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Case Report

Treatment of Severe Open Bite Malocclusion with Four-Piece Segmental Horseshoe Le Fort I Osteotomy

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Appropriate operations in severe anterior open bite (AOB) cases are extremely complicated to perform because of the multiple surgical procedures involved, the difficulty of predicting posttreatment aesthetics, and the high relapse rate. We herein report a 16-year-old girl with skeletal Class II, severe AOB malocclusion, and crowding with short roots, and aesthetic and functional problems. Four-piece segmental Le Fort I osteotomy with horseshoe osteotomy was performed for maxillary intrusion, and bilateral sagittal split ramus osteotomy (SSRO) and genioplasty were performed for mandibular advancement. The malocclusion and skeletal deformity were significantly improved by the surgical orthodontic treatment. Functional and aesthetic occlusion with an improved facial profile was established, and no further root shortening was observed. Acceptable occlusion and dentition were maintained after a two-year retention period. This strategy of surgical orthodontic treatment with a complicated operative procedure might be effective for correcting certain severe AOB malocclusion cases.

Key words: anterior open bite, short roots, severe crowding, four-piece segmental horseshoe Le Fort I osteotomy

Anterior open bite (AOB) has various etiologies and serious comorbidities including abnormal tongue, pernicious habits, respiration issues, neurological disturbances and muscular dystrophy, and the dental and skeletal morphology of such patients varies markedly [1-3]. Because of the multiple genetic and environmental factors involved, nongrowing patients with AOB are difficult to treat with orthodontics [4]. Treatment options for patients with AOB include the use of elastics combined with the multiloop edgewise archwire technique [5]. The use of titanium miniscrews as orthodontic anchorage devices also enables the counterclockwise rotation of the mandible because of the intrusion of the molars [6,7].

The general treatment for adult patients with skeletal AOB has been a combination of orthodontic therapy and orthognathic surgery [4]. In patients with severe skeletal AOB, more complicated operations such segmental maxillary osteotomy and differential maxillary impaction may be required [8]; other advanced procedures include horseshoe palatal osteotomy in combination with Le Fort I osteotomy [9]. Because of the difficulty of performing these complex operative procedures as well as the potential for relapse, AOB treatment must be approached strategically [10,11]. Furthermore, patients with AOB may have shortened root length and a high incidence of root resorption with orthodontic treatment [12]. This is yet another consideration in treating severe skeletal AOB patients.

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We herein report the efficiency of minimum tooth movement for short roots, and an effective strategy using optimal two-jaw surgery to correct a severe skeletal AOB deformity.

Case Report

A 16-year-old girl presented at the outpatient department of our hospital with a chief complaint of an inability to bite with her front teeth. Given the lack of contact of the upper and lower anterior teeth, she was deemed to have articulation impairment and masticatory disturbance. Her face showed left-right symmetry, but facial photographs shown in Fig. 1 document her convex profile and a long lower facial height. The relationship of the upper and lower lip to the E-line showed significant protrusion. She also had no lip seal (Fig. 1A).

The mandibular dental midline was deviated 1.5 mm toward the right compared with the maxilla, and the occlusal plane was canted (Fig. 1A). Although the stability of the mandibular position in occlusion was slightly flexible, a Class I relationship was observed at the centric occlusion bilaterally. Her overjet was 9.0 mm, and her anterior open bite was 9.5 mm. There was severe crowding in the maxillary and mandibular arch, with arch length discrepancies of −10.7 and −12.6 mm, respectively (Fig. 1B). The cephalometric analysis showed a skeletal Class II jaw-base relationship, a high mandibular plane angle, a normal range of maxillary incisor inclination with proclination of the mandibular incisors (Fig. 2A and Table 1) [13]. The posteroanterior cephalogram showed that the center of the maxillary and mandibular arch accorded with the facial midline (Fig. 2B). Panoramic and periapical radiographs showed shortened roots for all incisors and canines (Fig. 2C and D) as well as the impaction of all third molars (Fig. 2C).

Based on these findings, the patient was diagnosed with skeletal open bite malocclusion, a skeletal Class II jaw-base relationship, and severe crowding with shortened roots. Since the treatment objectives were to correct the skeletal deformity causing the open bite and to obtain ideal occlusion in a fully grown patient, the

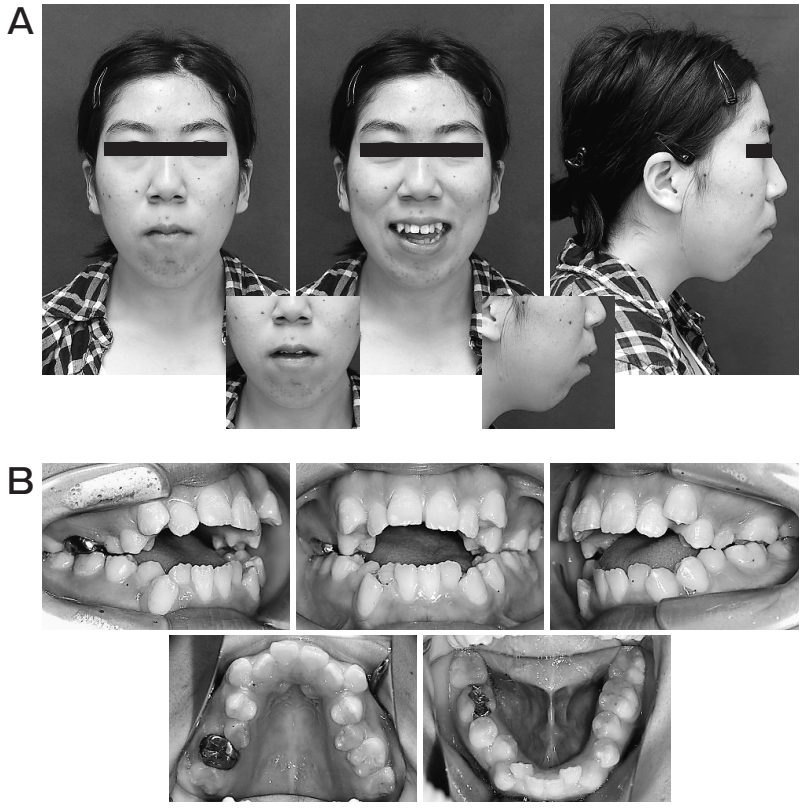

Fig. 1 Pre-treatment views. A, Facial photographs, Insets: Resting position; B, Intraoral photographs.

treatment was a combination of surgery and orthodontic therapy. Multi-piece Le Fort I osteotomy was planned to correct the open bite and long face, which were considered severe skeletal deformities [8]. Furthermore, four-piece segmental horseshoe Le Fort I osteotomy with differential impaction of the posterior segment was deemed useful in this case with two different occlusal planes in the upper arch and the high arched palate. To manage these issues, we decided to perform a combination of surgery and orthodontic therapy to improve both the dentofacial morphology and the stomatognathic functions. Bilateral sagittal split-ramus osteotomy (SSRO) and genioplasty were planned for after the autorotation of the mandible to correct the open bite and long face. All impacted third molars were to be extracted before surgery so as not to interfere with the surgical procedures.

We explained the aims of the treatment to the patient and obtained informed consent. After extraction of all canines, 0.018×0.025-inch preadjusted edgewise appliances were bonded to both arches, but not to the maxillary incisors at first. Leveling and alignment were started with 0.016-inch heat-activated nickel-titanium wires for the maxilla and mandible, respectively. After performing leveling and alignment for 7 months, 0.018-inch preadjusted edgewise appliances were bonded to the maxillary incisors. The initial alignment was achieved with 0.016-inch heat-activated nickel-titanium wires. Subsequently, tooth alignment was performed by changing the archwires sequentially, and 0.016×0.022-inch stainless steel wires were used to

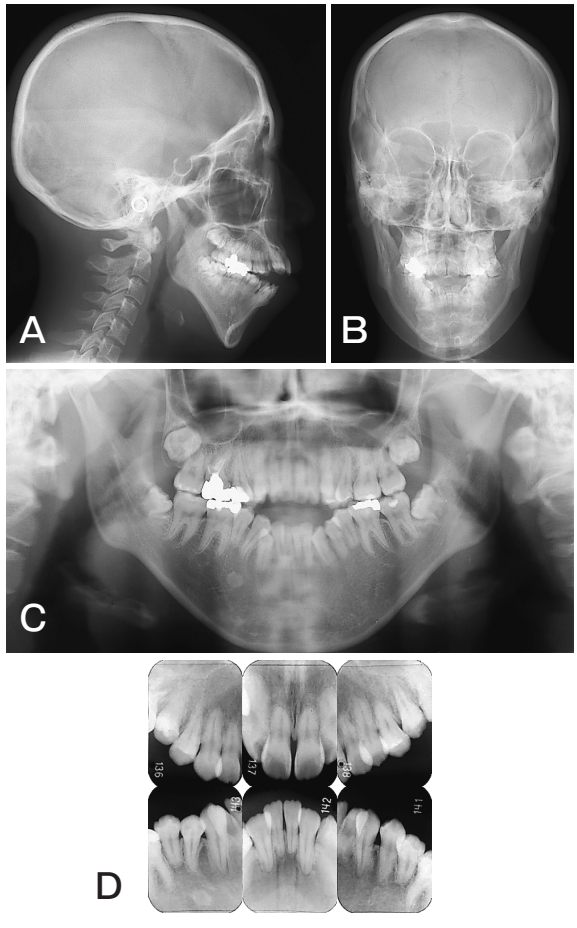

Fig. 2 Pre-treatment radiographs. **A**, Lateral cephalogram; **B**, Posteroanterior cephalogram; **C**, Panoramic radiograph; **D**, Periapical radiographs.

Table 1 Cephalometric summary

	Japanese norm (adult)		Pretreatment	Presurgery	Posttreatment	Postretention
	Mean	SD				
Angular (°)						
ANB	2.8	2.4	7.5	8.0	5.0	5.5
SNA	80.8	3.6	73.5	73.5	74.5	74.5
SNB	77.9	4.5	66.0	65.5	69.5	69.0
U1-FH	112.3	8.3	113.5	112.5	110.0	110.0
L1-FH	56.0	8.1	35.5	43.0	53.0	52.5
L1-Mp	93.4	6.8	87.5	80.0	80.5	80.5
Mp-FH (FMA)	30.5	3.6	57.0	57.5	46.5	47.0
Linear (mm)						
Overjet	3.1	1.1	9.0	9.5	3.0	2.5
Overbite	3.3	1.9	−9.5	−8.5	1.5	0.5
Ar-Go	47.3	3.3	71.0	71.0	77.5	77.5
Ar-Me	106.6	5.7	112.0	112.0	113.5	113.5

adjust the tooth positions before surgery. The first premolars were induced by wires to move into the positions formerly occupied by the canine teeth, thus relieving the severe crowding (Fig. 3). All third molars were extracted during leveling and alignment six months before surgery (Fig. 4). The cephalometric analysis showed a slight extrusion of the mandibular molars and clockwise rotation of the mandible (Fig. 5, Table 1).

After presurgical orthodontic treatment for 1 year and 10 months, a four-piece segmental Le Fort I osteotomy with horseshoe osteotomy was performed (Fig. 6). Maxillary osteotomy was achieved with posterior intrusion of 4.5 mm and advancement of 2.0 mm at the level of the first molars. Bilateral SSRO of the mandible was performed with counterclockwise rotation and advancement of 10.0 mm at the B point. Genioplasty was performed with advancement and intrusion of 4.0 mm each. Following the osteotomy, the maxillary anterior segment was repositioned practically unchanged and connected to the mandible with an appropriate overjet.

In the postsurgical orthodontic treatment, 0.016×0.022-inch stainless steel wires were installed to induce space closure of the maxillary dental arch spaces. Postsurgical orthodontic treatment was performed for 9 months. Detailing was initiated with 0.016×0.022-inch stainless steel wires in both arches, after which the edgewise appliances were removed. The total active treatment period was 2 years 11 months. The maxillary and mandibular wrap-around retainers were placed, and the patient was followed for two years.

The treatment led to both impaction of the maxillary posterior pieces and the counterclockwise rotation of the mandibular segment, which subsequently improved the patient's facial profile and incompetent lip seal. The distance of the upper lip to the E-line was reduced from 8.5 mm to −1.0 mm, and that of the lower lip to E-line was reduced from 10.5 mm to 2.0 mm. The lips' relation to the E-line also showed great improvement after treatment (Fig. 7A). The AOB and severe crowding were improved, and an adequate overjet and overbite were achieved. Well-aligned arches and good interdigitation of the teeth were obtained (Fig. 7B).

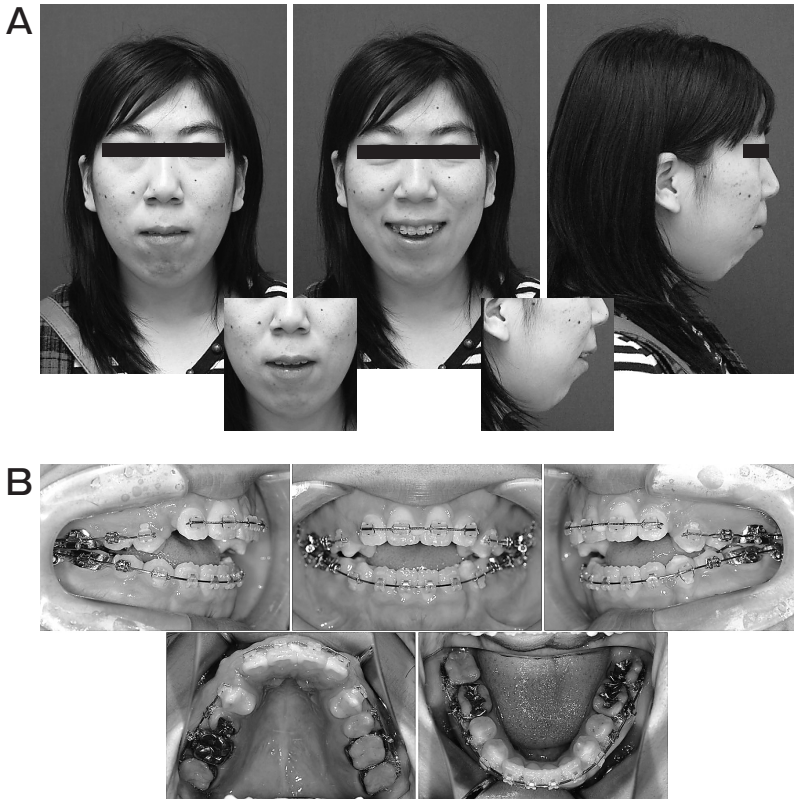

Fig. 3 Pre-surgery views. A, Facial photographs, Insets: Resting position; B, Intraoral photographs.

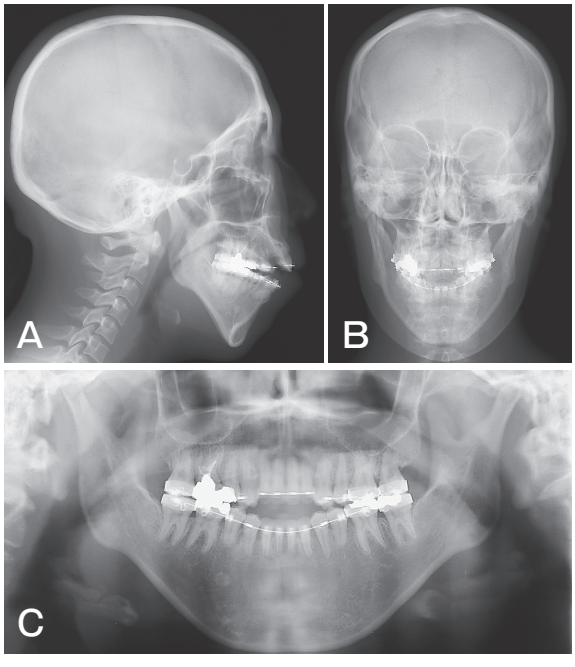

Fig. 4 Pre-surgery radiographs. A, Lateral cephalogram; B, Posteroanterior cephalogram; C, Panoramic radiograph.

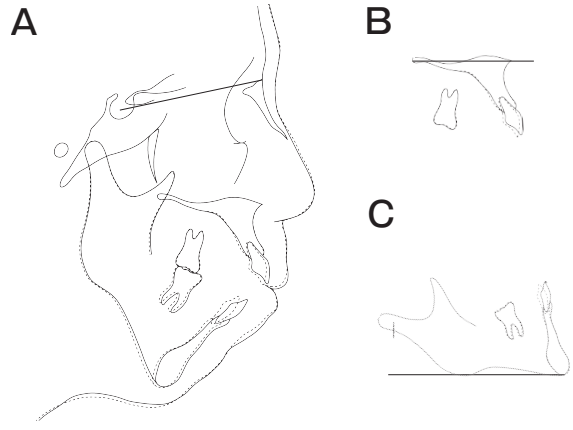

Fig. 5 Superimposed cephalometric tracings show the changes from pre-treatment (solid line) to pre-surgery (dotted line) stages. A, The overall superimposition on the sella-nasion plane at the sella; B, The superimposition on the initial palatal plane at the PNS; C, The superimposition on the mandibular plane at the menton.

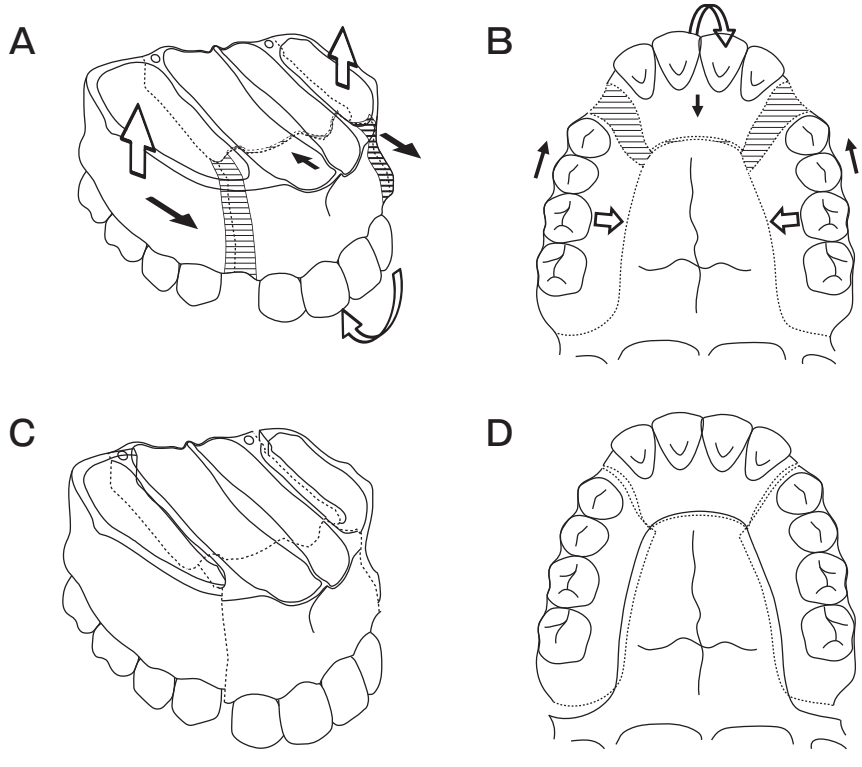

Fig. 6 A schematic illustration of the four-piece segmental horseshoe Le Fort I osteotomy procedure. A, B, Before osteotomy. These segments are allowed to move, as shown by arrows; C, D, After osteotomy. In B and D, hatched areas indicate bone that was surgically removed.

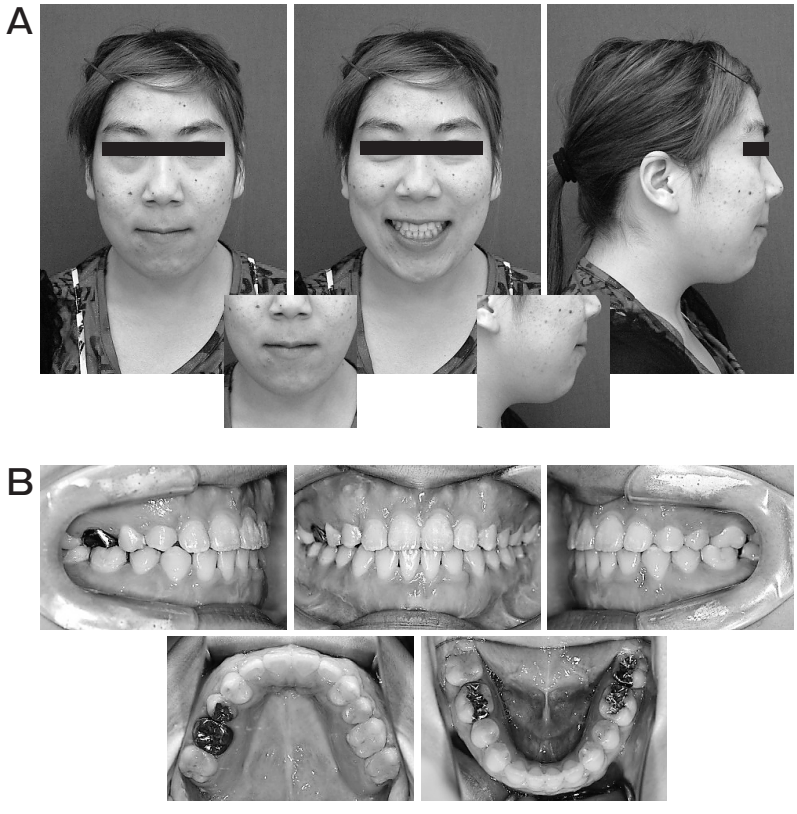

Fig. 7 Post-treatment views. A, Facial photographs, Insets: Resting position; B, Intraoral photographs.

The posttreatment cephalometric evaluation showed a decrease in the ANB angle, and a skeletal Class I jaw relationship was achieved. Surgical changes in the hard tissue resulted in maxillary advancement, posterior impaction and anterior segment repositioning as well as subsequent mandibular counterclockwise rotation. The posterior segment of the maxilla eventually demonstrated intrusion of 4.5 mm and advancement of 2.0 mm (Fig. 8A-D, Table 1).

The mandible was also set forward about 15 mm at the pogonion by bilateral SSRO and genioplasty. A posteroanterior cephalogram showed that the maxillary and mandibular midline coincided with the facial midline (Fig. 8B). No significant change in the maxillary incisor inclination was detected, indicating that the relevant incisor inclination had been maintained (Fig. 9, Table 1). Suitable root paralleling was observed on a panoramic radiograph (Fig. 8C). The posttreatment panoramic and periapical radiographs showed no remarkable apical root resorption or alveolar bone loss (Fig. 8C, D).

The duration of active orthodontic treatment was 2 years 11 months. After two years of retention, acceptable facial profile and occlusion were maintained despite indications of slight extrusion of the mandibular molars and clockwise rotation of the mandible on cephalometry (Table 1). The patient was satisfied with the treatment results.

Discussion

One trend in recent years is the use of camouflaged orthodontic treatment using miniscrew anchorage for the intruding maxillary and mandibular molars. Improvement of an anterior open bite can thus be obtained by the autorotation of the mandible. However, open bite malocclusion with an interincisal distance of more than 5 mm is extremely difficult to treat with orthodontics alone [7, 14]; such an approach cannot sufficiently improve a severe open bite with skeletal deformities. Furthermore, the relatively unstable results achieved with orthodontic treatment alone when there are skeletal discrepancies involved are further indication for orthognathic surgery. Correction of

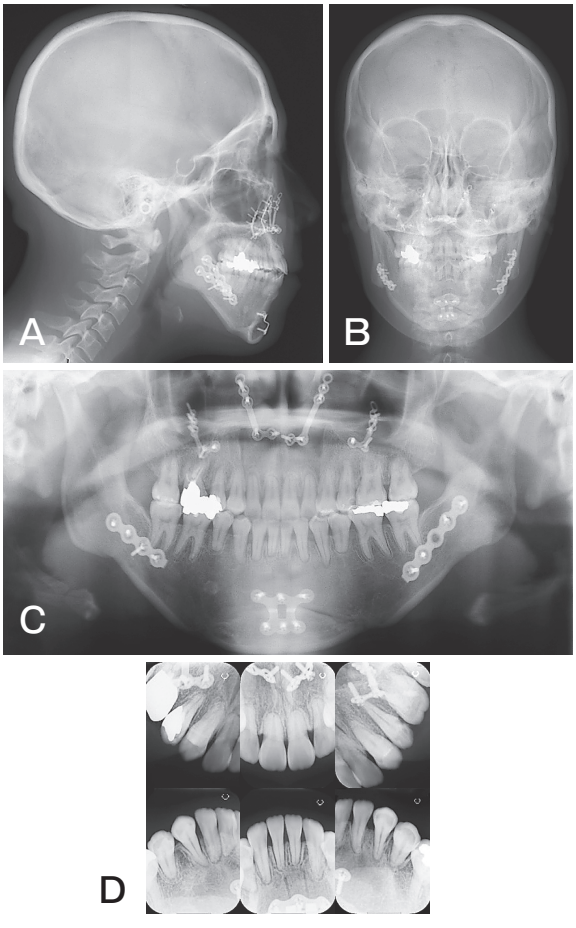

Fig. 8 Post-treatment radiographs. **A**, Lateral cephalogram; **B**, Posteroanterior cephalogram; **C**, Panoramic radiograph; **D**, Periapical radiographs.

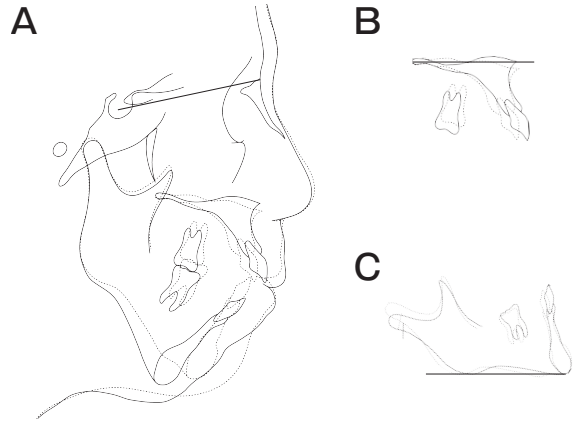

Fig. 9 Superimposed cephalometric tracings show the changes from the pre-treatment (solid line) to post-treatment (dotted line) stages. **A**, The overall superimposition on the sella-nasion plane at the sella; **B**, The superimposition on the initial palatal plane at the PNS; **C**, The superimposition on the mandibular plane at the menton.

severe skeletal AOB with an abnormal maxillomandibular relationship has been shown to be stable with treatment by two-jaw surgery rather than mandibular surgery alone [15]. Le Fort I osteotomy with posterior impaction and mandibular osteotomy has usually been used to treat adults with skeletal AOB [16].

In this case, the patient had extreme skeletal AOB with a long lower facial height, severe crowding and significant shortening of all incisor roots. Hence, adequate impaction of the posterior teeth and minimal tooth movement were two priorities of the treatment plan. Therefore, maxillary osteotomy was performed, employing a four-piece segmental horseshoe Le Fort I osteotomy with differential impaction and advancement of the posterior teeth segment combined with clockwise rotation of the anterior segment. The anterior-superior mandibular repositioning with counterclockwise rotation by bilateral SSRO and advance genioplasty were useful in improving the AOB and convex profile. Furthermore, extraction of both maxillomandibular canines in this case minimized the force on the anterior teeth. Minimizing the force on anterior teeth is an important consideration in AOB cases with lingual drift of the maxillary incisors, given the high incidence of root resorption in patients [12]. In fact, in our patient, even after about 3 years of orthodontic treatment, there was no further shortening of the roots.

In the present treatment plan, an unusually great distance of superior and forward movement was required in the maxillary posterior segment. As its achievement by standard Le Fort I osteotomy was deemed technically difficult, we performed a four-piece segmental Le Fort I with horseshoe osteotomy. The strategic advantage of this technique is that the differential movement of each segment is useful for avoiding osseous interference in the perpendicular portioning of the palatal bone and the horizontal sectioning of the pterygoid plate. Such a procedure reduces the bone trimming required for the anterior-superior movement in the posterior segment of the maxilla, and it also minimizes the risk of damage to the neurovascular bundle [9,17]. As the resulting movement during mouth opening and closing was smooth and stable, functional occlusion was deemed to have been achieved. This surgical approach may be an efficient alternative for improving oral aesthetics and promoting a good quality

of life [18].

Four-piece segmental horseshoe Le Fort I osteotomy is regarded as a useful and safe technique for achieving surgical impaction and advancement of the maxillary posterior area. The present report indicates that orthodontic surgery featuring the combination of Le Fort I osteotomy and bilateral SSRO with genioplasty can greatly improve the occlusion, aesthetics and stomatognathic function of severe AOB patients.

Conclusion

A case of severe open-bite malocclusion with shortened roots and crowding was treated by orthognathic surgery featuring the combination of four-piece segmental Le Fort I osteotomy with horseshoe osteotomy, bilateral SSRO and genioplasty. Functional and aesthetic occlusion and an aesthetic facial profile were established, and no further root shortening was observed after orthodontic treatment. Acceptable stability was observed after two years of retention.

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