Dental and Skeletal Changes Following Surgically Assisted Rapid Maxillary Anterior-posterior Expansion

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Background: Lengthening the maxillary dental arch as a treatment approach for patients with maxillary deficiency and dental crowding is seldom reported. The purpose of this study was to assess dental and skeletal changes in the maxilla in the correction of maxillary deficiency associated with a retruded maxillary arch using a surgically assisted rapid maxillary anterior-posterior expansion appliance.

Methods: Predistraction and postraction lateral cephalometric and periapical radiographs and maxillary dental casts of six young adolescents (four boys, two girls, mean age 11 years, 2 months) were examined. These patients received a maxillary anterior segmental osteotomy and distraction osteogenesis with an anteroposteriorly oriented Hyrax expansion appliance based on the biological principles of bone distraction.

Results: The retruded dental arch and dental crowding were successfully corrected. Significant forward movement of the point anterior nasal spine, point A, central incisors and first premolars was noted. The maxillary dental arch depth increased an average of 4.2 mm while the arch width remained unchanged. In total, 11.5 mm of dental space was created in the maxillary arch which was sufficient to resolve dental crowding. New bone formation along the distraction site was observed three months after distraction.

Conclusions: The use of maxillary anterior segmental osteotomy combined with a Hyrax expansion distraction appliance was effective in arch lengthening and creation of dental space. An overcorrection in this interdental distraction osteogenesis could be a good treatment option for children with maxillary deficiency combined with crowded maxillary dentition.

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Key words: maxillary anterior-posterior expansion, distraction osteogenesis, maxillary deficiency, dental crowding

Many appliances attached to premolars or molars have been described for horizontal and transverse expansion of the maxillary dental arch,[1-7] Appliances used to lengthen the dental arch and to correct abnormal molar relationships, include extra - oral traction,[1] Schwarz plate-type appliances,[2] removable spring appliances,[3] distal jet appliances,[4,5] magnets[6] and pendulum appliances.[7]

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However, for patients with maxillary and arch deficiencies, there are no appliances so far that can correct both skeletal horizontal deficiency and dental arch deficiency at the same time. A Le Fort I osteotomy or orthopedic face mask alone cannot correct dental crowding in these cases, and extraction of premolars may exaggerate the unfavorable soft tissue profile. Thus, a new approach is necessary to alleviate maxillary skeletal deficiency combined with dental crowding.

Distraction osteogenesis (DO) has been successfully applied in endochondral bone lengthening[8] and correction of facial deformities.[9,10] The effectiveness of segmental DO for protracting the anterior segment of the maxilla and lengthening the maxillary dental arch has been demonstrated in experimental animal models.[11,12] Block *et al* and Altuna et al. pioneered surgically assisted rapid orthodontic lengthening of the maxilla in primates. Distraction osteogenesis was subsequently performed in the human dento-osseous segment.[13,14] In 2000, Liou and colleagues reported success using surgically assisted approximation of the alveolar segments in cleft palate patients with a tooth-borne distraction device.[15] The proven effectiveness of DO combined with maxillary anterior segmental advancement to treat maxillary hypoplasia suggests that interdental DO can also be used to augment the maxillary dental arch in patients with maxillary deficiency.[16,17] Our previous long-term follow- up study documented the effects of interdental DO in patients with maxillary deficiency, revealing that the hard and soft tissue profile could be successfully corrected. Stable results were observed at the three-year follow-up.[18] As maxillary dental arch lengthening using a tooth-borne device is seldom reported, the current study examined skeletal and dental changes after distraction in six patients who underwent anterior maxillary segmental osteotomy with DO using a tooth-borne anteroposteriorly- oriented Hyrax expansion appliance for treatment of maxillary skeletal and dental arch deficiency.

METHODS

This is a case series study. The subjects for this study were selected from the Orthodontic Clinic, Department of Craniofacial Dentistry, Chang Gung Memorial Hospital and were treated consecutively by one author (CT Ho) with a Hyrax expansion appliance (Lewa Dental, Remchingen, Germany). Six young adolescents (four boys, two girls mean age, 11 years 2 months, range, 10 to 12 years) with maxillary deficiency associated with a retruded maxillary arch were chosen. Each met the following criteria: (1) bilateral Class I molar relationship with normal vertical growth pattern; (2) concave facial profiles with anterior cross bite; (3) crowded maxillary dental arch; (4) nonextraction plan; (5) no transverse discrepancy. All patients required maxillary dental arch lengthening with DO based primarily on maxillary anterior dental crowding and a retruded maxillary arch. The patients and their parents were informed about the proposed treatment plan involving the surgical phase (anterior maxillary segmental osteotomy) and the distraction phase (DO with a tooth-borne Hyrax expansion appliance).

Surgical procedure

Pre-surgical orthodontics was recommended to move adjacent roots apart before the interdental osteotomy in crowding cases. The surgical procedure was performed under general anesthesia. A left-premolar-to-right-premolar horizontal incision was made along the buccal vestibule of the maxilla in accordance with the following procedure. A superior mucoperiosteal flap of the maxillary buccal mucosa from the left second premolar to the right second premolar was elevated to expose the lower part of the anterior maxilla, the piriform margin, and the anterior floor of the nose for the horizontal maxillary osteotomy. A vertical mucoperiosteal tunnel was made from the interdental attached gingiva between the upper first and second premolars upward to the horizontal incision to expose the site of the vertical interdental osteotomy. A complete horizontal osteotomy was performed by sawing from the left first premolar to the right first premolars, 4-5 mm above the dental root apices and tooth buds, cutting through the vomer and maxillary sinus wall.[19] A vertical interdental corticotomy was then performed with a 1-mm round bur. To avoid damage to the adjacent roots, a hand piece with 1-mm round bur was applied only to cut the buccal cortical plate. The separation of the interdental cancellous bone and palatal cortical plate was done manually with a mallet and thin osteotome for final sectioning of the osteotomized segment. The incisions were then closed with 5-0 Dexon.

Construction of the tooth-anchored Hyrax expander distracting appliance

The tooth-anchored appliance was fabricated in our laboratory before surgery. The appliance was composed of a Hyrax expansion screw (Lewa Dental, Remchingen, Germany) soldered onto four orthodontic metal bands (Tomy, TM-305-00, Tokyo, Japan) (Fig. 1A, B). The screw was oriented in an anterior-posterior direction to move the anterior maxillary segment forward. The bands were cemented to the maxillary first premolar and first molar on the left and right sides with glass ionomer cement immediately after the interdental and horizontal osteotomy while the patients were still under general anesthesia. The distraction appliance served not only to secure the osteotomized anterior segment to the posterior segment of the maxilla, but also to distract the osteotomized segment forward.

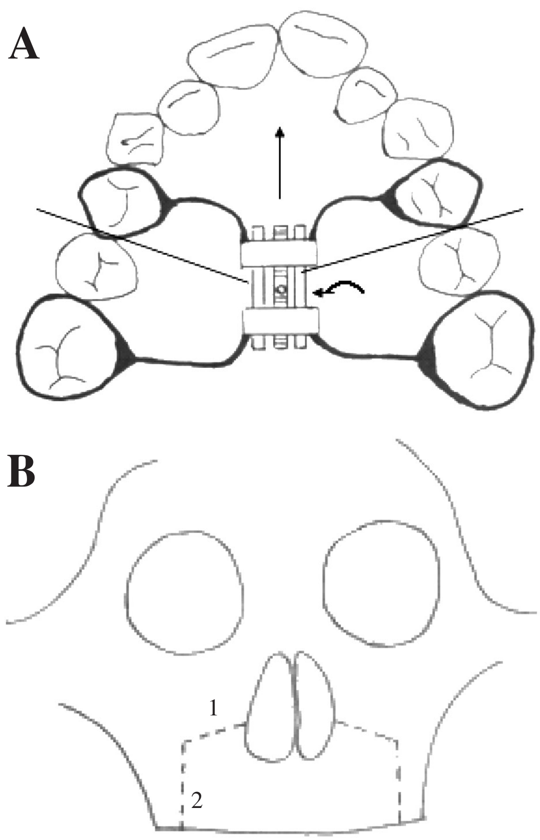

Fig. 1 The anteroposteriorly -oriented interdental distraction device including expansion screw and four metal bands. (A) Design of the Hyrax expander distraction device. The upper arrow denotes the direction of anterior segment movement, and the lower arrow represents the turning direction of the expansion screw. The two solid lines represent the site of interdental osteotomy. (B) Details of surgical cuts. 1, horizontal cut, through the maxillary sinus wall and anterior floor of the nose. 2, vertical cut, from the interdental attached gingiva between the upper first and second premolars upward to the horizontal incision, with final sectioning of the osteotomized segment with a mallet and thin osteotome.

Distraction protocol

Distraction of the anterior segment began 7 days after the osteotomy.[20,21] The tooth-borne device was activated by two one-quarter turns (0.5 mm advancement per day) to achieve a theoretical 7 mm advancement in 14 days. The screw was then fixed with a ligature wire and covered with light cured resin to avoid dislodgement or relapse. The appliance was maintained in position for 3 months to allow bone consolidation.[22-24] After removal of the appliance, orthodontic tooth movement began. The adjacent teeth were moved into the newly regenerated bony tissue, and the maxillary arch was coordinated with the mandibular arch.

Data recording and analysis

Stone casts of the maxillary arch, cephalograms, and periapical radiographs of the maxillary teeth were taken before the treatment (T1) and 3 months after DO (T2). The following measurements and observations were made.

Measurements from the dental casts

To measure changes in the arch in the supporting area and the premolar region of the maxilla after distraction, a line connecting the mesial contact points of the maxillary first molars was used as a horizontal reference line and a line passing through mesial contact point of the central incisors, incisive papilla and midpalatal raphe was used as a vertical reference line. The perpendicular distances between the reference points on the teeth and the horizontal and vertical reference lines were measured to evaluate anteroposterior and transverse dental changes. The casts were measured to the nearest 0.01 mm as follows with digital sliding calipers (Dentaurum, Ispringen, Germany) positioned parallel to the occlusal plane on each maxillary cast to minimize the error from the vertical discrepancy of the landmarks (Fig. 2).

1. The distances between the distal contact point of the first premolar and the mesial contact point of the first molar were measured in both quadrants to determine the additional space created by the DO procedure. The distances between the right side and left side were averaged to yield one value which was defined as space creation (Fig. 3).

2. The transverse arch changes in the molars and premolars were determined by measuring the distance between the central fossa of the first premolars and the first molars which were registered on each side.

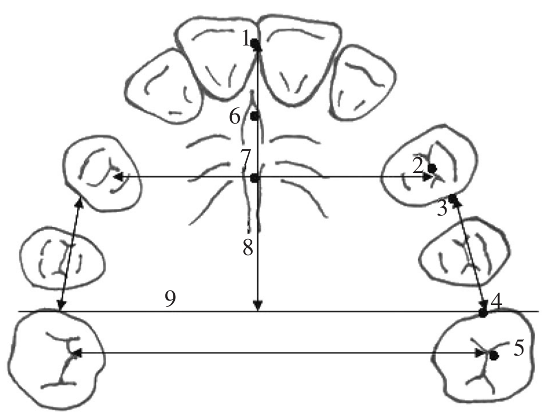

Fig. 2 Maxillary dental cast measurements with reference lines and landmarks. 1, contact point of the central incisor; 2, central fossa of the first premolar; 3, distal contact point of the first premolar; 4, mesial contact point of the first molar; 5, central fossa of the first molar; 6, incisive papilla; 7, midpalatal raphe; 8, vertical reference line; 9, horizontal reference line.

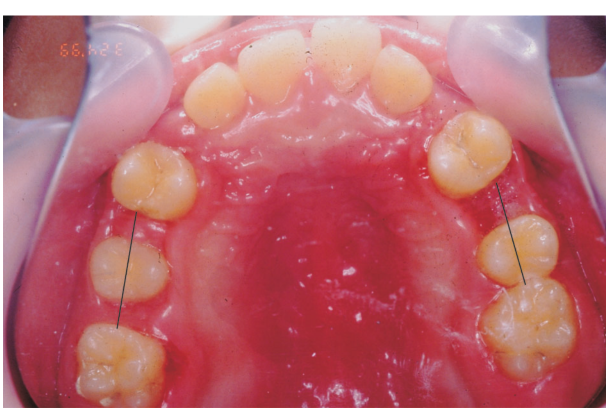

Fig. 3 Occlusal measurement of space creation. The contact points between two teeth have been measured (black lines).

3. The maxillary arch depth was measured as the distance between the contact point of the central incisors and the line bisecting the mesial contact point of the left and right first molars.

Cephalogram measurements

All cephalograms (Gx-Ceph, Gendex Corporation, Lake Zurich, IL, U.S.A.) were taken under the same standardized setting. Twelve hard tissue landmarks were identified on each cephalometric film from which 9 angular and 10 linear measurements were taken. A line 7° below the Sella-Nasion (SN) plane (SN-7°) was defined as the horizontal reference line (X-axis), and a line perpendicular to SN-7° through the sella was used as the vertical reference line (Y-axis).[25] The sella-nasion line registering on the sella was used for superimposition. The forward movement of the anterior maxillary segment was measured at point A and the anterior nasal spine (ANS) (Fig. 4).

Observations from periapical radiographs

Periapical radiographs (Asahi, Roentgen Ind. Co., Kyoto, Japan) were taken at the distraction site. Special attention was directed to signs of new bone formation (i.e., transformation from radiolucency to radiopaque).

Method error

To estimate the error of localizing the reference points and the manual procedure, 6 randomly selected radiographs were retraced and remeasured by the same examiner (CT Ho) and dental casts were also remeasured by the same examiner after 3 weeks. The causal error was calculated according to Dahlberg`s formula,[26] ($S=\sqrt{\Sigma d^2/2n}$, where S is the error variance, d is the difference between the 2 measurements of the same variable, and n is the number of double measurements). The systematic errors were ascertained using paired t tests.[27] The greatest mean error for angular measurements did not exceed 0.84°, and the greatest mean error for all linear measurements did not exceed 0.53 mm. The paired t test for differences between the replications showed no statistically significant difference. These results indicated the reliability of the measurements.

Statistical analysis

Descriptive statistical analysis was performed

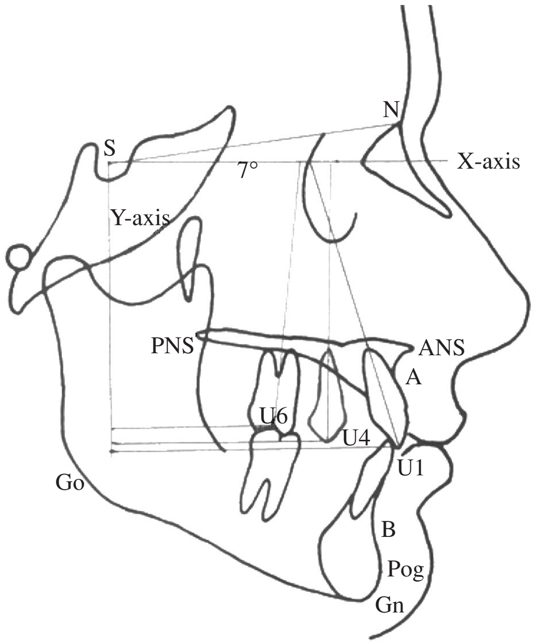

Fig. 4 Cephalometric analysis: the sella(s), center of the sella turica; nasion (N), the most anterior point of the nasal frontal suture; anterior nasal spine (ANS), the most anterior point of the spine; point A (A), the most anterior limit of the maxillary alveolar bone at the level of the incisor root apex; posterior nasal spine (PNS), the intersection between the nasal floor and the posterior counter of the maxilla; tip of the maxillary incisor crown (U1T); upper first molar mesial buccal cusp (U6MB); point B (B), the most anterior limit of mandibular alveolar bone at the level of the incisor root apex; gnathion (Gn), the most anterior and inferior point on the mandibular symphysis, pogonion (Pg), the most anterior limit of the mandibular symphysis; gonion (Go), the point at the greater convexity of the mandibular gonial region; X-axis, the horizontal reference line registered on the sella and defined by the sella-nasion minus 7°; Y-axis, the vertical reference line perpendicular to the X-axis and passing through the sella.

for all measurements at T1 and T2. All values recorded in this study were presented as mean ± SD. The Wilcoxon signed-rank test was used to test the changes in outcome variables from T1 to T 2, and $p < 0.05$ (*) was considered significant.

RESULTS

Dental arch measurements

Table 1 presents all maxillary arch measurements.

The average increase in the space between the first molar and the first premolar after distraction was 5.75 ± 1.03 mm anteroposteriorly at T2. With forward movement of the anterior maxillary segment, the change in maxillary arch depth was significant from T1 to T2 (4.15 ± 0.5 mm increase). This change was accompanied by an increase in overjet (5.66 ± 1.16 mm) and a decrease in overbite (1.50 ± 2.05 mm).

The transverse arch change in the intermolar width at the central fossa was insignificant from T1 to T2 (0.08 mm). Changes in the first interpremolar width were also insignificant (0.15 mm).

Cephalometric evaluation

Table 2 presents the cephalometric measurements of all patients before and after distraction. The saggital skeletal and dental changes in the maxilla after distraction were statistically significant.

In the analysis of the angular measurements, Sella-Nasion-point A (SNA), point A-Nasion-point B (ANB) and the angle of convexity increased 4.16°, 4.75° and 9.33°, respectively. Proclination of the maxillary central incisors was 4.2°. As the maxillary first premolars tipped mesially (1.66°), the max-

Table 1. Maxillary Arch Measurements before (T1) and after Distraction (T2)

Measurements (mm)	T1		T2		T2–T1		*p*
	Mean	SD	Mean	SD	Mean	95% CI	
Maxillary arch width							
Interpremolar (first)	38.92	0.67	39.06	0.58	0.15	0.00 – 0.30	0.625
Intermolar	47.71	0.83	47.78	0.84	0.08	-0.01 – 0.15	1.000
Maxillary arch depth	25.16	0.22	29.30	0.78	4.15*	3.93 – 4.37	0.031
Overjet	-2.2	1.76	3.66	2.06	5.66*	4.44 – 6.88	0.031
Overbite	2.00	2.45	0.5	1.18	-1.5*	-3.65 – 0.65	0.031
Space creation (one side)	7.21	0.51	12.95	0.56	5.75*	4.66 – 6.84	0.031

*: $p < 0.05$.

Table 2. Cephalometric Measurements in Skeletal and Dental Variables before (T1) and after Distraction (T2) (n = 6)

Variables	T1		T2		T2–T1		*p*
	Mean	SD	Mean	SD	Mean	95% CI	
Angular changes							
SNA	79.08	2.61	83.25	2.48	4.16*	3.90 – 4.42	.031
SNB	81.25	3.31	80.75	3.68	-0.50	-1.31 – 0.31	.250
ANB	2.25	2.78	2.50	2.14	4.75*	3.62 – 5.89	.031
Convexity	-4.66	4.33	4.83	4.71	9.33*	8.27 – 10.39	.031
SN-MP	32.16	5.56	33.41	6.06	1.25	0.12 – 2.38	.062
PP-SN	11.08	2.37	10.91	2.53	-0.16	-0.89 – 0.57	.050
U1-FH	117.00	5.51	121.16	4.50	4.16*	1.92 – 6.40	.031
U4-FH	90.50	6.09	92.16	4.40	1.66	-2.77 – 6.09	.062
U6-FH	74.58	3.77	73.75	4.07	-0.83	-1.62 – -0.04	.125
Linear changes							
Horizontal changes							
ANS-X axis	65.91	3.70	70.08	4.01	4.16*	3.45 – 4.87	.031
A-X axis	63.02	3.11	67.25	3.31	4.26*	3.74 – 4.79	.031
Is-X axis	68.08	4.03	74.08	3.61	6.01*	4.50 – 7.52	.031
U4-X axis	49.25	2.48	54.33	2.65	5.08*	3.91 – 6.25	.031
U6-X axis	36.08	3.23	35.23	3.41	-0.85	-1.30 – -0.40	.062
Vertical changes							
ANS-Y axis	45.41	0.73	45.25	0.75	-0.16	-0.58 – 0.26	.062
A- Y axis	49.75	2.01	49.66	1.83	-0.08	-0.47 – 0.14	1.000
Is- Y axis	71.25	3.37	71.02	4.51	-0.25	-1.56 – 1.06	.750
U4-Yaxis	68.16	4.84	68.83	4.71	0.66	0.12 – 1.20	.250
U6-Y axis	65.16	4.25	65.65	4.04	0.50	0.07 – 1.07	.250
Overjet	-2.2	1.76	3.66	2.06	5.66	4.44 – 6.88	.031

*: $p < 0.05$.

illary first molars were relatively stable with only 0.8° of distal tipping.

The statistically meaningful increases in the linear measurements of point ANS and point A from T1 to T2 of 4.16 mm and 4.26 mm showed increases in maxillary length. The maxillary first molars moved distally, the maxillary first premolars moved mesially and the maxillary central incisors moved anteriorly. The mesial movement of the first premolars and the anterior movement of the central incisors were statistically significant (5.08 mm and 6.01 mm), but the distal movement of the first molars was not significant (0.85 mm).

Vertical changes in the positions of point ANS, point A, the central incisors, first premolars and first molars were all insignificant. However, the extrusion (0.5 mm) of the maxillary first molars yielded clockwise mandibular rotations that led to a slight increase in the SN-MP (1.25°) measurements and reduction in the Sella-Nasion-point B (SNB) angle (0.5°) (Fig. 5).

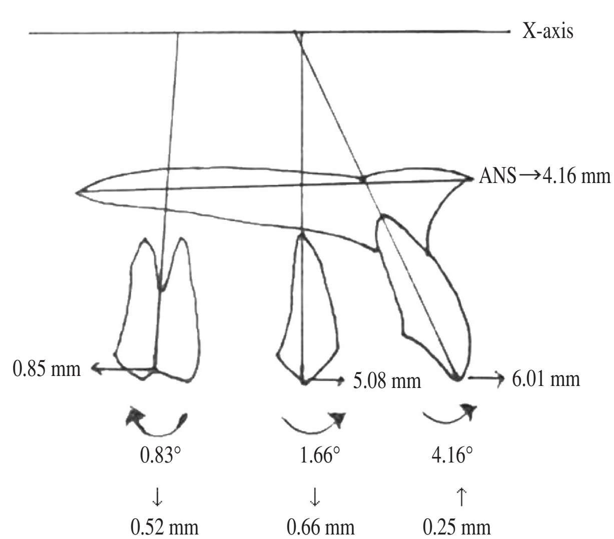

Fig. 5 Changes in position of the 1st molar, 1st premolar, central incisor and ANS in the saggital plane and mesial or distal tipping toward the X-axis.

Fig. 6 illustrates an example of changes in the facial profile and dental arch in a 10-year-old girl.

Periapical radiograph findings

The banded first molar and first premolar showed parallel separation in periapical radiographs immediately after distraction (14 days later) (Fig. 7). A distraction gap was observed, but no bone formation was evident at this stage (Fig. 7B). The gap was filled with new bony tissue after 3 months (Fig. 7C). The second premolars were still erupting and were accompanied by alveolar bone growth. However, bone height never reached the original level (Fig. 7D). Upon completion of orthodontic treatment, all teeth were aligned and leveled, and interdental spaces were closed at the distraction site. The interseptal bone at the distraction site was indistinguishable from other interseptal bone (Fig. 7E). Three years follow-up of all patients revealed no complications, and no further osseous management was required.

DISCUSSION

Maxillary expansion is usually performed to correct transverse deficiency and to increase the arch perimeter.[28] In contrast to transverse expansion of the dental arch using a rapid palatal expander,[29,30] this distraction appliance with a palatal expansion screw was oriented anteriorposteriorly to allow forward movement of the anterior maxillary segment. The current method is based on the technique of gradual repositioning of the anterior segment of the maxilla using the principal of distraction osteogenesis. The anteroposteriorly oriented Hyrax expansion appliance is a tooth-borne intraoral appliance. It uses

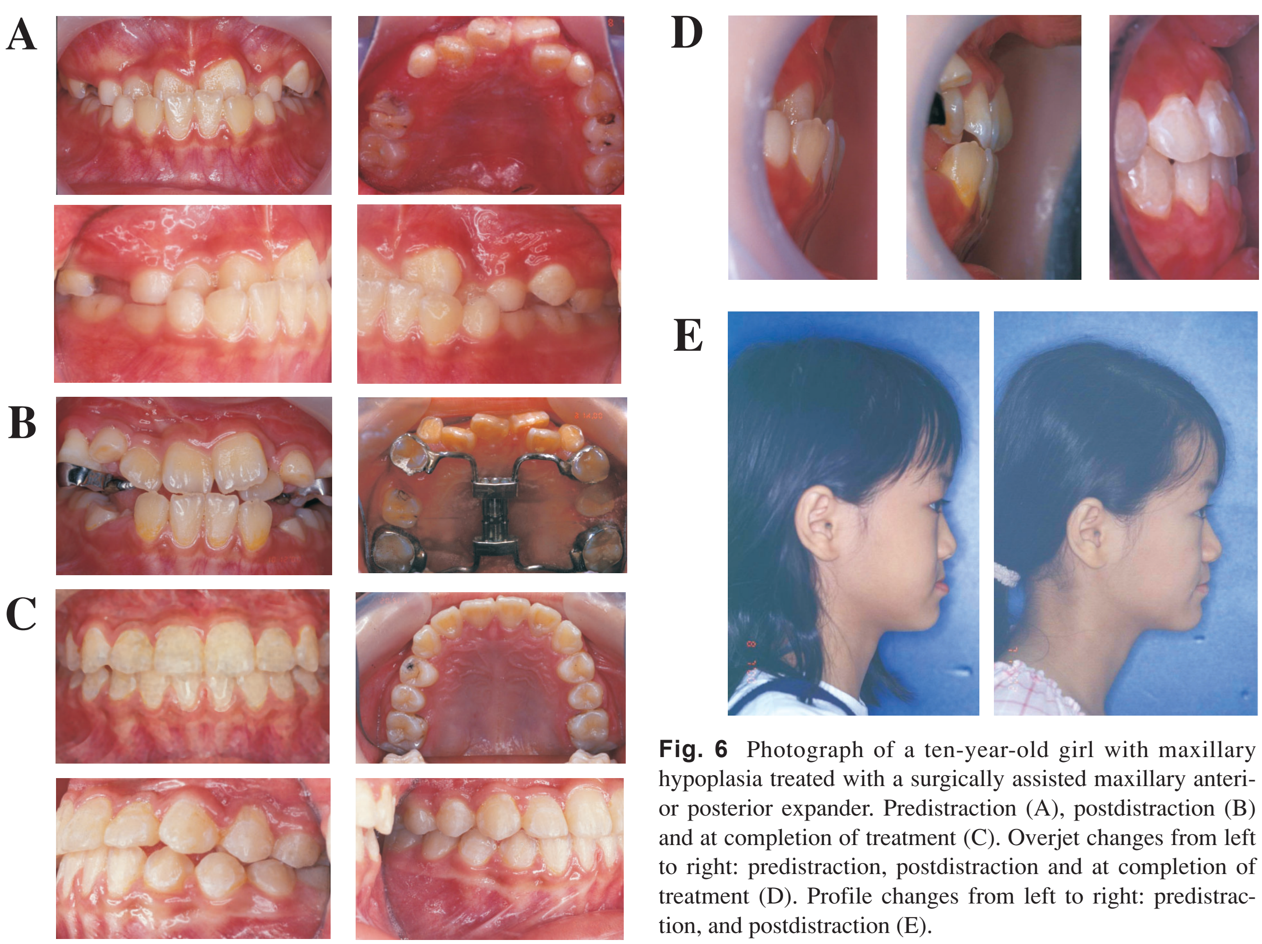

Fig. 6 Photograph of a ten-year-old girl with maxillary hypoplasia treated with a surgically assisted maxillary anterior posterior expander. Predistraction (A), postdistraction (B) and at completion of treatment (C). Overjet changes from left to right: predistraction, postdistraction and at completion of treatment (D). Profile changes from left to right: predistraction, and postdistraction (E).

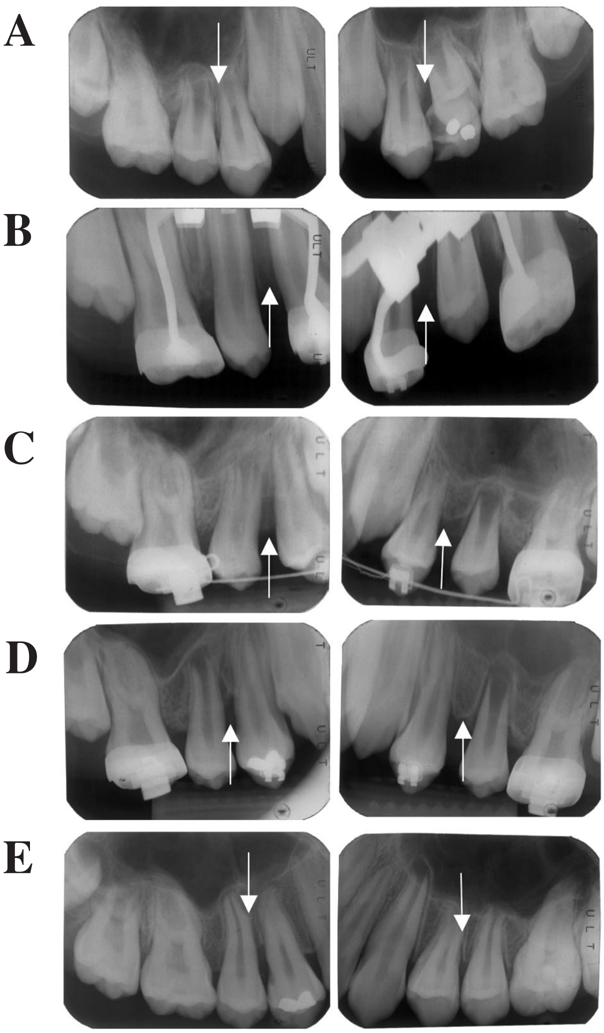

Fig. 7 Radiograph changes in tooth movement and interseptal bone during and after interdental distraction (one patient). (A), Predistraction (arrows indicate surgical site). (B), 14 days after distraction, (arrows illustrate the formation of a distraction gap); (C), device removal after 3 months of consolidation and beginning of orthodontic treatment; newly formed alveolar bone was visible distal to the first premolars (see arrows); (D), continued repair of the alveolar bone after 6 months (see arrows); (E), completion of treatment, the interseptal alveolar bone was undistinguishable from the adjacent alveolar bone.

the maxillary molars as anchorage for forward movement of the anterior segment assisted by a maxillary anterior segmental osteotomy. After surgery, the moveable anterior segment can be distracted forward easily with the expansion appliance. To our knowledge, this study is the first to evaluate skeletal and dental changes, including changes in the saggital direction of the anterior maxillary segment, transverse dimension of the dental arch, arch depth and dental inclination, produced by a surgically assisted rapid maxillary anterior-posterior Hyrax expansion appliance.

The results showed that the arch depth was increased due to the lengthening (expansion) effect produced by the expansion appliance, especially in forward movement of the anterior osteotomized segment. However, the anchored teeth (maxillary first molars and first premolars) still displayed some reciprocal dental inclination and extrusion (0.8° in distal tipping and 0.5 mm of extrusion for the maxillary first molars, 1.66° in mesial tipping and 0.66 mm of extrusion for the first premolars and 4.16° proclination of the central incisors) in addition to movement of the bony base (Fig. 5). This confirmed expectations that the tooth-borne appliance would have dental effects other than skeletal effects.[11,12] A skeletal anchor design (osseous implant as anchorage) might be needed to resist the reciprocal distal force from the appliance and dense palatal tissue.

In this study, six young adolescents underwent anterior maxillary segmental osteotomy and (interdental) segmental distraction osteogenesis to treat maxillary deficiency associated with dental crowding and all were successfully treated. The results of the procedure indicate that this method is able to lengthen the dental arch, allowing adjacent crowded teeth to move into the regenerated bony tissue to improve dental interdigitation. Distracting the anterior maxillary segment by an average of 4.3 mm (point A) and creating new dental arch space (4.3 mm on both the left and right sides) were achieved at the time of T2. Together with the tooth separation of 5.75 ± 1.03 mm on each side, a total increase of 11.5 mm in arch length was achieved, enough to resolve dental crowding in all patients. The significant increases in the maxillary arch depth led to an increase in the arch perimeter, a clinically favourable result in nonextraction treatments. The maxillary arch width measurements between the posterior teeth remained unchanged, indicating that anteroposterior expansion of the maxillary arch was achieved due to skeletal and dental movement. The vertical effect of the tooth anchored expansion appliance was observed on the mandible which demonstrated statistically insignificant clockwise rotation due to the wedge effect of the maxillary first molars which displayed distal tipping and extrusion. This finding corresponds to studies indicating that an orthodontic rapid palatal expander may incur alveolar bending, lateral tooth movement and tooth extrusion in the maxilla which consequently has a bite-opening effect on the mandible.[29,30]

Reports on tooth-borne appliances for maxillary advancement have shown varying results. Block *et al*.[11] reported that more dental movement than bony movement occurred when a tooth-borne device was used to distract the anterior maxillary segment. Liou developed a tooth-borne interdental distraction device which was successfully applied in cleft patients to protract the osteotomized segments;[15] the author reported that most movement was skeletal. Here, a tooth-borne device was used for distraction, and the results revealed that the upper incisors moved forward by an average of 6.01 mm linearly (measured at the tip of the upper incisors with increasing 4° labial tipping) whereas the bone moved forward only 4.3 mm at point A. With the device applied in this study, skeletal movement was approximately 70% (4.3 mm/6.01 mm) of total movement, and dental movement was only 1.7 mm, indicating that skeletal movement dominated dental movement. This finding was different from that of Block's animal study. The mean 1.7 mm dental compensation which clinically appeared in proclination of the incisors might have been caused by tooth movement through the alveolar bone instead of tooth movement with bone. Fortunately, dental compensation was minimal and easily corrected in the post-distraction phase due to the increased arch perimeter. These experimental results are consistent with the observation by Liou that segmental DO can move osteotomized segments forward, and suggest that DO can be used to advance the maxillary dental arch in patients with maxillary hypoplasia.[15]

Distraction osteogenesis occurred at the site of the surgical cut (osteotomy) by stretching the soft tissue callus.[20,21] Progressive periapical radiographs (Fig. 7) showed that new bone formed between the first and second premolars. Initially, the new bone was not visible immediately after distraction as demonstrated by radioluscency in the periapical radiographs. During the healing process, new alveolar bone was generated and remodeled rapidly on the tension side of both segments and became radiographically mature within 3 months after distraction. The healing process and the osteogenesis of the distraction site resembled that of mandibular distraction.[31-33] None of the subjects in this study complained of pain or other complications. As the maxillary arch was lengthened, removing healthy teeth was not necessary to gain additional space. Upon completion of orthodontic treatment, the teeth of all patients were well aligned, leveled and in good interdigitation. The new bone growth (interseptal bone) between the first and second premolars (distraction site) did not differ from other interseptal bone except for minor osseous defects on one distraction site. Fortunately, the minor localized periodontal damage had no effect on occlusal function. As such, this treatment was used in our patients as an alternative to maxilla lengthening, and the arch length was adequate for correction of maxillary deficiencies and dental crowding.

Interdental DO appears suitable for patients with mild to moderate maxillary deficiency requiring anterior maxillary segment protraction. However, in severe maxillary deficiency, a bone-borne distractor[34] (eg., using an osseous implant as anchorage) or a Le Fort I osteotomy may be needed if significant skeletal movement is necessary,[35] due to the limited activation of the distraction screw. Although the main disadvantage of tooth-anchored distractors in interdental DO is the increased risk of unwanted tooth movement and limited activation, these devices have several advantages. They are small and simple, easy to apply and remove, and capable of reducing the risk of wound complications. Conversely, bone-borne devices can cause mucosa ulceration around the appliance or loosening of the distraction module, and removal requires minor surgery under secondary anesthesia (local or general).[36,37] Additionally, use of intraoral devices does not cause facial scarring, can lengthen the maxillary arch and can create new alveolar bone and gingival tissue.[38] Because they do not have to be as small as bone-borne devices, the cost as well as the risk of damage or failure is reduced.

The effects of the LeFort I segmental osteotomy on maxillary growth are disputed. Ross reported that a conventional LeFort I osteotomy in growing patients inhibited further horizontal growth of the maxilla.[39,40] Epker reported that some anteroposterior growth could be expected after a horseshoe maxillary osteotomy because the nasal septum remains attached to the stable palate and only dentoalveolar structures are mobilized.[41] Our previous report showed that the mean maxillary forward growth after surgery in our patients was 0.17 mm/yr,[18] which is less than the normal rate of 1.3 mm/yr in children.[39,42] However, the diagnosis for all patients in our study was maxillary deficiency and as the cause of maxillary deficiency is deficient maxillary growth, normal growth cannot be expected after surgery. Therefore overcorrection of an anterior cross bite is recommended to counteract postdistraction growth deficiency in the maxilla.

One disadvantage of this study was the small sample size, with possible variations in the response to interdental DO treatment and the post-distraction growth pattern, which could prevent us from making a general outcome prediction. The results from this study demonstrate that for a growing patient with mild to moderate maxillary hypoplasia and a narrow upper arch, early correction is possible with maxillary and dental arch lengthening using interdental DO. Finally, we believed that an overcorrection in this interdental DO could be a good treatment option for patients with maxillary deficiency associated with a retruded maxillary arch without mandibular prognathism.

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輔以手術作上顎骨前後擴張後的骨骼及牙齒的變化

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背 景： 許多矯正裝置可用於作上顎牙床的前後向與橫向擴張之用，然而以上顎牙床延長術來治療上顎後縮合併齒列擁擠則少見於報導。此研究目的爲探討以前後擴張方向擺置的擴張器，輔以上顎骨前段截骨術，來作上顎牙床的延長，對上顎骨骼及牙齒所產生的變化。

方 法： 6 位小孩 (4 男 2 女) 牽引前後側顱 X 光片、根尖片及上顎牙齒模型被拿來比較。他們都接受以前後擴張方向擺置的擴張器，輔以上顎骨前段截骨術，以牽引性骨生成技術來作上顎骨的延長。

結 果： 施予牽引性骨生成技術後，上顎後縮的牙床及齒列擁擠被成功的改正過來。上顎骨的 ANS 點、A 點、上顎門齒與第一小臼齒都明顯往前移動；相對的，上顎第一大臼齒往後與垂直方向移動並不明顯，然而當作支撐的第一大臼齒與第一小臼齒發生彼此方向相反的牙齒傾斜效應。牙床深度增加 4.2 mm，而牙床寬度沒有改變，共有 11.5mm 牙齒空間被創造出來，此量足以解決齒列擁擠的問題。牽引後的三個月，在牽引處可見明顯新骨生成。

結 論： 以 Hyrax 擴張器結合上顎骨前段截骨術，似乎可有效延長上顎牙床並創造牙齒空間。對上顎骨後縮合併牙齒擁擠的小孩，本法看來可以是另一種好的治療選項。
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關鍵詞： 上顎前後擴張，骨生成牽引，上顎骨發育不足，齒列擁擠

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