Autotransplantation of premolars and space closure in a patient with inflamed sinuses

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Congenital absence of permanent teeth can be treated by means of dental implants and prosthetics. Tooth autotransplantation is an alternative in growing patients because continued eruption of the transplanted tooth and associated alveolar bone growth can be expected. This clinical report presents tooth autotransplantation in a 10-year-old boy with chronic maxillary rhinosinusitis, diagnosed by the department of otorhinolaryngology. The patient's mandibular second premolars were transplanted to a congenitally edentulous maxillary premolar region. There was insufficient alveolar bone during transplantation because of pneumatization, but normal root development with vertical alveolar bone growth was observed during a 3-year follow-up. Healing of the transplant in the right side without closing of the apex and without signs of obliteration after 4 years is exceptional. (Am J Orthod Dentofacial Orthop 2019;155:276-87)

Autotransplantation is the repositioning of autogenous teeth to an extraction socket or an edentulous site.[1] There could be many reasons for missing teeth, including congenital loss. Reported prevalence of congenital absence is 3.5%-6.2%.[2-4] Treatment options for missing teeth are based on a comprehensive evaluation. Implant restoration is an alternative, but not advisable for the young because growth will adversely affect the outcome of the treatment.[5,6] In the adolescent, space maintenance of the edentulous site for future implant replacement has risks. Patient compliance with retainers is unpredictable, and even if crown position is maintained, the roots tend to migrate into the implant site. Moreover, alveolar ridge constriction occurs over time.[7] Autotransplantation before a donor root is completely formed can be very reliable and provides the young patient with a natural tooth that can function normally and be esthetically superior to prosthetic restoration.[8]

The aim of the present clinical report was to assess the autotransplantation of the mandibular premolars to the maxillary posterior region during the healing process of maxillary sinus endoscopic surgery.

ORTHODONTIC DIAGNOSIS

A 10-year-old boy was evaluated with a chief complaint of congenitally missing teeth. The general medical history was unremarkable with no pathologic findings on clinical and radiographic examination. Pretreatment records showed congenitally missing upper premolars in mixed dentition, and the lower deciduous molars were in infra-occlusion. Class III skeletal pattern was observed from cephalometric analysis (Fig 1; Table[9]), and anterior teeth of maxilla and mandible were lingually inclined. Dentally, he had anterior crossbite of the left incisors and an open bite in the buccal region resulting from the infra-occlusion of the deciduous molars (Fig 1). Upper permanent molars were mesially tipped toward the edentulous space, and the upper right canine had drifted distally. Consequently there was a space between the upper right incisors.

All premolars of the maxilla were congenitally absent, but all permanent teeth were developing in the lower arch. To obtain functional occlusion, 3 treatment options were presented to the patient: first, dental implants to replace 4 missing teeth after growth completion were

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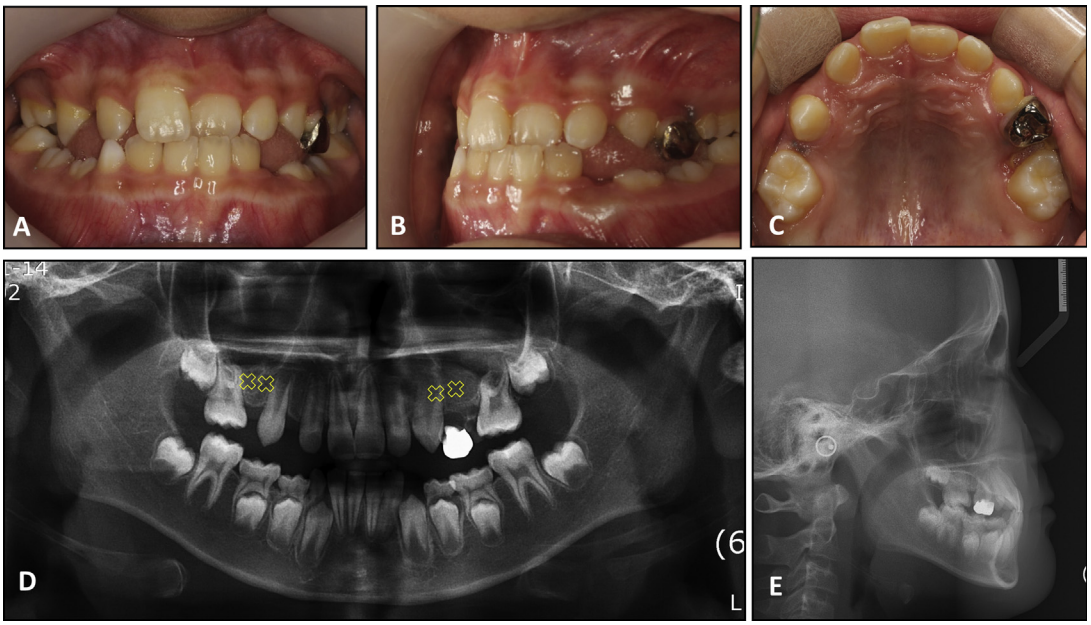

Fig 1. Pretreatment examination. **A-C,** intraoral view, and **D,** pretreatment panoramic radiography show ankylosed lower deciduous molars and congenitally missing upper four premolars. **E,** Pretreatment lateral cephalogram (10 years of age).

Table. Cephalometric analysis

Variable	*Average (male)*[9]	*Before treatment*	*After treatment*
SNA (°)	82.5	75.0	74.0
SNB (°)	80.4	76.5	75.5
ANB (°)	2.1	−1.5	−1.5
Wits (mm)	−2.2	−5.8	−7.1
SN-GoGn (°)	30.3	36.0	37.0
FMA (°)	22.7	24.0	25.0
U1 to NA (°)	26.2	23.5	23.0
U1 to NA (mm)	8.0	2.9	5.0
L1 to NB (°)	27.3	18.0	5.8
L1 to NB (mm)	8.0	2.9	1.3
IMPA (°)	96.6	87.0	75.0
Interincisor angle (°)	124.4	139.0	151.5
Pog to NB (mm)	2.1	0	2.1

considered; second, only 2 dental implants inserted after upper molar protraction to Class II molar relationship; and third, autotransplantation of lower second premolars to the upper premolar region followed by lower molar protraction. The patient's parents selected the third option.

ORTHODONTIC TREATMENT

Initially, fixed appliances were used on the incisors and first molars to align the teeth. Four months after leveling, a removable 3-way sagittal appliance with an expansion screw (Forestadent Co, Pforzheim, Germany) was used in addition to correct the anterior crossbite. The active plate combined with fixed appliances treatment was performed for 16 months for slow expansion and retention, and upper space consolidation was performed simultaneously (Fig 2, *A-C*). Upper canines were mesialized with the use of Elgiloy open coil spring and steel archwire. The upper arch was stabilized before autotransplantation. The lower ankylosed deciduous molars were extracted to allow premolar eruption.

Autotransplantation of the lower right second premolar (with open apex and three-fourths of root formation) was conducted under local anesthesia at the age of 11 years 11 months (Figs 3 and 4), 2 weeks before endoscopic sinus surgery on the left maxillary sinus. One week after transplantation, the patient was referred to the department of otorhinolaryngology (Fig 2, *F*). Chronic sinusitis in the left maxillary sinus was diagnosed. The sinusitis did not subside despite 2 weeks of medication, so endoscopic sinus surgery (ESS) was performed under general anesthesia. The left autotransplantation was delayed 4 months as recommended by the otolaryngologist. Fifteen weeks after ESS, even though mild swelling and discharge in the left maxillary sinus still remained, the left lower second premolar was transplanted to the maxilla (Figs 5 and 6) with permission from the otorhinolaryngologist.

After transplantation, increase in archwire sizes progressed for leveling. Transplanted teeth were excluded from orthodontic force application. 0.019 × 0.025-

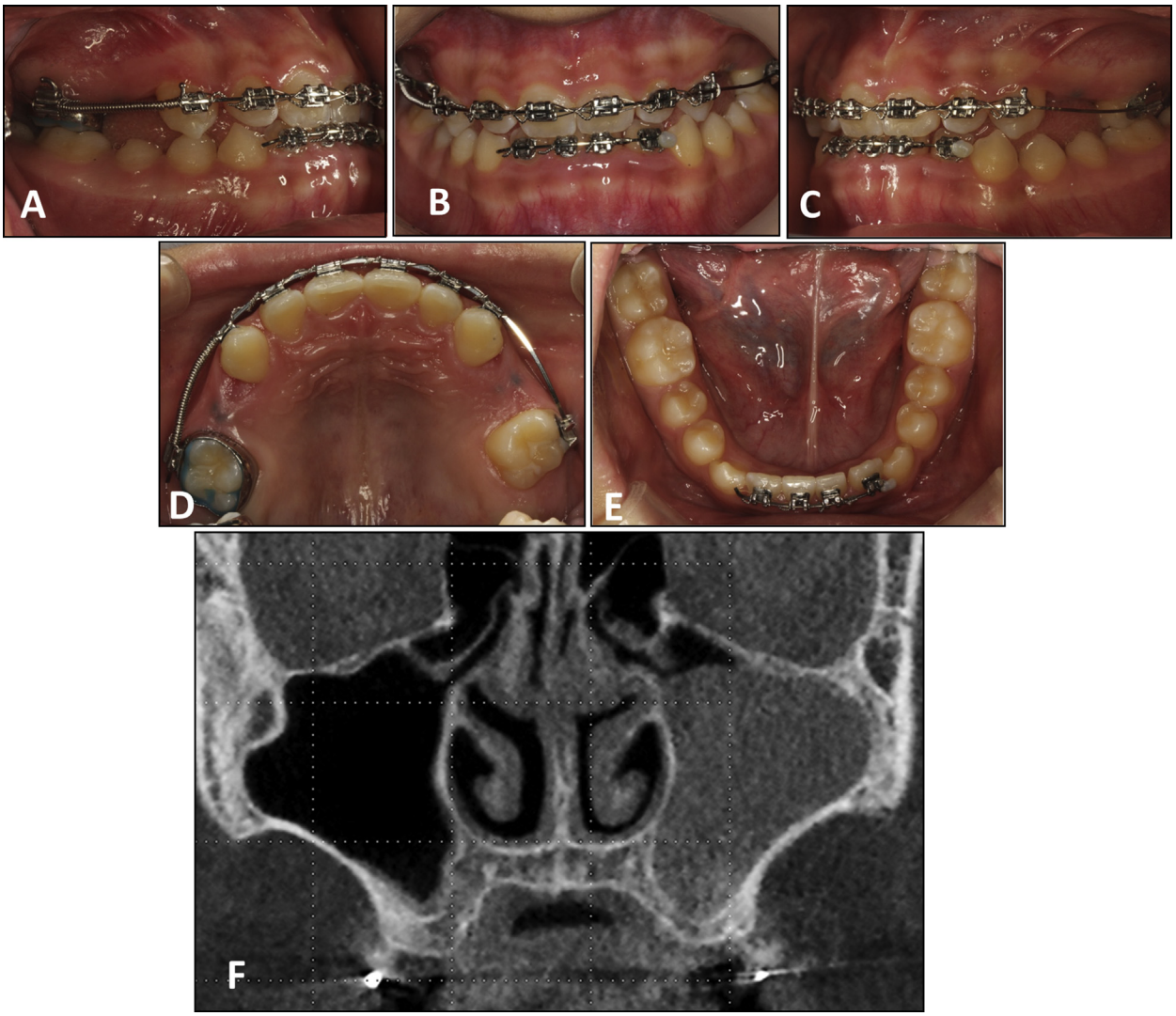

Fig 2. A-E, Intraoral view 1 month before right-side transplantation. **F,** Coronal section of the CBCT scan through the sinonasal complex. There was greater mucociliary activity at the left maxillary and ethmoidal sinuses. Sinusitis was diagnosed from the radiographic findings and clinical examinations at left side (11 years 10 months of age).

inch SS closing loops were positioned anterior to lower first molars and 1 mm of loop activation was conducted every month (Fig 7).

The reaction force of molar mesialization would influence anterior teeth and first premolars. Anchor loss of anterior teeth would be expressed as lingual tipping and extrusion. Lower canines and first premolars were splinted with the use of a bonded lingual arch for anterior anchorage reinforcement. An orthodontic C-tube microplate (Jin Biomed Co, Bucheon, Korea), fixed with 2 miniscrews, was placed at the interradicular space of the lower central incisors in a Biocreative strategy.[10] The C-tube was used to anchor the anterior segment both vertically and sagittally. A ligature wire was tightly tied from the C-tube to the anterior region of the lower archwire to prevent lingual tipping of the lower incisors. Accordingly, the lower molars could be protracted with minimal anterior tooth movement.

There was dental midline discrepancy when the space was almost closed. Open coil spring and segmented wire were inserted between the C-tube and auxiliary tube bonded at the lower right premolar (Fig 7, *E-I*), but the patient wanted the appliance to be removed earlier. The patient and his parents accepted a slight midline discrepancy and space anterior to molars. Orthodontic force was not applied to the transplanted teeth

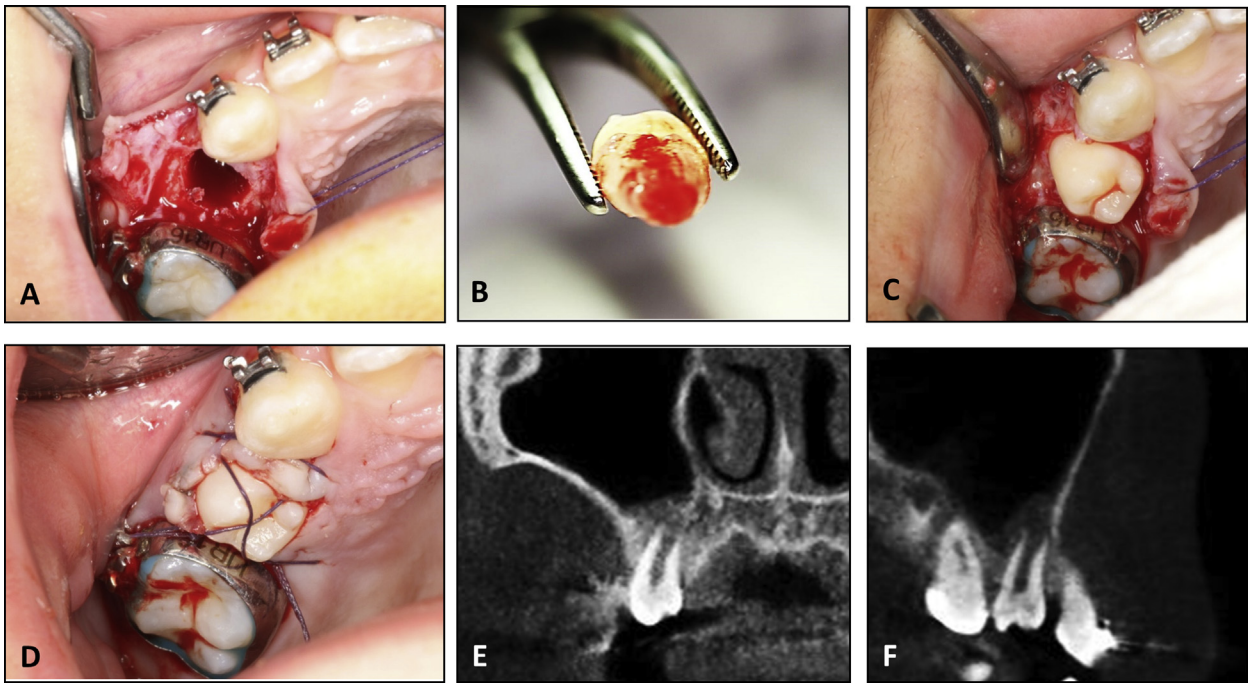

Fig 3. Surgical process of autotransplantation**: A,** flap elevation; **B,** tooth handling using instrument on crown portion only to avoid PDL damage; **C,** donor tooth placed in recipient site; **D,** loose fixation with the use of sutures (11 years 11 months of age). **E, F,** root development near maxillary sinus 1 month after surgery (12 years of age).

throughout treatment. Bonded lingual retainer was applied in maxilla and mandible after treatment (Fig 8).

REVIEW OF AUTOTRANSPLANTATION PROTOCOLS

There are a number of studies regarding autotransplantation. Reports of success rates of autotransplantation are positive, with good aesthetic results and great patient satisfaction, although we note that the definition of "success" among the reports is not consistent.[5,11,12] Scientific evidence has accumulated in the past decades regarding transplants in terms of graft surgery, periodontal and pulp healing, and orthodontic force application. The factors inducing a good prognosis of transplants are minimal extraoral time, atraumatic extraction of the donor tooth, application of physiologic occlusal load after periodontal healing, the type of donor tooth, and a compact root canal filling. Root development stage at the time of transplantation is one of the most critical factors. It is recommended to transplant the donor teeth with two-thirds to three-fourths of root development.[8,13,14]

In recent studies, a tooth replica, fabricated with the use of 3-dimensional (3D) image data, has been used to minimize extraoral time of donor tooth.[15,16] The use of the tooth replica for preparing the donor site has diminished the extraoral time of the tooth transfer to less than 1 minute.[16] This technique is even more beneficial when the donor tooth is multirooted. Bonding to the donor tooth and applying light orthodontic force before surgery can facilitate the extraction.[17] The increased periodontal ligament (PDL) width from the orthodontic force application to the donor tooth provides more resistance to damage during the surgical removal. Suzaki et al reported that the time of exposed root surface, which might induce dentoalveolar ankylosis, was significantly less with an orthodontic force application group compared with a control group.[18] In conclusion, orthodontic force application before the donor tooth removal might decrease possibilities of resorption or ankylosis after transplantation.

Teeth can even be transplanted to a grafted recipient site.[19,20] In a cleft lip and palate patient, transplantation was performed 11 months after placement of an iliac bone graft in the alveolar defect, and the transplanted tooth was well retained for 68 months of follow-up.[20] Another reported option was to transplant into a sinus lift area by osteotome, with or without allogenic bone graft, before the transplantation.[19,21] Thus in the case of a low sinus floor, a sinus lift could be used to make a

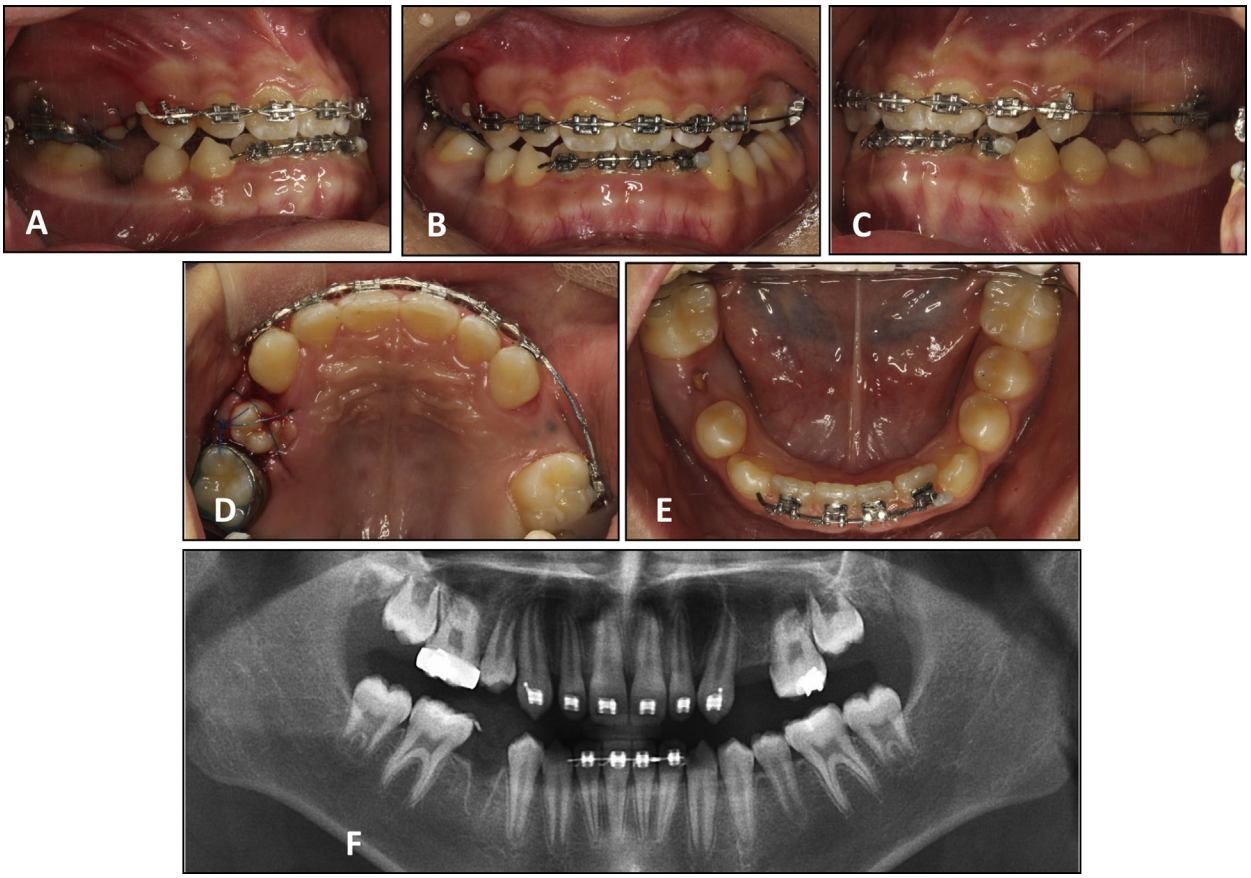

Fig 4. A-E, intraoral view, and **F,** panoramic radiography after transplantation on right side (11 years 11 months of age).

site for maxillary premolar and molar transplantation. In young patients who are missing 1 or 2 permanent teeth, autotransplantation could be the first treatment option, when open apex donor teeth are available. Survival rates and success rates are high, and the transplanted tooth can continue eruption and be accompanied with alveolar bone growth.[14,16] Orthodontic treatment commonly includes tooth extraction to resolve arch length discrepancy or to correct skeletal discrepancy. The extracted teeth could be used as donor teeth. Autotransplantation of premolars to another premolar region is a reliable approach with a high success rate.[14,22] Transplantation of the autogenous tooth has advantages of greater resistance to occlusal loading, maintenance of the PDL and surrounding bone, and potential for better esthetics.[23]

THE AUTOTRANSPLANTATION IN THE PRESENT CASE

Maxillary sinus lifting was considered before surgery. Based on cone-beam computerized tomography (CBCT), the surgeon decided it was not necessary on the right side. Although the vertical alveolar bone height of recipient site was not sufficient, transplantation was nevertheless recommended because the donor teeth were in the development stage. Sinusitis was another factor to influence final decision.

On the left side, an osteotome sinus floor elevation was performed without a bone graft (Fig 5, *B*). The surgical procedure started with flap elevation in the edentulous area. The flap was opened and fixed with silk to avoid bur damage (Fig 3, *A*). A round bur in a low-speed straight handpiece, under saline solution irrigation, was used to remove cortical bone. The donor tooth was carefully extracted and handled only with forceps to avoid damage of the PDL and cementum (Fig 3, *B*). Placement of the donor tooth into the socket was tried, and proximal reduction of the maxillary first molar was performed on the left (Fig 5, *C*). After placement into the recipient site (Fig 3, *C*), the tooth was stabilized with the use of sutures (Fig 3, *D*).

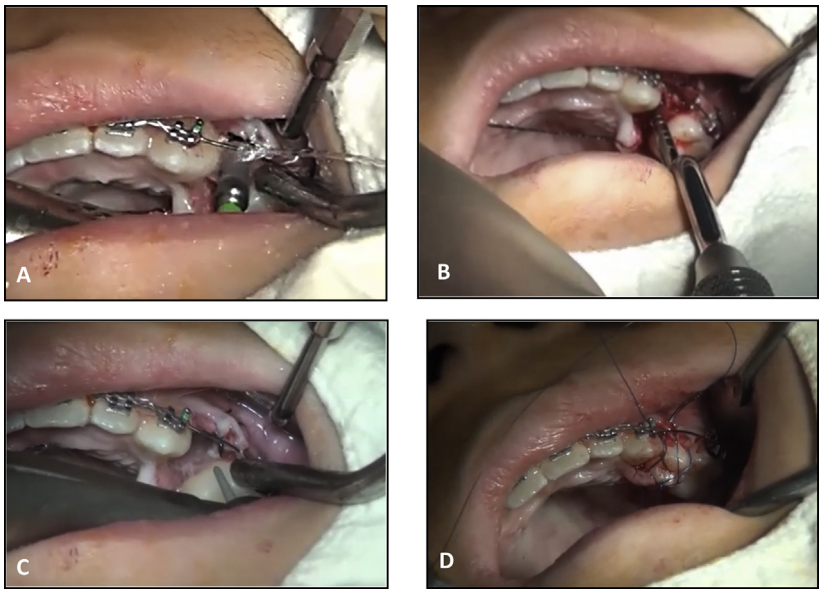

Fig 5. Surgical process of left autogenous transplantation: **A,** socket preparation under saline solution irrigation; **B**, osteotome surgery; **C,** interproximal reduction of maxillary left first molar; **D,** stabilization of transplant by means of suture (12 years 3 months of age).

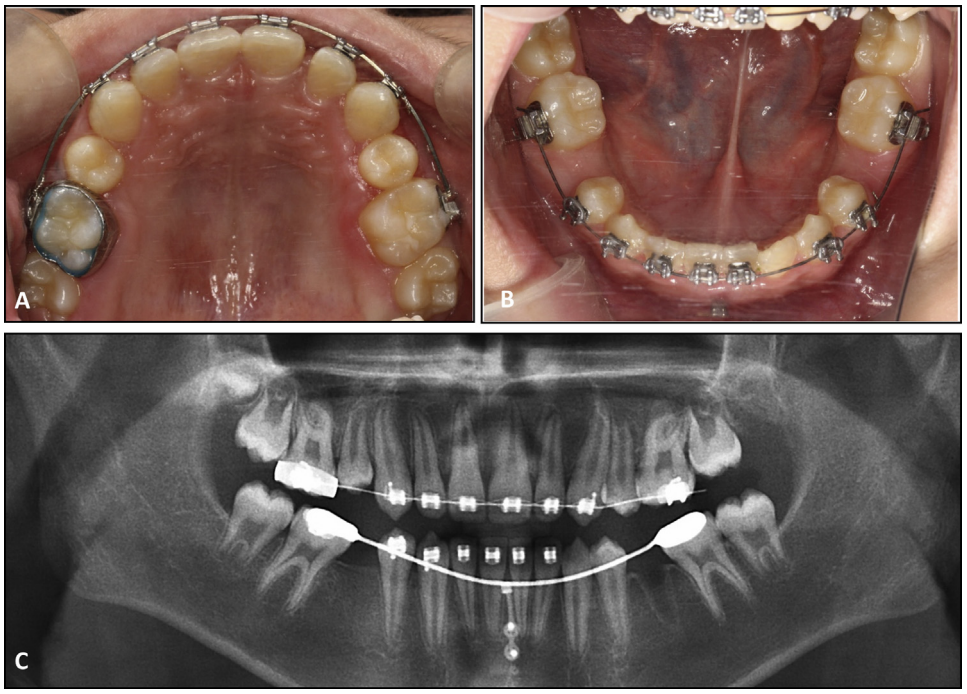

Fig 6. A, B, Intraoral view 4 months after left-side transplantation (12 years 6 months of age). **C,** Panoramic radiograph immediately after second transplantation (12 years 3 months of age).

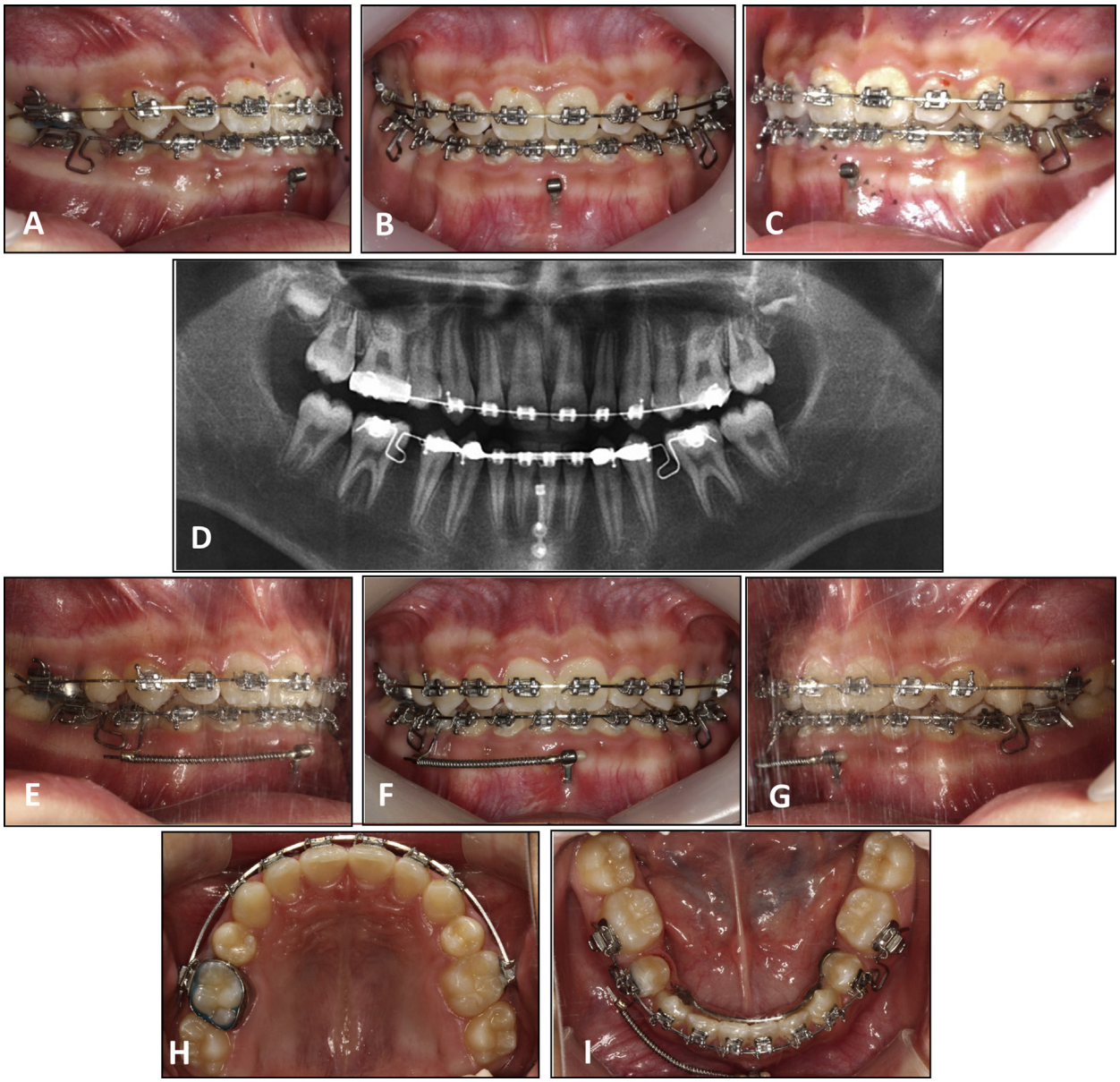

Fig 7. Treatment process: **A-C,** intraoral view, and **D,** panoramic radiography during molar protraction. The space of donor teeth was closed by protraction of lower molars. C-tube miniplate was used to prevent lingual tipping of lower anterior teeth after autotransplantation (13 years 3 months of age). **E-I,** Intraoral view of dental midline correction with the use of C-tube and open coil spring (13 years 6 months of age).

TREATMENT RESULT

Class I molar and canine relationship and functional occlusion were achieved (Figs 8 and 9; Table). Total treatment period was 43 months. Almost all space that was a result of extraction or congenital absence was closed. The lower first molars were successfully protracted, maintaining normal angulation (Fig 8, *F*). Some dental compensation occurred owing to growth in a Class III skeletal pattern (Fig 9). Positive overjet and overbite were accomplished.

The patient had natural teeth instead of prosthodontic restoration or implant placement. Adequate alveolar bone growth around the transplants occurred with continuing vertical eruption. No inflammatory

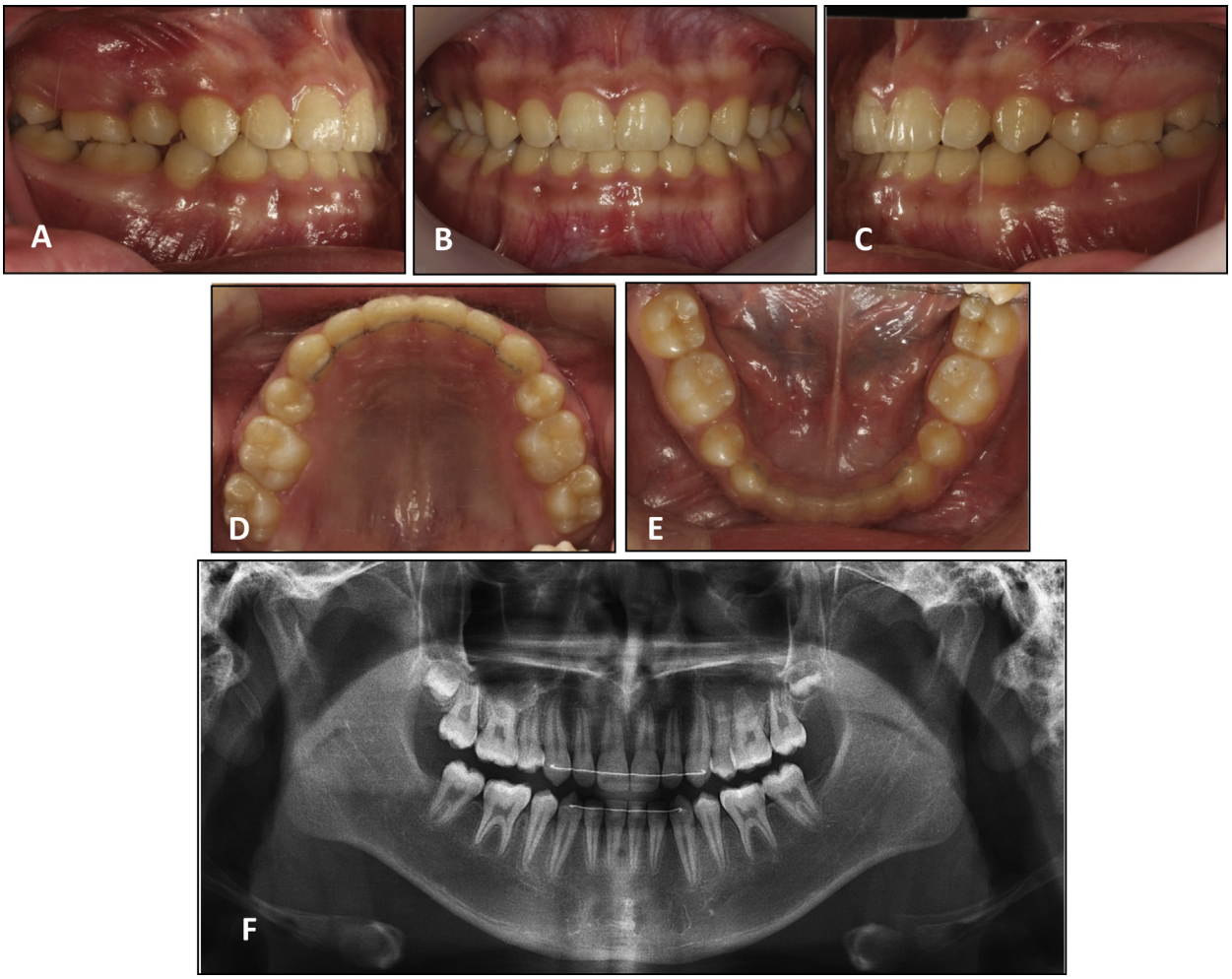

Fig 8. Posttreatment intraoral photos and panoramic radiography showed Class I molar key and functional occlusion. Total active treatment period was 43 months. Radiographic evaluation shows sufficient root length with no periodontal problem or pulp resorption.

resorption or replacement resorption was detected in 2-year retention CBCT images (Fig 10). Four-year follow-up after the autotransplantation showed no pathologic findings in the clinical or radiographic evaluation (Fig 11). Pulp sensibility, pocket probing depth, and mobility were normal. The transplanted teeth were normal in a percussion test as well. Dental root development continued to completion on the left, and the crown-root ratio was sufficient for stability. Pulp obliteration was observed. Intact lamina dura was evident around both teeth despite incomplete apexification on the right side.

DISCUSSION

In the young patient, autogenous tooth transplantation combined with orthodontic treatment can be an attractive treatment alternative to prosthetic replacement of a missing tooth. Studies have shown survival rates of 68.2%-97.5% of autotransplanted teeth.[14,22,24] Reports of transplanted premolars showed a 89.68% success rate, with a 98.21% survival rate after 6 years 3 months follow-up.[25] This was higher than the success rate of molar autotransplantation. Minimal time outside of the socket for the donor tooth is a critical factor of autotransplantation success.[22] When the recipient site is an edentulous area, a socket that will fit with the donor tooth must be prepared with minimal time lapse. Preoperative practice on a plaster model can be helpful to improve manual dexterity and select the proper surgical instrument. To reduce preparation time, a replica made by a 3D printer could be used.[15] In the present case, a CBCT scan was used to measure the size of donor teeth

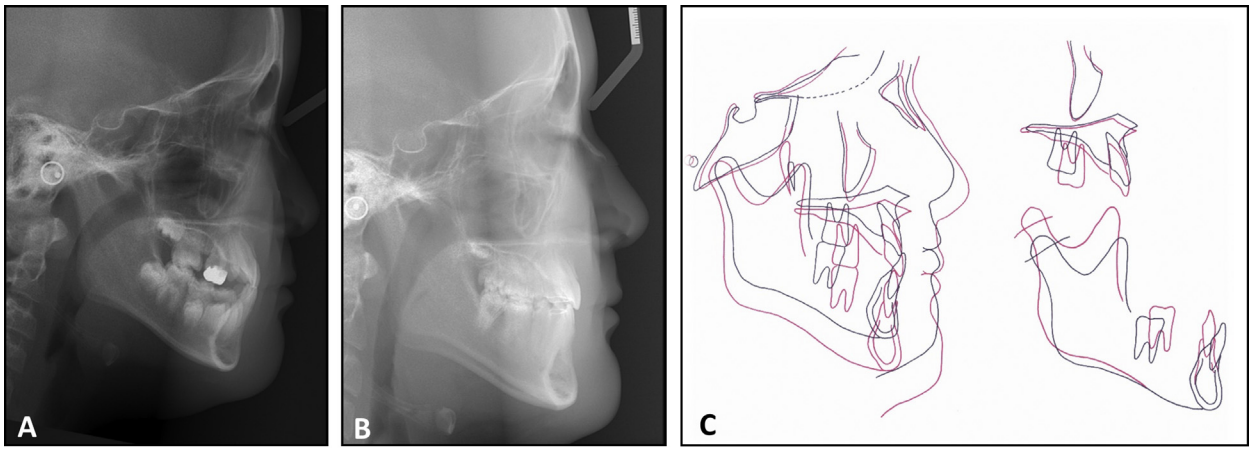

Fig 9. A, B, Pretreatment and posttreatment lateral cephalograms. Anterior overbite and overjet was stable and mandibular plane angle was maintained. **C,** Superimposition of pretreatment and posttreatment lateral cephalograms.

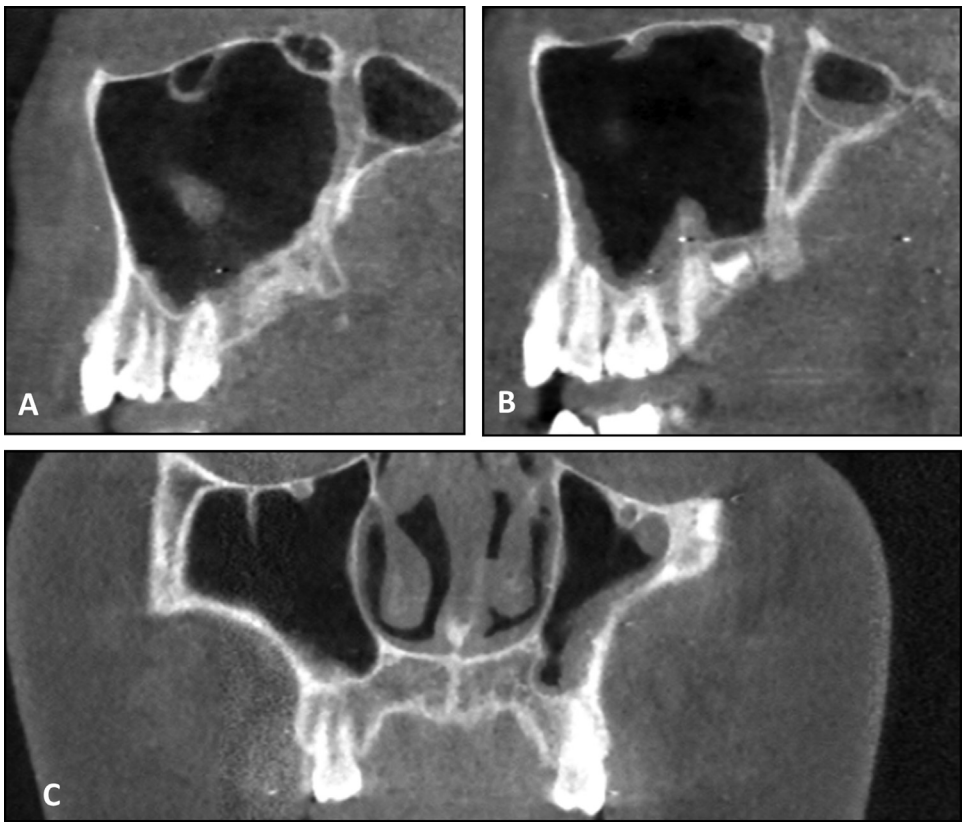

Fig 10. CBCT scans at 2 years' retention period. **A,** Autotransplanted right premolar shows sufficient vertical height and stability. **B,** On the left side, there remained sinusitis in the maxillary sinus. There is proximity between the apex of the transplant and the sinus floor. **C,** The coronal section showed good prognosis and stability (14 years 7 months age).

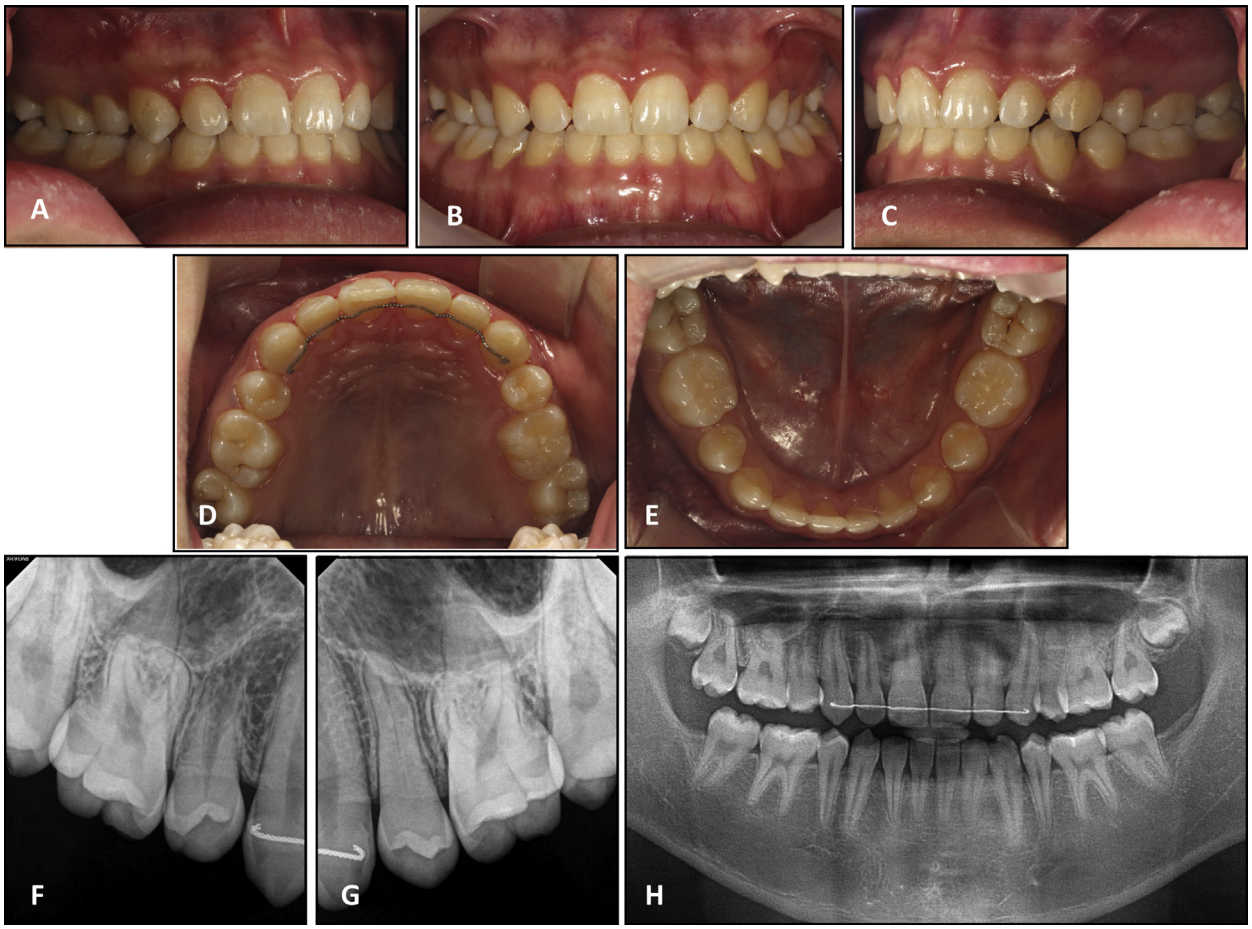

Fig 11. A-E, intraoral view, **F, G,** dental standard radiographs, and **H,** panoramic radiograph 4 years after tooth transplantation (16 years 2 months of age).

and to evaluate the rhinosinusitis. A 3D replica was not used owing to high cost. The donor teeth were single rooted, so the difficulty of surgery was estimated to be not complex. If cost is not a consideration, a 3D replica would facilitate the socket preparation and thus reduce out-of-the-mouth time for the donor tooth.

Orthodontic treatment is simpler when the biomechanics of right and left side are similar. After transplantation of the right premolar, the left transplantation was delayed because of rhinosinusitis. Ideally, the recipient site should be free of all pathologic conditions. Therefore, initially, the second transplantation was intended to be done after complete healing of maxillary sinusitis. After consultation with the otorhinorharyngologist, the left transplantation was performed despite some sinusitis persisting so as to reduce side-effects and biomechanical difficulties. There was an interval of 4 months between the left- and right-side transplantations. Although swelling and sinusitis remained at surgery, the follow-up data showed no pathologic effect on the transplants. Cooperative planning with the department of otorhinorharyngology was important in this case.

We used a lower anterior C-tube microplate and a Biocreative orthodontics strategy to protract both of the mandibular molars without lingual tipping or retraction of the anterior teeth.[26] Even though lower anteriors were tightly ligated to the microplate, mild lingual tipping of lower incisors occurred because of mandibular overgrowth. Orthognathic surgery was not considered as a treatment option, so dental compensation was permitted for camouflage treatment. Lundberg et al reported that only 7 of 166 cases in an autotransplanted open apex group showed complete root formation.[27] In a study of 40 transplanted premolars, pulp survival rate of open or half-open apices was 65% in long-term follow up.[14] In the present case, normal root development was observed despite severe maxillary sinus pneumatization. Transplantation of teeth with a closed

apex requires root canal treatment. Concern for the need of endodontic treatment and the possibility of ankyloses were the reasons to proceed with the left premolar transplantation before full healing of the sinusitis. A better outcome is likely if the PDL is maintained, because destruction of those cells is related to ankylosis and root resorption. Cautious management of donor tooth is essential. The fully erupted donor tooth in an adult might have merit as a donor because the tooth can be extracted with the use of forceps only.[28] Root development must be considered; Andreasen et al presented evidence that the risk of root resorption of the transplant could increase with increasing root development.[29]

The present clinical report demonstrated calcification of the pulp chamber and canals at the left recipient site with stability and no evident internal-external resorption or periapical radiolucency. Careful manipulation, stabilization of the transplant, postoperative care, and healthy periodontal membrane and cementum around the implanted tooth were notable factors that are likely to increase the success rate and to improve prognosis. In a long-term follow-up study over 10 years after transplantation, pulp obliteration was seen in all vital teeth within 12 months and in 75% of vital teeth within 6 months.[14] Pulp necrosis, external and internal root resorption, and ankylosis can be associated with transplantation.[30] Nevertheless, with the adolescent, the benefits of autogenous tooth transplantation regarding alveolar bone growth and conservation of neighboring teeth must be considered when the orthodontist plans treatment. In this clinical report, autotransplantation to an artificially formed socket during prolonged healing of sinusitis had a risk of ankylosis due to possible absence of a PDL attachment and concern for failure because of the close proximity between the sinus base and the transplanted tooth apex. However, good timing and careful attention to the blood supply during surgery enhanced the long-term success.

Physiologic force and occlusal forces applied to transplanted teeth can be beneficial to prohibit ankylosis.[12,31] However, for the first 8 weeks after surgery, the transplanted teeth must be free from excessive occlusal forces during periodontal healing.[31] Slight surface resorption and apical resorption could occur after orthodontic treatment, but generally, orthodontic treatment did not affect the prognosis of this possibiity.[14,31,32]

CONCLUSIONS

Autotransplantation with orthodontic treatment in an adolescent who had congenitally missing teeth proved to be a valuable treatment option to achieve functional occlusion. Subsequent alveolar bone growth around the erupting transplanted tooth in the growing patient will improve periodontal support and esthetics. The root development stage of the donor tooth is an important key to success. Before treatment, the donor tooth roots and the pneumatized floor of the maxillary sinus were very close, but root development seemed to proceed normally anyway. Maxillary sinusitis was shown to be not necessarily a contraindication for tooth autotransplantation. Normal root development and stable retention was achieved even though autotransplantation was performed 3 months after ESS.

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