

CONTINUING EDUCATION ARTICLE

Skeletal anchorage system for open-bite correction

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A skeletal anchorage system was developed for tooth movements. It consists of a titanium miniplate that is temporarily implanted in the maxilla or the mandible as an immobile anchorage. In this article, we introduce the skeletal anchorage system to intrude the lower molars in open-bite malocclusion and evaluate the results of treatment in two severe open-bite cases that underwent orthodontic treatment with the system. Titanium miniplates were fixed at the buccal cortical bone around the apical regions of the lower first and second molars on both the right and left sides. Elastic threads were used as a source of orthodontic force to reduce excessive molar height. The lower molars were intruded about 3 to 5 mm, and open-bite was significantly improved with little if any extrusion of the lower incisors. No serious side-effects were observed during the orthodontic treatment. The system was also very effective for controlling the cant and level of the occlusal plane during orthodontic open-bite correction. (*Am J Orthod Dentofacial Orthop* 1999;115:166-74)

It is very important for vertical correction of skeletal open-bite to control the height of the posterior dentoalveolar regions. However, traditional biomechanical techniques, such as the use of a multibracket appliance, an extraoral anchorage, an active vertical corrector with magnets, a vertical-pull chin cap, etc, cannot effectively control intrusion of the molars, especially in adult patients. This is because it is extremely difficult to establish a rigid anchorage for molar intrusion in such

cases. To obtain a rigid anchorage, dental implants and bone screws have been reported as orthodontic and orthopedic anchors.¹⁻²⁰ Some new types of implants have been designed to provide anchorage for orthodontic tooth movements.^{21,22} For example, Jenner and Fitzpatrick²³ reported a clinical case in which surgical bone plates were used to provide skeletal anchorage.

Recently, as a result of advances in biocompatible medical materials, osteointegrated titanium implants have been developed and used in bone screws and miniplates for rigid fixation in orthognathic surgery. This application leads to the hypothesis that a titanium miniplate^{24,25} might also be used as a source of stationary anchorage for tooth movements. Therefore we developed a skeletal anchorage system (SAS) in our clinic using a titanium miniplate that is temporarily implanted in the maxilla and/or mandible as an immobile intraoral anchorage, particularly for intrusion of the molars.

The purpose of this study was to use the SAS for open-bite correction. This article presents the results of

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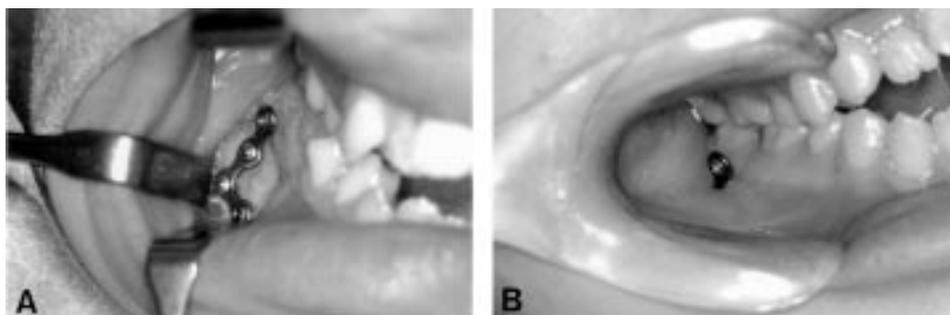


Fig 1. Implantation of a titanium miniplate. **A**, Surgical procedure, **B**, after healing of the wound.

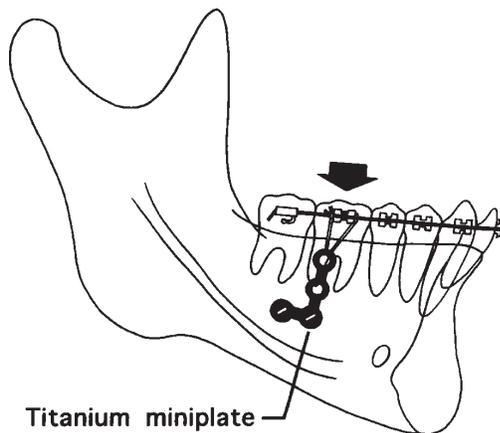


Fig 2. Scheme of the treatment mechanics for open-bite correction with SAS.

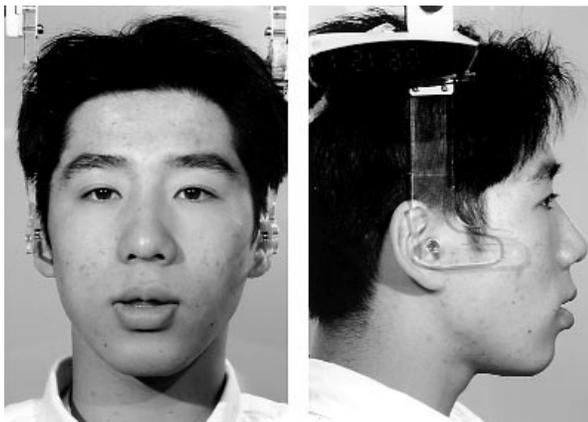


Fig 3. Case 1: Pretreatment facial photographs.

treatment in two severe open-bite cases that were treated by this new method.

SURGICAL PROCEDURES FOR THE IMPLANTATION OF TITANIUM MINIPLATES (Figs 1 and 2)

Titanium miniplates were implanted after a local anesthesia had been administered with intravenous sedation. First, a mucoperiosteal incision was made at the buccal vestibule directly under the first or second lower molars. The mucoperiosteal flap was then elevated, and the surface of the cortical bone at the apical region of the molar was exposed. An L-shaped miniplate (Leibinger, Mühlheim-Stelten, Germany) was adjusted to fit the contour of each cortical bone surface and was fixed by bone screws (length, 5 mm or 7 mm) with the long arm exposed to the oral cavity from the incised wound (there are two holes in the long arm of the miniplate; the exposed hole will be used to directly receive the intrusive force). We confirmed that the



Fig 4. Case 1: Pretreatment intraoral photographs.

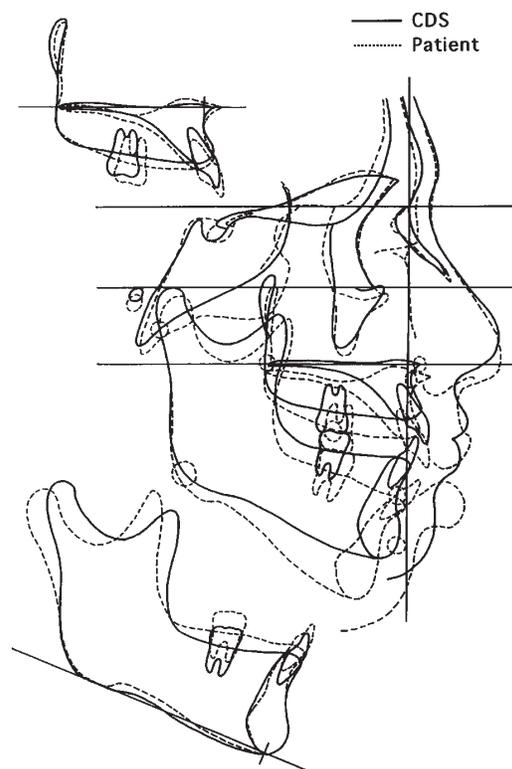


Fig 5. Template cephalometric analysis with CDS.

miniplate did not disturb mandibular movement, and the wound was then closed and sutured. All of the miniplates were transfixed at the region of the buccal vestibule. About 10 minutes was required for each implantation. While orthodontic force could be applied to the miniplate immediately after implantation, it is advisable to wait until the wound is healed. During this period, the patient can be instructed in how to clean the peripheral region of the miniplates.

Table I. Summary of cephalometric measurements

Measurements	Norm (CDS, Male)	Pretreatment	Posttreatment
SNA	83.9	83.0	83.0
SNB	80.7	78.0	78.7
ANB	3.1	5.0	4.3
Wits (mm)	0.5	-2.6	0.0
YAXIS	63.7	76.7	75.7
ANS-Me (mm)	69.9	85.0	82.5
SN-Mand pl	31.4	41.0	39.5
SN-OP	13.3	22.0	17.8
SN-OPi		26.5	15.8
U1 Angle (SN)	107.7	108.0	106.0
L1 Angle (FH)	61.7	45.2	56.3
L1 Angle (MP)	94.1	101.5	91.7
Is-Is' (mm)	29.2	32.5	34.2
Ms-Ms' (mm)	24.4	27.5	27.5
Ii-Ii' (mm)	46.2	49.6	51.8
Mi-Mi' (mm)	35.6	42.2	38.7

OP, Conventional occlusal plane; OPi, mandibular occlusal plane; Is-Is', upper incisor dental height; Ms-Ms', upper molar dental height; Ii-Ii', lower incisor dental height; Mi-Mi', lower molar dental height.

Table II. Problem list and treatment objectives for Case 1

Problem list	Treatment objectives
Soft tissue	
1. Large interlabial gap	Aggressively intrude the molars to allow for autorotation of the mandible
2. Insufficient exposure of the upper incisors in relaxed lip posture	
3. Slightly retrognathic profile	
Skeletal	Level the incisors to an esthetic position
1. Excessive anterior lower facial height	Aggressively intrude the molars to allow for autorotation of the mandible
2. Slightly retruded mandible	
3. High mandibular plane angle	
4. Excessive incisal and molar alveolar height (more particularly lower molar alveolar height)	
5. Skeletal Class II tendency Class I	
Intraoral and denture	Maintain
1. Severe anterior open-bite	Tip the incisors lingually
2. Class I molar relationship	
3. Labial inclined lower incisors	
4. Tongue thrust	
	Myofunctional therapy if necessary

APPLICATION OF SAS

Case 1

A 19-year-old Japanese male presented with an anterior open-bite and occlusal disturbance. His anamnesis was not significant.

Figs 3 and 4 show the patient's facial and oral photographs. Fig 5 shows a lateral cephalometric template analysis using the craniofacial drawing standard (CDS).²⁶ Cephalometric measurements are shown in Table I. As illustrated in Table II, the patient had many vertical dental and skeletal problems. Therefore the treatment objectives essentially consisted of vertical

control of the posterior dentoalveolar regions. The treatment plan for this case was as follows:

1. Extract all of the third molars.
2. Construct a multibracket system on both dental arches.
3. Implant titanium miniplates at the apical regions of the lower molars on both the right and left sides.
4. Intrude the lower molars by SAS in conjunction with Multiloop Edgewise Archwires (MEAW).²⁷
5. Place a wraparound-type retainer on the upper arch and bond a lingual wire between the right and left lower first premolars. Myofunctional therapy may be considered if the patient continues to display tongue thrusting.



Fig 6. Panoramic radiograph immediately after implantation of titanium miniplates.



Fig 7. Precision lingual arch to avoid molar buccal flaring during intrusion.

Treatment Progress

The upper and lower teeth were banded or bonded with a 0.022 inch straight wire bracket appliance. Alignment of the teeth was begun. About 1 month before beginning intrusion of the molars, titanium miniplates were implanted at the apical regions of the lower first and second molars of both the right and left sides (Fig 6). To intrude all of the lower molars, four miniplates were implanted. An MEAW arch was fabricated with a molar tip back bend and intrusion bend. Intrusion of the lower molars was achieved with the application of elastic orthodontic force on the SAS, as shown in Fig 2. Lingual crown torque was applied to the lower molars with Burstone's precision lingual arch²⁸ to avoid buccal flaring during intrusion (Fig 7). Three months after intrusion was begun, the lower arch wire was changed to a plain stiff wire to avoid distortion of the arch by intrusive force. The upper arch wire was changed to a plain wire with an anterior step-down bend to correct insufficient exposure of the upper



Fig 8. Five months after intrusion was begun.



Fig 9. Posttreatment facial photographs.



Fig 10. Posttreatment intraoral photographs.

incisors. The intrusion was completed after 5 months (Fig 8). Arch wires were left for retention of the intruded molars for about another 4 months. After 18 months of orthodontic treatment, the fixed appliance and the

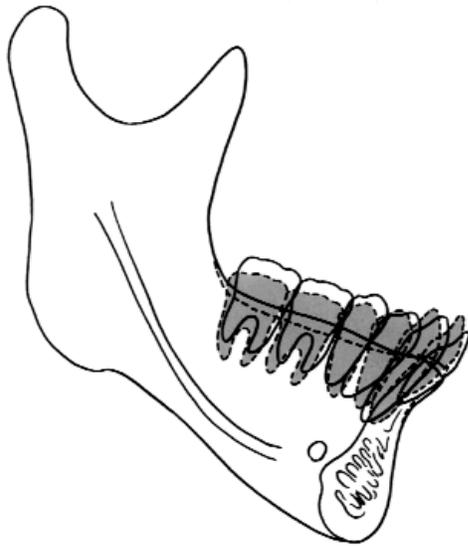


Fig 11. Superimposition of cephalometric tracings of mandible.

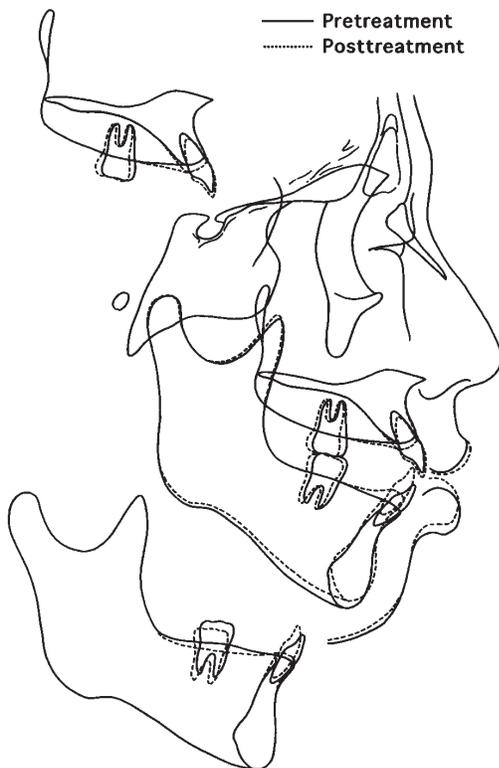


Fig 12. Overall superimposition of cephalometric tracings.

miniplates were removed. Immediately after debonding, the patient was provided with a wraparound-type retainer on the upper arch and a lingual bonded retainer on the lower arch between the right and left first pre-



Fig 13. Case 2: Pretreatment facial photographs.



Fig 14. Case 2: Pretreatment intraoral photographs.

molars. In this case, chewing training was given to establish harmonious masticatory functions.

Results Achieved

The large interlabial gap was improved, and favorable interdigitation with Class I occlusion was achieved (Figs 9 and 10). Lateral excursions demonstrated canine-guided occlusion without interference at the contralateral side.

Figs 11 and 12 show superimpositions of cephalometric tracings. These demonstrate the manner of tooth movement and dentofacial changes as follows:

1. Intrusion of the lower molars
2. Upright premolars and upper molars
3. Upright lower incisors as a result of lingual crown torque, which was introduced after molar intrusion
4. A slight extrusion of the upper and lower incisors
5. Counterclockwise rotation of the occlusal plane
6. Autorotation of the mandible
7. Decrease in the anterior lower facial height
8. Decrease in the interlabial gap

Table III. Summary of cephalometric measurements

Measurements	Norm		
	(CDS, Female)	Pretreatment	Posttreatment
SNA	83.1	82.5	83.0
SNB	79.5	77.0	78.0
ANB	3.6	5.5	5.0
Wits (mm)	-1.3	-1.5	0.0
YAXIS	65.0	76.5	74.2
ANS-Me (mm)	66.1	77.0	74.3
SN-Mand pl	36.8	41.9	37.7
SN-OP	17.7	21.5	18.4
SN-OPi		24.0	16.8
U1 Angle (SN)	104.5	110.0	102.5
L1 Angle (FH)	60.3	44.5	49.5
L1 Angle (MP)	90.7	98.2	97.0
Is-Is' (mm)	28.6	29.4	31.6
Ms-Ms' (mm)	22.6	22.0	23.4
Ii-Ii' (mm)	43.6	43.0	45.0
Mi-Mi' (mm)	33.0	33.8	33.8
Mi-Mi' (7) (mm)		33.6	28.6

OP, Conventional occlusal plane; OPi, mandibular occlusal plane; Is-Is', upper incisor dental height; Ms-Ms', upper molar dental height; Ii-Ii', lower incisor dental height; Mi-Mi', lower molar dental height.

Cephalometric measurements (Table I) indicated that the mandibular plane angle tilted from 41.0° to 39.5°, mainly due to a decreased posterior vertical dimension. The lower molars were intruded 3.5 mm, and the occlusal plane showed counterclockwise rotation of 4.2°.

Case 2

A 13-year-old Japanese female complained of open-bite and occlusal disturbance. Her anamnesis included chronic otitis media and adenoids.

Figs 13 and 14 show the patient's facial and oral photographs. Fig 15 and Table III show the results of a cephalometric analysis that was performed as it was in Case 1. Her problems and treatment objectives are shown in Table IV. The treatment plan was as follows:

1. Request that an ear, nose, and throat (ENT) specialist resolve her ear and throat problems.
2. Extract the lower right third molar.
3. Construct a multibracket system.
4. Expand the upper dental arch with a precision transpalatal arch.
5. Implant the titanium miniplates at the apical regions of the lower second molars on both the right and left sides.
6. Intrude the lower second molars by SAS.
7. Perform a glossectomy.
8. Fix a lingual arch on the upper arch and a lingual bonded retainer on the lower arch between the lower right and left first premolars. Myofunctional therapy may be considered if the patient continues to display tongue thrusting.

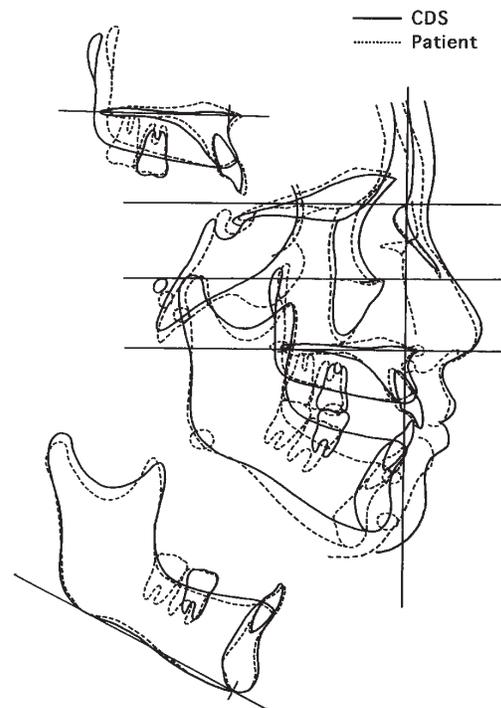


Fig 15. Template cephalometric analysis with CDS.



Fig 16. Expanding upper arch and leveling before application of SAS.

Treatment Progress

An ENT physician advised that her tonsils and adenoids should be left as they were, at least for the present. Upper and lower teeth were banded or bonded with a 0.022 inch straight wire appliance. The upper arch was aligned with progressive expansion by a precision transpalatal arch (Fig 16). Titanium miniplates were implanted at the apical regions of the lower second molars (Fig 17). A plain stiff arch wire and a precision lingual arch were placed on the lower arch. The molars were simultaneously intruded using SAS with elastic



Fig 17. Panoramic radiograph immediately after implantation of titanium miniplates.



Fig 18. Onset of intrusion of lower molars with SAS.

Table IV. Problem list and treatment objectives for Case 2

Problem list	Treatment objectives
Soft tissue	
1. Large interlabial gap	Aggressively intrude the lower second molars to allow for autorotation of the mandible
2. Retrognathic profile	
3. Mentalis strain	
Skeletal	
1. Excessive anterior lower facial height	Aggressively intrude the lower second molars to allow for autorotation of the mandible
2. Retruded and steep mandible	
3. Skeletal Class II tendency Class I	
Intraoral and denture	
1. Severe open-bite	Expand the upper arch width to allow for alignment of the dental arch with lingually inclined incisors
2. Overeruption of the lower second molars	
3. Narrow upper dental arch and broad lower dental arch	
4. Crowded upper dental arch	Tip the incisors lingually
5. Slightly labial inclined upper incisors	
6. Slightly labial inclined lower incisors	Myofunctional therapy if necessary and reduce the tongue size
7. Low-lying large tongue and tongue thrust	
8. Abnormal tonsils and adenoids and severe mouth-breathing	Improve the otorhinolaryngologic disease

threads (Fig 18). The overeruptions of the lower second molars improved significantly in 9 months. The functional and esthetic treatment objectives were achieved, but the patient refused a glossectomy. Miniplates were removed after 5 months of wire retention. After 26 months of orthodontic treatment, the fixed appliances were removed. Immediately after debonding, a lingual arch was placed on the upper arch and a lingual bonded retainer was placed on the lower arch between the right and left first premolars. Myofunctional therapy was used to improve her tongue thrusting.

Results Achieved

After orthodontic treatment with SAS, the patient's long face profile and retruded chin were greatly

improved, and mentalis strain disappeared (Fig 19). The teeth were well aligned and favorable interdigitation was achieved (Fig 20). Functional occlusion with the canines and molars in a Class I position was attained.

Although she showed a significant amount of mandibular growth during the postpubertal period, the tooth movements and dentofacial changes were almost the same as those in case 1, except for the upright lower molars (Figs 21 and 22). As shown in Table III, cephalometric measurements revealed that the mandibular plane angle and occlusal plane angle were flattened, mainly due to the decreased posterior vertical dimension. The lower second molars were intruded approximately 5.0 mm by SAS.



Fig 19. Posttreatment facial photographs.



Fig 20. Posttreatment intraoral photographs.

Glossectomy may be considered if she shows a relapse of open-bite during an ongoing observation period.

CONCLUSION

Molar intrusion is normally required when a skeletal open-bite is corrected without orthognathic surgery. However, it is very difficult to achieve virtual intrusion of the molars with the use of ordinary orthodontic procedures because adequate anchorage is extremely difficult to establish for molar intrusion. As shown here, SAS can provide a significant amount of intrusion of the lower molars. This molar intrusion is associated with minimum extrusion of the lower incisors and counterclockwise rotation of the occlusal plane. Compared with other dental implants, SAS offers the following advantages: no preparation is necessary to obtain a location for implantation, a stable rigid anchorage is ensured, and tooth movement is possible shortly after implantation. SAS made it possible to

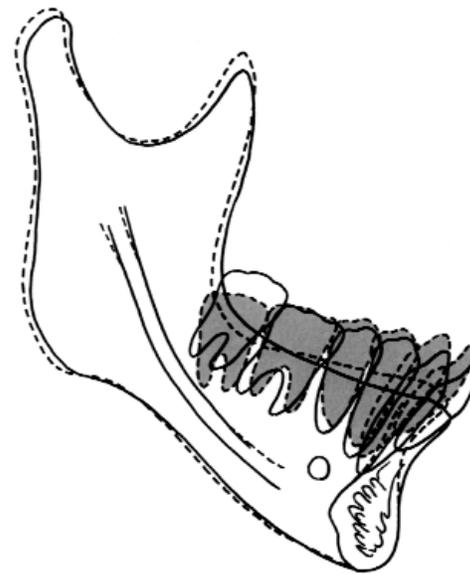


Fig 21. Superimposition of cephalometric tracings of mandible.

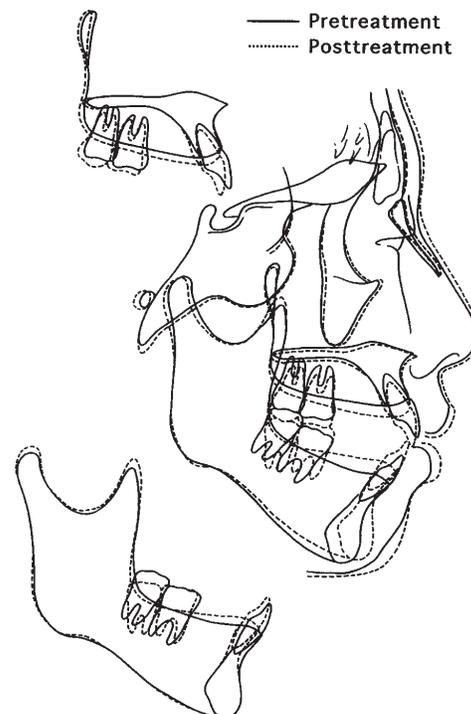


Fig 22. Overall superimposition of cephalometric tracings.

achieve the exact treatment goals, simplified treatment mechanics, shortened the orthodontic treatment period, and minimized discomfort during treatment. In addition, no serious side effects were observed includ-

ing peripheral inflammatory changes around SAS apparatus.

These results indicate that SAS is an effective adjunctive biomechanical procedure for correction of skeletal open-bite malocclusion without unfavorable side-effects.

The stability of the treatment results of open-bite is under the control of many factors, especially existent etiologic factors of open-bite. The patients discussed in this article as well as other patients treated by SAS are undergoing posttreatment observation in our clinic. We are planning to evaluate the stability of occlusion treated by SAS in comparison to other procedures for open-bite correction.

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