B (mm)	3.7	4.0	4.7	4.9
UI-LI (°)	136.6	128.3	125.3	133.2
Upper OP-FH (°)	7.7	4.3	1.1	6.0
Facial Convexity Angle (°)	4.4	5.9	4.5	0.8
Upper Lip Length (mm)	19.6	22.8	24.2	24.4
0-Meridian to Sn	8.4	10.8	6.1	6.7
0-Meridian to Pog'	8.5	13.9	4.2	3.7

Conclusions

Treatment strategies for adolescent skeletal class III patients

Studies have shown that about 75% of adolescents with skeletal class III have maxillary hypoplasia, or maxillary hypoplasia combined with mandibular hyperplasia. For patients with maxillary hypoplasia, before the peak of growth and development, maxillary orthopedic treatment should be considered first, and the skeletal class III deformation should be corrected or alleviated as much as possible by promoting the sagittal development of the maxilla. Attention should also be paid to the presence of deficiencies in the length and width of the maxilla. In this case, we first used the headgear to move the molars distally to expand the length of the maxillary arch to provide spaces for eruption of premolars, effectively reducing the crowding of the maxillary dentition and reducing the probability of tooth extraction. In view of the problem of insufficient width of maxillary dental arch, the maxillary width is increased by maxillary arch expander. In addition, the mandibular third molars should be extracted in time, and the growth and development trend of the mandible should be observed at the same time, and when the mandible growth tends to stop, the extraction/non-extraction orthodontic treatment or orthodontic-orthognathic combined treatment should be selected according to the profile and occlusion.

The growth and development of the jaw

Interstitial hyperplasia of the bone suture is one of the main growth and development modalities of the maxilla. The biomechanical mechanism of maxillary orthopedic treatment is that force is transmitted to the bone sutures around the maxilla, causing the growth of bone sutures. The condyle is the main growth center of the mandible. Bjork (1963) found that during childhood, the condyle grows 3 mm per year, declines slightly before puberty, and subsequently grows 5.5 mm per year until the age of 14.5. Hagg (1992) found that the condyle growth is 11.3mm/3 years before puberty and 9.6mm/3 years after the pubertal peak. It is generally believed that mandible development reaches its peak during CVMS3~4.

Timing of Maxillary protraction with FM therapy

Kama (2006) reported that greater skeletal effects can be achieved in the deciduous dentition than in the mixed dentition, or in the early mixed dentition compared with the late mixed dentition[1]. Suda (2000) argues that the midpalatal suture is broad and smooth during the “infantile” stage (age 8-10), but becomes more squamous and overlapping in the “juvenile” stage (age 10-13)[2]. Consequently, the optimal time to treat a skeletal Class III malocclusion is immediately after eruption of the maxillary incisors. Professor Zeng proposed in "Modern Orthodontic Diagnosis and Treatment Manual" that it is the best time to start treatment after the eruption of 16/26/12-22. Of course, the timing of treatment depends on a variety of factors, including the patient's age at initial diagnosis, replacement of permanent teeth, type of appliance, degree of fit, etc., and cannot be generalized.

Effectiveness and stability of Maxillary protraction with FM therapy

Effectiveness and stability of Maxillary protraction with FM therapy is generally recognized. Some literature compares the effects of different arch expansion methods on the treatment effect of Maxillary protraction, pointing out that compared with the rapid expansion and slow expansion group, the forward growth of the maxilla in the rapid expansion and constriction group is more obvious, which can reach 3.87mm, and the skeletal effect is more obvious, which can reach 88.7%[3]. In addition, there is a lot of literature on the follow-up evaluation of the stability of the treatment of anterior traction. It is generally believed that Maxillary protraction has good stability[4-7]. For example, there are literature on maxillary mask anterior traction therapy for up to 5-10 years of follow-up, found long-term stability of 70-75%, recurrence rate of 25-30%, the main cause of recurrence is the growth and development of mandible, therefore, overcorrection is recommended when performing maxillary mask anterior traction therapy[8].

Expert discussions

Professor Ji Fang, the Ninth People's Hospital Affiliated to Shanghai Jiao Tong University School of Medicine

Professor Ji believes that this is a typical skeletal class 3 adolescent patient, combined with maxillary hypoplasia and Mandibular hyperplasia. The lower incisor is lingual inclined as well. So, it is a difficult treatment. Clinically, we should fully consider the growth and development trend of the mandible in sagittal and vertical dimension. For this patient, the timing for treatment is optimal. After stage 1 orthopedic therapy for maxillary, the stage 2 did not start right away. After 2 years of follow up, it was found that the jaw growth was stable, then the stage 2 treatment was started. This will significantly improve the stability of the treatment results. In this case, before anterior protraction, the headgear was used to upper distalize molars to extend the length of the maxillary arch and provide the spaces for the eruption of the premolars. In recent years, with the continuous improvement of orthodontic appliance technology, more and more multi-functional appliances are available. So, we can try to find an appliance that simultaneously performs upper molar distalization, maxillary anterior protraction, and upper arch expansion, which could significantly shorten the treatment time.

Professor Pan Xiaogang, the Ninth People's Hospital Affiliated to Shanghai Jiao Tong University School of Medicine

Professor Pan Xiaogang pointed out that in this case, headgear was used for molar distalization, with neck band low traction, about 300 grams. Need to remind everyone that the use of headgear should pay attention to force and traction direction, 300-500g force value is mainly used to push molars backwards, when the force exceeds 500g is a kind of orthopedic force, will inhibit the forward development of the maxilla.

In addition, for adolescents with skeletal class III, it is important to distinguish hypoplasia of the maxilla and hyperdevelopment of the mandible. In patients with hyperplasia of the mandible, trends in the growth and development of the mandible are important for treatment outcomes, so staged treatment is essential. The development of the mandible is later than that of the maxilla, so orthopedic treatment of the maxilla should be started early, and better treatment results can often be obtained. About 25-30% of patients may face combined orthognathic-orthodontic therapy, which requires adequate communication with the patients.

Professor Tang Guohua, the Ninth People's Hospital Affiliated to Shanghai Jiao Tong University School of Medicine

Professor Tang Guohua believes that the treatment outcome should be predicted before the anterior protraction of maxilla. Maxillary anterior protraction therapy is often effective in patients with both sagittal and horizontal (width) insufficiency. In patients with normal horizontal (width) and only sagittal insufficiency, the effect is often unsatisfactory. In this case, the bone suture can be released alternately by maxillary expansion and contraction to promote the therapeutic effect of maxillary anterior protraction. Because the force in the treatment directly acts on teeth, we can often find dental effect in the traditional maxillary protraction treatment, which is not what we expect. Therefore, we need to minimize the dental effect, the expansion and contraction alternating method introduced in this case is one of the optional methods. It can better release the bone suture, so that protraction gets more skeletal utility. In addition, Micro-implant Assisted Rapid Maxillary Expansion (MARPE) is also a good method to effectively open the middle palate suture. For example, MSE appliance moves the force point away from the tooth, which avoids the occurrence of dental effects.

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