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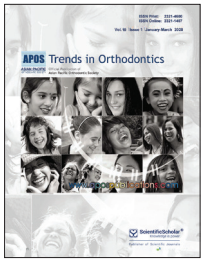
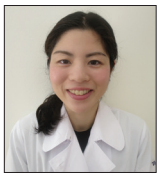


Clinical Pearl

Orthodontic movement of a contralateral maxillary central incisor across the midpalatal suture

Chiho Kato, Satoshi Kokai, Takashi Ono

Department of Orthodontic Science, Graduate School, Tokyo Medical and Dental University, Bunkyo-ku, Tokyo, Japan.



***Corresponding author:**
Chiho Kato,
Department of Orthodontic Science, Graduate School, Tokyo Medical and Dental University, Bunkyo-ku, Yushima 1-5-45, Tokyo, Japan.

katorts@tmd.ac.jp

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ABSTRACT

There are several options for replacing a missing maxillary central incisor in orthodontic treatment. Substituting a missing central incisor with the contralateral one can be a useful approach to reduce the number of teeth that require extraction during the treatment. Normal tooth movement across an ossified midpalatal suture (MPS) has only been observed in an animal experiment. Herein, we describe the treatment of a 26-year-old woman who had lost multiple teeth on one side, including the maxillary right central incisor, which required extraction due to endodontic failure. The maxillary left central incisor was moved into the position of the maxillary right central incisor. All other left maxillary teeth were moved mesially to close the space. After completion of orthodontic treatment, acrylic build-up was performed on the maxillary left lateral incisor, which underwent morphological modification to replicate the morphology of a maxillary right incisor. The patient was pleased with the treatment outcome. Cone-beam computed tomography provided evidence of tooth movement across the MPS. Although the movement of the tooth across the MPS is feasible, the treatment plan should also take other treatment options into consideration.

Keywords: Adult treatment, Anatomy, Midpalatal suture, Orthodontic treatment, Tooth movement

INTRODUCTION

Dental problems, such as periodontal disease, caries, and missing teeth, have a greater disruptive effect on adult orthodontic treatment plans than on orthodontic treatment in children and adolescents. The use of temporary anchorage devices (TADs) has diminished orientation- and direction-related restrictions in the orthodontic movement of teeth, thereby facilitating treatment. However, in cases involving many missing teeth on one side of the maxilla and/or mandible, the use of dental implants, prostheses, and autotransplantation are occasionally unavoidable.

Maxillary central incisors on one or both sides may be lost due to caries or traumatic avulsion. These tooth deficiencies may result in functional, esthetic, and psychological problems. In the orthodontic treatment of missing maxillary central incisors, there are several options for replacing one or both central incisors. In adult patients, the treatment options include autotransplantation, a partial denture, dental implants, and closure of a single edentulous space by substituting the missing central incisor with the ipsilateral lateral incisor.

Tooth movement across the midpalatal suture (MPS) is a treatment option for closing a maxillary central incisor space, which might help avoid prosthetic treatment, reduce the number of extractions of healthy teeth, and help correct crowding and incisor proclination. Orthodontic treatment with translocation of a maxillary central incisor across the MPS has been described

previously, but all of these reports involved young or adolescent patients with a MPS that had not yet ossified.[1-5] In the previously published cases, in which midline-crossing techniques were used, treatment was mostly initiated during the mixed dentition phase and completed by 13 years of age,[1] including one case involving a 19-year-old patient who received treatment before ossification of the MPS.[2] In these cases, the MPS was distorted in the same direction as the tooth movement and the connective tissue of the suture were incorporated into the periodontal ligament.[1,2] However, tooth movement across an ossified MPS has been reported only in animal experiments,[6] and there are no reports describing the movement of a central incisor across an ossified suture in adult patients.

This article presents a case in which a maxillary central incisor was moved to the opposite side across the ossified MPS in an adult patient.

CASE REPORT

The patient was a 26-year-old woman with the chief complaints of masticatory disturbance caused by missing teeth and crowding of the mandibular anterior teeth. The molar relationships were angle Class II on the right side and angle Class I on the left side [Figure 1]. The right mandibular first molar and the maxillary left lateral incisor were in crossbite. Crowding was observed in both maxillary and mandibular anterior regions. The overbite was 6.0 mm and the overjet was 3.0 mm. The maxillary right second premolar had been extracted due to caries and the maxillary right molars had moved mesially. A residual root of the mandibular left first premolar was present. Endodontic treatment had been performed for the maxillary right central incisor, but it could not be saved. Clinical and panoramic radiographic evaluations of the dentition revealed semi-impaction of the mandibular left third molar and the presence of distal subgingival caries in the mandibular left second molar; the patient reported moderate pulp symptoms [Figure 2]. A restoration with accurate adaptation would have been extremely difficult to achieve in this molar because the caries was subgingival. The cephalometric analysis showed a skeletal Class I malocclusion (ANB angle: 3.1°) [Figure 2 and Table 1]. The patient demonstrated labial inclination of the maxillary and mandibular central incisors (IMPA: 108.7° and FMIA: 49.8°). A posteroanterior (PA) cephalometric radiograph showed that her maxillary dental midline had deviated 4.0 mm to the left, while her mandibular midline had deviated 2.0 mm to the right. The landmarks were selected on the basis of previously published PA reproducibility studies. Cone-beam computed tomography (CBCT) was performed, but whether the MPS was open or closed was not clear [Figure 3a-d].

The patient was diagnosed as having an angle Class II, Div 1 subdivision, right side malocclusion with a skeletal Class I relationship and multiple teeth with poor prognoses.

Treatment objectives

The treatment objectives for this patient were to: (1) Eliminate crowding, (2) establish an ideal overjet and overbite and to achieve a functional and stable occlusion in a Class I molar relationship, (3) achieve maxillary and mandibular dental midline coincidence with the facial midline, and (4) make the oral environment easy to maintain while saving as many healthy teeth as possible.

The treatment plan included the following steps: (1) Extraction of the maxillary right central incisor and movement of the maxillary left central incisor across the MPS followed by mesial movement of the left lateral incisor and left posterior teeth, (2) extraction of the maxillary right third molar and distalization of the maxillary right posterior teeth with TADs

Figure 1: Pre-treatment intraoral photographs.

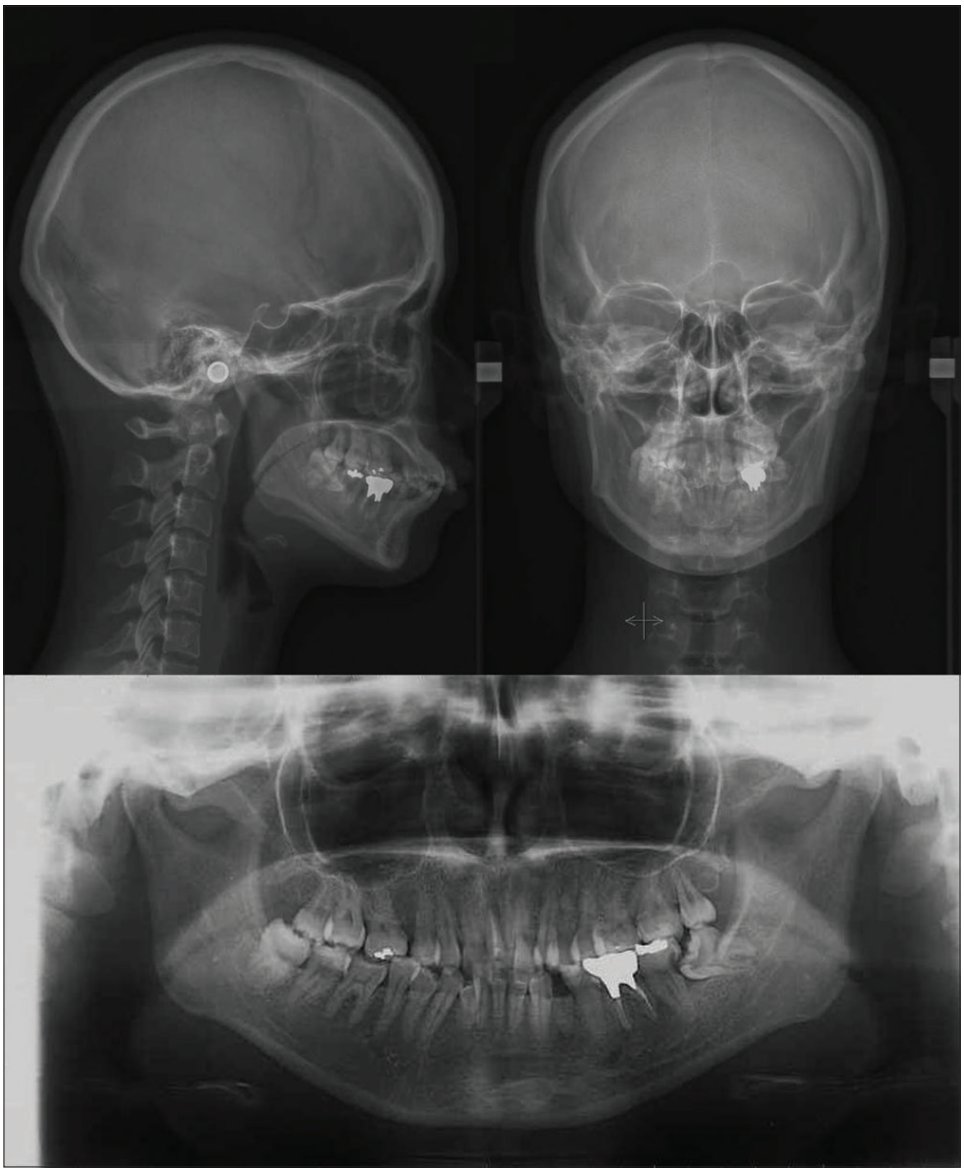

Figure 2: Pre-treatment lateral and posteroanterior cephalometric and panoramic radiographs.

to obtain Class I molar relationships, (3) extraction of the mandibular right second premolar and left first premolar, (4) extraction of the mandibular left second molar to mesialize and upright the third molar, and (5) spare the maxillary left third molar for use as a potential donor tooth for future autotransplantation. To achieve the required orthodontic movements, placement of a multibracket appliance on both arches would be required. Post-treatment modifications of the shapes of the crowns of the maxillary anterior teeth including the maxillary left canine would also be necessary.

Table 1: Changes in the cephalometric variables.

Variables (degrees)	Pre-treatment (degrees)	Post-treatment (degrees)	Japanese norm (degrees)
SNA	88.4	87.7	82.3±3.5
SNB	85.3	85.2	78.9±3.5
ANB	3.1	2.5	3.4±1.8
FMA	21.5	21.4	28.8±5.2
U1 to SN	138.0	126.7	104.5±5.2
FMIA	49.8	52.4	58.0

Treatment alternatives

The first alternative was prosthetic replacement using dental implants or bridges, or tooth transplantation. The maxillary left first premolar would have to be extracted to be able to correct the maxillary anterior crowding and the overjet. In addition, the protrusion of the maxillary anterior teeth would be corrected with the aid of TADs. The problems with

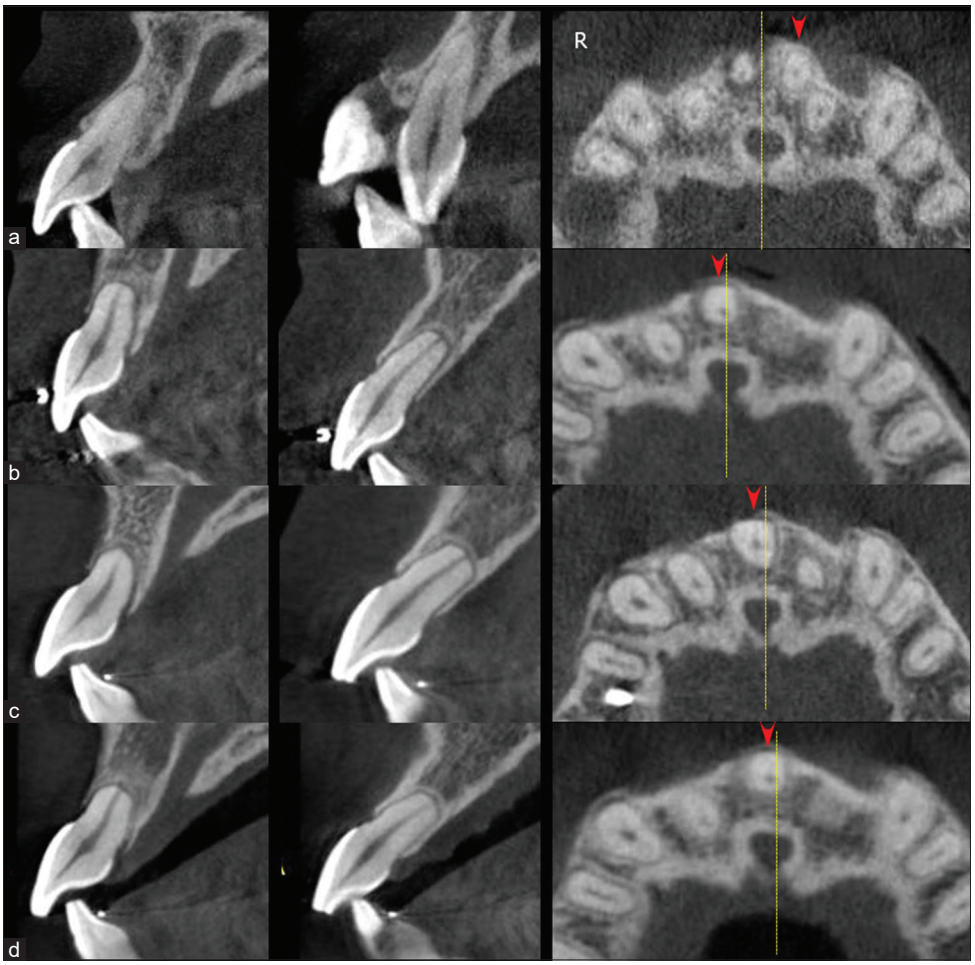

Figure 3: Cone-beam computed tomography sagittal (upper and middle) and horizontal (bottom) images of the maxillary left central and lateral incisors and the maxillary anterior area in the horizontal plane. The red arrowheads indicate the root of the maxillary left central incisor and the yellow broken line depicts the midline that corresponds with the midpalatal suture. (a) Pre-treatment; (b) after completion of the space-closing procedure; (c) post-treatment; (d) post-retention. R: Right.

this treatment alternative would be many. Although dental implants are permanent and do not require cutting down the adjacent teeth, the disadvantages include limitations associated with their cost and invasiveness, along with the required maintenance. Bridges are less costly; usually, the entire process can be completed in a few weeks. However, in the construction of bridges, cutting down several natural teeth is necessary, thereby increasing the risk of caries that leads to periodic replacement.

The second alternative plan considered included the movement of the maxillary left central incisor into the position of the right central incisor extraction space. In addition, mesial movement of the left lateral incisor into the position of the left central incisor would require modification of the crown morphology of the central incisor using composite resin; mesial movement of the left canine into the position of the left lateral incisor would require correction of its form by enameloplasty; and mesial movement of the left first premolar into the position of the left canine would require correction of the angulation and torque. This second alternative was chosen because the extraction of the maxillary left first premolar and the prosthetic replacement using dental implants or bridges, or tooth transplantation into the right central incisor area, would not be necessary. In addition, since this patient had a high risk for caries, we decided to spare the maxillary left third molar for use as a potential donor tooth for future autotransplantation. The maxillary right third molar had caries, while the left one was intact. Furthermore, the crowding in the maxilla was severe. Therefore, the total distalization plan was set aside and TADs were used only in the right side of the maxilla.

Based on the above treatment strategy, an orthodontic setup model was prepared, which showed that the extent of lingual tipping at the left maxillary central incisal edge was 6 mm, while that at the mandibular central incisal edge was 2 mm. Due to the restricted but inevitable incisal movement, it

was thought that the protrusive anterior tooth could not be retracted to within the normal range.

Treatment progress

Treatment began with extraction of the following teeth: The maxillary right third molar, the mandibular left first premolar, the mandibular left second molar, and the mandibular right second premolar. Then, 0.018 × 0.025-inch pre-adjusted edgewise brackets (Dentsply-Sankin and Tomy, Tokyo, Japan) were bonded to all maxillary teeth and the mandibular lateral posterior teeth, and 0.016 × 0.022-inch improved super-elastic nickel-titanium (Ni-Ti) alloy wires (L&H, Tomy, Tokyo, Japan) were used for the initial leveling. Orthodontic miniscrews (Dual top, Jeil Medical Co., Korea) were inserted between the maxillary right first premolar and first molar to reinforce anchorage for distalization of the maxillary right canine, first premolar, and molars [Figure 4a]. The mandibular left third molar was tracked using an elastic power chain. A Ni-Ti alloy open-coil spring (100 g) was used to move the maxillary left central incisor to the right side, across the MPS [Figure 4b]. Once the maxillary left central incisor had been moved to the right side, traction was commenced on the maxillary left lateral incisor. After 12 months of treatment, a panoramic radiograph indicated that the apex of the root of the left central incisor was still to the left of the MPS [Figure 4c]. After 1 year and 10 months of orthodontic treatment, the maxillary left lateral incisor position was corrected, and both the maxillary and mandibular dental arches were almost leveled [Figure 3a-d]. The maxillary left central incisor root had moved through the MPS and severe root resorption was observed on the CBCT, so we did not attempt further bodily movement of the tooth. Improved super-elastic Ni-Ti alloy wires (0.018 × 0.025-inch; L&H, Tomy, Tokyo, Japan) were used for detailing. After 3 years and 8 months of edgewise appliance treatment, the brackets were removed and a circumferential-type retainer was placed in the maxilla while a Hawley-type retainer was placed in the mandible. Furthermore, a canine-to-canine fixed lingual retainer was bonded to the lower anterior teeth.

After 3 months of retention, the maxillary left lateral incisor underwent acrylic build-up for morphological modification. We performed enameloplasty on the maxillary left central incisor as well as canine. However, the extent of enameloplasty was minimal because of the patient's demand to perform as little enameloplasty as possible. The maxillary left and mandibular right third molars were spared in the interim so that the maxillary left third molar might be used as a donor tooth for future autotransplantation. Thus, the maxillary left third molar was covered with the maxillary retainer, to prevent overeruption during the retention period.

TREATMENT RESULTS

An angle Class I molar relationship, and optimal overjet and overbite, was achieved [Figure 5]. The maxillary and mandibular dental midlines were coincident with the facial midline [Figure 6] Superimposition of the before and after treatment [Figure 7] and the pre- and post-treatment cephalometric analysis [Table 1] showed lingual retroclination of the maxillary and mandibular incisors and an improvement in labial inclination (IMPA: 106.2° and FMIA: 52.4°).

The maxillary left central incisor was bonded with a right central incisor bracket. Likewise, the maxillary left lateral incisor was bonded with a left central incisor bracket, and the left canine was bonded with a left lateral incisor bracket. These steps helped achieve thorough bodily movement of the teeth with good angulation and torque. The mandibular left third molar underwent uprighting and mesialization to function as a second molar. The pre-treatment PA cephalometric radiographs showed that the maxillary and mandibular dental were not coincident with the facial midline [Figure 8a]. The post-treatment PA cephalometric radiographs showed that the maxillary and mandibular dental was coincident with the facial midline [Figure 8b]. We moved the crown of the maxillary left central incisor to the right side of the MPS but not the apical 1/3rd of the root. Movement of the maxillary left central incisor across the midline was achieved because root resorption was detected. In CBCT images, root resorption

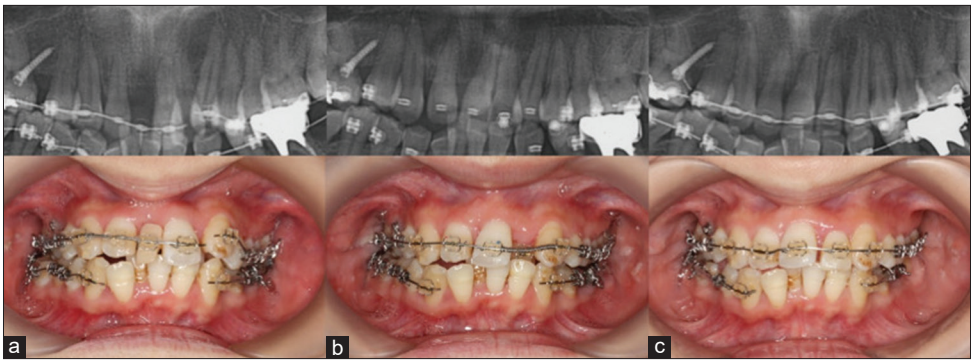

Figure 4: Intraoral photographs and panoramic radiographs showing treatment progress after (a) 3 months; (b) 7 months; and (c) 12 months.

Figure 5: Post-treatment intraoral photographs.

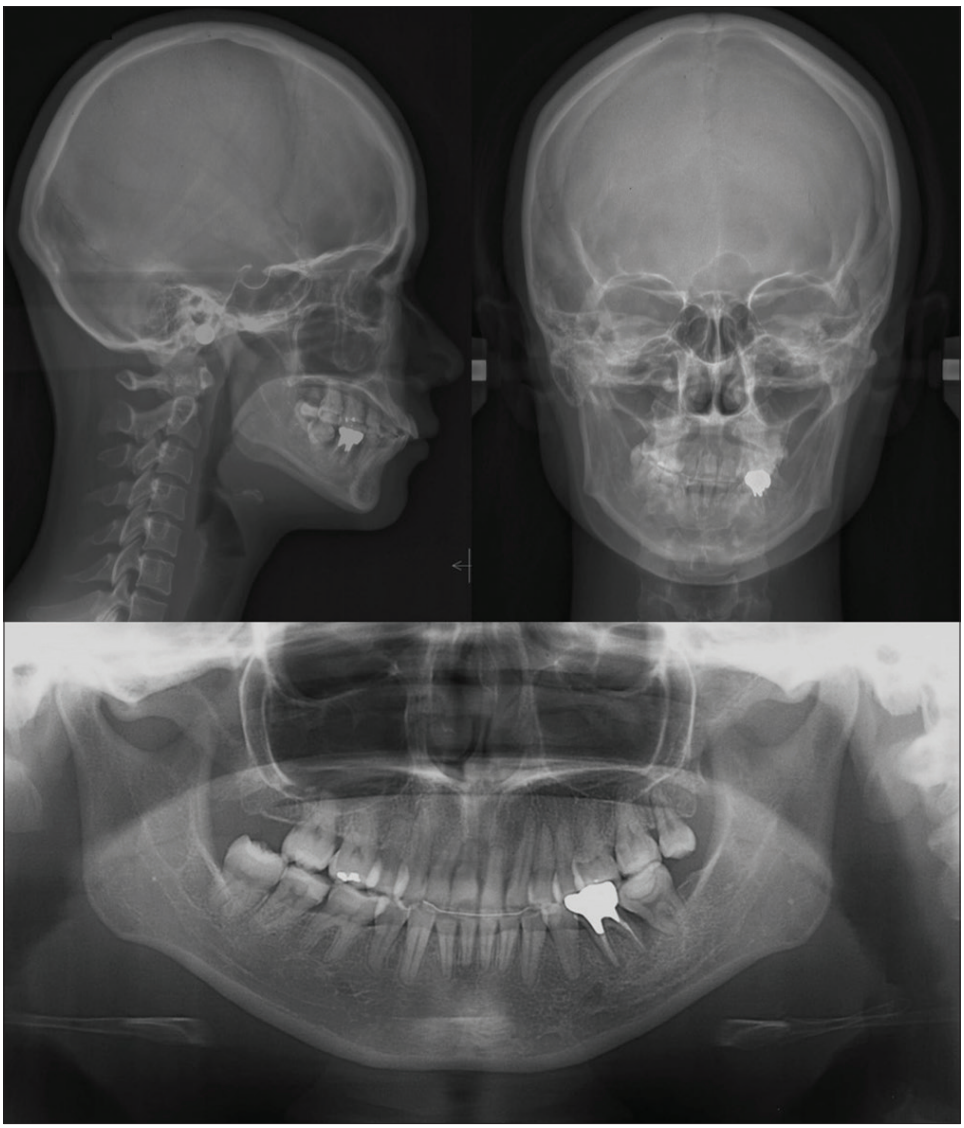

Figure 6: Post-treatment lateral and posteroanterior cephalometric and panoramic radiographs.

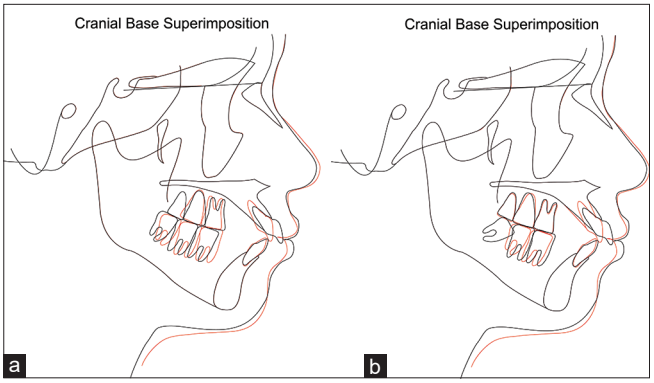

Figure 7: Superimposed tracings of the pre-treatment (black lines) and post-treatment (red lines) cephalometric radiographs. (a) Right; (b) left.

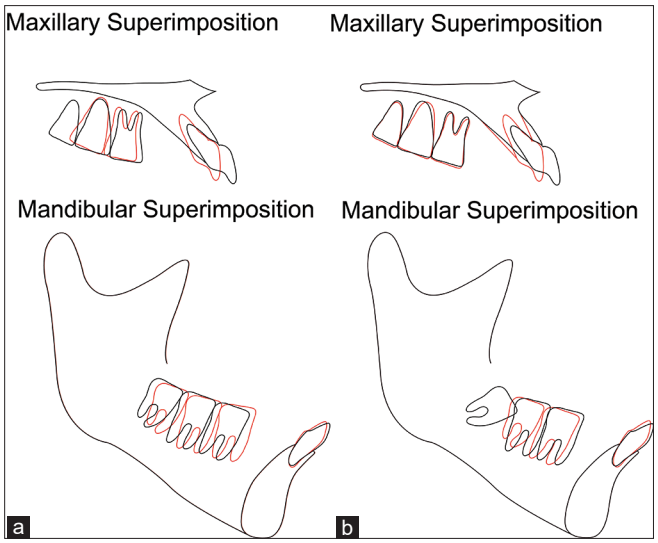

Figure 8: Tracings of the posteroanterior cephalometric radiographs. (a) Pre-treatment; (b) post-treatment.

was seen not only in the maxillary left central incisor but also in the lateral incisor [Figure 3a-d]. Quantitative changes in the root lengths of the maxillary anterior teeth are shown in Table 2. Post-treatment stability of the occlusion was assessed in follow-up examinations over 2 years [Figure 9]; the occlusion was acceptable 2 years post-treatment without the progression of root reabsorption [Figure 3a-d].

DISCUSSION

In this case, the maxillary right second premolar had been previously extracted. In addition, extraction of the maxillary right central incisor was planned due to an untreatable apical root lesion, and the left first premolar and second molar of the mandible could not be preserved because of caries. There was no need for tooth extraction on the left side of the maxilla and on the right side of the mandible for dental treatment. For orthodontic treatment in cases with two or more missing teeth on one side of the jaw, a prosthesis, or a dental implant, or autotransplantation is required. On the left side of the mandible, the extraction of the second molar was compensated by uprighting the third molar and moving it mesially. Extraction in the maxilla was avoided to improve the maxillary labial incisor inclination and crowding on the left side of the maxilla, and we planned to move the maxillary left central incisor across the MPS to the right side to substitute for the prosthesis.

The post-treatment PA cephalometric radiograph showed that the maxillary and mandibular dental midline was on the facial midline. After evaluating the post-treatment location of the root of the maxillary left central incisor using 69 horizontal CBCT images [Figure 10], we found that the crown of this tooth had moved to the right of the MPS, while 8.7% of the apex remained on the left side of the MPS [Figure 11 and Table 3]. Previous reports have suggested that the maxillary central incisors should typically have a 3° distal tip, which means that their long axes should be divergent.[7] The left central incisor in this patient also showed a 3° distal tip before treatment. Due to the radiographic appearance of root resorption in this tooth, we avoided uprighting it fully. Thus, the root apex of the maxillary left incisor was located approximately in the center of the MPS.

CBCT has the advantage of isolating the MPS without interference of other anatomical structures. With the maturation of histological studies on the human MPS and advancements in CBCT technology, the identification rate of fused MPS has been increasing in patients older than 25 years of age.[8,9] However, one study reported that approximately 30% of women aged 30 years or older did not have a complete MPS fusion based on CBCT images.[10] In that previous report, the MPS maturation was determined by the central cross-sectional axial slice from the nasal to the oral surface. Before ossification, the morphology of MPS is identified as one relatively high-density line. During an early stage of ossification, MPS is identified as two parallel, scalloped, high density linens with a small low density space in between. As the ossification progresses, two scalloped, high-density lines remain visible only at the midline on the maxillary portion of the palate, but no longer in palatine bone. When sutural fusion has occurred, the density in the parasutural bone becomes identical to the density in other regions of the plate, and the MPS cannot be identified.[11]

In a previous report of orthodontic treatment with a maxillary central incisor across the MPS, the MPS lines remained visible in CBCT images at the midline on the maxillary portion of the palate after treatment, suggesting that MPS ossification was incomplete at the time of treatment.[2] In contrast, in the present case, the MPS could not be identified in CBCT images: In the horizontal images showing the anterior tooth roots, the sutural bone density was the same as that in other regions of the ossified palate.

Table 2: Changes in the root lengths of the maxillary incisors.

Root length	Right lateral incisor	Right central incisor	Left central incisor	Left lateral incisor
Pre-treatment (mm)	14.2	13.7	14.5	14.3
Post-treatment (mm)	11.5	-	11.2	10.5
Reduction rate (%)	19.0	-	22.7	26.5

Figure 9: Post-retention intraoral photographs.

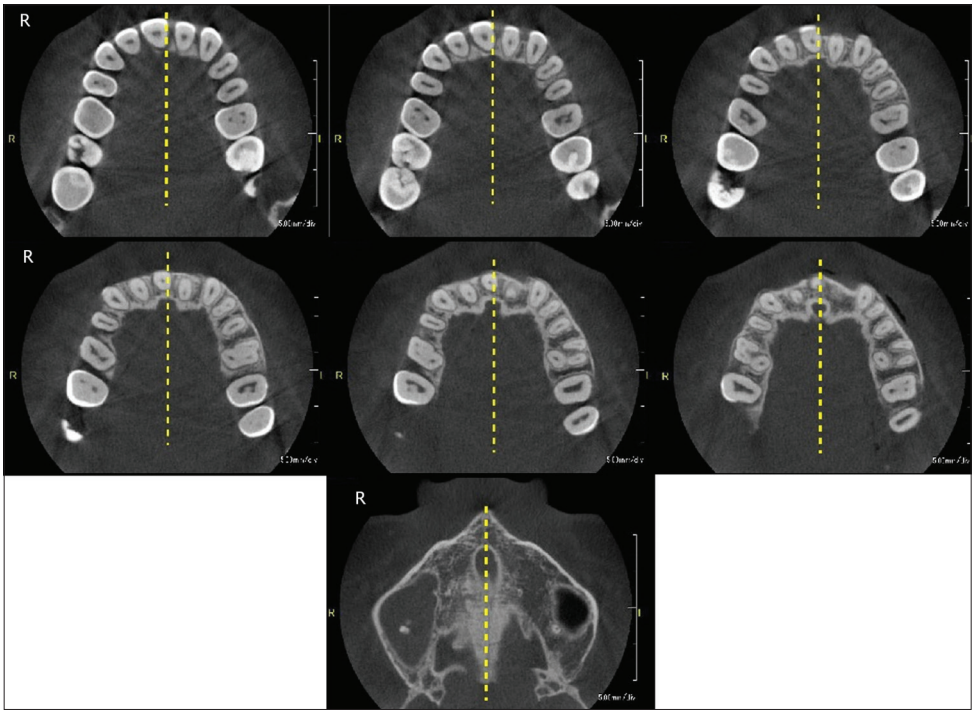

Figure 10: Representative cone-beam computed tomography images of the maxilla in the horizontal plane from the crown to the apex of the maxillary left central incisor (from the left of the upper row to the right of the middle row). We determined the midpalatal suture (MPS) in the image immediately beneath the nasal floor (yellow broken line in the bottom image). The MPS indicated by the yellow broken line was then transferred to the other images. R: Right.

When a lateral incisor is substituted for a central incisor, the canine takes the position of the lateral incisor. In this case, the left maxillary canine was placed in the position of the lateral incisor and the first premolar was moved into the position of the canine. This approach is usually employed for treating a missing lateral incisor or rearranging a canine-

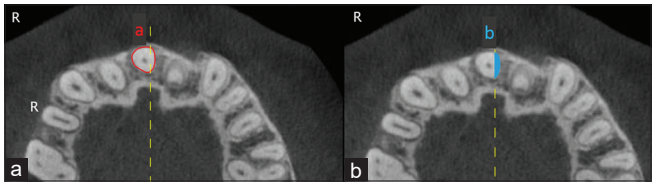

Figure 11: Quantitative evaluation of the post-treatment location of the maxillary left central incisor with reference to the midpalatal suture (MPS). (a) The total cross-sectional area (CSA) of the root (open red circle, a); (b) The remaining CSA of the root in the left side of the MPS (filled blue area, b).

Table 3: Post-treatment CSAs and the right-left proportion of the maxillary left central incisor root in reference to the midpalatal suture.

	Right	Left	Total
CSAs (mm^2)	602.2	54.5	656.7
Proportion (%)	91.7	8.3	100

The CSAs are the sum of each CSA of the root of the maxillary left central incisor on 69 horizontal CBCT images. CSA: Cross-sectional area, Right: Right side of the midpalatal suture, Left: Left side of the midpalatal suture, CBCT: Cone-beam computed tomography

premolar transposition after orthodontic treatment with different tooth positions.[12] In such cases, it is important to determine whether chewing can be performed without any functional impairment after treatment. In particular, since the position of the first premolar, rather than that of the canine, is important in lateral jaw movement, lateral group function was prioritized to prevent overload on the first premolars.[13] In this case, the occlusal state of the group function on both the left and right sides reduced the load on the left first premolar. Moreover, symmetric lateral jaw movement was observed after orthodontic treatment.

In this patient, the root resorption of the maxillary left central incisor occurred. Animal experiments have shown that movement of a tooth across the MPS appears to be faster in older adults with a closed MPS, but this movement also causes root resorption.[6] On the other hand, in patients with maxillary midline shift, the root proximity to the cortical plate of the incisor canal may be responsible for apical root resorption.[14,15] In this case, the buccopalatal width of the maxillary alveolar bone was narrow, and there was a possibility that the maxillary anterior tooth root might come into contact with the buccal cortical bone and cortical plate of the incisive canal. However, the maxillary left lateral incisor also showed root resorption after the orthodontic treatment. Thus, the root resorption of the maxillary left central incisor could not be solely explained by the movement across the MPS. Indeed, previous studies have identified multiple factors that may be associated with apical root resorption, including age, sex, treatment period, tooth type, root apex form, amount of tooth movement, orthodontic force, contact with the cortical plate, and endodontically treated teeth.[16]

A study evaluating the long-term status of teeth that had undergone root resorption during active orthodontic treatment showed no apparent changes after the removal of the appliance.[15] Although the maxillary left central tooth and the maxillary left lateral incisor showed 19–26.5% tooth root resorption [Table 3], there were no changes in mobility, depth of the periodontal pocket, nor in the bone height around the root.

The choices for restoring the anterior teeth include composite bonding, porcelain veneers, all-ceramic crowns, and metal-ceramic crowns. In general, the treatment of choice is the most conservative restoration that satisfies the esthetic requirements. Thus, in this case, the material used for the restoration was composite resin due to its availability and ability to create ideal tooth morphologies.

SUMMARY AND CONCLUSION

Although it is feasible to move the anterior tooth to the contralateral side across the MPS, other possible treatment options should be considered.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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