Original Article

Autotransplantation of 28 Premolar Donor Teeth in 24 Orthodontic Patients

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ABSTRACT

Objective: To test the null hypothesis that premolar autotransplantation is not successful for orthodontic patients.

Materials and Methods: In the present study, 28 premolar transplants from 24 orthodontic patients were associated with orthodontic treatment. At a routine 3-month appointment, patients underwent a dental radiograph and a chair-side observation for periodontal problems. Three sets of dental radiographs were taken by one dental assistant using a custom holder at: preoperation (T0), 2 year postoperation (T1), and retention (T2) (4- to 14-year follow-up observation) stages. All transplants were conducted in a one-phase operation by one operator (Dr Inoue). Recipient sites were: ten for missing maxillary canines, nine for maxillary centrals and laterals, eight for lower second premolar, and five for other missing premolar sites. All recipients maintained the retained primary tooth with a socket.

Results: The success ratio of all 28 transplants was 100%, although four transplants shorter than a 4-year period of observation were omitted. Two transplant patients, one with a medical history of histiocytosis and the other with a history of osteomyelitis of the maxilla without a recipient socket, were also excluded from this study. Eleven of 22 premolar transplants had a root canal treatment (RCT), four of which had RCT within 2 years after the operation.

Conclusions: The null hypothesis was rejected. The success ratio of premolar transplants was 100%.

KEY WORDS: Autotransplantation; Donor premolar; Hypodontia; Long-term follow-up; Orthodontics; Tooth movement

INTRODUCTION

Since the 1960s and 1970s, allotransplantation, cryotransplantation,[1] and autotransplantation have been applied in orthodontics and oral surgery.[2,3] Although both allotransplantation and cryotransplantation need a tooth bank, allotransplantation might result in an immune reaction for donors' and recipients' teeth. Experimental and clinical studies on tooth transplantation continue.[4–7]

Recently, a few papers on premolar donor autotransplantation have been published.[8–10] Although autotransplantation has historically been popular in northern European countries,[2,3,8–11] this could be related to the dentist's training background that was based on a closer relationship between dental surgery and medicine. On the other hand, there is lack of information on tooth autotransplantation from American

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Table 1. Characteristics of Donor Samples and Three Different Stages of Root Development

Variation of Root Development	Donors, N	Patients, N	Patient Age, Years	SD
Root length complete (Rc)	9	9	14.45	2.10
Root length 3/4 (3/4R)	17	13	12.34	0.57
Root length 1/2 (1/2R)	2	2	11.82	1.35
Total	28	24	12.55	1.82

and Asian orthodontists. In Japanese or Asian populations with a higher rate of extraction cases, there are numerous opportunities for autotransplantation of donor premolars to the sites of missing permanent teeth, eg, mandibular second premolar, maxillary incisors, and canines.

Most patients with partial anodontia (hypodontia) will benefit from autotransplantation, which could be successful over a long-term observation. There is only one original paper of tooth transplantation in a Japanese sample,[12] so there is still a lack of information for donor premolar autotransplantation related to orthodontic treatment.

MATERIALS AND METHODS

Thirty-three orthodontically treated patients from a private orthodontic clinic were treated with the autotransplantation of 38 donor premolars from 1988 to 2004. Five out of 33 patients, who were transferred from other orthodontists for autotransplantation, did not return for progress records. Four transplants with less than a 4-year period of observation were omitted. In addition to these, two transplant patients, one of which had a medical history of histiocytosis and the other a history of osteomyelitis of the maxilla without a recipient socket, were excluded. The present study consists of 24 donor patients associated with 28 donor premolars. All recipient sites had maintained the retained primary teeth.

Success was categorized as: (1) the crown:root ratio was 1:1; (2) longer than 4-year survival in the mouth; (3) nonankylosis; (4) nonsevere periodontal problems; and (5) physiological mobility. If one of these criteria was not met, the case was recorded as a failure.

A total of 24 donor patients consisted of 14 female and 10 male patients, ranging in age from 9 years and 8 months to 16 years. The majority (90%) of the donor patients were between 12 and 14 years old (Table 1). The period of follow-up observation for 28 premolar transplants is described in Table 2.

Twenty-eight premolar donors were autotransplanted to the recipient sites of missing teeth as follows: Ten donor premolars were autotransplanted to the sites of deciduous canines; seven were autotransplanted to the deciduous second premolar; and six were autotransplanted to maxillary central and lateral incisor sites. Five premolar donors were autotransplanted to the sites of other premolars (Figure 1).

Table 2. Period of Follow-Up Observation for 28 Premolar Transplants

Case Number 1–10		Case Number 11–20		Case Number 21–28	
Patient Number	Period, Years	Patient Number	Period, Years	Patient Number	Period, Years
1	12	11	10	21	6
2	12	12	11	22	5
3	14	13	10	23	5
4	14	14	10	24	4
5	14	15	8	25	4
6	13	16	10	26	4
7	13	17	9	27	10
8	4	18	7	28	4
9	13	19	6		
10	12	20	8		

Clinical and radiographic observations of all premolar donors were obtained. Root length measurements were done by radiographs taken prior to the operation (T0), 2 years postoperatively (T1), and 4 years thereafter (T2). Clinical checks (gingival condition, tooth mobility) were done semiannually, concurrently with the patient's visit.

Although Moorrees'[13] classification is popular for the evaluation of the eight stages of root development, our study simply classified root development into three different stages; half root (1/2R), quarter root (3/4R) and complete root (Rc) stages because the small sample size of transplants would not justify the classification into eight stages. The 1/2R stage is similar to stage 3 of Moorrees' classification; the 3/4R stage is stage 4, and root complete (Rc) is stage 5–7.The progress of each donor's root growth was studied at T0, T1, and T2 stages (Table 3). The length of the tooth crowns and roots were calculated (NIH Image, version 1.62, National Institutes of Health) on a computer incorporating a radiograph at T0, T1, and T2. The increase in root length at T0–T1, T1–T2, and T0–T2 was classified into a growth group and a decrease in length into a nongrowth or resorption group. The means of root progress were obtained (Table 3). The dental radiograph in this study was taken by a single dental operator using a Cone Indicator (Hanshin Technical Lab Ltd, Hyogo, Japan).

Surgical Procedures

There are a few papers discussing different surgical procedures in a one-stage or two-stage operation.[14,15] In the present surgical procedure, one oral surgeon (Dr Inoue), with a clinical periodontic background, performed all transplantations of the donor premolars in a one-stage operation. Operation procedures in the

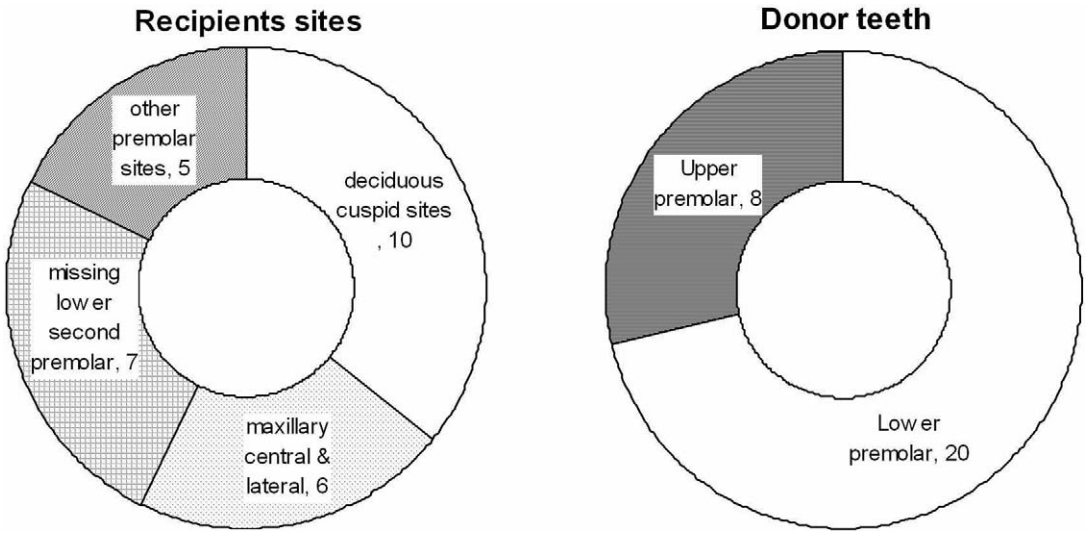


Figure 1. Donor and recipient sites of 28 premolar transplants.

Table 3. The Root Complete Progress of Premolar Donors at T0, T1, and T2 Stages

Stage of Root Growth[a]		n		Root Length, mm			Difference, mm		
				T0	T1	T2	T0–T1	T1–T2	T0–T2
Rc	Growth	3	Mean	12.59	13.94	14.42	1.52	−0.32	1.14
			(SD)	(1.96)	(2.45)	(2.41)	(0.57)	(0.47)	(0.12)
	Nongrowth or resorption	6	Mean	14.74	14.03	13.29	−0.42	−1.10	−1.74
			(SD)	(4.39)	(4.05)	(3.98)	(1.44)	(1.47)	(0.57)
3/4R	Growth	6	Mean	10.83	13.12	11.86	1.67	−1.26	0.87
			(SD)	(1.28)	(1.40)	(1.99)	(0.60)	(1.53)	(1.80)
	Nongrowth or resorption	11	Mean	11.05	10.46	11.08	−1.58	0.53	−0.83
			(SD)	(1.99)	(2.44)	(2.90)	(1.67)	(1.15)	(1.91)
1/2R	Growth	1	Mean	5.02	7.85	6.94	2.83	−0.91	1.92
			(SD)	(–)	(–)	(–)	(–)	(–)	(–)
	Nongrowth or resorption	1	Mean	13.53	10.85	11.61	−2.45	0.53	−1.92
			(SD)	(–)	(–)	(–)	(–)	(–)	(–)

[a] Rc indicates complete root; 3/4R, quarter root; 1/2R, half root.

present transplants were focused on: (1) the pilot drill, which is used in dental implants, was applied for socket enlargement; (2) the epithelial attachment of the recipient was retained without damage; (3) teeth from donors were extracted in about 10 minutes after jiggling to maintain the periodontal membrane and Hertwig's epithelial root sheath; and (4) the socket was carefully managed at recipient sites with two roots.

The orthodontic treatment progress and surgical procedures of the first patient are shown in Figures 2 through 4. The female patient was our first autotransplanted orthodontic case, and information on this patient was published previously.[16] The patient's records at pretreatment are shown in Figure 2A–E. The surgical procedures are described in Figure 3A–E, and the posttreatment records are shown in Figure 4A–E. Figures 5 and 6 are the panoramic radiographs at T0 and T1 and dental radiographs at the T0, T1, and T2 stages of premolar donors and transplants.

In this patient, the maxillary lateral incisors and canines were congenitally missing. The mandibular first premolar donors were transplanted to the sites of the remaining maxillary deciduous lateral incisors and canines. The premolar donor teeth were diagnosed for extraction to solve the orthodontic problems in the patient. There was no sacrifice of premolars in the patients. A few weeks following surgery, the donor premolars were transplanted to the sites of the maxillary anterior teeth. The maxillary anterior teeth were initially moved to correct their rotated position in order to minimize the risk of ankylosis. A few months after initial movement, the transplanted premolars were shaped to the morphology of lateral incisors or canines. Endodontic therapy was applied, if needed. Edgewise ap-

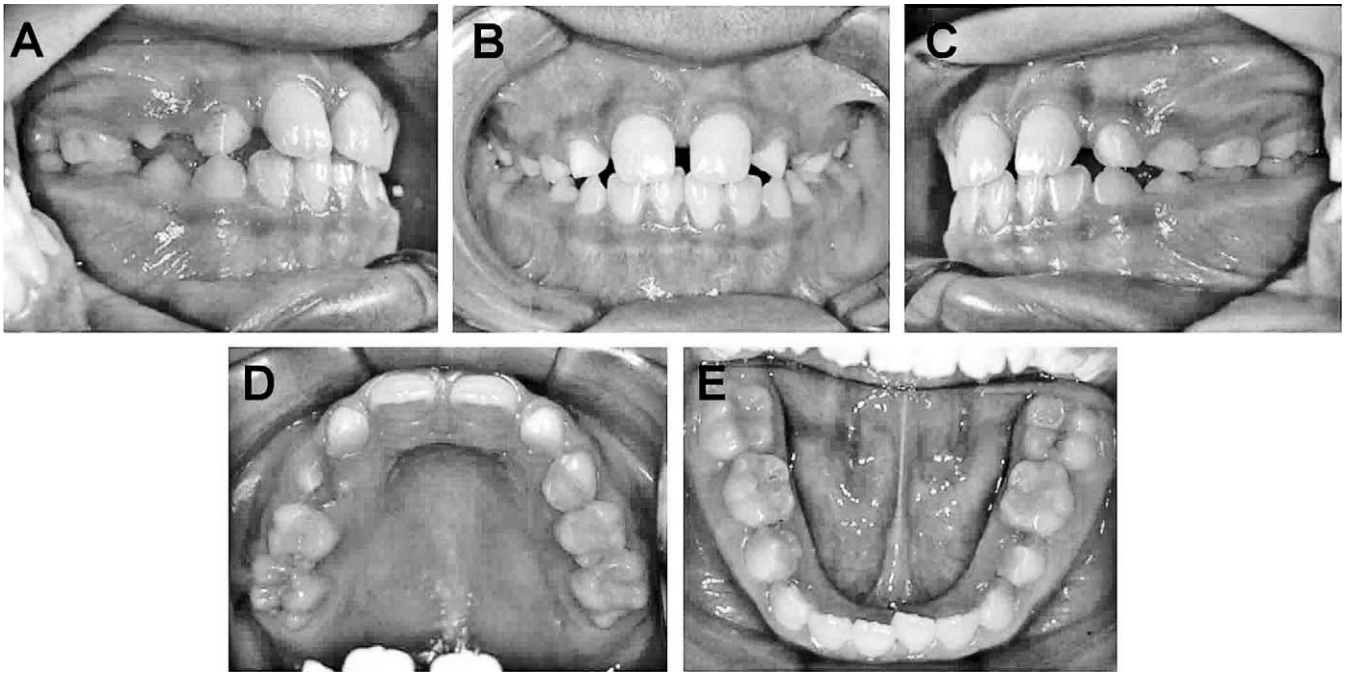


Figure 2. The first autotransplanted patient. (A–E) Oral photos at pretreatment records.

pliance therapy with a 0.018 pretorqued bracket was initiated, involving a sequence of Niti leveling arch wires and completed with a 0.017 × 0.025 finishing ideal arch wire. Treatment time was 45 months.

RESULTS

All 28 premolar donors were classified into three stages of root development. Another five premolar donors were autotransplanted in patients who had been referred from other orthodontists to our clinics. Unfortunately, all referred autotransplanted patients did not return for follow-up observations.

All autotransplanted premolars were checked at a chair-side observation during the latest appointment. All donors were well-maintained in occlusion and presented a normal periodontal condition for an extensive follow-up (Table 2). However, there is a lack of history or records of detailed periodontal observation, eg, depth of pockets. Four pairs of twin sisters are included in these 28 cases, three of which showed a bilateral missing upper canine, while one was bilaterally missing the lower second premolars.

Sixteen premolars out of 28 premolar donors (57%) were autotransplanted to the sites of upper incisors and canines. Most premolar donors needed to be reshaped to the morphology of the upper incisors and canines (Figures 1 and 4D).

Root development of the autotransplanted premolars was studied. The amount of root development and nongrowth or resorption at T0–T1, T1–T2, and T0–T2 was studied in all premolar donors (Table 3).

At T0, there were nine premolar donors with Rc, 17 with 3/4R and two with 1/2R. At T1–T2 stages, root growth transplants of Rc subjects showed root resorption (mean −0.32 mm). Nongrowth transplants of 3/4R subjects showed root growth (mean 0.53 mm).

At T0–T2 stages, three out of 9 Rc premolars showed root growth (mean of 1.14 mm) and six premolars showed nonroot growth (mean of −1.74 mm). Six out of 17 premolars of 3/4R showed root growth (mean 0.87 mm), and 11 premolar transplants showed nongrowth (mean −0.83 mm). One of the 1/2R subjects showed growth (1.92 mm), while the other showed nongrowth (−1.92 mm). The overall progress of premolar transplants through T0–T2 stages is summarized in Table 4.

In the present study, the ratio of pulp survival in the transplants was 60.7%. Eleven out of 24 premolar transplants had root canal treatment (RCT), four of which had a RCT within 2 years after surgery. One out of 1/2R and 3/4R subjects showed root bending.

DISCUSSION

Recently, two excellent papers for autotransplantation were published.[8,9] Autotransplantation is a traditional method in the field of dentistry. This clinical trial focused on patients with missing teeth who needed orthodontic treatment. All donor premolars were extracted for orthodontic treatment and transplanted to the sites of the missing teeth without sacrificing any of the patient's teeth. Tsukiboshi[12] described 250 conventional autotransplantations in fully developed teeth

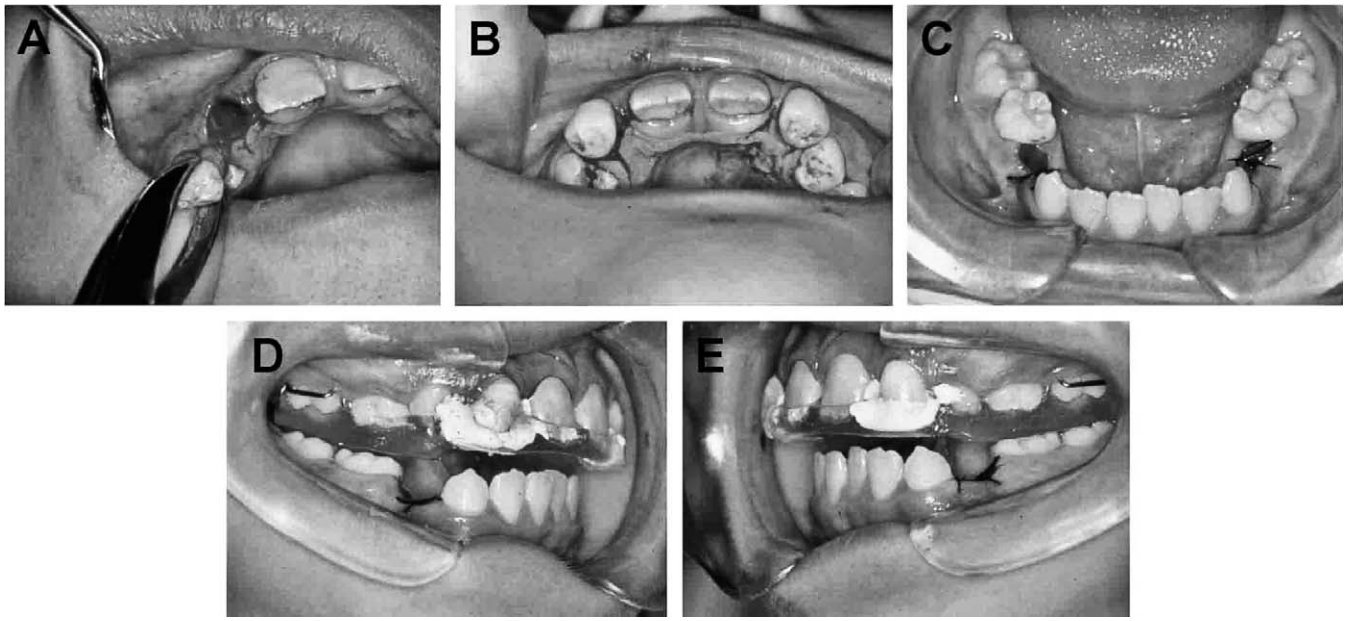


Figure 3. The procedures of autotransplant operation. (A) Removal of maxillary deciduous canine. (B) Transplantation of mandibular first premolar to the site of recipient. (C) Extraction of mandibular first premolar. (D, E) A plate was cemented.

that took place over a period of 15 years. The success rate was 82%, while that of artificially formed sockets was 60%.

Recently, Jonsson and Sigurdsson[9] reported the autotransplantation of 40 premolars to premolar sites with a long-term follow-up. The success rate of long follow-ups was 92.5%. In 35 out of 40 cases, the premolar transplants were utilized to substitute the missing mandibular second molar while the remaining five were used to replace maxillary premolars.

In the present clinical trial, 7 out of 24 premolar donors were applied to the sites of the missing mandibular second premolar. Interestingly, 16 donor premolars (57%) were placed at the sites of the missing maxillary central, lateral, and canine. In this study the success rate of premolar transplants was 100%, which is

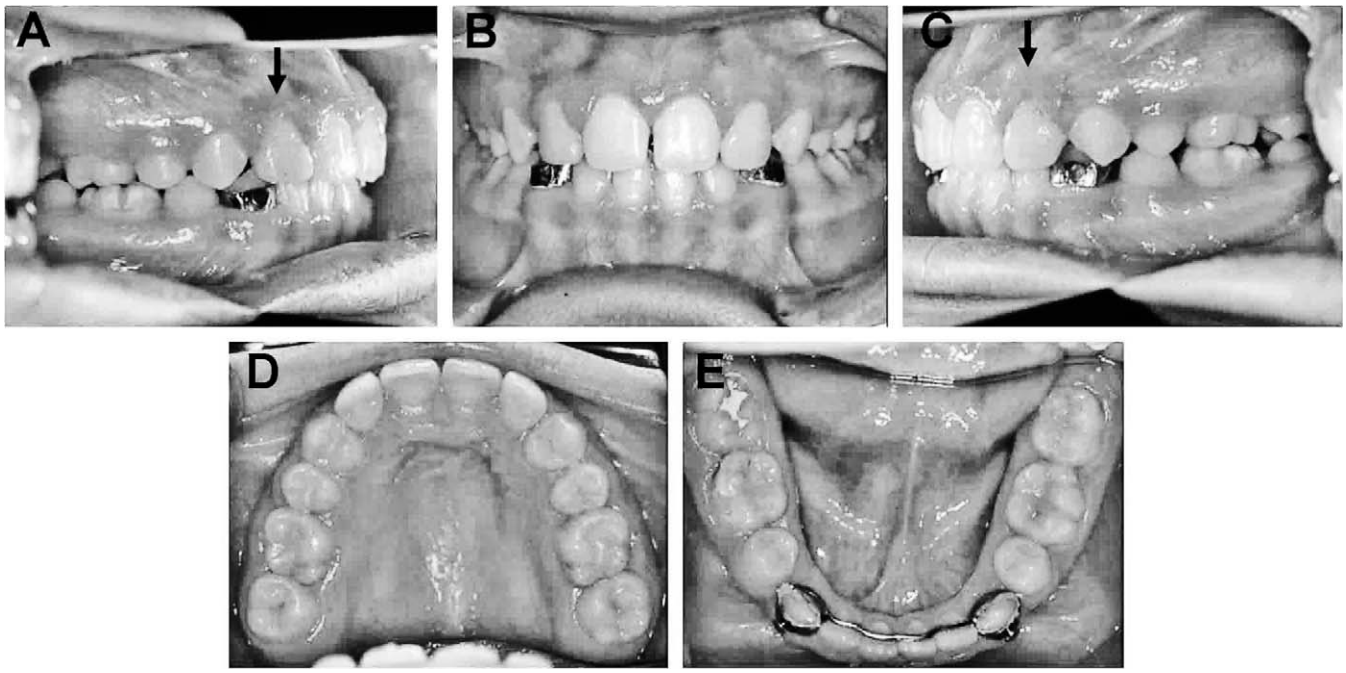


Figure 4. (A–E) Oral photos at posttreatment.

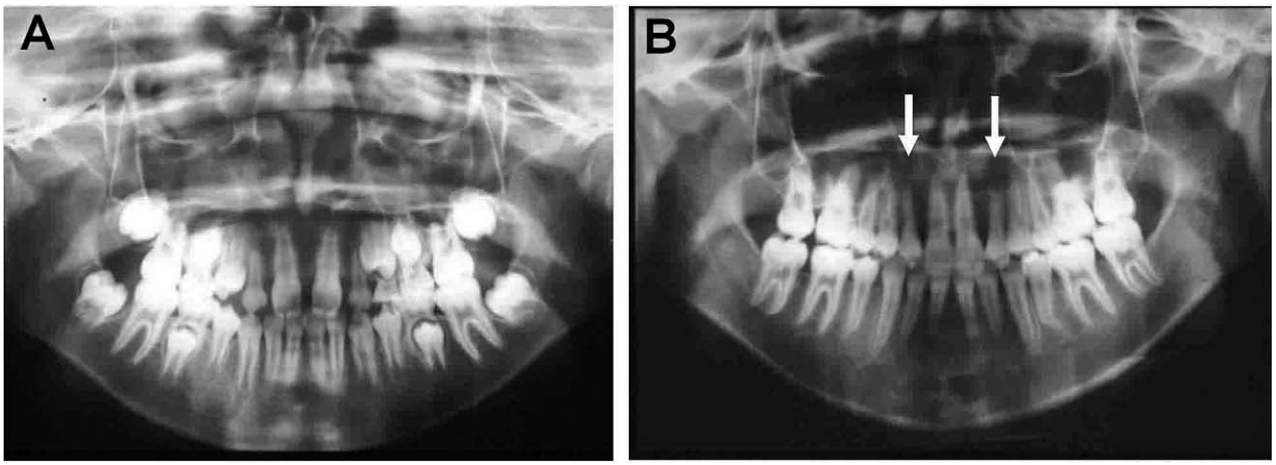


Figure 5. Panoramic radiographs at pretreatment and posttreatment.

a higher ratio than that reported in Jonsson and Sigurdsson's[9] data. Five premolar transplants with less than 4 years of observation were excluded from this study, but were well-maintained. The transplant in the patient with histiocytosis was maintained 4 years after the operation, and the transplant in the other patient with osteomyelitis of the maxilla fell out 7 years after the operation, resulting in severe bone loss.

However, one of the markers for the success of transplants is a 1:1 ratio of crown and root,[17–19] which clinically shows a shorter root than the usual root shape. Although the dental radiographs were taken by a Cone Indicator and a single operator to minimize the error of root measurement, measurement accuracy may be critical to evaluate the actual changes in root development in traditional radiographs. In the present study, the range of transplant root length was 11 mm to 14 mm, except for one 1/2R patient. The average root length for a normal first premolar and second premolar was 12 mm and 13 mm, respectively in Japa-

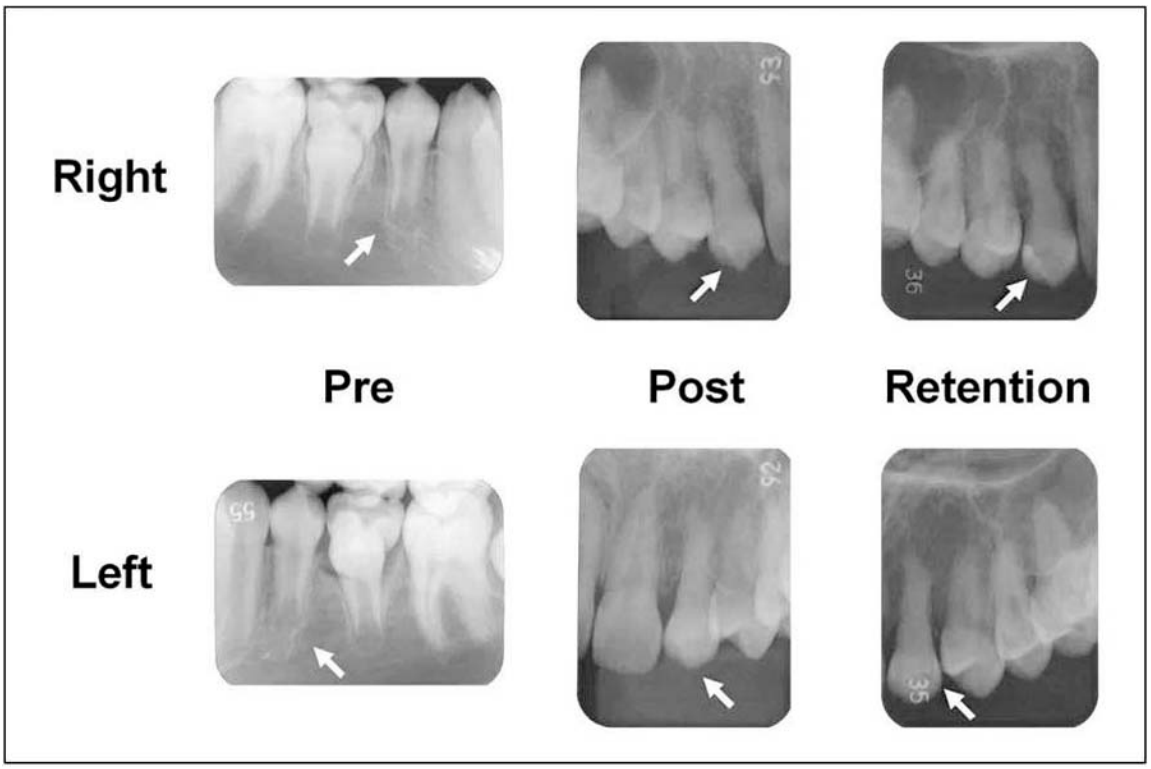
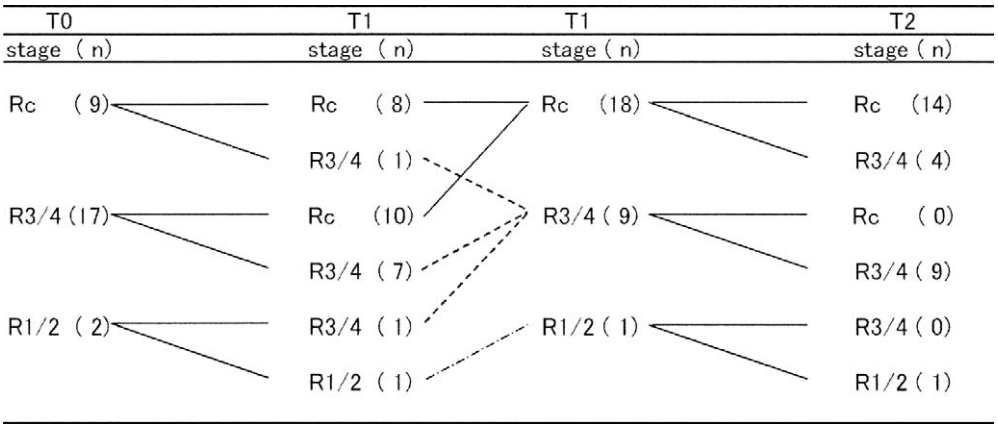


Figure 6. Dental radiographs of donors of mandibular left and right first premolars and the transplants at the sites of missing maxillary lateral incisors and canines at T1 and T2.

Table 4. The root complete progress of premolar donors from T0 to T2 stages



nese samples.[20] The premolar transplants maintained an almost normal root length in orthodontic patients. Three-dimensional evaluative methods for root development associated with root bending can result in more accurate data.

Premolar transplants, which are conventionally placed at the sites of maxillary incisors and canines, were placed at the rotated position because of a lack of bone width, and the rotated position was orthodontically corrected a month later. Crown reshaping of premolar transplants to the shape of recipient teeth was done 4 or 5 months later. An endodontic treatment was performed, if needed.

Jonsson and Sigurdsson[9] showed a 76% pulp survival in transplants with partly formed roots. Czochrowska et al[8] reported 30 transplants in 25 patients of which 22 had an orthodontic treatment without performing the endodontic treatment in the long-term follow-up. The ratio of pulp survival in the present transplants was 60.7%. This low ratio of pulp survival could be related to the recipient sites of upper incisors and canines, whose crown needed to be reshaped for the premolar transplants.

In the present autotransplantation cases with missing teeth, premolar extraction for the purpose of orthodontic treatment was needed in all cases. Except for surgical procedures, patients did not sacrifice teeth during autotransplantation. Although all donor teeth in the present study were the first or second premolar, the lower third molars could also be useful for autotransplantation without a risk to the patient.[21–23] The clinical application of a recently developed miniscrew[24–26] or miniplate[27] anchorage system could be another choice to close the space in missing teeth sites without causing side effects.

Slagsvold and Bjercke[11] report that half of root transplants might attain normal or almost normal lengths if autotransplantation could be ideally performed. They commented that genetics may control root growth, and the formation of adequate roots seems to be secured, provided epithelial sheath integrity is maintained.

Advanced biological research on bone-periodontal membrane biomaterials,[28,29] cultured membrane,[30] and pulpal reaction histobiology[31,32] can also improve the quality of tooth autotransplantation with more roots and bone development. Tooth regeneration is a future dream.[33]

CONCLUSIONS

- The null hypothesis was rejected. The success ratio of premolar transplants in orthodontic patients in this study was 100% after excluding two transplant patients, one with a medical history of histiocytosis and the other with a history of osteomyelitis of the maxilla without a recipient socket. The follow-up period of five transplants was shorter than the 4-year criteria, but they maintained good functionality in the mouth.

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