CASE REPORT

AJO-DO

Surgery-first approach in correcting skeletal Class III malocclusion with mandibular asymmetry

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This case report describes a surgical orthodontic case that used the recently introduced surgery-first approach to correct a severe skeletal Class III malocclusion. A 19-year-old woman presented with severe mandibular prognathism and facial asymmetry; she had been waiting for growth completion in order to pursue surgical correction. After prediction of the postsurgical tooth movement and surgical simulation, 2-jaw surgery that included maxillary advancement and differential mandibular setback was performed using a surgery-first approach. Immediate facial improvement was achieved and postsurgical orthodontic treatment was efficiently carried out. The total treatment time was 16 months. The patient's facial appearance improved significantly and a stable surgical orthodontic outcome was obtained. (Am J Orthod Dentofacial Orthop 2017;152:255-67)

A combined orthodontic and orthognathic surgery approach is accepted as the standard of care for patients who have a severe skeletal jaw discrepancy with facial asymmetry. It is often considered the only viable treatment option for improving facial appearance and restoring normal occlusal function.[1-3]

Although the conventional 3-stage surgical orthodontic approach, which includes presurgical orthodontics, surgery, and postsurgical orthodontics, has been well established as the gold standard in most cases,[4,5] some disadvantages have been recognized.[6,7] One drawback is the long presurgical treatment time that typically worsens facial appearance and exacerbates the malocclusion.[6-9] In some countries, these disadvantages have caused patients to seek plastic surgeons who are willing to perform orthognathic surgeries without collaboration with orthodontists or consideration for the final occlusion. Subsequently, orthodontists have witnessed many instances where patients have experienced adverse functional effects resulting from clinically unacceptable occlusal outcomes.

Recently, to address patient demand and satisfaction, the surgery-first approach was introduced to overcome some disadvantages associated with the conventional surgical orthodontic approach.[8-14] Several case reports have demonstrated successful outcomes with reduced treatment time and greater patient satisfaction using the surgery-first approach in surgical orthodontics. This approach demands more careful surgical planning and stronger collaboration between skilled orthodontists and surgeons to accurately predict postsurgical tooth movement and surgical movement. Therefore, previous advocates of this approach recommend only using the surgery-first approach for mild to moderate skeletal discrepancies. However, the scope of this approach has been expanding with advances in 3-dimensional (3D) imaging technology and 3D virtual surgical simulation,[15-18] the use of skeletal anchorage systems,[8,9] and better understanding of the biologic response after surgery.

This case report demonstrates successful surgical orthodontic treatment with a surgery-first approach in a patient with a severe Class III skeletal jaw discrepancy and facial asymmetry. See Supplemental Materials for a short video presentation about this study.

DIAGNOSIS AND ETIOLOGY

A 19-year-old woman visited the orthodontic department at Chonnam National University Hospital in

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Fig 1. Pretreatment facial and intraoral photographs.

Gwangju, Korea. Her chief complaints were anterior crossbite and mandibular prognathism. She reported no problems in her medical history, but she mentioned being recently diagnosed with internal derangement in both jaw joints, for which she had been receiving physical and occlusal splint therapy. Her symptoms had improved, and her temporomandibular joint specialist confirmed that her joint condition was stabilized. Her oral hygiene was well maintained.

Pretreatment facial photographs showed a concave profile, an increased lower facial height, and a significant facial asymmetry with chin deviation to the left. The maxillary dental midline was coincident with the facial midline, but the mandibular dental midline deviated 9 mm to the left (Fig 1). Intraoral photographs and study casts showed more than a full-cusp Class III molar relationship (−17.0 and −8.5 mm from the Class I position on the right and left sides, respectively). Her overjet was −8 to −10 mm, and her overbite was −2 mm. Anterior and posterior crossbites from the maxillary right first premolar to the left first molar were present. There was mild to moderate crowding in both the maxillary and mandibular arches (Figs 1 and 2). No functional shifts and discrepancies between centric relations and centric occlusion were detected anteroposteriorly or laterally.

All teeth, including the third molars, were present (Fig 3). Her mandibular third molars were fully erupted, and her maxillary third molars had complete root formation and were erupting. No caries or pathologies were observed, and the periodontal tissues were healthy. The frontal view of the cone-beam computed tomography (CBCT) image showed the extent of the mandibular skeletal asymmetry, which involved chin deviation of 5.0 mm toward the left side. The lateral cephalometric analysis indicated a skeletal Class III pattern, which was the result of both a retrognathic maxilla and a prognathic mandible (ANB, −5°; Wits appraisal, −21 mm; SNA, 78°; SNB, 83°), and a hyperdivergent pattern (SN-MP, 43°; FMA, 29°). The proclined maxillary and retroclined mandibular incisors represented a typical dentoalveolar compensation for a skeletal Class III malocclusion (U1-SN, 110°; IMPA, 77°) (Table). The 3D image analysis of facial asymmetry showed that both the frontal and lateral ramal inclinations and the mandibular body length were greater on the right side than on the left side; this contributed to the mandibular deviation toward the left (Fig 4). However, the maxillary and ramal heights were actually greater on the left side; this was an unexpected finding, since typically, the maxilla and the ramus on the deviated side are normal or small.[19]

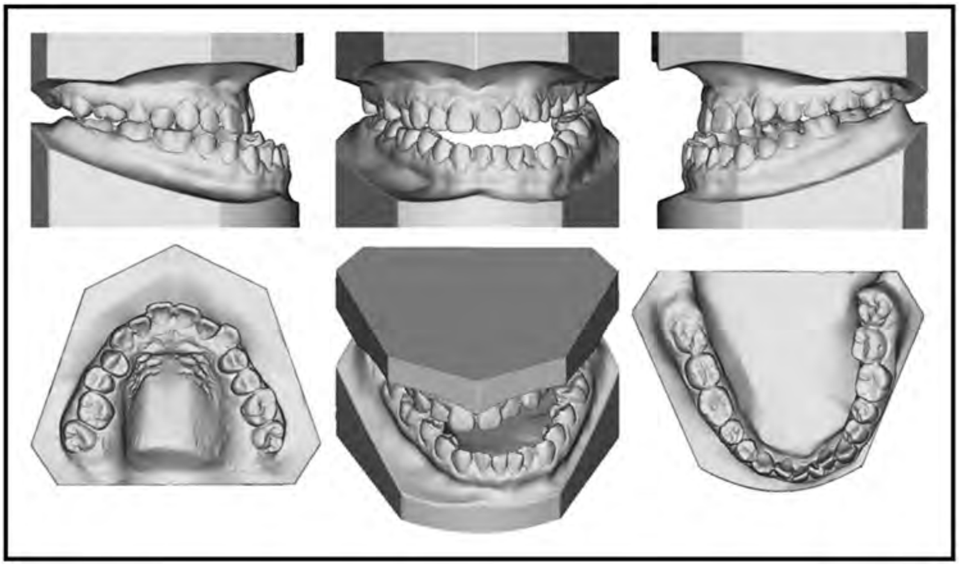

Fig 2. Pretreatment study casts.

Fig 3. Pretreatment radiographs generated from CBCT: **A,** frontal, lateral, and lateral soft tissue views; **B,** panoramic view.

The patient and her parents reported a family history of mandibular prognathism. The etiology of the skeletal Class III malocclusion appeared to be primarily hereditary with some potential environmental factors.

TREATMENT OBJECTIVES

The patient was diagnosed as having a skeletal Class III jaw discrepancy with facial asymmetry that was attributed to a retrognathic maxilla and a prognathic

Table. Cephalometric measurements

	Pretreatment	*Postsurgery*	*Posttreament*	*Norm ± SD*
Skeletal				
FH-SN (°)	13.9	13.4	13.1	6 ± 4
SNA (°)	77.7	82	81.2	82 ± 3.5
N-A (HP) (mm)	−5.9	−2.5	−1.5	2 ± 3.7
Maxillary unit length (Co-ANS) (mm)	74.1	78.6	78.6	90 ± 5
SNB (°)	82.8	77.8	79.1	80.9 ± 3
N-Pg (HP) (mm)	−0.6	−12.4	−5.8	−6.5 ± 5
Mandibular unit length (Co-Pog) (mm)	122.1	115.1	115.8	113 ± 8
ANB (°)	−5.1	4.2	2.3	1.6 ± 1.5
Wits appraisal (mm)	−20.8	−5.8	−6.5	−1 ± 1
MP-SN (°)	42.5	44.3	42.5	33 ± 6
Occlusal plane to SN (°)	26.6	26.5	24.5	14.4 ± 2.5
FMA (MP-FH) (°)	28.5	30.9	29.5	23.9 ± 4.5
Dental				
U1-SN (°)	109.8	108.8	104	102.8 ± 5.5
IMPA (L1-MP) (°)	77.2	75	88.1	95 ± 7
Interincisal angle (U1-L1) (°)	130.5	131.9	125	130 ± 6
Soft tissue				
Upper lip to E-plane (mm)	−5.1	1.5	−2.4	−6 ± 2
Lower lip to E-plane (mm)	−1.1	5.1	0	−2 ± 2
Nasolabial angle (Col-Sn-UL) (°)	91.2	81.1	98.6	102 ± 8

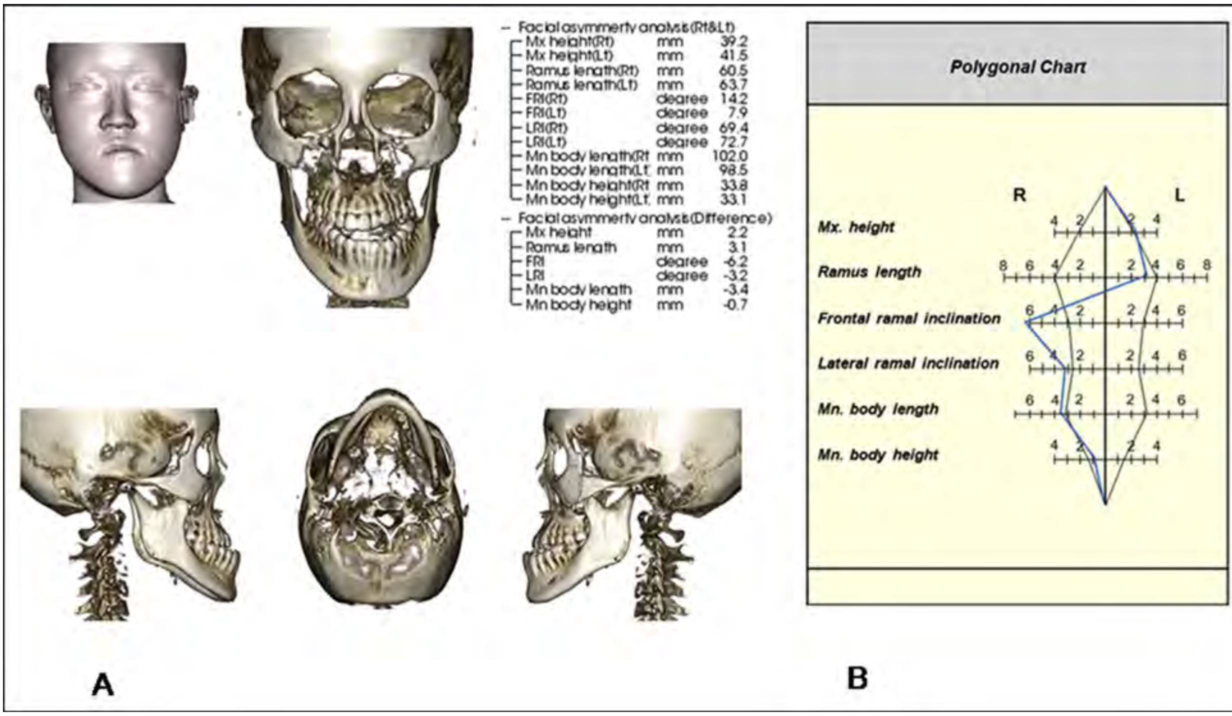

Fig 4. Three-dimensional image analysis of facial asymmetry: **A,** facial asymmetry analysis in InVivo5 (Anatomage, San Jose, Calif); **B,** polygonal chart demonstrating the source and magnitude of deviations in facial skeletal asymmetry.

and asymmetric mandible. The following treatment objectives were established: (1) correct the jaw discrepancy to obtain a harmonious facial appearance, (2) correct the mandibular asymmetry to achieve facial symmetry, (3) achieve a normal occlusion with Class I canine and molar relationships, (4) obtain normal overjet and overbite, (5) achieve coincident skeletal and dental midlines, (5) coordinate the maxillary and mandibular arch forms, and (6) resolve crowding and align the teeth. Because of her severe skeletal jaw discrepancy and facial asymmetry, surgical jaw correction was the only valid treatment approach for achieving these objectives.

TREATMENT ALTERNATIVES

An orthodontics-only approach would not be successful in correcting this severe skeletal jaw deformity. Therefore, orthognathic surgery was unavoidable. Since the mandible predominantly contributed to the severe jaw discrepancy and facial asymmetry, the possibility of having single-jaw surgery with only a mandibular setback was evaluated. After comprehensive assessment of the virtual surgical simulations for both single-jaw and 2-jaw surgeries, it was determined that both options could comparably improve facial appearance. However, the oral surgeon (H-K. O.) preferred a 2-jaw surgery approach because a mandibular setback alone would require more than 14 mm of surgical correction, which could potentially compromise the chin-throat profile and the stability of the surgical outcome.

Conventional surgical orthodontics include 3 phases: (1) presurgical orthodontics for decompensating the dentition to increase the magnitude of surgical movement, (2) orthognathic surgery, and (3) postsurgical orthodontics for finishing and detailing the occlusion. The literature has reported that the time required for presurgical orthodontics varies from 6 months to several years, but the average time is between 12 and 18 months.[4-7] In collaboration with oral surgeons, conventional 3-phase surgical orthodontics have been exclusively practiced as the gold standard in providing predictable and stable results. However, the surgery-first approach concept was recently introduced, and several successful case reports have demonstrated that it can be a viable alternative approach in surgical orthodontics.[8-15] By incorporating decompensational movement of the dentition into the surgical planning, the presurgical orthodontic stage is eliminated. During the postsurgical phase, all dental movements, which include alignment, incisor decompensation, and surgical relapse, are corrected. It is also well recognized that tooth movement after surgery is more effective. Therefore, the overall treatment time for a surgery-first approach is considerably shortened.

Since the patient had a strong desire to have surgery completed before leaving Korea to start college in the United States, the surgery-first approach was offered and accepted to accommodate her time constraint.

Under the condition of having orthognathic surgery, there were 2 alternative orthodontic treatment plans: nonextraction and extraction of maxillary premolars. The extraction of maxillary premolars has been most commonly used to reduce maxillary incisor proclination and to resolve crowding. However, for our patient, the following 3 factors led to a nonextraction approach: the crowding was not severe, a slight clockwise rotation of the maxilla during maxillary advancement surgery can improve the inclination of the maxillary incisors, and increasing the surgical movement was not desirable since more than 14 mm of surgical movement was already required.

After considering all alternative plans, the authors and the patient decided on a nonextraction, 2-jaw surgery-first approach: maxillary advancement surgery using a LeFort 1 osteotomy with a slight clockwise rotation and differential mandibular setback surgery using a bilateral sagittal split ramus osteotomy.

TREATMENT PROGRESS

The surgical plan was to perform 4 mm of maxillary advancement, and 18.8 and 10.8 mm of mandibular setback on the right and left sides, respectively. According to the plan, surgical occlusion was constructed to fabricate surgical splint (Fig 5). No appliances were placed before surgery. The 2-jaw surgery was performed as planned. After the surgical splint was placed, 4 intermaxillary fixation screws were inserted in the alveolar regions between the canines and first premolars in all 4 quadrants, and intermaxillary elastics were placed to stabilize the jaw position for 3 weeks (Fig 6). This was modified to a removable splint until fixed appliances were placed on the mandibular arch 5 weeks after surgery.

The postsurgery records taken immediately after the splint was removed showed that the patient had a convex profile and a dental Class II occlusal relationship with an open bite and 6 mm of overjet (Fig 7). Superimpositions demonstrated that the mandibular body length decreased by approximately 10 mm with a slight mandibular clockwise rotation, and the maxilla displayed about 4 mm of forward and downward movement (Fig 8). The right condyle maintained its presurgical position, but the left condyle was moved slightly downward by approximately 1 mm (Fig 9). The patient's temporomandibular disorder (TMD) was closely monitored during postsurgical orthodontics because of her previous history of therapy for TMD, but she reported no pain or other symptoms.

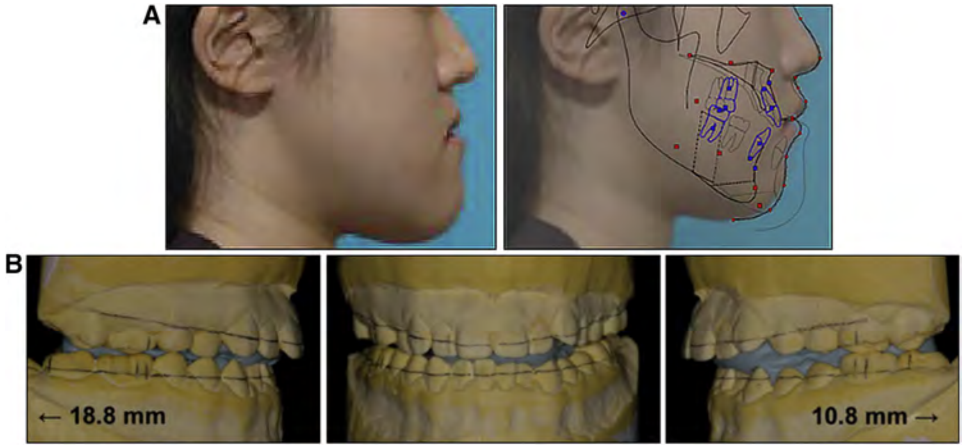

Fig 5. Surgical planning: **A,** visual surgical prediction in Dolphin Imaging (Chatsworth, Calif) showing maxillary advancement and mandibular setback; **B,** construction of surgical occlusion showing surgical movement of the mandible on the right and left sides.

Fig 6. Intermaxillary fixation using fixation screw placed in the alveolar regions between the canines and first premolars (1 week postsurgery).

Fig 7. Three-dimensional images immediately postsurgery.

Postsurgical orthodontics began with indirect bonding of 0.018-in slot preadjusted edgewise brackets (Fig 10). The maxillary and mandibular arches were aligned and leveled with continuous archwires, starting with 0.014-in nickel-titanium archwires. A precision lingual arch was placed to constrict the mandibular arch, and intermaxillary elastics were incorporated. Four months into postsurgical treatment, the open bite was closed, and the Class II relationship improved significantly. After transferring to the author (H.O.) at the University of the Pacific, coordination of the maxillary and mandibular arches and Class II correction were

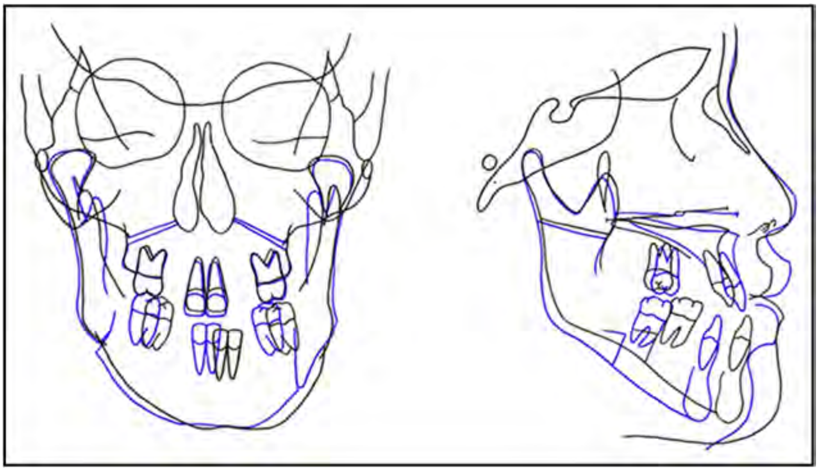

Fig 8. Superimposition of presurgery and postsurgery tracings based on cephalograms generated from CBCT.

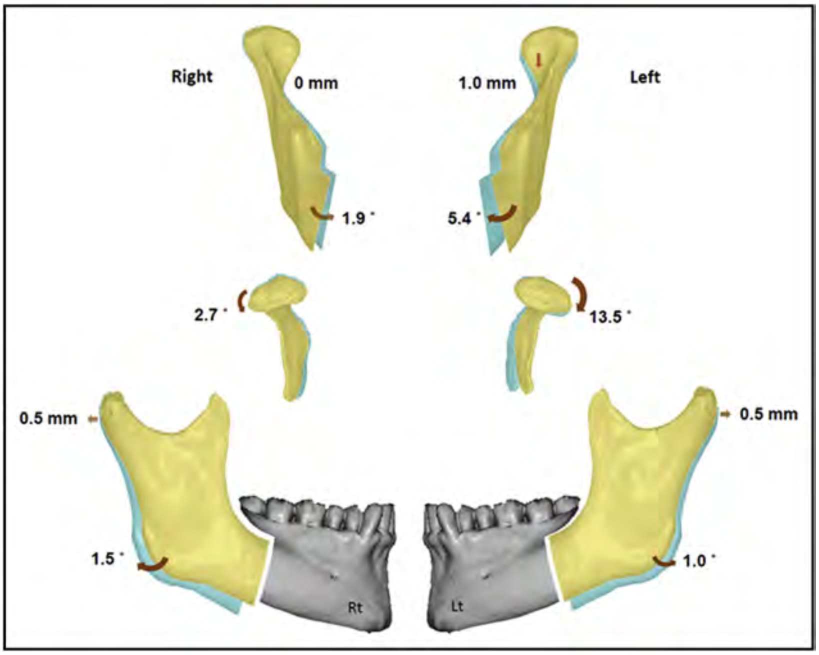

Fig 9. Changes in the condylar position and proximal segments of the mandibular body on the right and left sides.

continued. After 16 months of treatment, all appliances were removed, and maxillary and mandibular Hawley retainers were delivered.

TREATMENT RESULTS

Posttreatment records showed that all treatment objectives were achieved with good esthetic and occlusal results: facial symmetry was achieved, dental midlines were coincident with the facial midline, and ideal overjet and overbite with a Class I buccal occlusion were obtained (Figs 11-14). Cephalometric measurements showed that successful dental decompensation and surgical correction of the skeletal Class III jaw discrepancy were achieved: the ANB angle and the Wits appraisal increased from −5° to 2.3° and from −21 to −6.5 mm, respectively;

Fig 10. Changes during postsurgical orthodontic treatment: **A,** at 5 weeks after surgery, full bonding was initiated; **B,** 3 months after surgery; **C,** 8 months after surgery.

the mandibular incisors were proclined from 77° to 88° relative to the mandibular plane (IMPA); the maxillary incisors were uprighted from 110° to 104° with respect to SN (U1 to SN); and the mandibular plane angle (SN-MPA, FMA) was maintained (Table). Cephalometric superimpositions of pretreatment and posttreatment radiographs showed that the maxilla moved forward with a slight posterior impaction, the mandible moved back considerably, and the nose tip moved upward as a result of the maxillary advancement. Tooth movements included a slight downward movement of the anterior maxillary dentoalveolar portion that included the incisors, a slight distal movement of the maxillary molars, and proclination of the mandibular incisors with some extrusion (Fig 14).

Considerable changes in the facial profile and neck outline were observed throughout treatment (Fig 15). After surgery, changes in the position of the hyoid bone were observed through time in the 3D voxel-based volume superimposition on the cranial base structure. The hyoid bone did not directly follow the 10-mm posterior surgical movement of the mandible, but rather it moved straight downward and contributed to the poor throat configuration after the surgery. However, 4 months after surgery, the throat contour improved as the hyoid bone moved upward and slightly posteriorly. By the end of treatment, the hyoid bone was located only slightly posterior to its original position, and throat contour improved significantly (Fig 16).

The patient did not show any TMD signs or symptoms after the surgery, even though some condylar rotational change was observed on the left side. Overall, she was satisfied with the improvement in her facial appearance and her normalized occlusal function, which were both achieved in a short time. Posttreatment follow-up of the patient at the 1-year mark showed stable occlusal and facial results.

DISCUSSION

The surgery-first approach provides several positive aspects.

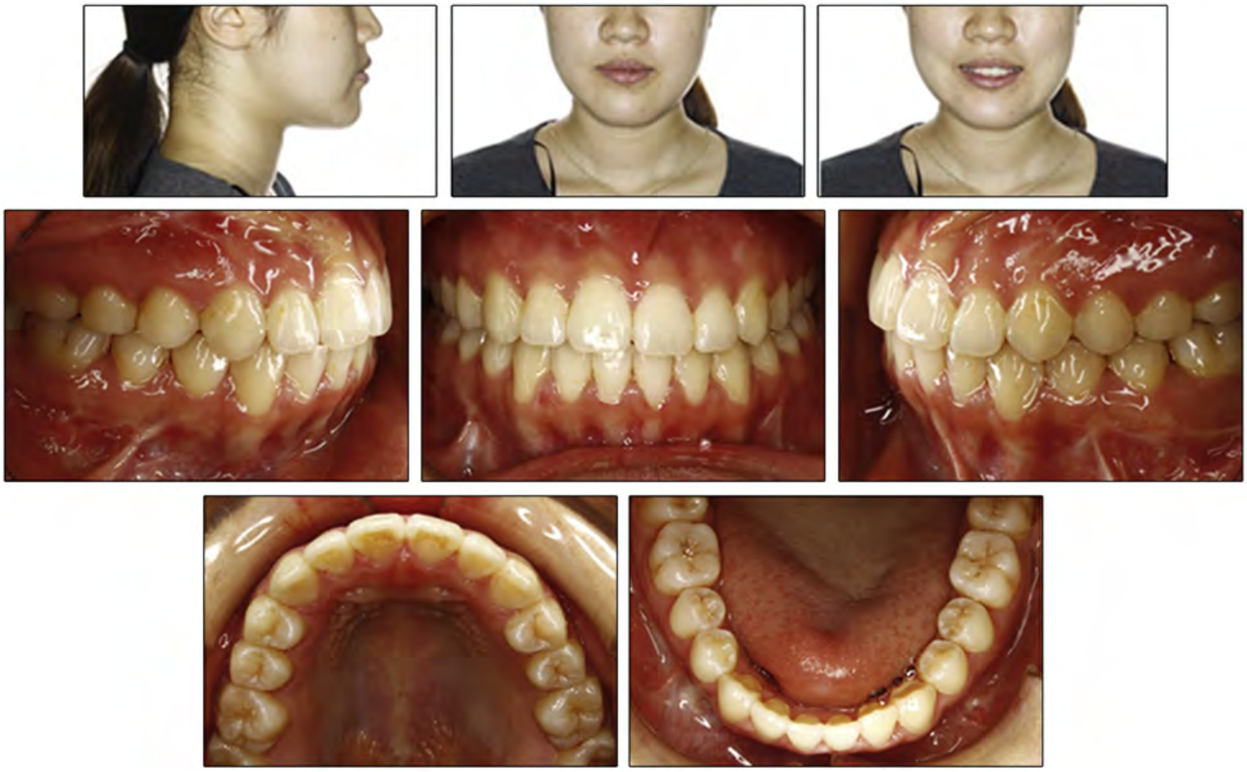

Fig 11. Final facial and intraoral photos after 16 months of treatment.

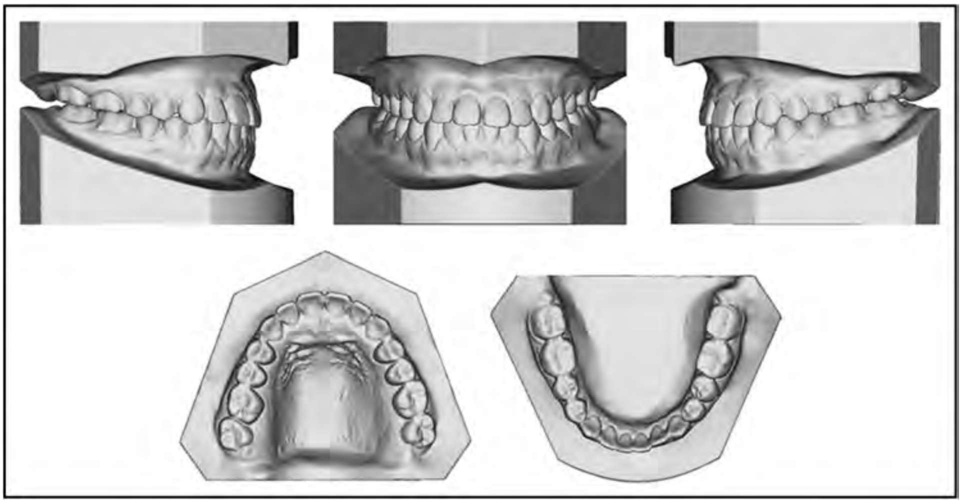

Fig 12. Posttreatment study casts.

1. Immediate improvement of facial appearance, rather than worsening before surgery.[8-14]
2. Reduced total treatment time by eliminating the presurgical orthodontic stage and facilitating tooth movement after surgery. The phenomenon of postoperatively accelerated orthodontic tooth movement has been attributed to the regional acceleratory phenomenon (RAP).[20-22] The RAP is a complex physiologic process that involves accelerated bone turnover and decreased regional bone density. It increases tissue reorganization and healing through a transient burst of localized severe bone

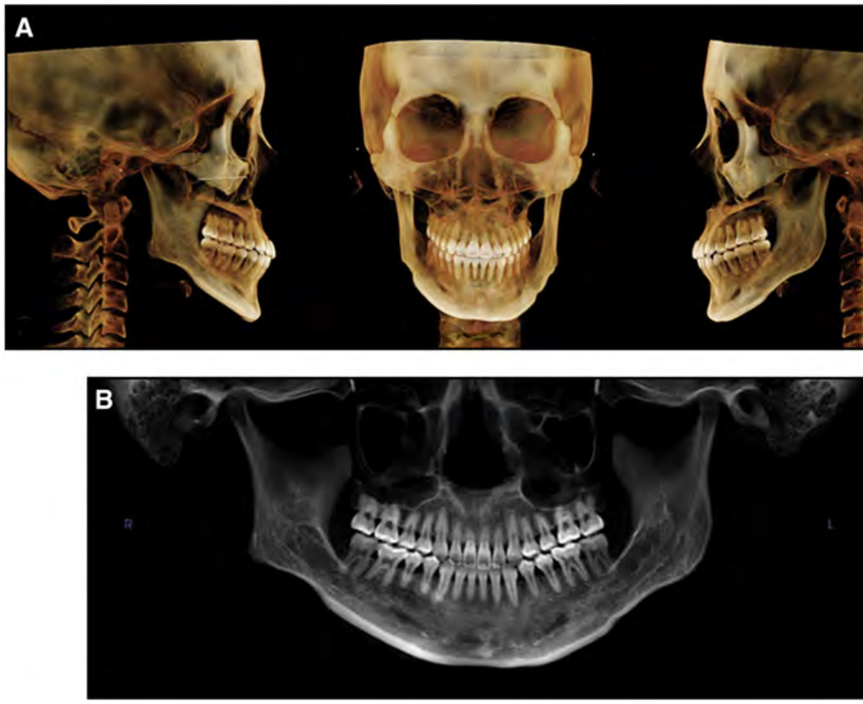

Fig 13. A, Posttreatment CBCT volume images; **B,** panoramic view, generated from CBCT volume image.

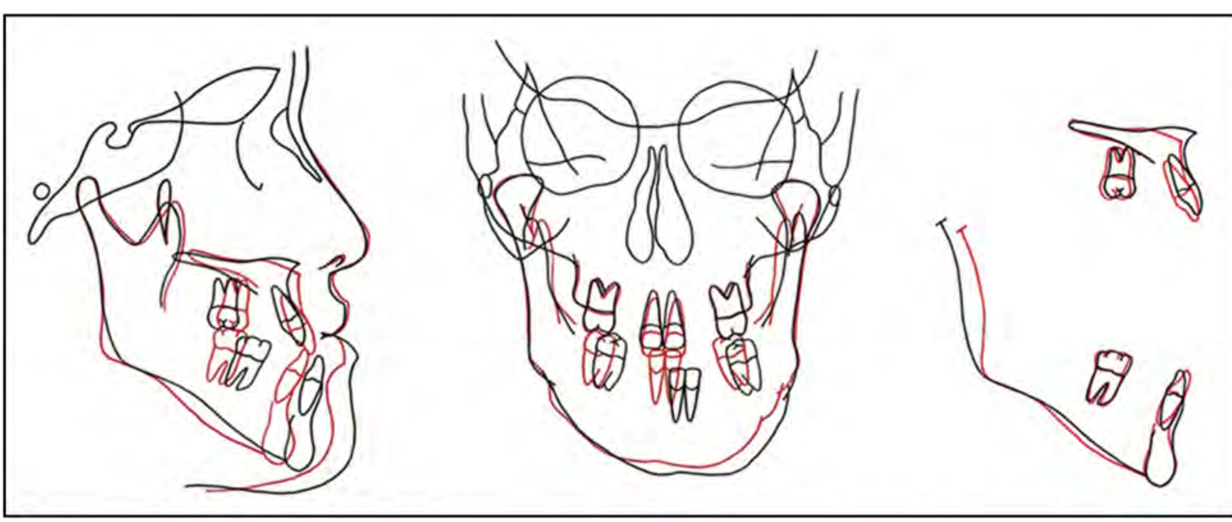

Fig 14. Superimpositions of pretreatment and posttreatment tracings based on cephalograms generated from CBCT volume images.

resorption followed by remodeling.[20-22] Several mechanisms have been proposed for the osteopenic effect in RAP.[20-23] Recently, Liou et al[14] reported that the level of serum C-terminal telopeptide of type 1 collagen, a bone resorption metabolite of type 1 collagen in bone, significantly increased in the first week to the third month postoperatively. In addition, the amount of serum alkaline phosphatase, an enzyme for bone formation, significantly increased in the fourth week to the fourth month postoperatively. Both events indicated increased osteoclastic and osteoblastic activities.[14] It was postulated that orthognathic surgery triggered a 3- to 4-month period of higher osteoclastic

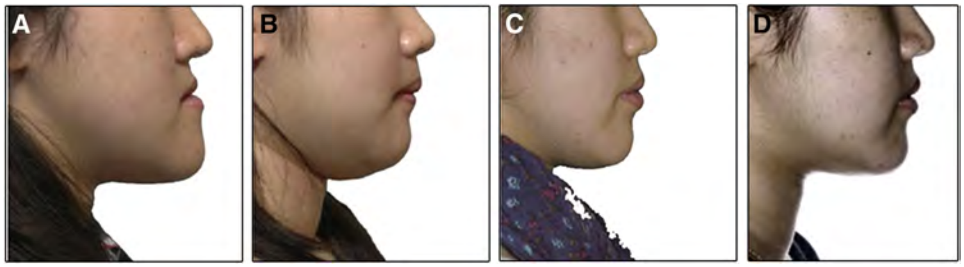

Fig 15. Changes in facial profile: **A,** initial; **B,** 3 weeks postsurgery; **C,** 8 months postsurgery; **D,** final at 16 months postsurgery.

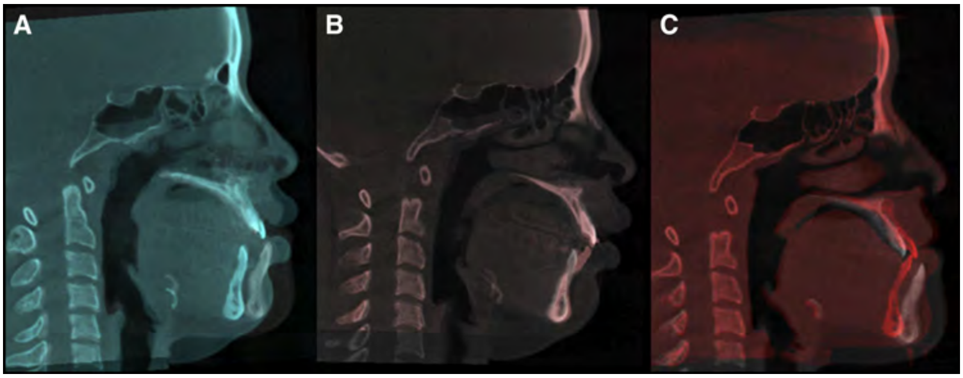

Fig 16. Three-dimensional superimpositions in the sagittal sections showing the changes in hyoid bone position: **A,** presurgery and immediately postsurgery; **B,** immediately postsurgery and 4 months postsurgery; **C,** pretreatment and posttreatment at 16 months postsurgery.

activities and metabolic changes in the dentoalveolus that potentially accelerated postoperative orthodontic tooth movement.

3. Orthodontic tooth movement is easier and more physiologically favorable after surgical elimination of the skeletal disharmony because the direction of tooth movement for decompensation is not against the soft tissue pressure, whereas the opposite is true in presurgical orthodontic movement.[24,25] In addition to accelerated orthodontic tooth movement during the 3- to 4-month RAP period, we believe that this physiologically favorable decompensation process is the major contributing factor in significantly reducing treatment time with the surgery-first approach. For instance, as seen in this case report, a Class III malocclusion became a Class II relationship after surgery; this improved the tone of the upper lip and tongue and increased the force on the incisors in both arches to make incisor decompensation more efficient.[8]
4. If any challenging 3D tooth movements are required, skeletal temporary anchorage systems (miniplates on the zygoma or mandible) can be readily incorporated during the surgery with little additional cost or time.[8,9]
5. In patients with severe root resorption before orthodontic treatment, this surgery-first approach is preferred over the conventional 3 stages of surgical orthodontics because less dense bone due to RAP and the efficient decompensation process not only minimize root resorption, but also facilitate tooth movement.

Among all the advantages, the instant improvement in facial appearance has the greatest impact on patients, particularly those who have experienced significant psychological and self-esteem problems while waiting for jaw growth to cease for the surgical correction. Thus, increased patient satisfaction potentially translates into greater motivation and cooperation during postsurgical orthodontics. With the conventional 3-stage approach, patients are commonly frustrated by presurgical orthodontic treatment when reversed treatment mechanics and extraction patterns to decompensate the dentition exacerbate the malocclusion and facial appearance to express the true underlying skeletal jaw discrepancy. In addition, soft tissue resistance can considerably increase the time required to correct severely compensated dentitions.[24,25]

In contrast, negative aspects of the surgery-first approach are also recognized.

1. The occlusion cannot be used as a guide for the surgical movement.[8,9] It is believed that without appropriate dental decompensation preoperatively, the surgeon is limited by tooth position in fully correcting the skeletal deformity.[3] Therefore, the most important consideration in using this technique is that it requires close cooperation and communication between highly experienced orthodontists and orthognathic surgeons.[8,9,11]
2. A more comprehensive and labor-intensive planning process using 3D virtual models or study cast setups is necessary because postsurgical tooth movements for decompensation, resolving crowding, and leveling and aligning need to be incorporated into the surgical movement.[11,17]
3. An unstable occlusion without presurgical orthodontics can lead to surgical instability. A postsurgical Class II malocclusion in a Class III surgical patient is generally quite unstable, so it is essential to use a surgical splint to guide mandibular repositioning. In addition, a removable occlusal splint is often required in the early stage of postsurgical orthodontic treatment.[8,9,11]
4. A complex and time-consuming wire bending procedure is necessary to place a passive surgical wire for intermaxillary fixation.[11] However, as shown with our patient, if some intermaxillary fixation screws are placed during surgery, the wire bending procedure is unnecessary.

This patient had no appliances placed before surgery, so intermaxillary fixation screws and a surgical splint were used for fixation. In addition, she wore the removable splint in the maxillary arch until a reasonable bony union of the segments was obtained. Despite having her mandible set back more than 10 mm, a stable occlusion was obtained at the end of treatment, and an excellent treatment outcome was observed after 1 year of retention.

According to the literature, many factors influence surgical relapse and stability, but the introduction of rigid fixation has significantly improved surgical stability.[9,26-30] A special concern with the surgery-first approach that has been raised by orthodontists is obtaining surgical stability right after surgery because the occlusion is unstable without presurgical orthodontics. However, the prolonged use of an occlusal splint in 1 arch and light elastic wear can help achieve a stable occlusion and jaw position until bone healing with initial leveling and alignment is achieved. Even though there have been no long-term follow-ups for patients treated with a surgery-first approach and no randomized clinical trials on stability when comparing these 2 approaches (surgery-first vs conventional 3-stage surgical orthodontic approaches), several authors reported that the stability of a surgery-first approach is not much different from a conventional 3-stage surgical orthodontic approach.[11,31]

In addition, adaptation of neuromuscular structures and function must occur after surgery. In recent years, many dental and medical professionals have become increasingly interested in obstructive sleep apnea and airway issues.[32,33] With a mandibular setback of more than 10 mm, some decreases in the airway and posterior movement of the hyoid bone were expected. However, in our patient, the hyoid bone did not follow the direction of the surgical movement of the mandible and the original position was maintained. The literature provides conflicting results. This difference could be attributed to factors such as mandibular setback being combined with maxillary advancement, the patient's age and sex, and the original airway condition. Since previous studies primarily used 2-dimensional images, newly available 3D imaging and measuring software can improve our ability to analyze changes to answer these important health questions.

Although there is no evidence that the patient's malocclusion contributed to her temporomandibular joint issues, several studies have reported that mandibular asymmetry can be an etiologic factor for developing TMD problems.[34,35] Before treatment, the patient had a history of TMD problems and a reduced posterior disc space radiographically. After surgery, slight positional and rotational changes in the condyles were observed from the CBCT images and 3D superimpositions, but the patient did not experience any TMD problems. Some relapse in the midline was observed and corrected with the brief use of asymmetric elastics. At the end of treatment, the condyle assumed a stable position in the glenoid fossa, which did not differ much from its original position.

CONCLUSIONS

This case report demonstrates that the surgery-first approach can be successfully used in correcting a severe skeletal Class III malocclusion with facial asymmetry. Excellent facial appearance and occlusion were obtained. Treatment duration was reduced by eliminating the presurgical phase and taking advantage of the rapid bone remodeling process, which in turn accelerated tooth movement without noticeable side effects. In addition, worsening of facial appearance and function was avoided, and this resulted in high patient satisfaction.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at http://dx.doi.org/10.1016/j.ajodo.2014.10.040.

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