Case Report

Maxillary advancement using distraction osteogenesis with intraoral device

Yoko Takigawa[a]; Setsuko Uematsu[b]; Kenji Takada[c]

ABSTRACT

This article describes the surgical orthodontic treatment of maxillary hypoplasia in a patient with cleft lip and palate using maxillary distraction osteogenesis with internal maxillary distractors. Maxillary advancement was performed to correct the retrusive maxillary facial profile and Class III malocclusion. Rotational movement of the distraction segment was made to correct the upper dental midline. Although maxillary advancement was insufficient because of unexpected breakage of the intraoral distractor after completion of the distraction, skeletal traction with a face mask compensated for the shortage. Successful esthetic improvement and posttreatment occlusal stability were achieved with no discernible relapse after 2 years of retention. (*Angle Orthod.* 2010;80:1165–1175.)

KEY WORDS: Maxillary advancement; Distraction osteogenesis; Internal device; Retrusive maxillary profile

INTRODUCTION

Patients with cleft lip and palate often present restricted maxillary growth postsurgically, resulting in a typical skeletal Class III malocclusion. Early surgical interventions such as primary cleft lip and palate repair disturb maxillary growth, producing secondary deformities of the jaw and malocclusion.[1,2] The hypoplastic maxilla is usually advanced by Le Fort I osteotomy on completion of growth to reestablish facial proportion and occlusion.[3,4] It is often difficult, however, to mobilize the maxilla in patients with cleft lip and palate because of the presence of scarred soft tissue caused by the preceding operation. Patients with cleft lip and palate tend to show occlusal instability when treated by conventional Le Fort I maxillary advancement, as well as relapse, when compared with noncleft patients who have maxillary hypoplasia.[4–6]

Distraction osteogenesis (DO), which can provide skeletal advancement and expansion of soft tissue simultaneously, has become an effective surgical technique for patients with jaw deformities.[7] Moreover, maxillary DO is now in vogue as one of the possible treatment choices for cases of maxillary retrusion, especially in patients with cleft lip and palate.[8]

The rigid external distraction (RED) system has been used for maxillary advancement; this approach allows the management of patients from childhood to adulthood, with excellent and predictable functional and esthetic outcomes.[9] Among some of the approaches to maxillary DO, procedures employing an internal device are currently the most popular because these devices significantly reduce the amount of physical and psychological stress placed on the patient.[10,11] DO with internal devices has another advantage; it does not require the anchorage of teeth with protraction forces, although some disadvantages, such as less flexibility of vector control and a smaller amount of advancement, have been noted.[12]

The present case report describes surgical orthodontic treatment of a patient with cleft lip and palate with Class III malocclusion and a negative overjet caused by the hypoplastic maxilla. By employing maxillary DO with internal devices, a successful treatment outcome, including improvement in jaw function, good esthetics, and occlusal stability with no relapse, was achieved.

BACKGROUND AND PRESENT STATUS OF PATIENT

A 17-year-old female patient with cleft lip and palate on the left side was referred to us for correction of

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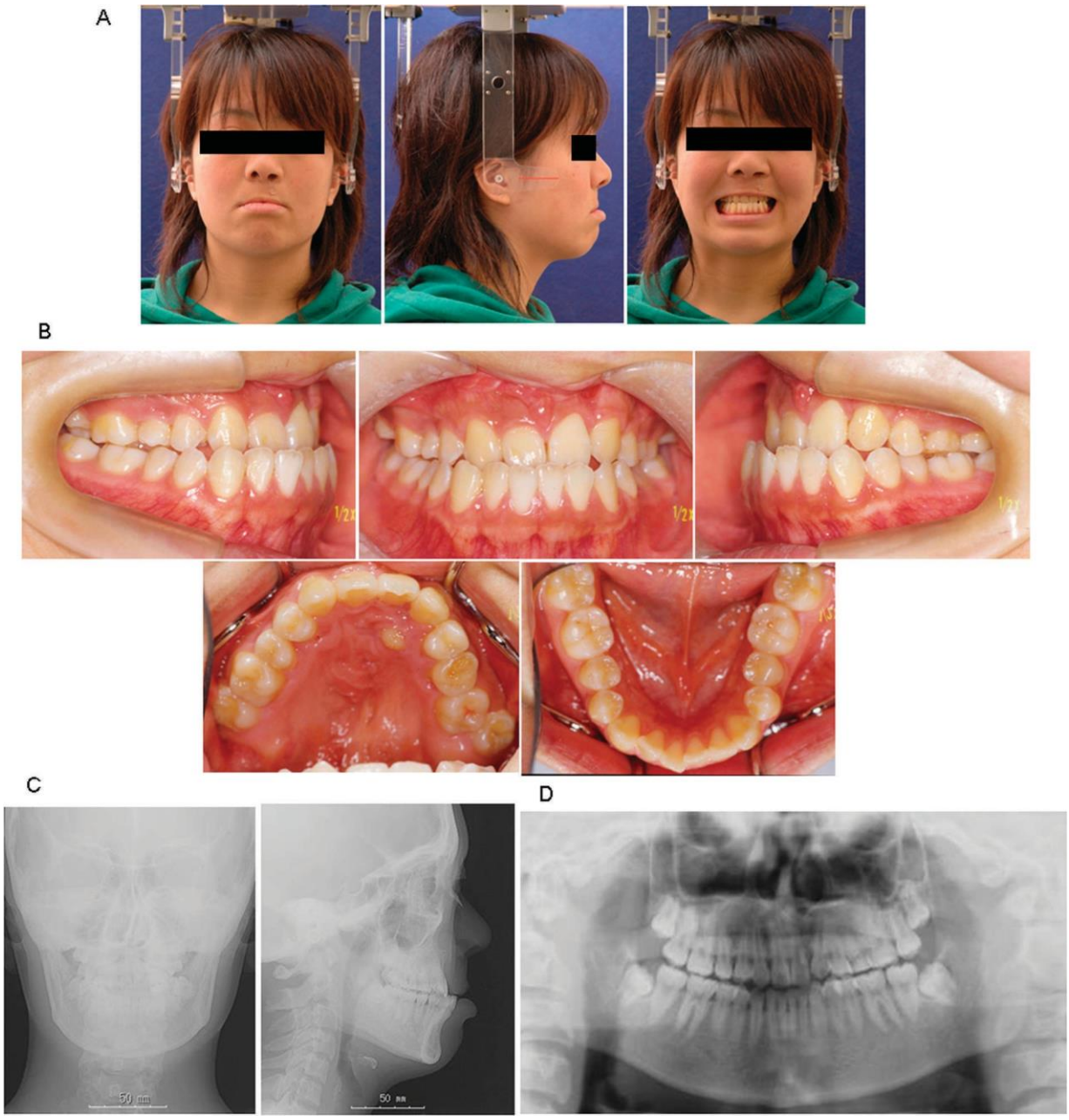

Figure 1. Pretreatment records (age, 17 years 11 months). (A) Facial photographs. (B) Intraoral photographs. (C) Frontal and lateral cephalograms. (D) Panoramic radiographs.

Class III malocclusion and dentofacial deformity before the start of Phase II orthodontic treatment. She had undergone cheiloplasty and palatoplasty at the ages of 4 months and 14 months, respectively. During Phase I orthodontic treatment, maxillary lateral expansion using the quad helix appliance was initiated at the age of 7 years. At the age of 12 years, a 0.022-inch preadjusted edgewise appliance was placed in the upper dental arch; this was followed by alveolar bone grafting at 13 years of age. Once leveling of the upper dental arch was completed, all appliances were removed at 14 years of age, and growth of the mandible was monitored until 17 years of age.

At the start of Phase II treatment, clinical examination showed a concave-type soft tissue facial profile with a retrusive maxillary-type facial deformity due to the hypoplastic maxilla (Figure 1A). Soft tissue analysis showed that the upper lip was 4.8 mm behind and the lower lip was 4.3 mm forward relative to the E-line at the resting position.

Intraoral examination revealed a Class III malocclusion with an incisor overjet of 25.2 mm and an

Table 1. Cephalometric Analysis at Pretreatment and Posttreatment Stages

Measurement	Pretreatment (17 y 11 mo)	Posttreatment (20 y 1 mo)	Normative Mean[a] (Adult, Female)	
			Mean	SD
Angular, degrees				
SNA	72.0	76.2	80.8	3.6
SNB	73.4	73.0	77.9	4.5
ANB	21.4	3.2	2.8	2.4
SNMP	36.2	35.5	37.1	4.6
FHMP	27.9	27.2	30.5	3.6
U1 to SN	93.5	99.8	105.9	8.8
U1 to FH	101.8	108.1	112.3	8.3
L1 to MP	98.9	93.8	93.4	6.8
L1 to FH	53.2	59.0	56.0	8.1
IIA	131.4	130.9	123.6	10.7
Linear, mm				
S-N	69.9	69.9	67.9	3.7
A-Ptm/PP	42.6	48.0	47.9	2.8
A-U6/PP	29.4	27.0	26.9	2.7
Go-Me	72.0	72.5	71.4	4.1
Ar-Go	52.6	52.6	47.3	3.3
Ar-Me	110.3	110.3	106.6	5.7
Overjet	25.2	2.9	3.1	1.1
Overbite	1.3	2.3	3.3	1.9
Soft tissue profile, mm				
Upper lip to E-line	24.8	21.8	20.4	1.7
Lower lip to E-line	4.3	3.1	1.6	1.7

[a] For Japanese normative mean.[15]

overbite of 1.3 mm (Figure 1B). The upper left lateral incisor, which was a microdont tooth, was in palatoversion. The upper right lateral incisor and the upper left second premolar tooth were found to be congenitally missing in the panoramic radiograph (Figure 1D).

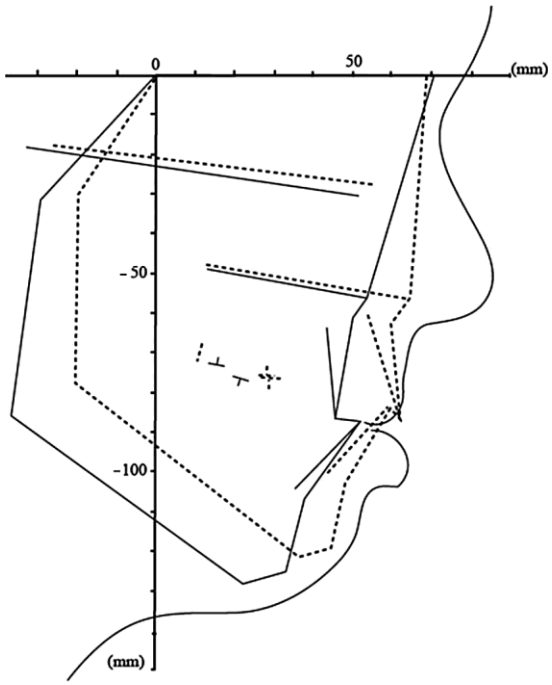

Figure 2. Superimposition of pretreatment profilograms (17 years 11 months, solid line) with the control profilogram (adult female, dotted line) on the SN plane registered at S.

The upper dental midline was deviated 2.3 mm toward the left from the facial midline because of the cant of the maxillary occlusal plane (Figures 1A through D and 7A). The lower skeletal and dental midlines coincided with the facial midline. TSS analysis[13,14] revealed a typical skeletal Class III sagittal jaw relationship with a grade of 1.0. Furthermore, lateral cephalometric analysis showed a skeletal Class III jaw relationship (ANB 5 21.4 degrees) with horizontal maxillary hypoplasia in comparison with the normative Japanese mean.[15] Maxillary anterior-posterior length was short, and the maxilla was located in a significantly retrognathic position (SNA 5 72.0 degrees, A-Ptm/PP 5 43.0 mm; Table 1, Figures 1C and 2). Mandibular body length and mandibular plane angle were normal, but the mandible was relatively retropositioned (SNB 5 73.4 degrees). The upper incisors were lingually inclined (U1 to FH 5 101.8 degrees); the lower incisors, however, showed a normal inclination.

Examination of nasopharyngeal function by a speech therapist revealed risks of language deterioration, moderate hypernasality, and incomplete velopharyngeal closure after maxillary advancement (see Figure 8A).

TREATMENT PLAN AND PROGRESS

The objective was to correct the Class III malocclusion and the retrusive maxillary-type facial deformity

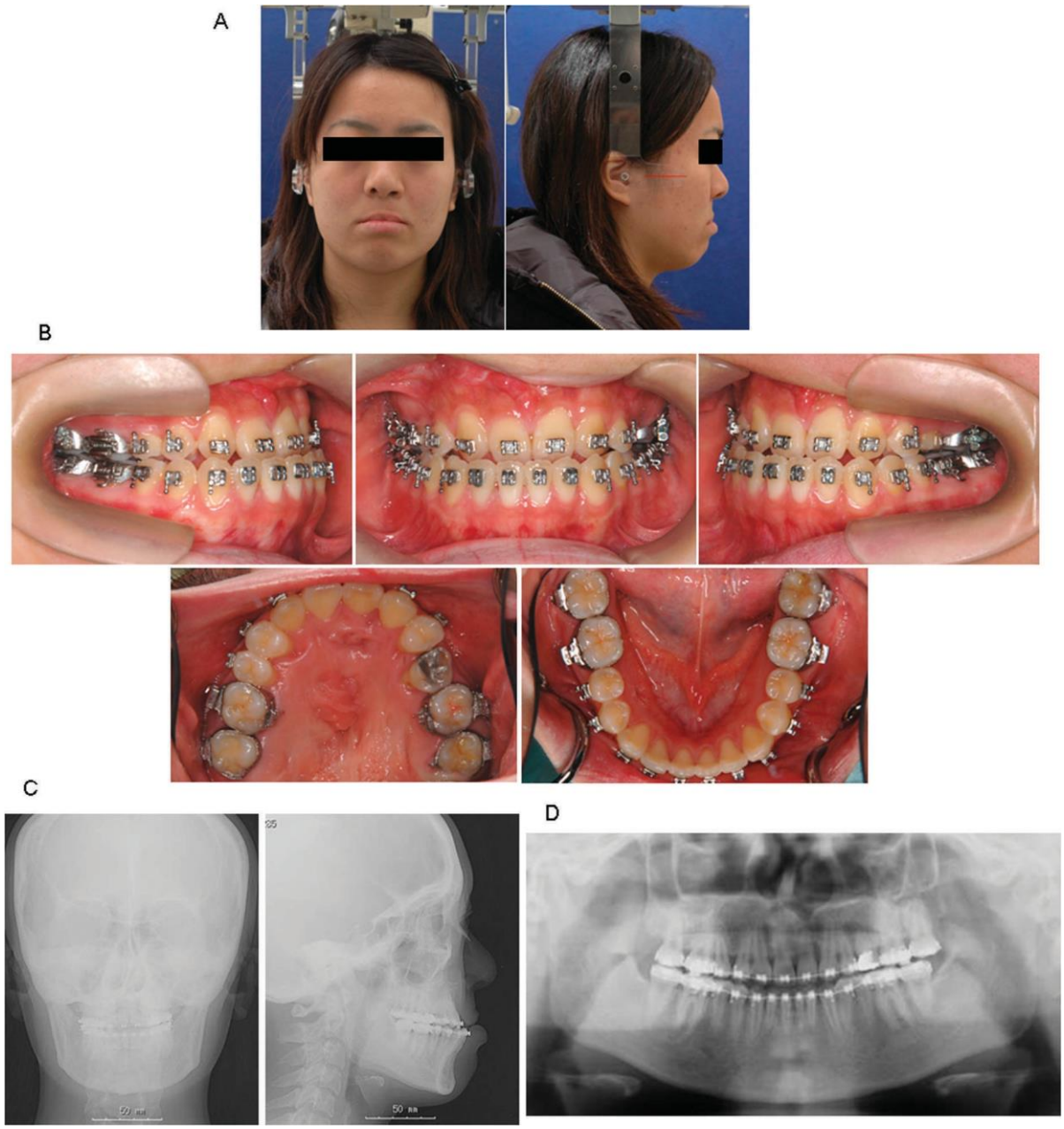

Figure 3. Preoperation records (age, 19 years 2 months). (A) Facial photographs. (B) Intraoral photographs.

caused by maxillary hypoplasia. The two-jaw surgical method (ie, maxillary advancement using DO and mandibular setback osteotomy) was considered. An intraoral distractor (Zurich Pediatric Maxillary Distractor; KLS Martin, Tuttlingen, Germany) was selected for maxillary distraction because the patient refused to wear a large external device and to remain hospitalized for a prolonged period.

The treatment plan proposed was as follows: (1) extraction of the upper left lateral incisor (a microdont tooth), (2) presurgical orthodontic treatment to align both dental arches using preadjusted edgewise appliances, (3) surgical advancement of the maxilla using DO, (4) mandibular setback by a sagittal split osteotomy, (5) postsurgical orthodontic treatment to achieve tight intercuspation of teeth, using occlusal adjustment, and (6) retention to stabilize the occlusion.

Presurgical orthodontic treatment began after the upper left lateral incisor was extracted. When the patient was 17 years 11 months old, 0.022-inch preadjusted edgewise attachments were placed in both dental arches, omitting the upper left second deciduous molar. After 16 months of orthodontic treatment (Figure 3A through D), surgical intervention was performed. The distraction started 7 days postoperatively with an elongation of 1.0 mm per day. After

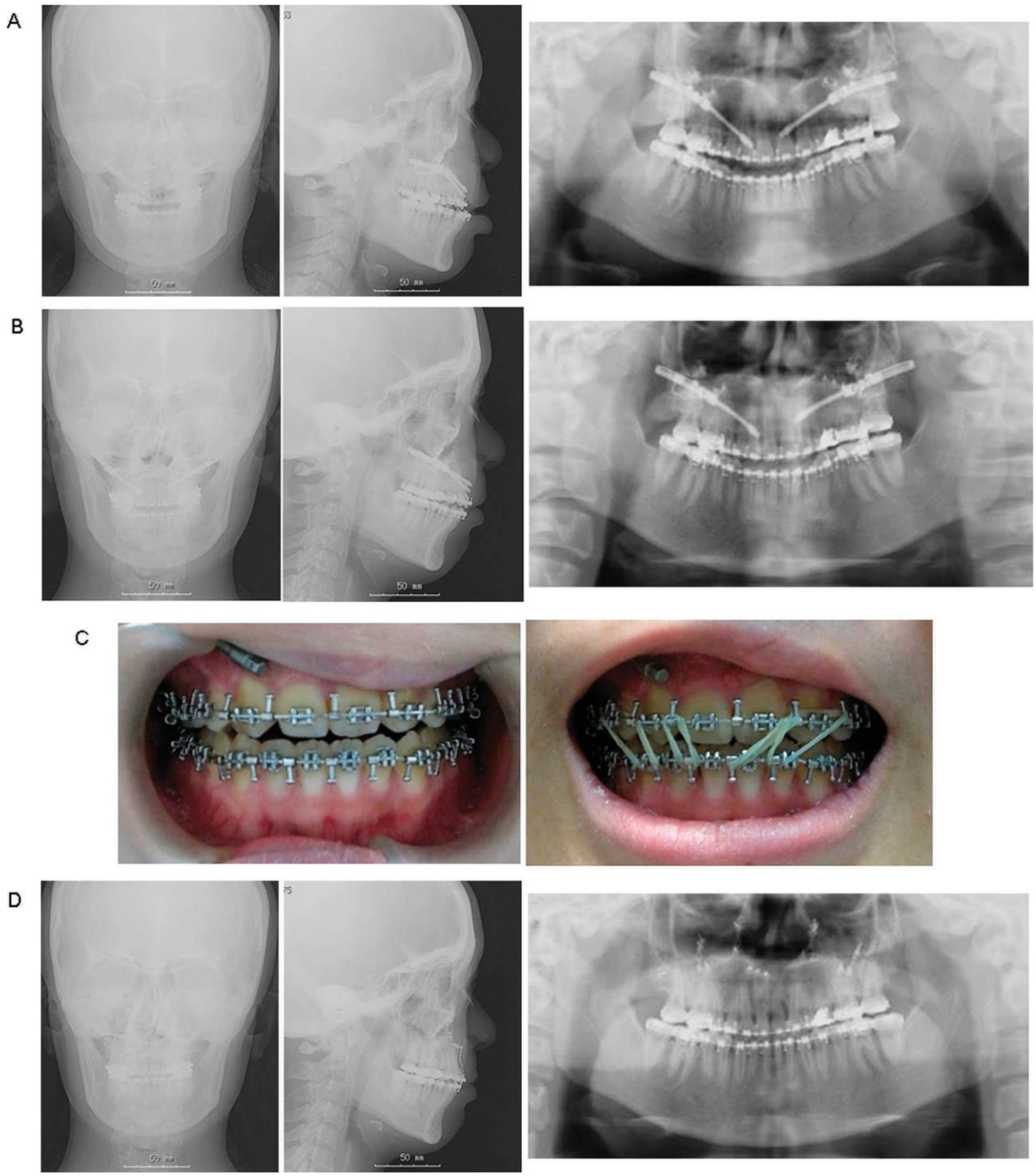

Figure 4. Cephalograms and panoramic radiographs during distraction, and intraoral photographs after distraction. (A) During advancement. (B) After advancement. (C) Orthodontic elastic traction after advancement. (D) 2 months after advancement.

the start of the maxillary advancement, the patient became reluctant to undergo the planned mandibular setback surgery. Consequently, the alternative treatment plan using only maxillary DO was proposed, including the explanation about possible limitation of vector control and distraction distance with the intraoral distractor. The maxillary advancement required was estimated to be 7.0 mm forward from the edge of the upper central incisors and 2.0 mm lateral toward the right side to make the upper and lower dental midlines coincide. To achieve the planned maxillary position, 9.0 mm advancement on the left side and 5.0 mm advancement on the right side were required. To support limited movement by the internal

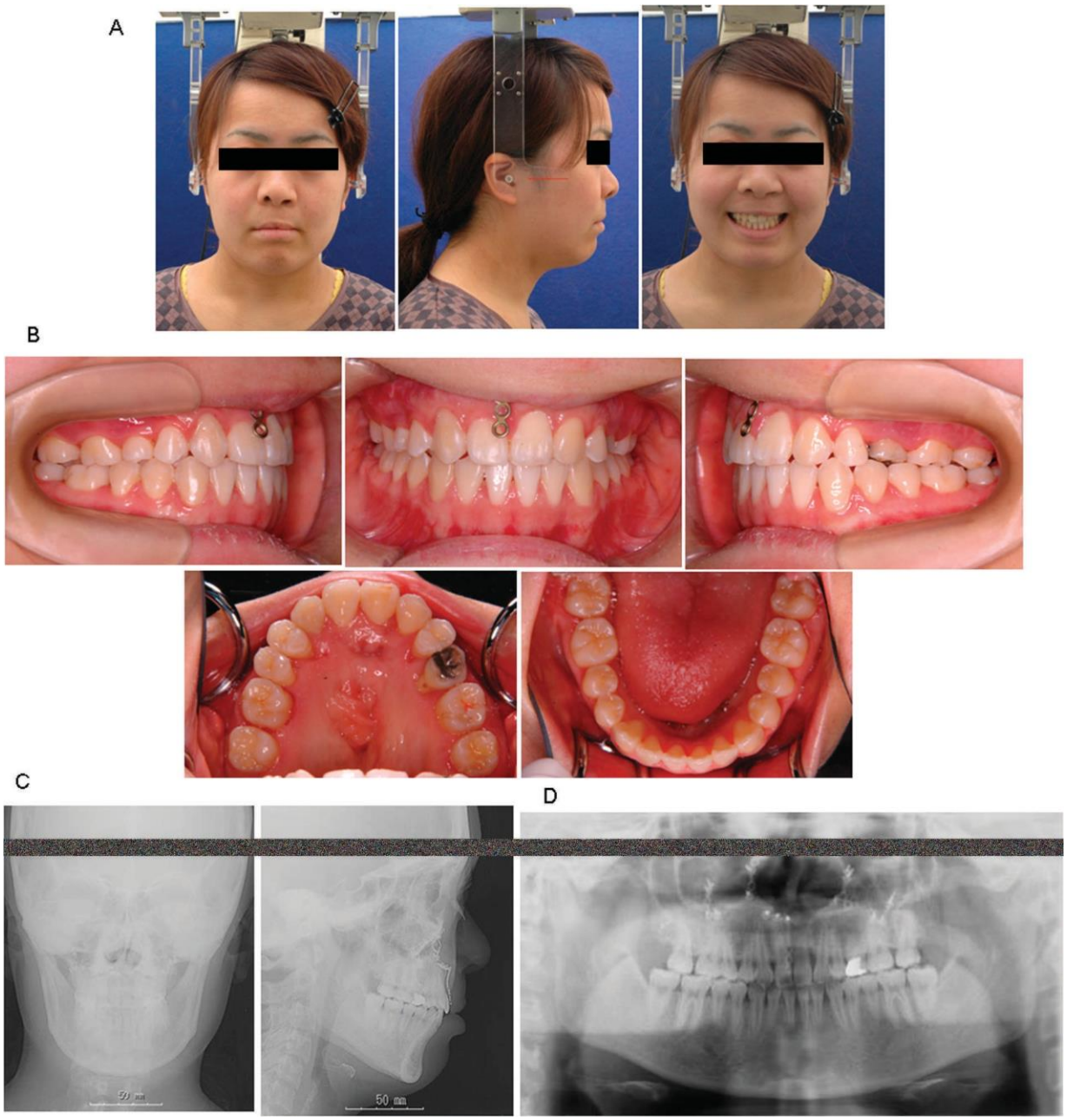

Figure 5. Posttreatment records (age, 20 years 1 month). (A) Facial photographs. (B) Intraoral photographs. (C) Frontal and lateral cephalograms. (D) Panoramic radiographs.

distractor, use of a maxillary-protraction headgear appliance was planned. After an explanation was given, informed consent was obtained from the patient.

To adjust the position of the maxillary dental midline, an additional elongation of 4.0 mm by the left distractor was required, subsequent to an advancement of 5.0 mm by both distractors. Advancement of the maxillary segment was confirmed by radiography during the distraction period (Figure 4A,B). After completion of this advancement as planned, the maxilla showed evidence of a relapse because at some point after the maxillary distraction, the left-side intraoral device had broken unexpectedly at the weak joint of the device. Therefore, the planned amount of advancement was not attained. The occlusion resulted in an undesirable consequence with an edge-to-edge interincisal relationship (Figure 4C). However, because immediate resetting of the left distractor by surgical means was rejected by the patient, maxillary advancement was continued with the use of a maxillary-protraction headgear appliance with elastics attached to the face mask. Class III and vertical

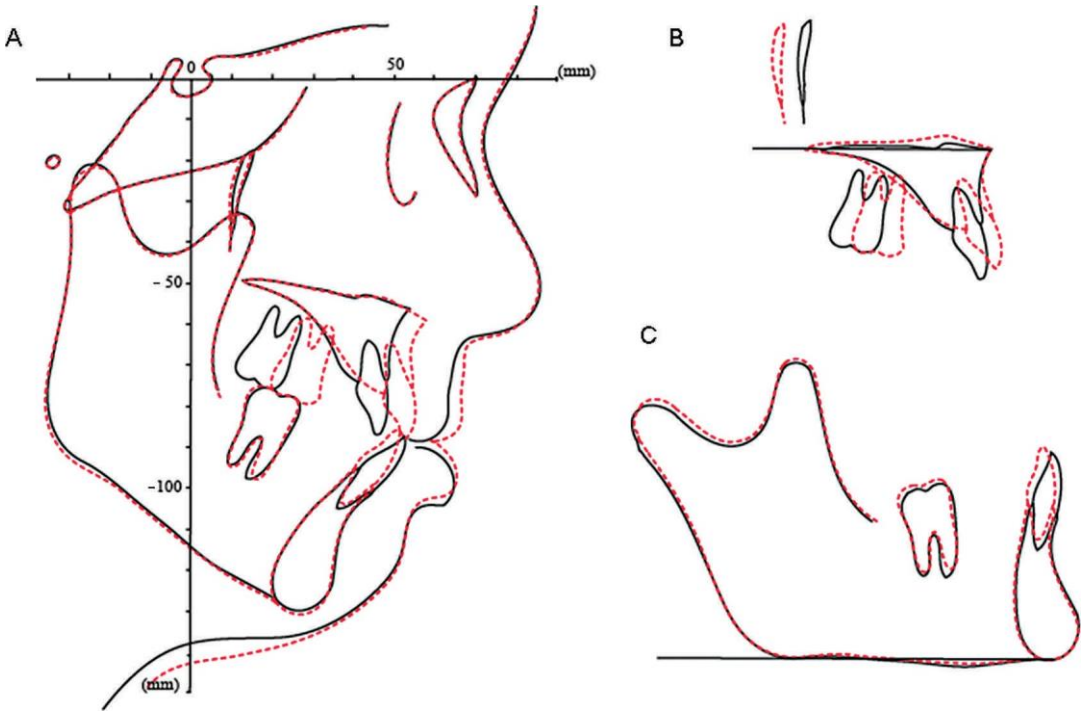

Figure 6. Superimposed cephalometric tracings, pretreatment (17 years 11 months) and posttreatment (20 years 1 month). (A) Superimposed on the SN plane registered at S. (B) Superimposed on the palatal plane registered at ANS. (C) Superimposed on the mandibular plane registered at Me.

intermaxillary elastics were prescribed 24 hours a day for 3 weeks to stabilize the maxillary midline and to increase the overbite and overjet (Figure 4C).

Removal of both distractors and fixation of the maxilla were done surgically, 1 month after the DO. Bone securing was achieved by titanium miniplates to fix the maxillary position (Figure 4D). The postoperative course was uneventful, and jaw function and facial esthetics improved.

After completion of the fixation, face mask therapy with the titanium miniplate anchorage continued to stabilize the position of the maxilla without dentoalveolar compensation (Figure 4D). The patient was instructed to wear the face mask for protraction regularly during the night for 2 months after completion of the maxillary advancement. Postsurgical orthodontic treatment was performed to achieve an acceptable overbite and overjet with tight intercuspation of teeth. All appliances were removed at the age of 20 years 2 months, and Begg-type retainers were placed in both dental arches. Titanium plates were removed 1 year after the fixation. The retainers were to be used full time for the first 12 months and at night only for the subsequent 12 months.

TREATMENT RESULTS

After surgical orthodontic treatment, distraction of the maxilla was achieved, the maxillary retrusive facial profile improved, and an acceptable interincisal relationship was obtained (Figure 5A through D). TSS analysis showed that the patient had a skeletal Class I sagittal jaw relationship with a moderate skeletal Class III tendency, with grades of 0.71 for skeletal Class I and 0.29 for skeletal Class III traits. The ANB angle changed from 21.4 degrees to 3.2 degrees (Table 1). The maxilla was advanced 5.4 mm horizontally and was displaced 1.5 mm downward at Point A relative to the sella-nasion (SN) plane and its perpendicular line (Figure 6). The upper incisors were tipped labially 2.0 mm anteriorly, and the molars were moved to the mesial 1.4 mm. The lower incisors were slightly rotated lingually and extruded. A good interincisal relationship was established without an increase in the mandibular plane angle.

The distraction moved the maxilla to its normal position, resulting in an improved sagittal jaw relationship and facial profile (Figures 5A through C and 7B). The negative overjet was corrected by forward movement of the upper incisors with elastics and the face mask after the distraction. Postoperative speech evaluation showed that the DO could prevent a decline in nasopharyngeal function after maxillary advancement (Figure 8B).

At the end of the orthodontic treatment, an overjet of 2.9 mm and an overbite of 2.3 mm were achieved. Class II molar relationships with tight intercuspation of

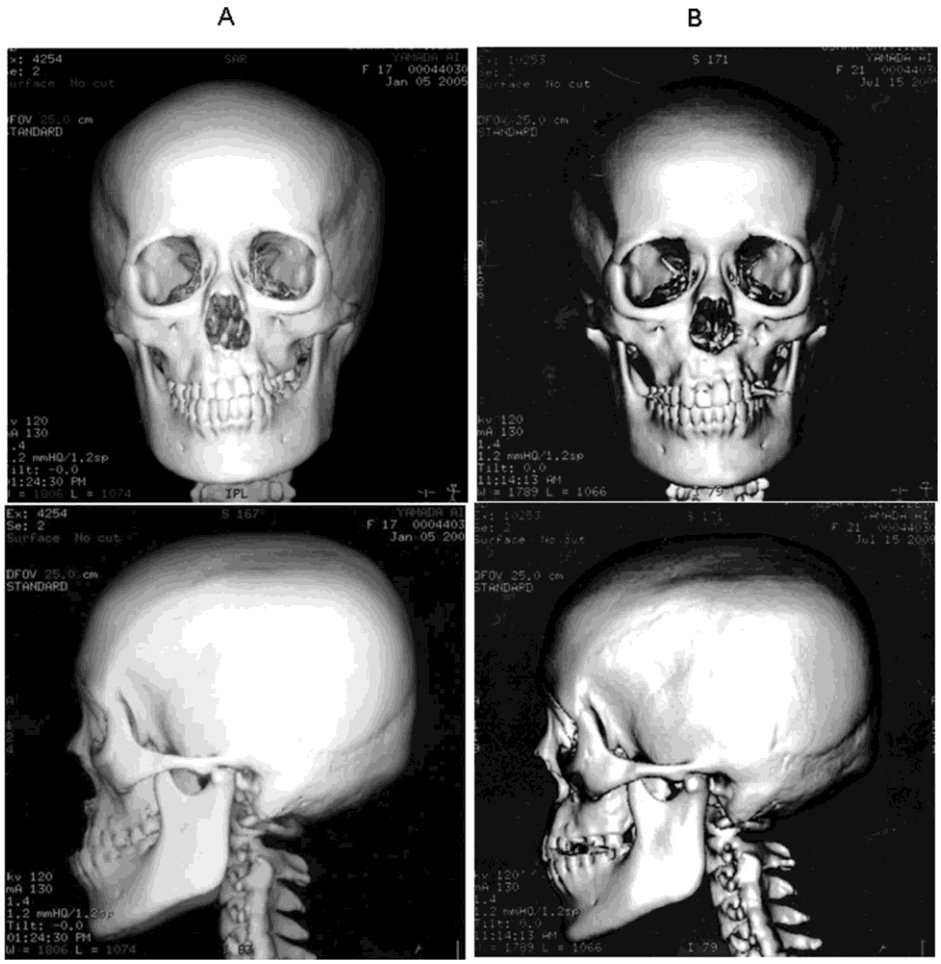

Figure 7. Computed tomography radiographs. (A) Pretreatment (17 years 11 months). (B) 1 year after treatment (21 years 1 month).

the teeth were established (Figure 5B). Deviation of the upper dental midline was corrected to coincide with the facial midline, as the cant of the upper occlusal plane was slightly improved (Figures 5A,B and 7A,B). A remarkable change in facial form from a maxillary retrusive-type facial profile to a straight-type profile was noted. The positions of the upper and lower lips relative to the esthetic line had improved (Figure 5A).

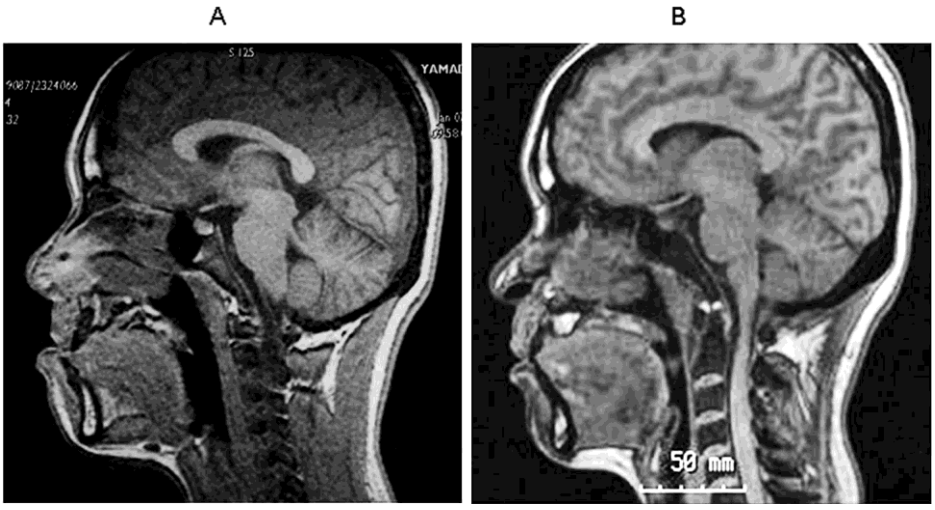

Figure 8. Magnetic resonance imaging (MRI). (A) Pretreatment (17 years 11 months). (B) 1 year after treatment (21 years 1 month).

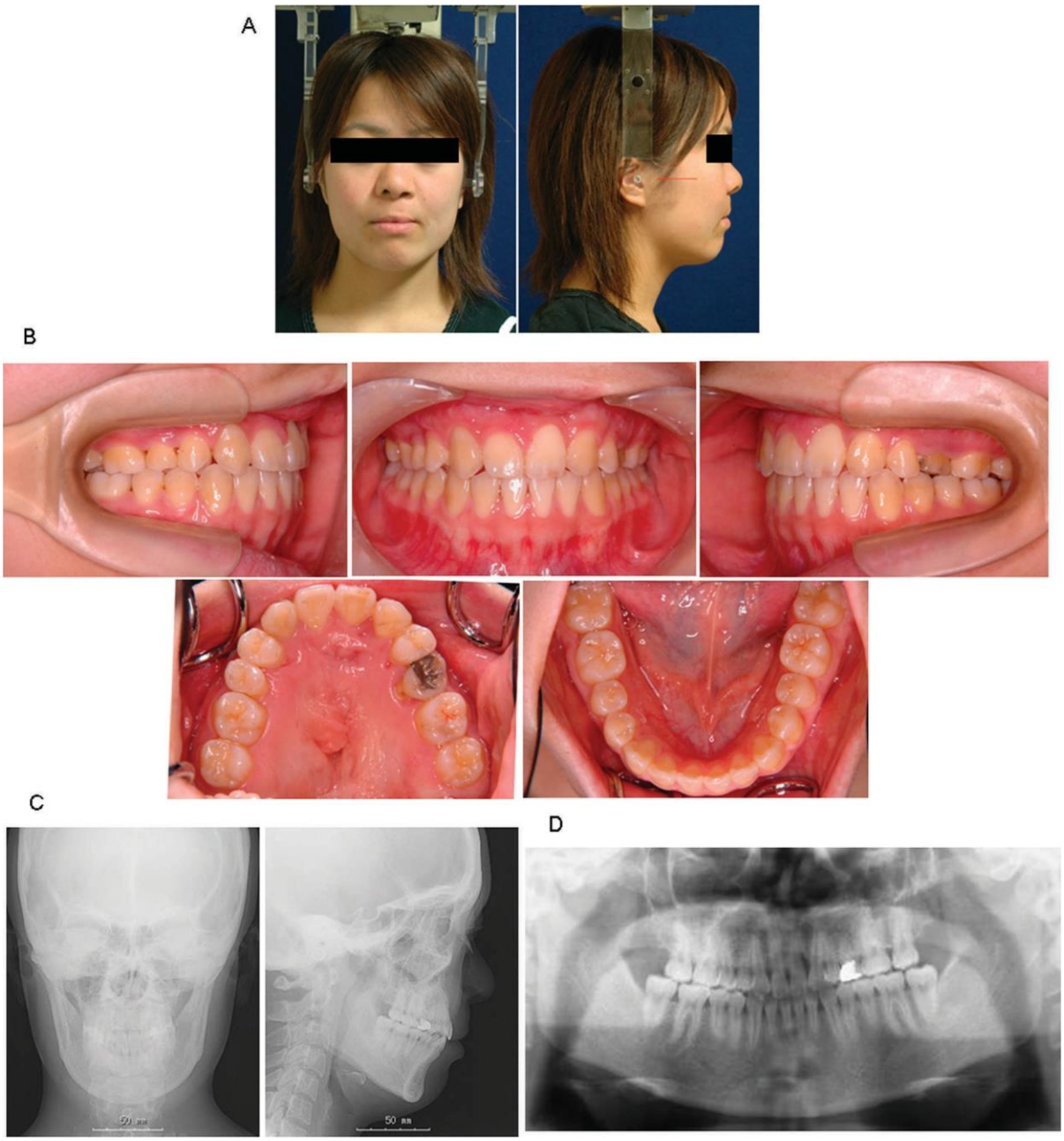

Figure 9. Postretention records (age, 22 years 1 month). (A) Facial photographs. (B) Intraoral photographs. (C) Frontal and lateral cephalograms. (D) Panoramic radiographs.

Twenty-four months later, a follow-up examination showed a well proportioned soft tissue profile. The occlusion remained stable with normal overjet and overbite, and the retained deciduous molar showed no mobility (Figure 9A,B,D).

DISCUSSION

Maxillary DO is often employed for correction of maxillary hypoplasia in patients with cleft lip and palate.[7] It allows a greater amount of jaw advancement than is noted with standard maxillary advancement.

An external distractor such as a RED system is beneficial in treating patients with cleft lip and palate because it has fewer limitations regarding the amount and direction of jaw advancement.[9] The patient, however, has to wear a relatively large device, which is fixed in the lateral temporal area for a long consolidation period and may turn out to be a serious cause of postoperative complications caused by psychological stress and the potential risk of accidental head injury.

In contrast, the internal distractor offers some benefit in terms of postoperative complications be-

cause it causes less psychological stress and demands a shorter hospitalization period.[10] Moreover, DO with internal distractors does not necessarily require the patient's cooperation during the retention period, and compared with the RED system, it does not leave scars caused by fixation screws.

Potential complications of the internal distractor are defective distraction vectors and insufficient distraction; disadvantages include less freedom of choice of direction and restricted jaw advancement. Maxillary DO with internal distractors generally requires bilateral devices. Some reports have emphasized that it is important but difficult to place two devices in parallel, while keeping their positions rigid and controlling their directions.[16] Essentially, the two internal distractors can move the maxilla in a straight line, but they are not designed for advancement that requires some rotational movement. Moreover, it is impossible to adjust the vertical direction of jaw advancement to compensate for the cant of the occlusal plane. On the other hand, it may be possible to perform some rotational movement with the flexibility of the device, although as demonstrated, risk of device breakage may result from excessive force delivered to the fragile points of the device.

In the present case, the amount of jaw advancement on each side was different because the maxilla had to be rotated to correct the maxillary dental midline. Breakage of the intraoral device on the left side occurred after the distraction period because of excessive strain on the device; the resulting complete distraction was unsatisfactory. To recover from this situation, elastic traction and a face mask were immediately used and maxillary forward traction continued. Finally, normal interincisal and sagittal jaw relationships were obtained. When using DO, it is usually difficult to displace the maxilla forward to a specific position. The flexibility of the device can, however, help to guide the maxilla to the planned occlusion after distraction has been completed.[17,18] The maxilla was advanced 5.4 mm at Point A, achieving an acceptable overjet and molar relationships without dentoalveolar compensation. Bone fixation by miniplates after the distraction fixed the maxillary position rigidly. The miniplate, which was placed in the middle, was also used as orthodontic anchorage for maxillary traction from the face mask. The face mask and intermaxillary elastics could be used as adjuncts to cover the defect of the internal device.

One of the advantages of DO is the expansion of associated soft tissues. DO also can minimize the resistance of muscles, ligaments, and skin, which may be responsible for relapse.[1,17] In the past, surgical correction of maxillary deficiencies in patients with cleft lip and palate was considered an unpredictable procedure with high relapse rates.[4–6] In this case, however, after 24 months of posttreatment follow-up, no discernible relapse was found.

Speech evaluation revealed no deterioration in the postoperative period (Figure 8). Maxillary DO with internal devices provided superior skeletal, dental, and esthetic changes, and it could bring about sufficient effect on the maxillary protrusion, while preserving velopharyngeal function.

REFERENCES

1. Rachmiel A, Aizenbud D, Peled M. Long-term results in maxillary deficiency using intraoral devices. *Int. J Oral Maxillofac Surg*. 2005;34:473–479.
2. Bardach J, Salyer EK. *Surgical Techniques in Cleft Lip and Palate*. St Louis, Mo: Mosby; 1991:224–232.
3. Heliovaara A, Ranta R, Hukki J, Rintala A. Skeletal stability of Le Fort I osteotomy in patients with isolated cleft palate and bilateral cleft lip and palate. *Int J Oral Maxillofac Surg*. 2002;31:358–363.
4. Houston WJB, James DR, Jones E, Kavvadia S. Le Fort I maxillary osteotomies in cleft palate cases: surgical changes and stability. *Int J Oral Maxillofac Surg*. 1989;17:9–15.
5. Adlam DM, Banks P. A retrospective study of the stability of midface osteotomies in cleft lip and palate patients. *Br J Oral Maxillofac Surg*. 1989;27:265–276.
6. Ayliffe P, Banks P, Martin C. Stability of the Le Fort I osteotomy in patients with cleft lip and palate. *Int J Oral Maxillofac Surg*. 1995;24:201–207.
7. Mofid MM, Manson PN, Robertson BC, Tufaro AP, Elias JJ, Vander Kolk CA. Craniofacial distraction osteogenesis: a review of 3278 cases. *Plast Reconstr Surg*. 2001;108: 1103–1114.
8. Rachmiel A. Treatment of maxillary cleft palate: distraction osteogenesis versus orthognathic surgery. Part one: Maxillary distraction. *J Oral Maxillofac Surg*. 2007;65:753–757.
9. Figueroa AA, Polley JW. Management of severe cleft maxillary deficiency with distraction osteogenesis: procedure and results. *Am J Orthod Dentofacial Orthop*. 1999; 115:1–12.
10. Kitai N, Kawasaki K, Yasuda Y, Kogo M, Murakami S, Kreiborg S, Takada K. Rigid external distraction osteogenesis for a patient with maxillary hypoplasia and oligodontia, *Cleft Palate Craniofac J*. 2003;40:207–213.
11. Iida S, Yagi T, Yamashiro T, Okura M, Takada K, Koga M. Maxillary anterior segmental distraction osteogenesis with the Dynaform System for severe maxillary retrusion in cleft lip and palate. *Plast Reconstr Surg*. 2007; 120:508–516.
12. Iida S, Kogo M, Aikawa T, Masuda T, Yoshimura N, Adachi S. Maxillary distraction osteogenesis using the interoral distractors and the full-covered tooth-supported maxillary splint. *J Oral Maxillofac Surg*. 2007;65:813–817.
13. Takada K, Sorihashi Y, Stephens CD, Itoh S. An inference modeling of human visual judgment of sagittal jaw-base relationships based on cephalometry: Part I. *Am J Orthod Dentofacial Orthop*. 2000;117:140–147.
14. Sorihashi Y, Stephens CD, Takada K. An inference modeling of human visual judgment of sagittal jaw-base relationships based on cephalometry: Part II. *Am J Orthod Dentofacial Orthop*. 2000;117:303–311.

15. Wada K. A study on the individual growth of maxillofacial skeleton by means of lateral cephalometric roentgenograms. *J Osaka Univ Dent Sch*. 1977;22:239–269.
16. Nakagawa K, Ueki K, Takatsuka S, Marukawa K, Yamamoto E. A device for determining the position of interoral distractors for protracting the maxilla. *J Craniomaxillofac Surg*. 2003;31:234–237.
17. Lauwers F, Mayorca-Guiliani A, Lopez R, Woisard-Bassols V, Paoli JR, Boutault F. Maxillofacial intraoral distraction osteogenesis followed by elastic traction in cleft maxillary deformity. *Int J Oral Maxillofac Surg*. 2005;34:85–88.
18. Suhr MAA, Kreutsch T. Technical considerations in distraction osteogenesis. *Int J Oral Maxillofac Surg*. 2004;33: 89–94.

SEGUE ABAIXO, ARTIGO SOBRE INFLUÊNCIA DO “GAP” ENTRE OS COTOS ÓSSEOS E NEOFROMAÇÃO ÓSSEA.

Meeson, R., Moazen, M., Sanghani-Kerai, A., Osagie-Clouard, L., Coathup, M., & Blunn, G. (2019). The influence of gap size on the development of fracture union with a micro external fixator. Journal of the Mechanical Behavior of Biomedical Materials, 99, 161–168.

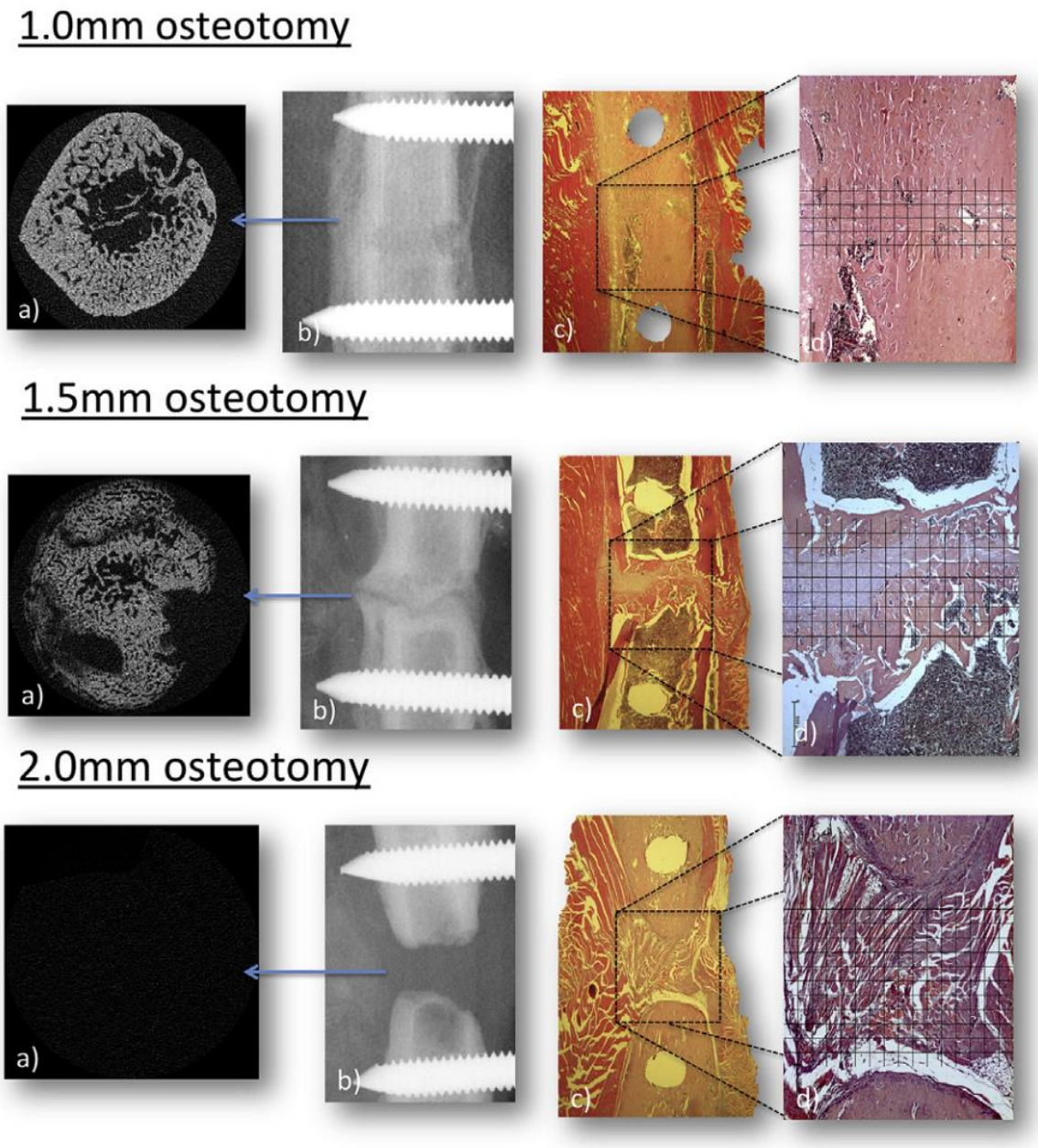

Fig. 2. Representative images from the analysis of healing for each fracture gap size. a) Shows the central transverse 5 μm thick slice from the centre of the osteotomy from microCT analysis. b) Shows a lateral-medial radiograph centred over the two innermost fixator pins and the osteotomy. c) Shows a 1x magnification image of the central sagittal slice, Hematoxylin and Eosin stained. d) Shows a 2.5x magnification image of the central region of the femur with the histomorphometric grid applied for quantitative morphometry.