Treatment of Child with Four Lost Maxillary Incisors due to Traffic Injury

Hiromi Homma\textsuperscript{1)}, Miki Miyashima-Okada\textsuperscript{2)}, Ayano Nakauchi\textsuperscript{3)}, Eri Osawa\textsuperscript{3)}, Nobuko Nagai\textsuperscript{1)}, Atsuo Sakurai\textsuperscript{1)} and Seikou Shintani\textsuperscript{1)}

\textsuperscript{1)} Department of Pediatric Dentistry, Tokyo Dental College, 2-9-18 Kanda-Misakicho, Chiyoda-ku, Tokyo 101-0061, Japan
\textsuperscript{2)} Okada Dental Clinic, 5-6-1 Hinode, Fukui City, Fukui 910-0859, Japan
\textsuperscript{3)} Department of Pediatric Dentistry, Tokyo Dental College, 1-2-2 Masago, Mihama-ku, Chiba 261-8502, Japan

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Abstract

Tooth injury is frequently encountered in pediatric clinical practice. A clinician may be requested to not only respond at the time of injury, but also properly diagnose how such injury will affect the teeth and dentition. Here, we present a case of a child who lost 4 bilateral maxillary incisors due to a traffic accident, and in whom marked mesial inclination of the bilateral maxillary canines and bilateral maxillary first premolars would subsequently occur. Dental management was provided over an extended period. The boy, aged 9 years 11 months, visited our department with the chief complaint of premature loss of 4 bilateral maxillary incisors and eating disturbance associated with the loss of these teeth. Initially, a denture was fitted. The bilateral maxillary canines subsequently demonstrated marked mesial inclination, however, and erupted from an area equivalent to that of the bilateral central incisors. The bilateral maxillary first premolars also showed mesial inclination and rotation. Taking esthetics into consideration, a Nance holding arch with resin buttons that extended to the maxillary incisors and attached to artificial teeth was used. This appliance was also equipped with a retracting hook, and the bilateral maxillary canines were moved downward and distally. Presently, the removable partial denture is worn for the purposes of retention, esthetics, and mastication. Long-term oral management will be necessary. Therefore, final prosthetic treatment for the missing maxillary incisors is planned for when the patient reaches adulthood.

Key word: Traffic injury—Premature loss—Anomaly in tooth eruption—Long-term management
Introduction

Dental injuries in children are not uncommon and on such occasions they are more likely to visit a dental clinic for examination and treatment without an appointment. This means that the dental clinician must be able to diagnose the problem and treat accordingly without prior notice. Children fall easily, as their physical functions are premature, and the ratio of their head to body length is rather large\(^1\). Moreover, they often do not break such falls with their hands, increasing the likelihood of a maxillofacial injury. Falling is the most frequent factor involved in injury to the permanent teeth, and the type of such injuries shows greater variation than those affecting the deciduous teeth\(^2,5,17\). Traffic accidents account for approximately 2% of cases of permanent tooth injury. In this case, facial injuries are also likely to occur, often seriously affecting the maxillofacial surface, which is frequently associated with loss of maxillary anterior teeth, as well as alveolar bone\(^1,10\).

The loss of maxillary anterior teeth exerts a wide range of effects, not only in terms of inducing malfunction, such as difficulty in pronunciation or mastication, but also esthetics. Therefore, when treating a patient with a maxillofacial injury, a number of factors must be kept in mind, including occlusion, masticatory function, and esthetics\(^1,6,9,10,14\).

Here, we present a case of premature loss of 4 bilateral maxillary incisors in a boy aged 9 years 1 month due to a traffic accident, which later resulted in marked mesial inclination of the bilateral maxillary canines and first premolars. Long-term dental management was provided until the occlusion of the permanent teeth stabilized. Our findings and experience with this case are described.

Case Presentation

1. Background to injuries

Written informed consent for reporting the details of this case was obtained from the patient and his parents. A boy aged 9 years 11 months visited our department. Ten months prior to this visit, he had been struck by a car while walking and transported to a nearby critical care center in an emergency vehicle. No head or abdomen abnormalities were noted. However, because of a hard strike to the face, the maxillary alveolar bone had fractured and complete luxation of 4 bilateral maxillary incisors was confirmed.

On the day following the accident, the patient was transferred to the oral surgery department of a local general hospital. That same day, open reduction and fixation using a resorbable plate were performed for the fractured maxillary alveolar bone, as well as replantation and fixation of the bilateral maxillary central incisors under general anesthesia (Fig. 1). After removal of fixation, root canal therapy was provided for the bilateral maxillary incisors. Tooth mobility and external resorption were markedly severe, however. As a result, the teeth were extracted due to a poor prognosis, with the resorbable plate mounted for treatment of the alveolar bone fracture removed at the same time.

2. Findings on first examination at our department

The patient visited our department with the chief complaint of premature loss of 4 bilateral maxillary incisors due to traffic injury, which had disturbed eating function. Although he had no pain, the patient was unable to bite through food with his anterior teeth. He also exhibited difficulty in pronun-
cation, such as in producing ‘s’ and ‘t’ sounds.

The patient was 136 cm in height and 31 kg in weight. There were no systemic findings contributing to the condition of the patient. As for oral findings, loss of 4 bilateral maxillary incisors and severe deflection of the occlusal plane due to elongation of the mandibular incisors were noted. Vertical bone mass deficiency was noted in the alveolar bone in the vicinity of the maxillary anterior teeth (Fig. 2). The left maxillary deciduous canine showed mesial inclination in comparison with the normal position, while the right mandibular canine had not yet erupted and the left mandibular deciduous canine showed tooth mobility (Figs. 2, 3). No teeth were affected by caries, and the oral condition was clean (Figs. 2, 3). No soft tissue abnormality was observed, except for the superior labial frenulum being cut short (Fig. 2).

The patient covered his mouth with a mask before and after the examination, indicating that he was concerned about poor esthetics due to the premature loss of the 4 incisors.

3. Diagnosis and therapeutic strategy

The diagnosis was premature loss of 4 bilateral maxillary incisors due to the effects of a traffic accident-induced injury. Eating disturbance, articulation disorder, and esthetic dissatisfaction resulting from premature loss of the bilateral maxillary incisors were observed. Therefore, the therapeutic strategy comprised the provision of a denture for the area in which premature loss had occurred in order to restore esthetics and function as early as possible.

Clinical Procedures and Outcomes

1. Prosthetic treatment

A denture was immediately fabricated and applied for the lost bilateral maxillary anterior teeth (Fig. 4). Soon after application of the appliance, the right mandibular canine started to erupt, while the left mandibular deciduous canine fell out (Fig. 4). A panoramic X-ray obtained at the age of 10 years 8 months revealed marked mesial inclination in both of the maxillary canines due to premature loss of the 4 incisors. No resorption of the roots of the bilateral maxillary deciduous canines was observed (Fig. 5). Furthermore, the left maxillary first premolar showed slight mesial inclination and rotation. Root resorption was observed in the other deciduous first molars. Therefore, it was considered neces-
sary to move the bilateral maxillary canines and the left maxillary first premolar back to their original position.

2. Re-diagnosis and therapeutic strategy

At 11 months after the start of denture placement, the bilateral maxillary canines started to erupt at positions corresponding to the maxillary central incisor (Fig. 6). This was diagnosed as anomalous tooth eruption of the bilateral maxillary canines and first premolars due to the traffic injury based on oral findings. Marked curving of the occlusal plane was noted, necessitating referral for treatment by a specialized orthodontist. The boy and his parents refused full-mouth orthodontic therapy, however, as considerable mental stress had already been caused by the traffic injury, and such therapy would mean additional stressful visits for treatment. Accordingly, it was decided that subsequent treatment would comprise distal movement of the bilateral maxillary canines and first premolars only to secure space for attachment of a denture until the patient reached adulthood.

When performing dental treatment in patients with functional disorder and esthetic dissatisfaction due to injury, a therapeutic plan that takes into consideration their psy-
psychological stress resulting from the incident is necessary. In the present patient, both maxillary canines began to erupt bilaterally from a position corresponding to the maxillary central incisor. Therefore, we decided to provide treatment by taking esthetic problems into consideration, even when performing tooth movement.

3. Treatment flow

Bearing in mind the particular esthetic concerns and functional problems in the present case, artificial teeth were fashioned by extending the resin buttons of a Nance holding arch to the maxillary incisors. An appliance equipped with a retracting hook was also used for the distal aspect of the bilateral maxillary deciduous canines (Fig. 7). The right maxillary canine began to erupt more mesially than the left canine. Therefore, the cervical aspect of the artificial teeth for the right maxillary central and lateral incisors and a portion of the plate were removed (Fig. 7). Lingual buttons were attached to the left maxillary canine, and later attached to the right maxillary canine after surgical exposure. Following extraction of the bilateral maxillary deciduous canines and right maxillary first deciduous molar, which showed marked mobility, downward and distal movement of the bilateral maxillary canines was started by use of the appliance, elastics, and lingual buttons. Elastics were applied to hooks of the Nance holding arch and lingual button to retract the maxillary canine.

Panoramic X-ray findings obtained at 2 months after the start of retraction (age 11 years 2 months) showed that eruption of the bilateral mandibular canines was complete, while that of first premolar was still ongoing. The axial inclination of the bilateral maxillary canines showed considerable improvement (Fig. 8). In terms of periodontal condition, plaque control temporarily worsened while the fixed-type appliance and bracket were mounted. More favorable conditions soon returned, however, with regular visits by the patient, at which time the fixed-type appliance was removed and thorough oral cleaning performed.

After the bilateral maxillary canines and first premolar had completely erupted, artificial teeth for the bilateral maxillary central incisors and left maxillary lateral incisor and extended resin button were fabricated again. A sectional arch equipped with an Ni-Ti wire and bracket was used for distal movement of the bilateral maxillary canines and first premolars. This bracket was also attached to the bilateral maxillary second premolars after completion of eruption. Distal movement was maintained by use of the sectional arch.

Fig. 7 Oral photographs obtained at time of appliance attachment (age 11 years 0 months)

Fig. 8 Panoramic radiograph image obtained at 2 months after start of retraction (age 11 years 2 months)
At 2 years 0 months after the start of retraction (age 13 years 0 months), the bilateral maxillary canines and premolars were guided into alignment, and no tooth mobility or periodontal symptoms, such as pocket formation, were observed (Fig. 9). In addition to completion of retraction and distal movement, it was confirmed that the space between the bilateral maxillary canines and the premolars had closed, and that all the deciduous teeth had been completely replaced. The left maxillary second molar had also started to erupt (Fig. 9). Panoramic X-ray findings obtained at that time showed that the marked mesial inclination of the bilateral maxillary canines had improved, while mesial inclination and rotation of the bilateral maxillary first premolars also showed improvement (Fig. 10). No root resorption of the bilateral maxillary canines or premolars, which were moved distally, was observed (Fig. 10). Although a fixed-type appliance with artificial teeth was used, thorough professional oral cleaning together with the patient’s own toothbrushing resulted in successful prevention of dental caries. A denture was applied to restore esthetics and masticatory function, as well as retention, following completion of distal movement.

Eruption of the bilateral second molars and relatively stable occlusion were confirmed at the age of 16 years 6 months (5 years 6 months after the start of retraction). The patient was able to use the denture without any problems (Fig. 11). Final prosthetic treatment for the missing 4 bilateral maxillary incisors will be reconsidered when the patient reaches adulthood at the age of 18 years.

**Discussion**

Accidental injury in children is often attributed to their physical and mental immaturity, as well as environmental conditions, so clinical findings and the extent of damage are likely to vary accordingly. As children are still in the process of physical and mental development, they are more inclined to act on impulse than adults, in addition to which various types of motor function have yet to
mature. This means that the causes of injury are likely to vary accordingly. It has recently been reported that accident-related injuries in children are on the increase. It has also been pointed out that agility and reflexes specific to children are reduced in association with changes in environmental factors, such as housing, physical exercise, and mode of transportation. This indicates that the chances of a child encountering a variety of incidents, such as accidents during sports or play outside, as well as traffic accidents, are on the increase. This means that unscheduled visits to a dentist due to injury to the jaw, face, or oral area are also likely to increase. Traffic accidents can cause serious injuries to and subsequent disorders of the maxillofacial region, such as fracture, luxation, loss teeth, pronunciation disorder, and malocclusion.

In treating such problems, it is important to bear both functional and esthetic considerations in mind, which often necessitates comprehensive dental treatment, including prostheses for missing teeth such as dentures, orthodontic therapy, dental bridges, and implant placement. It is also important to take any psychological factors into account when determining a treatment plan, as the patient may be experiencing severe mental stress from the accident.

In the present case, the therapeutic plan was designed to be implemented as soon as possible while taking into consideration both psychological aspects and matters related to
mastication, articulation, and esthetics. This patient seemed to be particularly worried about poor esthetics, as evidenced by his tendency to cover his mouth with a mask, except when undergoing an oral examination. We believe that it is important to fully understand the emotional needs of the patient before determining a therapeutic plan in such cases. Therefore, efforts should be made to obtain an understanding of the details of the treatment to be given on the part of the patient prior to seeking consent; efforts should also be made to alleviate the concerns of the patient and their parents regarding such. Fortunately, the present patient showed no signs of any mental disability, such as dissociative disorder or post-traumatic stress disorder, during therapy. On the other hand, the patient had no memory of the details of the accident.

Maxillofacial bone fracture due to a traffic accident is noted in 17–30% of all cases reported, while a fracture involving the maxillary and mandibular bone accounts for 13%\(^8\). It has been reported that falling was the most frequent cause of such fracture in children aged 0–12 years, while a traffic accident was the most common in those aged 13–15 years\(^9\). In providing proper care, the dental clinician must conduct a careful visual inspection and obtain X-ray images. Clinical symptoms, including tooth and bone fracture, root resorption, tooth displacement, and damage to the periodontium should not be overlooked. Moreover, it is difficult to improve occlusion and masticatory function in children with loss of permanent teeth or alveolar bone due to a traffic accident, as new problems, such as an eruption of a malpositioned tooth or disturbance of the development of the jawbone, are likely to occur during this period of growth. Therefore, long-term follow-up is indispensable in treating children with injuries to the jaw, face, or oral area.

However, although several clinical studies have reported jawbone fracture cases, those with subject cohorts limited to children are few\(^1,10\). Furthermore, very few studies have reported long-term follow-up findings. In the present case, dental treatment was provided for approximately 7 years after the initial visit, and for nearly 6 years after performing retraction and distal movement, by which mastication, articulation, and esthetics were improved, resulting in patient satisfaction and a good therapeutic outcome.

Causes of mesial inclination of the axis of a maxillary canine include abnormal dental germ position and direction of eruption of the tooth, excessive space on the mesial side of maxillary canine due to the presence of an undersized maxillary lateral incisor or a congenital deficiency, and morphologic change related to the maxillary sinus enlarging in an anteroinferior direction along with growth\(^4\). In the present case, marked mesial inclination of the bilateral maxillary canines and first premolars was noted and considered to be the result of fracture of the maxillary alveolar bone and premature loss of 4 bilateral maxillary incisors. Moreover, the loss of those incisors caused masticatory and esthetic problems. Accordingly, an attempt was made to improve the mesial inclination of the teeth without impairing masticatory function or esthetics. A fixed-type appliance with artificial teeth was also fabricated, which produced good results. Although cases of permanent tooth loss in the mixed dentition period are not rare in clinical practice, there are few reports concerning treatment of malpositioned teeth to simultaneously induce functional recovery. Orthodontic treatment, autotransplantation of mandibular teeth, or bone grafting have been performed for the loss of maxillary permanent teeth due to a traffic accident\(^1,12\). However, recovery of masticatory function and esthetics could not be achieved during tooth movement in those studies. There is no doubt that patients with permanent tooth loss demand early recovery of dysfunction and esthetics. To the best of our knowledge, no other studies to date have reported use of a fixed-type appliance with artificial teeth as orthodontic treatment in such injuries during the mixed dentition period.

Specialized orthodontic treatment was con-
sidered applicable in the present case. The patient and his parents expressed a desire for limited orthodontic pretreatment prior to prosthetic treatment, which was limited to improvement of the maxillary dentition, their chief complaint. For a child who has lost their anterior teeth in a traffic accident, as well as their parents, an increase in mental stress is likely if the number of treatment sites other than maxillary anterior teeth is also increased. On the other hand, if deflection of the occlusal plane and elongation of the mandibular incisors remains, future prosthetic treatment may be more difficult. However, the present patient used a removable denture, and did not have any discomfort. Accordingly, it was considered necessary to perform individualized treatment in the present case, taking account of not only functional and esthetic factors, but also emotional stress.

Long-term management is necessary in the present case. Our intention is to consider final prosthetic treatment for the 4 missing maxillary incisors after the patient has reached adulthood. We believe that dental implants, bridges, and partial dentures are all applicable to these missing teeth, although implants remain the most favorable option. However, examination of the alveolar bone in the area of the missing teeth will be needed as loss of alveolar bone was observed due to the traffic accident.

References

1) Anitua E, Mendinueta-Urkia M, Galan-Bringas S, Murias-Freijo A, Alkhraisat MH (2017) Tooth autotransplantation as a pillar for 3D regeneration of the alveolar process after severe traumatic injury: A case report. Dent Traumatol 33:414–419.
2) Ashrafullah, Pandey RK, Mishra A (2018) The incidence of facial injuries in children in Indian population: A retrospective study. J Oral Biol Craniofac Res 8:82–85.
3) Bedoya MM, Park JH (2009) A review of the diagnosis and management of impacted maxillary canines. J Am Dent Assoc 140:1485–1493.
4) Bishara SE (1992) Impacted maxillary canines: a review. Am J Orthod Dentofacial Orthop 101:159–171.
5) Dai W, Liu A, Kaminga AC, Deng J, Lai Z, Wen SW (2018) Prevalence of posttraumatic stress disorder among children and adolescents following road traffic accidents: A meta-analysis. Can J Psychiatry https://doi.org/10.1177/0706743718792194
6) Dang KM, Day PF, Calache H, Tham R, Parashos P (2015) Reporting dental trauma and its inclusion in an injury surveillance system in Victoria, Australia. Aust Dent J 60:88–95.
7) Evren BA, Basa S, Ozkan Y, Tanyeri H, Ozkan YK (2006) Prosthodontic rehabilitation after traumatic tooth and bone loss: a clinical report. J Prosthet Dent 95:22–25.
8) Goettens ML, Torriani DD, Hallal PC, Correa MB, Demarco FF (2014) Dental trauma: prevalence and risk factors in schoolchildren. Community Dent Oral Epidemiol 42:581–590.
9) Kaneko H, Onozawa K, Abe H (2012) A study of reconstruction with a pedicled myocutaneous flap after oral cancer surgery. Tokyo Joshi koka daigaku Zassi 82:360–365. (in Japanese)
10) Kao SJ, Fong JH, Chou SJ, Wu JH, Tu HF, Yeung TC (2007) Segmental osteotomy to reposition multiple osseointegrated dental implants in the anterior maxilla in a trauma patient. Dent Traumatol 23:56–59.
11) Karlberg J (1989) A biologically-oriented mathematical model (IGP) for human growth. Acta Paediatr Scand Suppl 350:70–94.
12) Mimura H, Fukuyo S (2012) Orthodontic reconstruction with autotransplantation and bone grafting after a traffic accident. Am J Orthod Dentofacial Orthop 141: S119–S129.
13) Stein DJ, Karam EG, Shahly V, Hill ED, King A, Petukhova M, Atwoli L, Bromet EJ, Florescu S, Haro JM, Hinkov H, Karam A, Medina-Mora ME, Navarro-Mateu F, Piazza M, Shalev A, Torres Y, Zaslavsky AM, Kessler RC (2016) Post-traumatic stress disorder associated with life-threatening motor vehicle collisions in the WHO World Mental Health Surveys. BMC Psychiatry 16:257.
14) Tanaka N, Shionoya K, Suzuki K, Kimijima Y, Kimijima S, Sato Y, Miyamoto T, Amagasa T (1994) Clinical investigation of pediatric maxillofacial fractures. Nippon Kokugeka Gakkai Zasshi 49:770–775. (in Japanese)
15) Tipton PA (2002) Esthetic restoration of the traumatized and surgically reconstructed anterior maxilla. J Esthet Restor Dent 14:267–274.
16) Tome W, Uematsu S, Yamashiro T (2015)
Multidisciplinary treatment for a patient with traumatically intruded permanent canine and premolar. Aust Dent J 60:536–539.
17) Tomkinson GR, Olds TS (2007) Secular changes in pediatric aerobic fitness test performance: the global picture. Med Sport Sci 50:46–66.

Correspondence:
Dr. Atsuo Sakurai
Department of Pediatric Dentistry,
Tokyo Dental College,
2-9-18 Kanda-Misakicho, Chiyoda-ku,
Tokyo 101-0061, Japan
E-mail: sakuraia@tdc.ac.jp