Case Report

Correction of Complete Maxillary Crossbite with Severe Crowding using Hyrax Expansion and Fixed Appliance

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An 18-year-old Thai man who presented with a secondary cleft palate, maxillary hypoplasia and severe crowding was treated by rapid maxillary expansion and fixed orthodontic appliances. Initial assessment found skeletal Class III malrelationship and dental Class II malocclusion with anterior and bilateral posterior crossbites. Camouflage orthodontic treatment was planned using a rapid maxillary expansion appliance and correcting crowding with extraction all four premolar teeth. A Hyrax appliance and vertical loop arch wire were placed for maxillary arch expansion of 9.5 mms at first molars and canines, and 5.5 mms at the premolars and obtained positive overjet. Both acceptable skeletal and soft tissue relationships and satisfactory occlusion were produced. After 14 months of postoperative follow-up, the occlusal result was stable and no skeletal reversals could be detected.

Keywords: *Cleft palate, Rapid maxillary expansion, Hyrax appliance, Camouflage orthodontic treatment treatment*

J Med Assoc Thai 2013; 96 (Suppl. 4): S149-S156
Full text. e-Journal: *http://jmat.mat.or.th*

Pradubwong et al[1] reported the distribution of cleft lip and palate live births in Northeastern Thailand, 45.7% having both cleft lip and palate, 31.8% with cleft lip only while 22.5% had a cleft palate only. Although isolated cleft palate seems to be the least severe condition among all cleft groups, the repair of cleft palate can cause unfavorable effects on maxillary growth because of scar contraction after surgery[2,3]. The constricted maxilla resulting from scar tissue contraction causes anteroposterior and transverse growth deficiencies with development of skeletal and dental Class III malocclusions with anterior and/or posterior crossbite and severe crowding.

Several treatment modalities have been used to correct these problems depending on age. Growth modification for growing patients, orthodontic therapy, and orthognathic surgery combined with orthodontic treatment are modes of choice for correction. Adult borderline skeletal Class III patients with mild to moderate skeletal discrepancy, could be treated with either surgical-orthodontic therapy or orthodontic camouflage treatment. Proffit et al[4] showed the characteristics of a good candidate for camouflage orthodontic treatment were mild Skeletal Class III, good vertical proportions and unsuccessful growth modification cases.

Several orthodontic devices have been developed for correcting posterior crossbites such as removable expansion plates, slow maxillary expansion (SME)[5,6], rapid maxillary expansion (RME)[7-10], surgically-assisted rapid maxillary expansion (SARME)[11-13] and transpalatal distraction osteogenesis (TPDO)[14]. The mid-palatal suture of non-cleft patients becomes more interlocked with increasing age. RME is recommended to separate the suture in pubertal or prepubertal period[15] before such interlocking, but should not be used in pre-school children because of adverse effects on nose contour[4]. RME can produce heavy force that creates orthopedic expansion not only of the intermaxillary suture but is also distributed to adjacent craniofacial bones such as sphenoid and zygomatic bones[16] with a screw turn-rate 0.2 to 0.4 mm per day. This force generates maximum orthopedic expansion with minimal orthodontic tooth movement[8,17]. However, in non-cleft patient, gaining the maxillary transverse width originates half from true skeletal expansion and half through bilateral orthodontic movement of the buccal teeth[4]. Garrett et al[18] showed decreasing orthopedic skeletal effect whereas increasing alveolar bone bending and dental tipping effect from premolar to molar teeth.

RME appliances[4,15,19] are indicated for unilateral or bilateral posterior crossbite correction,

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cases with skeletal, dental maxillary constriction or combination, cleft lip and cleft palate patients with collapsed maxilla[20-23]. Moreover, they are appropriate for patients who need to gain arch width for correcting moderate maxillary crowding or need to expand the maxilla more than 4 mms. Additionally, nasal airway resistance may be improved by use of RME[7,9,18,24], although there may be little long term benefit[25].

RME appliances should be avoided in likely non-cooperative patients (although screw-turning is usually the responsibility of another person such as a parent), single tooth crossbite, buccal inclination of posterior teeth and patients with anterior open bite, steep mandibular plane and convex profile. Furthermore, patients with facial asymmetry, severe anteroposterior and vertical skeletal discrepancies, and where different amounts of expansion are required in cases with different anterior and posterior maxillary dental arch widths, such as some cleft palate cases that require rotational and not parallel dental arch expansion, are not recommended to have RME.

RME appliances can be divided into two types: tooth-and-tissue-borne type (Haas appliance) and tooth-borne type (Hyrax appliance). Because the Hyrax appliance can control the force passing through maxilla, assure mid-palatal separation, with less palatal irritation of mucosa and easy-to-control oral hygiene, this appliance was used for the patient reviewed in this report.

Case Report

Case history

The patient was an 18-year old Thai male with a repaired complete cleft palate and skeletal Class III malocclusion. The cleft palate was repaired at 3 years of age. Extraoral examination (Fig. 1A) shows a symmetrical mesofacial type with a straight profile and slightly flat paranasal area due to underdeveloped maxilla. The mandibular plane is slightly steep. Intra-orally (Fig. 1B, 1C), there is severe crowding in the maxilla arch (28 mms) with palatal displacement of #12, #22, #15, and #25, and 3.5 mms in the mandibular arch, mainly of the mandibular anterior teeth. Upper lateral and second premolar teeth are in palatoversion, with molars Class II relationship and total maxillary crossbite, and negative overjet 2 mms. The upper dental midline is at the center and lower dental midline has shifted to the right 2 mms. Cephalometric analysis shows a skeletal Class III relationship (ANB-4°) due to a slightly retrognathic maxilla (SNA 76°, A-Nperp-1 mms) and slightly prognathic mandible (SNB 80°, Pog-Nperp 8.5 mms). There were normal vertical skeletal relationships (SN-MP 34°, SN-PP 11°, PP-MP 23°, PFH: AFH 63, N-ANS: ANS-Me 45.7: 54.3). The upper incisors relative to their alveolar bone bases have normal inclination and position whereas lower incisors are retroclined and retruded (L1 to MP 80°, L1-NB 2.5 mm) (Fig. 1, Table 1). According to Korkhaus analysis, the anterior arch width (AAW) is 4.5 mms less than the norm, whereas posterior arch width (PAW) is 10.5 mms less than the norm.

Treatment

Although the age of this patient is greater than usually accepted for use of RME, the fact that he appeared to have a still-patent anterior suture along with the residual cleft of the bony posterior palate made use of this RME expansion acceptable.

The treatment plan was orthodontic camouflage with extractions, initially of palatally displaced #15, and #25, and later of #34, and #44. The Hyrax appliance expansion was applied immediately following the premolar extractions combined with orthodontic treatment to correct the anterior crowding. A Hyrax appliance was soldered to bands on the maxillary first premolars and molars. The patient activated the jackscrew at the rate of 0.2 mm, twice a day for three weeks until the occlusal aspect of maxillary lingual cusps of first molars contacted the occlusal aspect buccal cusps of mandibular first molars

Fig. 1 These picture show as follows:
A: Extra-oral examination.
B: Intra-oral examination; right side, frontal view and left side, respectively.
C: Intra-oral examination; upper and lower arch, consecutively.

Table 1. Cephalometric measurements at pre-treatment, post-treatment and 14 months in retention

Measurements	Thai norm	Pre-treatment	Post-treatment	Retention
SN-FH (degree)	7±2.6	10	10	10
SNA (degree)	85.4±4	76	75.5	75.5
A-N perp. (mm)	4.3±4.6	-2	-4	-4
SNB (degree)	81±3.7	80	78	78.5
Pog-N perp (mm)	0.3±7	6	2.5	3
ANB (degree)	4±2	-4	-3	-3.5
Wit appraisal (mm)	0±5	-8	-4.5	-3
SN-MP (degree)	30±5	34	36	36
SN-PP (degree)	8±5	11	11	11
PP-MP (degree)	22±5	23	25	25
ANS-ME (mm)	73.5±5	66	70	70
PFH: AFH (%)	65±2.8	63	62.9	62.9
N-ANS: ANS-Me (%)	45:55	45.7:54.3	45.3:54.7	45.3:54.7
Gonial angle (degree)	120±6	131	131	131
Y-axis to FH (degree)	59±3	56	60	60.5
U1 to SN (degree)	107±6	108	112	113
U1 to NA (degree)	21±2	31	37	37.5
U1 to NA (mm)	4±2	4.5	7	8
L1 to NB (degree)	30±5	15	11	11
L1 to NB (mm)	7±2	2.5	0	1
L1 to MP (degree)	97±6	80	75	76
Interincisal angle (degree)	124±7	136	135	133
Profile angle (degree)	163±4	185	180	180.5
Holdaway angle (degree)	14±3.83	10.5	14	14
U lip to E-line (mm)	-1±2	-6.5	-6	-6
L lip to E-line (mm)	1.5±2	2	-3	-3
Nasolabial angle (degree)	110±6.5	83	91	91

and bilateral positive buccal overjet was obtained (Fig. 2). Leveling and aligning by using a pre-adjusted edgewise appliance and sequence of 0.014, 0.016 inch NiTi wires, and 0.018 inch stainless steel wires were initially used. Vertical loop 0.014 stainless steel wire was then applied to upper anterior teeth for regaining space allowing #12, #22 to be moved forward. The RME appliance was stabilized for six months and then it was removed. Advantage was taken of the mandibular extractions to retract the mandibular anterior segment using power chain to the posterior anchorage as part of the plan to treat the Class III malocclusion by camouflage, this also helping closure of the extraction spaces. The treatment extended over four years, being interrupted during that period by need for mid-face plastic surgery, including rhinoplasty, for mid-face injury. At the end of orthodontic treatment, the patient was instructed to wear wraparound retainers.

Fig. 2 Orthodontic treatment photographs shows facial appearance and occlusion at the conclusion of hyrax maxillary arch expansion.

Results

The preadjusted edgewise technique provided the spacing for relieving severe anterior maxillary arch crowding derived from both lateral and

anterior dental arch expansion. Table 1 shows that the patient's ANB angle improved only slightly from -4 degrees to -3.5 degrees, while the mandibular plane angle increased by 2 degrees. During the orthodontic treatment phase, the maxillary incisors became more proclined and protruded (U1-SN 112°, U1-NA 37° and U1-NA 7 mms). The lower incisors were more retroclined and retruded (L1-MP 75°, L1-NB 11° and L1-NB 0 mm), and U1-L1 angle decreased by 1 degree. The soft tissue profile was improved from 185 degrees to 180 degrees after treatment (Table 1, Fig. 3). Cephalometric tracing superimpositions (Fig. 5) demonstrate maxillary and mandibular changes from the pre-treatment to post-treatment and retention stages. The maxilla moved downward. The prognathism of mandible was reduced by opening rotation of the mandible. The patient was recalled after 14 months of retention. There was a slight relapse, lower incisor crowding (Fig. 4).

From model measurements, the changed distances of maxillary arch expansion are shown in Table 2 as inter-canine width (distance between cuspal midpoints of the canines), inter-premolar width (distance between the tips of buccal cusps of the maxillary first premolars) and inter-molar width (distance between the tips of the mesiobuccal cusps of the maxillary first molars). The increases in maxillary width of inter-dental distances of canines, premolars and molars change were 9.5 mm, 5.5 mm and 9.5 mm, respectively. The evaluation of buccal crown tipping was evaluated from the different amount of maxillary arch expansion at gingival level and occlusal level after treatment (Table 3). Canine and molar teeth had slight buccal crown tipping, whereas premolars teeth had amounts of arch expansion at gingival level the same as at occlusal level. The relapse of maxilla arch width after removing all orthodontic appliances was around 1 mm at each interdental distance.

This case report was approved by the Khon Kaen University Ethic Committee (number HE562109).

Fig. 3 Post-treatment photographs shows facial appearance and occlusion after orthodontic appliance removal.

Fig. 4 Retention period photographs, 14 months after orthodontic appliance removal.

Discussion

The Class III skeletal discrepancy creates a challenge for orthodontists to decide to proper treatment. Some studies[26-29] have tried to establish some threshold values for treatment decisions in Class III adult patients who need orthognathic surgery. Proffit and Ackermann[26] illustrated the treatment concepts of three envelopes of discrepancy: growth modification, orthodontic treatment alone, and orthodontics combined with orthognathic surgery using incisors positioning which were moved forward or backward to guide the treatment planning. 2 mm of maxilla protrusion and 3 mm of mandibular retrusion set the limits for orthodontic treatment alone. Kerr et al[27] suggested threshold values to help the orthodontist to make a decision for treatment planning. The patients with an ANB angle of less than -4, lower incisor inclination of 83 degrees, maxillary to mandible length (Mx/Md) ratio of 0.8 and Holdaway angle of 3.5 degrees should be for surgical intervention. Stellzig-Eisenhauer et al[28] used four variables: Wits appraisal, anterior cranial base length, Mx/Md ratio and lower gonial angle to separate adult Class III cases with orthodontic treatment alone from those requiring orthognathic surgery. Tseng et

al[29] suggested six criteria for determining the need of orthognathic surgery for skeletal Class III malocclusion, such as overjet, overbite, Wits appraisal, L1-MP angle, Mx/Md ratio and gonial angle. Moreover, the soft tissue appearance, the acceptance of surgical treatment of each patient, and psychosocial and financial circumstances should be also evaluated when selecting a treatment plan.

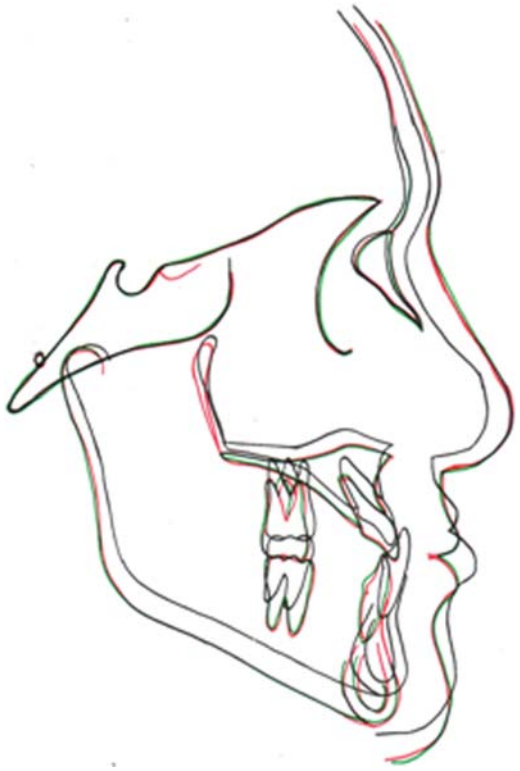

Fig. 5 Cephalometric superimposition: pre-treatment (black line), post-treatment (red line), 14th month retention phase (green line) maxillary and mandibular movement and direction were compared.

The aim of this treatment for this patient was not to bring cephalometric values within the normal range, but rather to improve facial esthetics and to allow a good chewing function. However, the financial status of this patient did not allow support for the surgical approach even though this was indicated even though the cephalometric radiograph of the patient showed a concave skeletal profile due to slightly retrognathic maxilla and orthognathic mandible. Because of the acceptable soft tissue profile and the patient not willing to have surgical therapy, orthodontic treatment alone was performed to conceal the skeletal discrepancy. The inevitable effect of nonsurgical orthodontic treatment was slightly increasing the mandibular plane angle with backward rotation of the mandible and slightly improved profile angle (Table 1, Fig. 5).

Typically, young patients show a dental diastema between upper central incisors after opening of the midpalatal suture[17]. This occurred in this case and space was closed subsequently. After orthodontic appliances were placed for leveling and aligning, the teeth moved and closed together and space for the maxillary lateral incisors increased. A stainless steel arch with vertical loops was used to provide more space and procline the maxillary anterior teeth (Fig. 2).

Table 2. Increased width of the maxillary dentition using RME appliance: Inter-canine width, inter-premolar width and inter-molar width

Inter-canine width			Inter-premolar width			Inter-molar width		
Pre-tx	Post-tx	Change	Pre-tx	Post-tx	Change	Pre-tx	Post-tx	Change
29.5	39	9.5	42.5	48	5.5	44.5	54	9.5

Table 3. Increased width of the maxillary dentition using RME appliance at the gingival and occlusal levels of teeth as measured from the study models

Level/teeth	Gingival levels (mm)			Occlusal levels (mm)		
	Pre-tx.	Post-tx.	Change	Pre-tx.	Post-tx.	Change
Canine	24	30	6	29.5	39	9.5
Premolars	26	32	5.5	42.5	48	5.5
Molars	33	37	5.5	44.5	54	9.5

Previous studies have found maxillary inter-molar width increases in the range 4.3 to 9.5 mm[30-33] using RME in non-cleft patients. Gohl's study[25] showed RME appliances increase the inter-canine and inter-molar width at CEJ levels around 2.79 and 3.27 mm, respectively, using three-dimensional computed tomography. Our patient showed at the gingival level, an inter-canine width increase of 6 mm whereas inter-molar width increased 5.5 mm. The obviously different values between this case and Gohl's study may come from cleft palate patients having discontinuity of the palatal shelves, which may be the reason that this patient had a larger response with less resistance to expansion. Chaconas and Caputo[34] showed that the connections between the two halves of the maxilla and pterygoid plates of the sphenoid bone were the limiting factors to expanding the maxilla. Moreover, in this case, the width dimension change at the occlusal level of first maxillary molars slightly was more distance than at gingival level. This condition means that there was slight molar buccal tipping after using RME appliance. Generally, RME appliances are very rigid and generate heavy forces resulting in rapid movement. They provide specific amounts and direction of expansion. However, RME appliances could produce undesirable side effects such as root resorption[35], damaging buccal cortical plates and developing gingival recession[36]. These conditions tend to present during expansion. Post-treatment periapical radiographs for this patient (Fig. 7) did not show clear indication of any significant root resorption of maxillary buccal teeth. Periapical radiographs taken before and after orthodontic treatment (Fig. 6, 7), show the horizontal alveolar bone loss was 2 mms and 4 mms for #11 and #12, respectively, but with signs of root resorption of the maxillary incisor teeth. This problem may not come from RME appliance, but from labial proclination of the maxillary incisors. Proffit et al[4] stated that tipping teeth facially and root moving palatally in Class III camouflage can cause damage to periodontal tissues and root resorption.

In addition, the effect of RME appliances is not only effective in the transverse plane but the vertical plane may also change. From superimposition of lateral cephalometric tracings (Fig. 5), the occlusal plane was lowered along with slightly increased mandibular plane angle. Moreover, retroclining of the lower incisors contributed to slight retrusion of the lips. The small skeletal and dental camouflage changes enhanced the esthetic effect on the facial profile.

Other complications in this case are shown in the clinical evaluation. Mild gingival recession at #31

Fig. 6 Periapical radiograph before orthodontic treatment.

Fig. 7 Periapical radiograph after orthodontic treatment.

occurred after removal of the orthodontic appliance, but it did not progress 14 months after completion of active treatment (Fig. 3 and 4). There was also mild re-crowding of lower incisors with right and left slipped proximal contacts. In retrospect, interproximal reduction of the mandibular incisor towards the end of active treatment and use of a mandibular lingual bonded retainer may have helped avoiding this. The patient was very satisfied with treatment outcome while being warned of the likelihood of further mandibular anterior crowding.

Conclusion

This case report describes the treatment of a young adult with skeletal class III relationships. Camouflage treatment was the option for achieving an acceptable occlusion and a good esthetic result, helped by good lip posture compensations. The dental compensations and expansion maxilla provided satisfactory outcomes.

Acknowledgement

The authors wish to thank (a) Prof. Keith Godfrey for his suggestion and assistance with the English-language presentation of the manuscript and (b) the Tawanchai Foundation for Cleft Lip-Palate and Craniofacial Deformities and the Center of Cleft Lip-Cleft Palate and Craniofacial Deformities, Khon Kaen University, in association with the Tawanchai Project.

Potential conflicts of interest

None.

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การแก้ไขภาวะขากรรไกรบนสบไขว้อย่างสมบูรณ์ร่วมกับฟันซ้อนเกชนิดรุนแรงโดยใช้เครื่องมือขยายขากรรไกรแบบไฮแรกซ์ร่วมกับเครื่องมือจัดฟันชนิดติดแน่น

ทัศนีย์ วังศรีมงคล, มนเทียร มโนสุดประสิทธิ์, พูนศักดิ์ ภิเศก, พรนภา ลีลาสินเจริญ

ผู้ป่วยชายไทยอายุ 18 ปี มีปัญหาเพดานโหว่แบบทุติยภูมิร่วมกับภาวะโครงสร้างกระดูกขากรรไกรบนเติบโตเล็กกว่าปกติและมีการฟันซ้อนเกชนิดรุนแรง ได้รับการรักษาด้วยเครื่องมือขยายขากรรไกรแบบไฮแรกซ์ร่วมกับเครื่องมือจัดฟันชนิดติดแน่น การประเมินเบื้องต้นพบว่าผู้ป่วยมีลักษณะโครงสร้างกระดูกขากรรไกรผิดปกติประเภทที่สาม และการสบฟันผิดปกติประเภทที่สองร่วมกับภาวะสบไขว้ทั้งทางด้านหน้าและด้านข้าง การจัดฟันแบบอำพรางสามารถทำได้โดยใช้เครื่องมือขยายขากรรไกรอย่างรวดเร็วร่วมกับการแก้ไขการซ้อนเกของฟัน ด้วยการถอนฟันกรามน้อยทั้งสี่ซี่ การใช้เครื่องมือไฮแรกซ์และการดัดห่วงแนวตั้งสามารถขยายขากรรไกรบริเวณฟันกรามใหญ่ซี่ที่หนึ่งและฟันเขี้ยว 9.5 มิลลิเมตร ที่ฟันกรามน้อยสามารถขยายได้ 5.5 มิลลิเมตร และทำให้เกิดการเหลื่อมแนวราบมีค่าบวก การรักษาพบว่าความสัมพันธ์ของโครงสร้างกระดูกขากรรไกรและฟันเป็นที่ยอมรับได้และน่าพึงพอใจ ภายหลังการรักษา 14 เดือน พบว่ามีเสถียรภาพในการสบฟันร่วมกับไม่พบการเปลี่ยนโครงสร้างกระดูกขากรรไกรกลับเป็นเหมือนเดิม