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Case Report

Minimum Surgico-Orthopedic Treatment using Computer-Assisted Single-Tooth Osteotomy in an Adolescent Skeletal Class III Patient with Anterior Ankylosed Tooth: A Case Report

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Main Points

- Children having skeletal Class III malocclusion and traumatic anterior teeth may show a difference in alveolar bone height and open bite due to bony ankylosis of traumatized teeth.
- In this case, the alveolar bone height cannot be improved by fixed orthodontic appliance, and esthetic results may not be obtained even if the implant or prosthetic treatments are attempted after the completion of growth.
- Orthodontic treatment accompanied with CAD/CAM-based minimal surgery is helpful especially when the alignment of the teeth is impossible and the overjet and overbite of the ankylosed tooth area are not improved. Therefore, it would be very esthetically disadvantageous by previous methods of orthodontic treatment.
- Minimal surgery such as single-tooth osteotomy during orthodontic treatment immediately improves the patient's quality of life in terms of socio-psychology or esthetics and the patient would not need alveolar bone augmentation on the anterior maxilla for dental implant at the time of growth completion.

ABSTRACT

Traumatic tooth avulsion can lead to ankylosis, which may interfere with growth of the alveolar bone in a growing patient. The resulting difference in alveolar bone height and position can lead to esthetic problems such as open bite.

A growing 13-year-old female patient presented skeletal Class III malocclusion with bone ankylosis of a maxillary anterior tooth. Even after 2 years of orthopedic and orthodontic treatment, little improvement was achieved regarding the positions of the anterior maxillary teeth, or the vertical position of the maxillary right central incisor. Therefore, surgical treatment by single-tooth osteotomy (STO) and corticotomy for the anterior ankylosed tooth were considered and performed using a CAD/CAM surgical guide, based on presurgical computer-based simulation surgery. Orthodontic and orthopedic treatments were completed at 10 months after surgery. The patient showed a favorable course of healing, with no mobility issues or gingival recession 3 years after single-tooth osteotomy and corticotomy surgeries. A favorable outcome was finally achieved by applying orthopedic treatment combined with STO and corticotomy for the anterior ankylosed tooth. Orthodontic treatment with minimally surgical method is recommended in an adolescent patient with skeletal Class III malocclusion and anterior open bite.

Keywords: Ankylosed tooth, pediatric orthopedics, single-tooth osteotomy, corticotomy, skeletal Class III malocclusion

INTRODUCTION

Following traumatic tooth avulsion, the tooth must be quickly replanted and root canal therapy should be performed. Even if the avulsed tooth is successfully replanted, it can become ankylosed. When dental trauma results in bone ankyloses during growth, it can interfere with the vertical and anterior growth of alveolar bone, producing an open bite with unfavorable overjet that may lead to functional and esthetic issues.[1,2]

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It can be difficult to move the ankylosed teeth responsible for an anterior open bite and unfavorable overjet using only orthodontic treatment. Moreover, even with successful tooth movement, esthetic problems can remain due to the difference in alveolar bone height and anterior–posterior (AP) position difference.

In such cases, single-tooth osteotomy (STO) with/without corticotomy can be performed to simultaneously move the ankylosed tooth and the alveolar bone.[3] When an ankylosed tooth also limits the degree to which the adjacent teeth can be moved by orthodontic treatment, corticotomy can be performed to facilitate tooth movement.[4] Trauma-induced bony ankylosis that occurs during the growth period can hamper the vertical growth of alveolar bones. This condition results in an open bite that poses esthetic and functional problems.[1,2] A single-tooth dento-osseous osteotomy may be the optimal treatment plan.[2,3]

Recent advances enable surgical planning using simulations based on preoperative CT data, as well as easier and more accurate surgery performance using CAD/CAM-based equipment.[5] This study introduced a CAD/CAM-based method to assist surgeons in performing single-tooth dento-osseous osteotomies for delicate and elaborate surgery. In this method, a surgical guide was manufactured with CAD/CAM technology. The surgical guide was based on preoperative surgical simulation data. We showed that this method was highly conducive to successful single-tooth dento-osseous segmental osteotomy. Especially in this case report, a growing patient presented skeletal Class III malocclusion with an open bite due to bone ankylosis of a maxillary anterior tooth. A favorable outcome was achieved by performing orthopedic treatment combined with STO and corticotomy.

CASE PRESENTATION

A 13-year-old female patient visited the hospital with protrusive mandible and malocclusion, reverse overjet of anterior teeth, and an open bite. Five years earlier, the patient had experienced trauma causing avulsion of the right central incisor, which had been treated by reduction and endodontic treatment. The subsequent combination of palatoversion, lack of vertical eruption of the maxillary right central incisor, and insufficient vertical growth from the maxillary right canine to the maxillary left canine had resulted in malocclusion and an open bite (Figures 1 and 2). The patient was diagnosed as skeletal Class III with open bite due to tooth bony ankylosis.

Orthodontic and orthopedic treatments were planned to improve the patient's open bite and overall occlusion. After 2 years of orthopedic treatment using face mask, AP maxillary discrepancy was corrected. However, orthodontic treatment achieved little improvement in the positioning of the anterior

Figure 1. Pretreatment facial and intraoral photographs

Figure 2. Radiographs from the patient's initial diagnostic evaluation

maxillary teeth, or the vertical and AP position of the maxillary right central incisor (Figure 3).

It was decided that the patient should undergo STO, because correction of anterior alveolar bone and tooth position was needed for resolving the psychological problem due to the anterior open bite. A canine-to-canine labial corticotomy was also planned to improve the tooth axis and the vertical and AP position of the maxillary anterior teeth.

Preoperative digital simulation surgery was performed to minimize the risk of damaging the surrounding teeth during osteotomy, and to ensure movement of the ankylosed tooth to a functionally and esthetically favorable position (Figure 4). A three-dimensional (3D) reconstruction was generated from maxillary CT images, and osteotomy of the maxillary right central incisor was simulated. The simulation aimed to determine the precise location of the osteotomy relative to the root apices of the maxillary right central incisor, and with regard to its relationships with the left central incisor and the right lateral incisor.

A thickness of 0.7 mm was selected for the osteotomy line (STO and corticotomy), accounting for the thickness of the piezosurgical device to be used in the actual operation. The osteotomy line was planned to minimize injury to the nearby dental roots. Surgical simulation was also performed to determine the position of the corticotomy from the maxillary right to left canine. These osteotomy line and maxillary data were used with CAD/CAM technology to design and manufacture a surgical guide to be placed on the maxilla during the actual osteotomy procedure (Figure 4). The surgical guide was fabricated from a biocompatible material using a 3D printer (ProJet 3500 HDMax 3D Printer, 3D Systems, Inc., Rock Hill, SC).

In the operating room, the initial surgical incision was made near the maxillary incisor. Next, the surgical guide was placed on the alveolar bony area, and the guide fit and the osteotomy line position were checked. A piezoelectric saw blade was used to make a cut, following the groove in the guide to ensure a consistent position and angle as measured depth during the surgical simulation (Figure 5). For osteotomy to the left and right of the maxillary right central incisor and periapical osteotomy, the cut depth was determined with reference to the distance between the guide and the palatine bone, as measured during the simulation. For the corticotomy from the right to the left maxillary canine, the surgeon referred to the thickness of the cortex and the device in CT images, and relied on the manual sensation of cortical perforation to perform the corticotomy safely.

After the osteotomy, the segment was slowly moved inferiorly, taking care not to separate the tooth-bone segment from the palatal mucoperiosteal flap under verifying blood circulation (Figure 5). Following inferior movement of the tooth-bone segment, a xenogeneic bone (Geistlich Bio-Oss, Geistlich Pharma AG, Wolhusen, Switzerland) was grafted in the empty bone space. Upon confirming the stable position of the tooth-bone segment, the surgical wound was sutured with application of manufactured human plasma fibrinogen, completing the operation.

Figure 3. Intraoral photographs after 2 years of orthodontic treatment

After a 1-week postoperative latency period (Figure 6), postoperative orthodontic treatment was resumed to correct the patient's open bite, and the vertical and AP position and axis of the maxillary right incisor. Orthopedic and orthodontic treatment were completed 10 months after surgery, the open bite had improved, and favorable occlusion was obtained (Figures 7 and 8). The patient showed a favorable course of dental occlusion and mandibular growth without temporomandibular disorder (TMD) issues. There is no complication as severe gingival recession or relapse, 3 years after the STO and corticotomy surgeries (Figures 9 and 10).

All the above procedures were performed with patient consent. The patient also consented to the publication of the data in this study.

DISCUSSION

In patients with skeletal Class III malocclusion and ankylosed anterior tooth, if the anterior cross bite is properly improved through orthopedic treatment during the growth period and the leveling of anterior teeth can be maintained through STO, the possibility of the need for orthognathic and implant surgery after the termination of growth, can be significantly reduced. It may also be the best treatment in terms of socio-psychology or esthetics. Even for a growing patient, improvement in esthetics is of great social and psychological importance, and these procedures must be considered in the treatment of skeletal Class III patients with ankylosed teeth. The management of ankylosed tooth with STO in conjunction with orthognathic surgery is also an alternative treatment method.[6]

However, STO has a risk of postsurgical problems affecting the blood supply to the tooth-bone segment, which can result in complications such as gingival recession.[3,5] Even when the open bite is improved by surgery, gingival recession and adjacent tooth injury may lead to esthetic problems and a poor long-term prognosis.

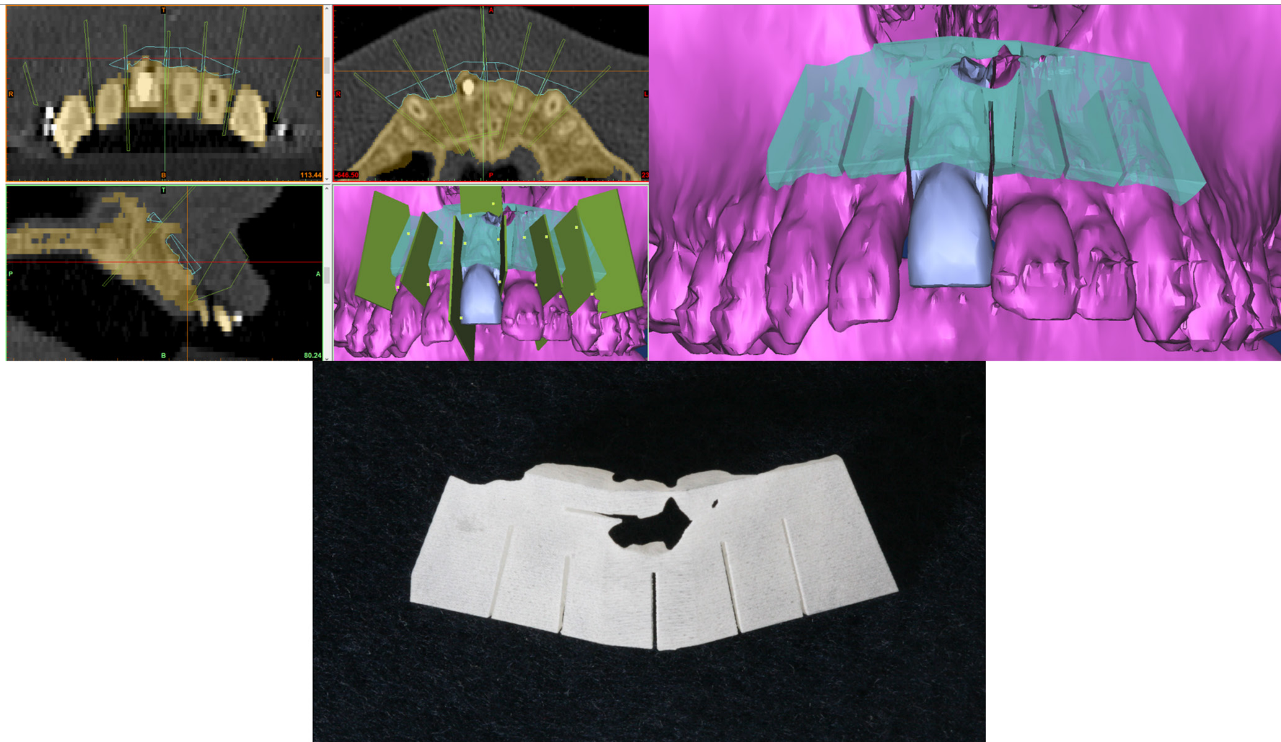

Figure 4. Surgical simulation and surgical guide 3D printing by biocompatible materials. The simulation aimed to determine the precise location of the osteotomy relative to the root apices of the maxillary right central incisor, and with regard to its relationships with the left central incisor and the right lateral incisor. The surgical guide was fabricated from a biocompatible material using a 3D printer.

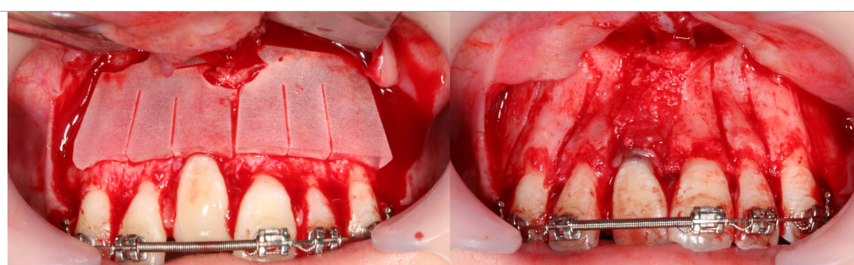

Figure 5. Operation of single-tooth osteotomy with corticotomy. The initial surgical incision was made near the maxillary incisor. Next, the surgical guide was placed on the alveolar bony area, and the guide fit and the osteotomy line position were checked. For osteotomy to the left and right of the maxillary right central incisor and periapical osteotomy, the cut depth was determined with reference to the distance between the guide and the palatine bone, as measured during the simulation. Following inferior movement of the tooth-bone segment, a xenogeneic bone was grafted in the empty bone space.

Figure 6. Postoperative intraoral photos and periapical radiograph

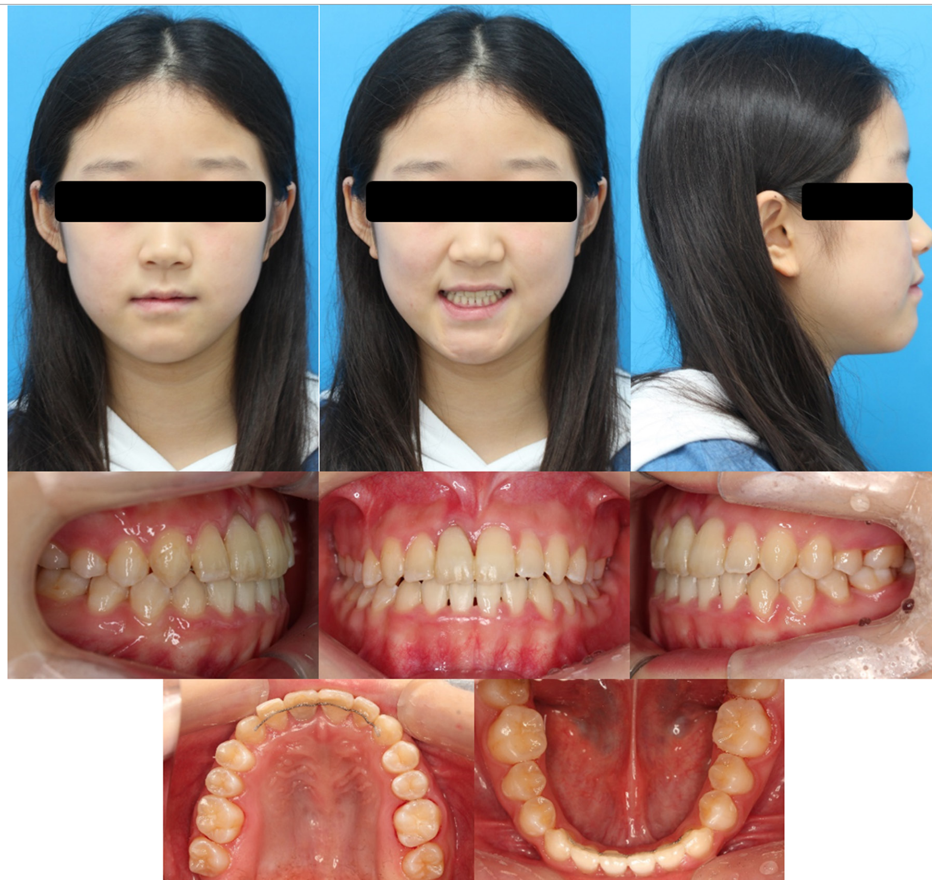

Figure 7. Post-treatment facial and intraoral photographs

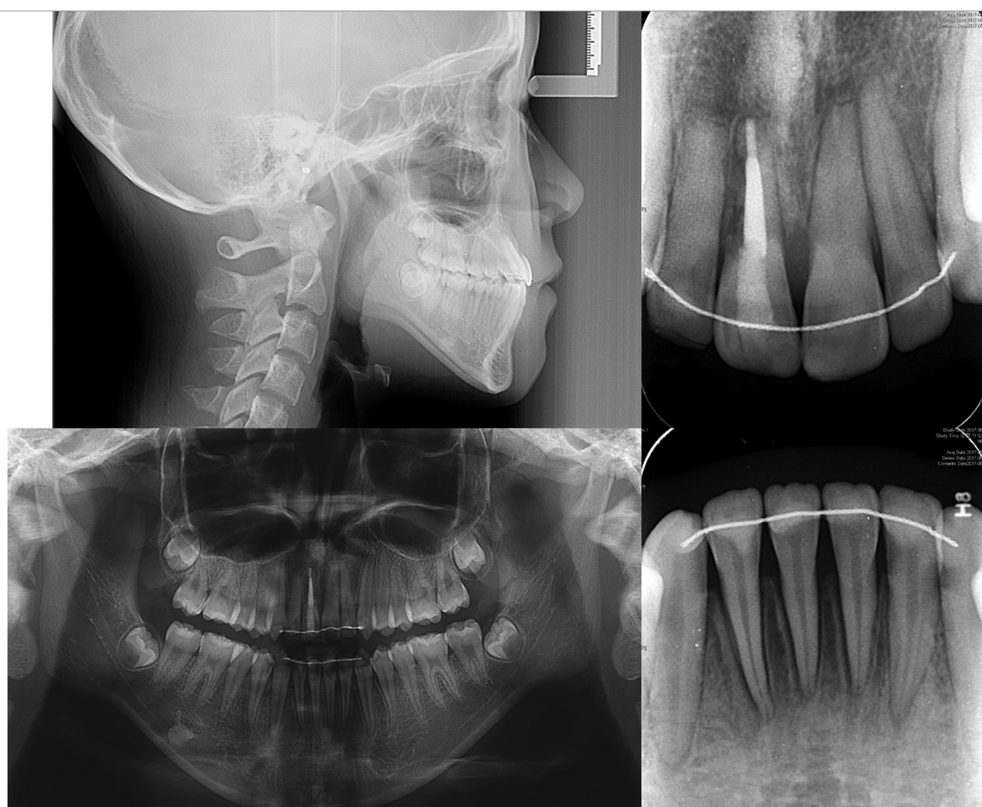

Figure 8. Post-treatment radiographs

Figure 9. Facial and intraoral photographs of 3 years' retention

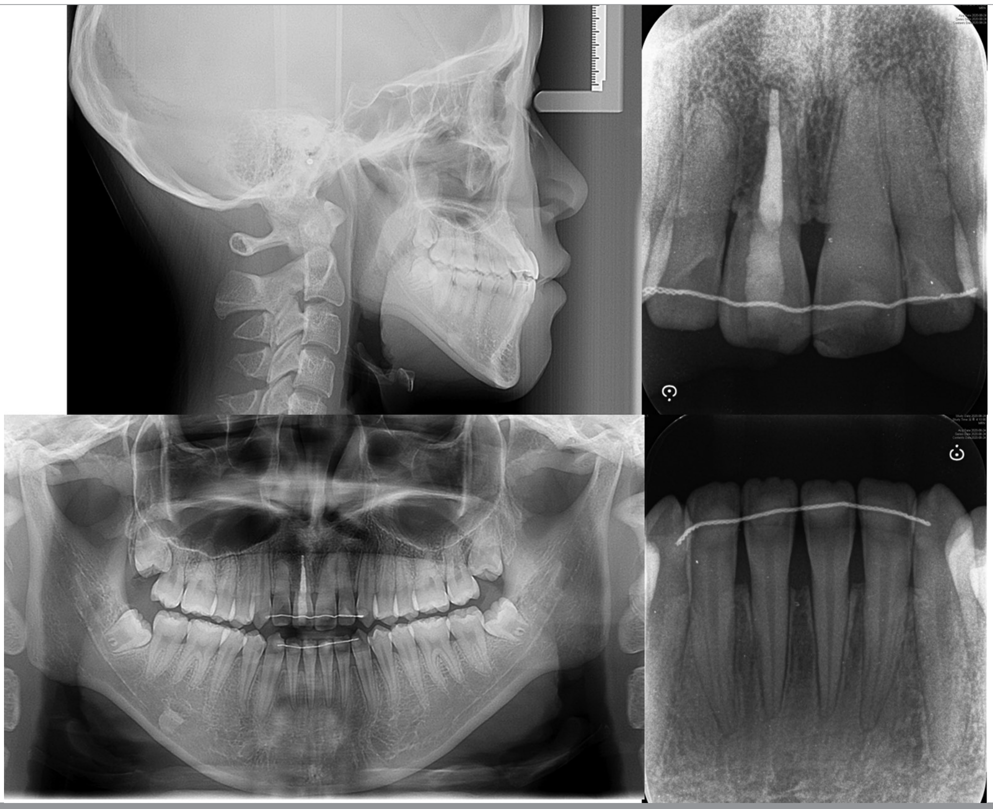

Figure 10. Radiographs 3 years after the completion of postoperative orthodontics

The ubiquity of CT imaging and the development of computer-based surgical simulations enable the determination of an ideal osteotomy position. Preoperative surgical simulation, and the use of surgical devices manufactured based on simulation data, can promote favorable outcomes and reduce dental injury and surgery duration.[5]

The patient in the present case required STO for the maxillary anterior teeth, with simultaneous corticotomy. Corticotomy on the premaxilla between both canines may have also been helpful to move the teeth adjacent to the ankylosed tooth. STO and corticotomy can be used in the patients in whom orthodontic movement by ordinary traction is difficult.[7]

To facilitate the forward movement of the teeth, corticotomies of the 6 maxillary anterior teeth were also performed in this case and they significantly helped to improve the overjet and overbite of this skeletal Class III patient. Even if the skeletal Class III malocclusion was improved by orthopedic treatment through face mask, patients with the ankylosed maxillary anterior teeth would be subject to tooth movement during orthodontic treatment. It can affect the anterior growth as well as the downward growth restriction of the ankylosed tooth area, and this growth restriction exacerbates the overjet. It is also more disadvantageous in patients with skeletal Class III malocclusion. Without STO, the alignment of the teeth would be impossible, and even if the skeletal malocclusion were relieved, the overjet and overbite of the ankylosed tooth area would not be improved, thus being very esthetically disadvantageous.

Computer-based preoperative simulation surgery and the use of manufactured surgical devices can promote favorable outcomes and reduce dental injury and surgery duration.[5] A guide for STO is small and simple to design using data from the simulation surgery. Using a 3D printer, such a guide can be manufactured with biocompatible materials. The application of a CAD/CAM surgical guide can reduce surgery time and trauma during surgery, which is expected to improve surgical outcomes. When using a CAD/CAM guide, it is essential to verify the guide's position during surgery, since deviating from the planned osteotomy position can cause damage to the surrounding teeth. The thickness of the osteotomy saw blade must be considered when determining the width of the groove in the surgical guide. The guide must be thick enough to resist the osteotomy. If the guide is too thin, it can break during surgery.

The osteotomy depth can be determined based on information from the surgical simulation regarding the distance from the superior aspect of the guide to the maxillary palate, thereby reducing damage to the palatine flap. It is thought that corticotomy can be safely performed by utilizing information about the cortex thickness obtained from CT images, as well as relying on the surgeon's manual sensation of cortical perforation. Piezoelectric devices are useful for STO and corticotomy.[8,9]

When STO is performed alone, the application of inappropriate traction force can break the cervix of the ankylosed tooth. Thus, it can be preferable to insert a screw into the tooth-bone segment and then to use the screw to apply traction to the whole segment.[10] Mini-implants can be also used for the tooth traction.[11] With this procedure, orthodontic traction must be applied to the tooth-bone fragment in cases showing dental root resorption. An alternative method was used in the present case. Rather than inducing bone regeneration by traction, the procedure was intended to achieve as much movement as possible during surgery, to minimize the bone defect by performing a bone graft, and to prevent the tooth-bone fragment from postoperatively returning to its original position. Further studies including a larger number of cases are needed to determine which method is better in STO.

The correction of anterior cross bite is properly improved through orthopedic treatment during the growth period, and the leveling of anterior teeth can be maintained through STO. This may also be the best treatment in terms of socio-psychology or esthetics, concerning the strong relationship between malocclusion and oral health-related quality of life.[12] It is reported that there is a strong relationship between malocclusion, especially the Class III group, and oral health-related quality of life in adolescent orthodontic patients.[13] The use of orthopedic appliances to correct Class III malocclusion in growing patients would not be considered as a risk factor for the development of TMD.[14] Through the current treatment method, the patient would not need not only the orthognathic surgery for Class III malocclusion but also alveolar bone augmentation on the anterior maxilla for dental implant.

In skeletal Class III growing patients, an orthopedic treatment can be considered depending on the amount of remaining growth, even though growth control is controversial. Therefore, orthopedic treatment and STO for improvement of alveolar bone height should be considered at an appropriate time in skeletal Class III patients with a traumatized anterior tooth.

In this patient, the skeletal disharmony was relieved through a face mask and the posterior occlusal relationship was improved. The occlusal relationship in the posterior teeth was overcorrected in consideration of the remaining pubertal growth, and an appropriate Class I occlusal relationship was obtained during the orthodontic treatment by fixed appliance.

In the present case, a young patient presented skeletal Class III malocclusion with an open bite due to ankylosis of an anterior maxillary tooth. This situation caused a severe esthetic problem and psychological stress for the patient. When orthopedic and orthodontic treatment alone failed to help, this issue was addressed by performing STO and corticotomy, with the use of a presurgical computer-based simulation, and a CAD/CAM surgical guide for the actual surgical procedure. After surgery, favorable orthopedic and orthodontic outcomes were achieved. These methods could be used to treat other young patients with reverse overjet and open bite due to traumatized ankylosed anterior teeth.

CONCLUSION

A favorable outcome was finally achieved by applying orthopedic treatment combined with STO and corticotomy for an anterior ankylosed tooth in the case where a young patient presented skeletal Class III malocclusion. CAD/CAM-based minimal surgery such as STO during orthodontic treatment immediately improves the adolescent patient's quality of life in terms of socio-psychology or esthetics. The patient's need for bone augmentation and dental implant on the anterior maxilla was reduced.

Orthodontic treatment with CAD/CAM STO is recommended in an adolescent patient with skeletal Class III malocclusion and open bite caused by traumatized ankylosed anterior teeth.

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

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