The Autotransplantation and Orthodontic Treatment of Multiple Congenitally Missing and Impacted Teeth

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Congenitally missing teeth are one of the most common dental anomalies. When permanent teeth are absent, various problems can occur. It is important to consider the facial profile, position of the incisor teeth, skeletal and dental development, and available dental space before planning treatment. Possible treatment methods include preserving and retaining the deciduous tooth, replacing the missing tooth with prosthesis, placing an implant, or performing a transplant after extracting the deciduous tooth. Among these possibilities, autotransplantation combined with orthodontic treatment corrects both function and esthetics.

This report describes the case of a 7-year-old girl with multiple congenitally missing teeth and an impacted right mandibular second premolar. Timely autotransplantation of the impacted mandibular tooth to the region of the congenitally missing right maxillary second premolar produced favorable results.

Keywords: *autotransplantation, congenitally missing tooth, impacted tooth*

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INTRODUCTION

Congenitally missing teeth are common developmental defects in humans, and are often related to oral abnormalities. The number of cases of congenitally missing teeth has been increasing, but it is not apparent whether this is due to improved diagnostic techniques or an actual increase in frequency. The frequency of missing teeth varies depending on sex, dental arch, population origin, and geography, but the development of most cases exhibits a distinct pattern. The frequency of missing permanent teeth is 1.6-9.6%, while that of missing a deciduous tooth is 0.5%-0.9%.[1,2] The prevalence of congenitally missing permanent teeth has been investigated in numerous studies. In a meta-analysis conducted by Polder et al., the mandibular second premolar is the most commonly missing tooth, followed by the maxillary lateral incisor and the maxillary second premolar.[3] Central incisors, canines, and molars were rarely affected. Approximately 48% of patients were missing only one tooth, 35.1% were missing two permanent teeth, and less than 1% of patients were missing more than six permanent teeth.[3]

Teeth may be absent due to the failure of tooth germs to develop. Factors affecting development include genetic factors, nutrients, hormones, mechanical trauma, radiation, infection, and drugs.[4] Missing teeth can occur alone, or alongside other systematic developmental disorders such as ectodermal dysplasia, oral-facial-digital syndromes, and syndromes involving oral-facial clefting.[1]

When permanent teeth are missing, the preceding deciduous tooth may lose erupting force. Missing permanent teeth can also result in a lowered occlusal plane. As a result, decrease in the height of alveolar bone, over-eruption of the opposite tooth, and tipping of the lateral tooth can occur. Treatment plans should be based on comprehensive evaluations that take into account the age of the patient, occlusion, space requirements, and the sizes and shapes of the adjacent teeth.[5] Patients who present with missing teeth often require orthodontic treatment for aesthetic reasons.

Therefore, it is important to assess the patient's complexion, position of the incisors, skeletal/dental development, and available/required space meticulously before selecting an appropriate treatment for congenitally missing teeth. Possible treatments include preserving the deciduous tooth, replacing the missing tooth using a prosthesis, placing an implant or performing a transplant after extracting the deciduous tooth.[6] Among these possible treatments, autotransplantation combined with orthodontic treatment corrects problems of both function and esthetics.

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Case Study

Clinical/radiographic features

A 7-year-old girl with no systematic health problems presented with multiple missing teeth, bilateral edema of the mandibular buccal mucosa, and a fistula. She showed bilateral edema near the mandibular deciduous second molars. Intraoral radiography showed periapical radiolucencies in #75 and #85 and the congenital absence of #15, 17, 27, and 35. Distal tipping of #45 was observed and was noted for possible surgical extraction later (Figure 1). We extracted #75 and #85 on the first visit since they had progressed to abscess formation. After several days, the patient was recalled for impressions and x-rays. Along with these examinations, orthodontic analysis was carried out to select a treatment for the congenitally absent teeth (Figure 2).

The patient had a straight and symmetric profile with mesoprosopic facial morphology. Intraorally, she had a mesial step molar relationship. The mandibular dental midline deviated slightly to the patient's right of the facial midline leading to a 2 mm dental midline discrepancy.

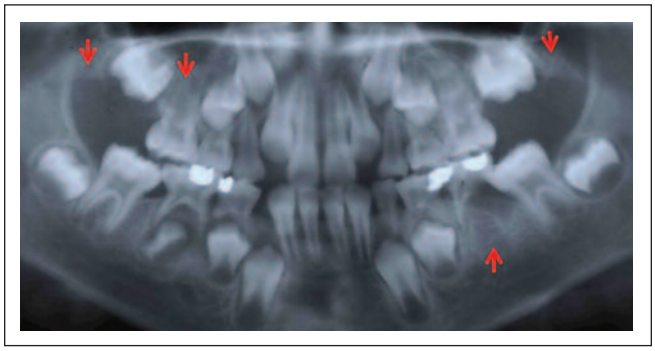

Figure 1. Initial panoramic radiograph revealing multiple congenital missing teeth (Red arrows). Patient age: 7 years 7 months)

Cephalometric analysis showed a skeletal Class I anteroposterior relationship (ANB angle = 3°). Along with the facial pattern, the inclination of the maxillary and mandibular incisors showed a normal relationship (Table 1). Because the patient's arch length discrepancy was 5.5 mm in the maxilla and -4.9 mm in the mandible, spacing of the maxilla and crowding of the mandible were anticipated (the sizes of the unerupted permanent teeth were measured using radiographs,[7] and missing teeth were not included) (Table 2). The patient's overall oral hygiene and periodontal condition were good, with no signs or symptoms of temporomandibular joint dysfunction.

Table. 1. Cephalometric summary

Measurement	*Normal*	*Before Treatment*	*After Treatment*
SNA (°)	82±2	77	77.5
SNB (°)	80±2	74	76
ANB (°)	2±1.5	3	1.5
FMA (°)	25	28	26
IMPA (°)	87	98	92
Wits (mm)	-0.6±3	0	-2
U1 to NA (mm)	4	4	4.5
U1 to NA (°)	28±4	28	20
L1 to NB (mm)	4	5	4
L1 to NB (°)	25±6	30	27

Table. 2. Mixed dentition space analysis

Dentition	Upper	Lower
Available space	95.9	85.0
Required space	90.4	89.9
Arch-length discrepancy	+5.5	-4.9

Figure 2. Initial intraoral photographs. (Patient age: 7 years 8 months)

Treatment alternatives

The objectives of treatment for this patient were to achieve proper skeletal and dental relationships and to obtain a normal facial profile either by closing the spaces caused by absent teeth or by opening the spaces and placing restorations.

Based on previous assessments and the treatment objectives, various treatment options were evaluated as follows:

1. After extracting the residual deciduous and impacted teeth, closing of the #15 and #35 spaces by orthodontic treatment would be attempted. The advantage of this method is that it does not require any prosthetic restorations. The patient had a normal facial profile and normal maxillary incisor inclination, which needed to be maintained. However, closing spaces arch and without changing the inclination of the maxillary incisors is extremely difficult, and may result in overbite and changes in the dental arch. In this case, maxillary teeth were absent unilaterally, so there was a risk of asymmetric dental arch development and midline discrepancy. In addition, lack of the maxillary second molar could cause decrease occlusal force and concentration of occlusal force only on #16, so there was a possibility of poor prognosis in young patient.
2. Maintain all spaces caused by missing teeth in the maxilla and mandible, and place prosthetic restorations or implants upon the completion of development. This method has the advantages of maintaining the facial profile, the maxillary incisor inclination, overbite, and molar relationships. However, maintaining the extraction sites until the appropriate time for prosthetic restoration and implants would be challenging. Although tipping of the proximal teeth and overextrusion of the opposite teeth can be prevented using removable space maintainers, there is still a risk of alveolar bone resorption. Therefore, this treatment option requires patient cooperation and observations for a prolonged period of time. Also high costs, long duration of treatment, and reductions of proximal teeth for prosthetic restorations make this method undesirable.
3. Close all spaces caused by missing teeth in the mandible and autotransplant the mandibular right second premolar into the space of the maxillary right second premolar. We selected this method for our patient.

Treatment progress

The patient started orthodontic treatment to close the extraction spaces of #75 and #85 at the age of 10. And extraction of #55 was performed because of physiological root resorption. A fixed orthodontic appliance was placed on the tilted #36 and #46 in an attempt to move them away from the alveolar socket. Radiographs were taken periodically to observe the positions of the root of #46 and the crown of #45 and the possible apical resorption of #46. The early orthodontic treatment was complete after closure of the space and correction of the axial angulation of the first molar. Late orthodontic treatment was scheduled after surgery on #45.

Autotransplantations may be considered when 3/4 of the tooth's root is formed. An autotranplantation was performed at the age of 13 along with late orthodontic treatment. Comprehensive orthodontic treatment was initiated after placing fixed orthodontic appliances in both the maxilla and the mandible. The space for #55 was closed only two years after the extraction of the tooth through the mesial tipping of #16, and the space for #45 autotransplatation was recreated by measuring the mesial width of #45 using 3-dimentional cone-beam computed tomography (CBCT) (Figure 3) and placing an open coil spring into the space.

After 6 months of adjustment which allowed for appropriate space opening, autotransplantation of #45 into the space of #15 was performed as follows. A recipient site was formed ahead of time to minimize the damage of the periodontal ligament of the donor tooth. An implant drill bur of a size estimated by a 3-dimentional CBCT and that was matched to the length and the width of the donor tooth, was used to prevent damage to the alveolar bone.

After flap formation in the donor tooth area, part of the buccal bone was excised, and the donor tooth was carefully removed. The tooth was stored in Hank's balanced salt solution (HBSS) while assessing the space to implant the donor tooth. The donor tooth was then positioned in the recipient site, and the flap was sutured. Occlusion was evaluated, and the occlusal plane of the donor tooth was appropriately reduced to prevent occlusal interference. A bracket was placed on the donor tooth, and a passive wire was aligned from #14 to #16 for two weeks (Figure 4a and 4b).

Follow-up continued for 1 year. Newly formed lamina dura and bone and the obliteration of the pulp chamber as the root formed were observed. But discoloration of the tooth and pathologic symptoms did not occur and the vitality of the pulp was maintained. And the root formation of mandibular right first premolar was not progressed (Figure 5). The orthodontic treatment was completed on 12 months

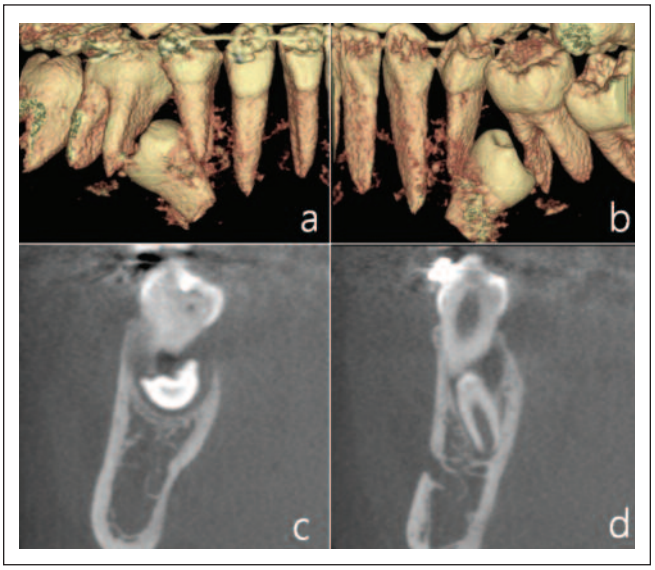

Figure 3. 3-dimentional CBCT on #45 (a : buccal side, b : lingual side, c~d : sagittal section c,d)

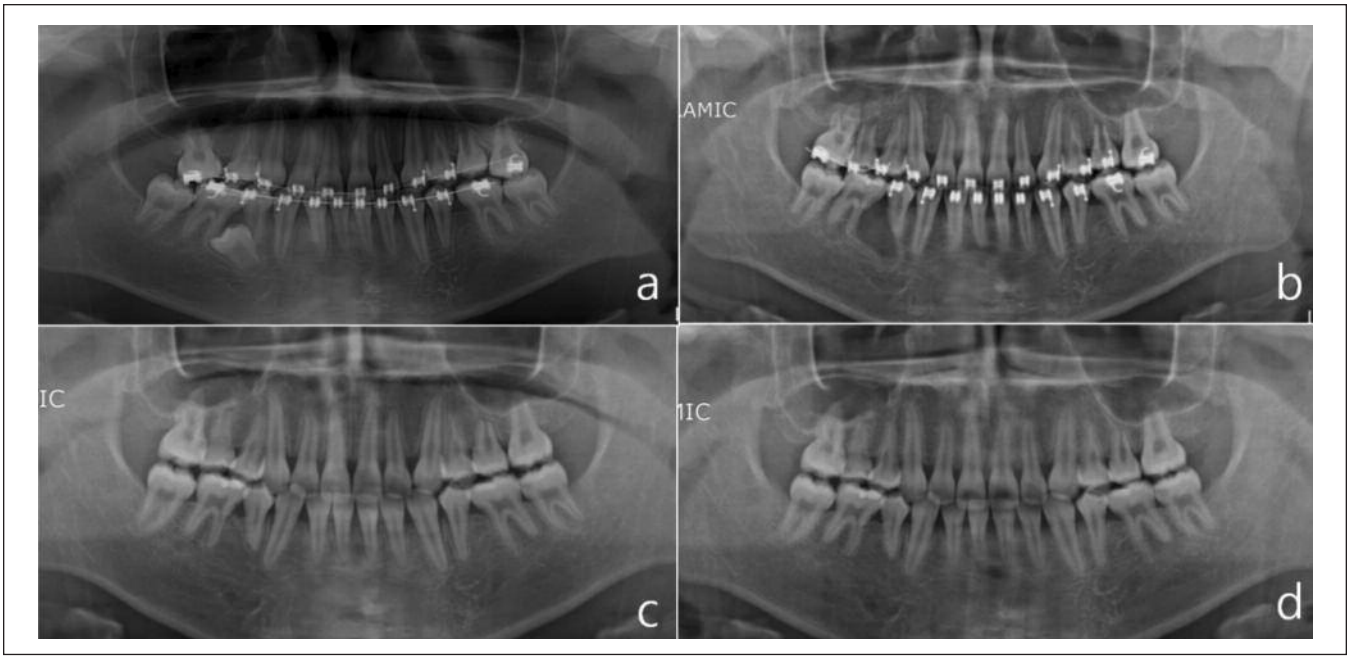

Figure 4. Pre- and post-operative panoramic radiographs: (a) Preoperative panoramic view at patient age 12 years 4 months. (b) Immediately post-operative panoramic view at 12 years 10 months. (c) Post-treatment panoramic view at 13 years 10 months. (d) Periodic follow-up panoramic view after 18 months after debonding. (Patient age: 15 years 4 months)

Figure 5. Post-operative follow-up periapical radiographs: Showing continuous root development, lamina dura formation and canal obliteration.

Figure 6. Post-treatment intraoral photographs. (Patient age: 13 years 10 months)

Figure 7. Intraoral photographs after 2 years after debonding. (Patient age: 15 years 10 months)

after the surgical procedure (Figure 4c and 6).

DISCUSSION

Treatment options for congenitally missing teeth are numerous. The survival rates of fixed prosthesis from University of Oslo were 80% after 10 years, 70% after 20 years, and 65% after 25 years, but generally, such restorations need to replaced after 20 years.[8] The lifetimes of resin bonded bridges are 76% for 5 years, 60% for 10 years, and the longevity of the implants is about 90% for 10 years.[9] Andreasen[10] and Lundberg,[11] who followed patients with autotransplanted premolars from 1 to 13 years after the procedure, reported a 94-98% survival rate. Czochrowska, who autotransplanted teeth in 28 patients, reported a survival rate of 79-90% after 17-41 years (average, 26.4 years) and claimed that autotransplantation was the most successful treatment option.[12]

The success of autotransplantation depends on the complete regeneration of the periodontal ligament, which can be assessed by the presence of continuous lamina dura in a radiograph, the absence of root resorption and periapical inflammation, the absence of symptoms of soft and hard tissues surrounding the autotransplanted tooth, and some other indicators.[13]

There are many factors determining the success of autotransplantation. One is the maintenance of healthy vital periodontal cells on the surface of the donor tooth. Therefore, in order to minimize the time spent extraorally, the use of a model tooth or formation of a recipient site using the actual size of the implant bur ahead of time is recommended. To minimize the extent of periodontal ligament damage, extraction should be performed by handling the crown of the tooth only, and not using an elevator.[10, 14]

Another factor determining success is the distance between the tissue of the recipient site and the surface of the replanted tooth. A tight contact allows for better flow of nutrients and blood, increasing the success rate of autotransplantation. However, if the contact is too close, mechanical damage may occur to the periodontal cells and result in pulp canal obliteration. Therefore, the recipient alveolar bone site needs to be created 1 to 2 mm larger and deeper than the donor tooth.[15, 16]

The third factor determining success is the stage of root development of the donor tooth. Open apex teeth have better success rates than closed apex teeth, and transplantation is preferred when 3/4-4/5 of the root is formed.[15] Open apex teeth have better prognoses because they are more likely to revascularize. However, if the open apex tooth is non-vital, root resorption can begin rapidly resulting in a thin, short root. Moreover, if there is a residual Hertwig epithelial root sheath on the developing tooth, the proliferation of capillaries and periodontal ligaments can occur through the apex, filling the pulp canal with vital tissues in a few months after autotransplantation. During this period, calcification of the root canal may be initiated, causing a complete or partial obliteration. Pulpal obliteration is a problem associated with autotransplantation, and can result in discoloration of the tooth. However, it does not determine the success of the procedure in vital pulp.[17]

Since endodontic treatment of teeth with obstructed root canals is challenging, these types of teeth deserve careful attention because of their caries risk.[18]

Finally, fixation needs to be applied for 7-14 days to allow for the physiologic movement and healing of the periodontal ligament. The method and duration of fixation depends on the contact of the donor tooth to the recipient site and the condition of the recipient site. Devices such as overcrown sutures or gingival packs must be removed after one week. However, if maintenance is difficult or an alveolar transplant was performed, they can stay in place for 4 to 8

weeks. The positioning of the transplanted tooth below the occlusal plane until the root sheath heals completely is also recommended. After one month, when the tooth is immobilized, light mastication can be created on the occlusal plane by building up the tooth with dental materials such as resin.[6,19]

Autotransplantation has many advantages. (1) It allows for new attachments of periodontal ligaments and maintains proprioceptors, which preserves the sense of mastication and reflexes for foreign subjects. (2) Patients feel less discomfort than they do when receiving exogenous implants, because the implanted tooth is their own. (3) Unlike prosthesis or an implant, the autotransplanted tooth continues to erupt with the proximal teeth, inducing formation of new bone, and also helps maintain the morphology of the alveolar ridge by proprioceptive stimuli. (4) The natural morphology of the transplanted tooth resists the torque of lateral forces more effectively than conical-shaped implants. (5) Interproximal papillae are maintained, as well as the natural appearance of the gingiva. (6) Transplanted teeth can also be moved using orthodontic appliances if needed.

The most noteworthy attribute of autotransplantion is that the healing of the root surface is carried out by its own periodontal ligament cells. This biological healing includes resuming the ability to create new tissues when needed. Histologically, periodontal cells are multipotent cells that can be converted from cementoblasts to periodontal ligament fibers to osteoblasts. As a result, when autotransplantation is performed in a severely deficient socket, periodontal cells are often observed during the process of alveolar bone regeneration.[6, 19] In this case, the development of donor tooth root had occurred but shortening and dilacerations of the donor root had observed. It is thought to be due to the cortical bone of the maxillary sinus wall.[20] Panoramic view after 18 months shows that root formation of mandibular right first premolar is not progressed any more. It is supposed of root damage during surgery (Figure 4d).

When there are congenitally missing teeth, autotransplantation in combination with orthodontic treatment can increase the quality of treatment. Pre-surgical Orthodontic treatment is needed in order to create space for the transplant and minimize orthodontic forces exerted on the tooth. Post-surgical orthodontic treatment must begin after the healing of the periodontal ligament, but before the complete healing of the alveolar bone or pulpal obliteration. In other words, orthodontic treatment after autotransplantation is recommended after 3-9 months.[21] In this case, there are edge-to-edge bite in posterior occlusion and severe marginal ridge discrepancies between the mandibular 1st and 2nd molars, these problems could affect adversely on long stability of this occlusion. However the result after 2 year observation period showed occlusal stability.

CONCLUSIONS

Patients with multiple congenitally missing teeth need to receive check-ups on a regular basis to examine the development of the skeleton and changes in dentition. The maintenance of deciduous teeth is preferred, but orthodontic or prosthetic treatments can be completed in cases when extraction of the deciduous teeth is necessary. In this case study, the patient was missing two second molars and two second premolar, and had an impacted second premolar. Autotransplantation was performed in combination with orthodontic treatment. Follow-ups to examine root development and skeletal changes demonstrated desirable results.

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