# Cone-beam computed tomography evaluation of orthodontic miniplate anchoring screws in the posterior maxilla

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**Introduction:** The purposes of this study were to evaluate the actual postplacement positions of orthodontic miniplate anchoring screws (MPAS) and to determine the risk factors for their failure and iatrogenic effects on the intraoral structures. **Methods:** Three-dimensional cone-beam computed tomography images were generated to examine 31 orthodontic miniplates and their MPAS (diameter, 1.5 mm; length, 4 mm), which showed good clinical stability 6 months after placement in the posterior maxilla of 18 patients. The cone-beam computed tomography data were analyzed with analysis of variance (ANOVA) statistics to evaluate the difference of placement depth and vertical distance of the MPAS from the cementoenamel junction to the center of the screw. The Fisher exact test was used to determine differences in MPAS position, root proximity, and sinus penetration. **Results:** The mean placement depth of the MPAS was 2.48 mm with no significant difference relative to their position. Twenty-six (of 74) MPAS were placed in the dentition area. Of these 26, 14 were placed in interdental spaces, and the other 12 followed the direction of the roots. Nine MPAS showed root proximity, and 7 MPAS had root penetration, all of which were placed in the central position of the miniplate. Thirty-nine MPAS penetrated the sinus, indicating a low interrelationship between placement depth and cortical bone thickness of the sinus. **Conclusions:** Miniplates were successfully retained by MPAS even with less-than-ideal placement. Root contact and proximity of MPAS seem to have minimal effects on the successful stabilization of miniplates. Pertinent guidelines should, however, be followed during MPAS placement to minimize the risk of damage to adjacent roots. (Am J Orthod Dentofacial Orthop 2009;136:628.e1-628.e10)

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Orthodontic miniplates are a reliable alternative to conventional orthodontic mini-implants and are closely associated with temporary skeletal anchorage devices.[1-5] The miniplate system has been reported to achieve greater stability compared with orthodontic mini-implant systems. However, miniplate protocol requires minor flap surgery for placement and removal that can cause swelling and discomfort.[5]

Many risk factors—eg, location, timing of force application, and others—have been identified as conditions that can affect successful placement of conventional mini-implants in interradicular spaces.[5,6] Of these adverse conditions, root proximity is a major factor for mini-implant failure in orthodontic anchorage applications.[7] Liou et al[8] maintained that mini-implants should be placed in an edentulous area if the patient does not have enough interradicular space or if there is less than 1 mm of space available between the mini-implant and the proximal root.

The high success rate and the availability of force application independent of adjacent teeth have made the miniplate anchorage system increasingly popular.

Clinicians use surgical miniplates for orthodontic anchorage by exposing the occlusal end of the plate to the intraoral environment. The miniplate design has been modified and developed by Sugawara et al[4] to act as a hook, whereas De Clerk and Cornelis[9,10] modified it as Ballard miniplate. However, the miniplate has certain drawbacks: eg, complicated design, need for more aggressive surgical procedures when placing it on the zygomatic buttress, and the risk of penetrating adjacent roots or even the sinus itself.[5,11] Chung et al[12,13] designed a 0.036-in diameter tube by curving the end of a titanium miniplate, called the C-tube. This clinical group maintains that the C-tube appliance can be positioned anywhere in the mouth similar to the conventional miniplate, with the primary recommended placement area in the posterior maxilla below the zygomatic buttress. Different C-tube designs have options of 2 to 4 holes for the 1.5-mm diameter × 4-mm length miniplate anchoring screws (MPAS) (Gebrüder Martin GmbH & Co. KG, Tuttlingen, Germany). The size of MPAS makes it unlikely to adversely affect adjacent roots; therefore, the C-tube miniplate is a feasible alternative to conventional independent orthodontic mini-implants in complex anatomic areas for optimal skeletal anchorage. These preclusive anatomic sites include narrow interradicular spaces, extended maxillary sinus, and areas with severe alveolar bone loss (Fig 1). Although many placements of miniplates have been considered successful based on clinical stability, the actual positions of miniplates placed by clinicians have not been evaluated by using three-dimensional (3D) imaging techniques. Currently, there are no scientific assessments of the frequency of MPAS and root proximity, root penetration, and maxillary sinus involvement after miniplate placement. There is no literature on the position of cortical bone penetration or the effects on the surrounding structures with the 4-mm length MPAS in patients.

The purpose of this study was to analyze 3D cone-beam computed tomography (CBCT) images of miniplates after placement in patients who had unfavorable anatomies for standard single mini-implant anchorage. We evaluated the actual position of miniplates and their MPAS, risk factors, and other effects of the 4-mm MPAS on adjacent anatomic structures.

## MATERIAL AND METHODS

All patients seeking orthodontic therapy at the Uijeongbu St. Mary's Hospital, Uijeongbu, Gyeonggi-do, Korea, were asked to volunteer for orthodontic therapy with a treatment plan involving a skeletal anchorage device placed in the posterior maxilla and 3D CBCT scanning after its placement. It was difficult to place orthodontic mini-implants in all patients who participated in the study because of anatomic limitations and treatment methods. Criteria for subject selection in this study were, therefore, limited to patients who had miniplates placed with a predefined size of MPAS in the posterior maxilla and then had a CBCT scan after miniplate placement. This CBCT study was approved by the institutional review board of this hospital by The Catholic University of Korea. Eighteen patients (9 men, 9 women; average age, 25.2 years) were selected after screening. Table I shows the categories, numbers of patients, and total miniplates placed.

A total of 74 drill-free MPAS (diameter, 1.5 mm; length, 4 mm) were used for miniplate placement. Orthodontic forces were applied a week after placement, and the miniplates were retained for 6 months or longer in all patients. The mean treatment time was 13.05 months.

Miniplate placement and orthodontic treatment are shown in Figure 2. The C-tube miniplate is anchored to the cortical bone near the posterior teeth instead of the zygomatic buttress. Two types of miniplates were used in this study: the I-type (n = 3) was placed with 2 drill-free MPAS in the posterior maxillary area when space was not optimal because of narrow interradicular spaces or dilacerated roots, and the cross-type C-tube (n = 28) was placed with either 2, 3, or 4 drill-free MPAS depending on the quality of bone and the required orthodontic vectors. All C-tubes were secured in the posterior maxilla.

The surgical protocol for the placement of C-tube miniplates was previously described in detail and is briefly summarized here.[12,13] The first 3-mm horizontal incision is made (#15 scalpel blade) where the head of C-tube will be placed, and the second 3-mm horizontal incision is made approximately 2 mm apical but parallel to the first incision. The C-tube miniplate is placed through the second horizontal incision, on the bone surface with the head of the C-tube exposed in the oral cavity (Fig 2), and then fixated with self-drilling MPAS (diameter, 1.5 mm; length, 4 mm). The surgical area is sutured with 4-0 silk (Fig 2, *D*), and the patient is prescribed nonsteroidal anti-inflammatory drugs and antibiotics for the next 3 days. The suture material is removed 1 week after miniplate placement. Typically, the head of the C-tube miniplate is placed at the junction between the attached and movable mucosa. In 5 patients with anterior protrusion, fixed appliances were not attached to the molars, and en-masse retraction was achieved with anchorage against the C-tube miniplates in the posterior maxillae (Fig 3, *A-C*). In 11 patients, either anchorage or hooks for intermaxillary elastics were used for distalization of either the maxillary and mandibular dentitions or only the mandibular dentition

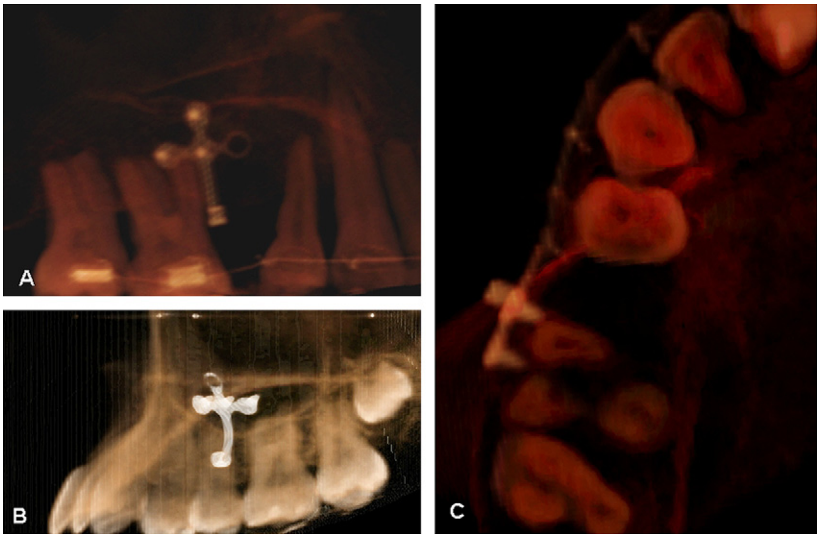


**Fig 1.** 3D reconstructed images (InVivo Dental, Anatomage, San Jose, Calif) of an orthodontic temporary anchorage device—C-tube miniplate.

**Table I.** Details of the miniplates placed

| *Category* | *Patients (n)* | *Miniplates (n)* |
|---|---|---|
| Narrow interradicular space or dilacerated roots | 6 | 10 |
| Full dentition distalization | 6 | 11 |
| Extended maxillary sinuses | 4 | 7 |
| Severe alveolar bone loss in posterior maxillae | 2 | 3 |

(Fig 3, *D-F*). C-tube miniplates were used in 2 patients with anterior open bites to intrude the posterior dentition.

A CBCT device (PSR 9000 N, Asahi Roentgen, Kyoto, Japan) was used to take postsurgical scans, with a field of view encompassing the entire maxilla at a resolution of 0.15 $mm^3$ voxel size. The patient's head was positioned so that the occlusal plane was parallel with the positioning beam and secured in place. The radiographic output was adjusted to 40-mm thickness and 36-mm width to accommodate the maxilla in the range of the positioning beam.[14]

CBCT data were saved in digital imaging and communications in medicine (DICOM) format by using the Picture Archiving Communication System (Infinit, Seoul, Korea) at KyungHee University Dental Hospital. V-works software (version 5.0, CyberMed, Seoul, Korea) was used to analyze the DICOM data for quantitative measurements. Since the objective of this study was to postsurgically evaluate the actual positions of MPAS and their effect on the stability of miniplates in complex anatomic conditions, placement height (PH), placement depth (PD), and root proximity (RP) were assessed 3 dimensionally. Also, the MPAS were categorized according to their placement hole location in the miniplate: position 1 (MPAS placed through the mesial hole of the miniplate), position 2 (MPAS placed through the center hole of the miniplate), position 3 (MPAS placed through the supercenter hole of the miniplate), and position 4 (MPAS placed in the distal hole of the miniplate) (Fig 4).

The PH and PD of the MPAS were evaluated (Fig 5). The PH of MPAS was the distance from the cementoenamel junction (CEJ) to the center of the screw. The PH can be measured with the adjusted sagittal image and cross-sectional image derived from the axial image (Fig 5, *A*). PD of MPAS is the actual length of the MPAS that penetrated the bone. The PD was also measured from the sagittal image. If the miniplates are fully adapted following the outer surface of the cortical bone, the PD is the distance from the intersection of the inner surface of the miniplate and MPAS to the apex of MPAS. If the miniplate was partially adapted to the outer surface of the cortical bone, the PD was measured along the MPAS that had bony contact to the tip of the MPAS (Fig 5, *B*).

The proximity of the MPAS to the adjacent roots and penetration of the maxillary sinus were also evaluated (Figs 6-9). By using the axial and sagittal planes of the CBCT images, the proximity of MPAS to the adjacent roots was evaluated. When actual root-MPAS contact was observed in any of 3 planes (axial, cross sectional, or sagittal), it was defined as RP.[14] After orientation of the frontal plane intersecting the axial plane, the distance between the apex of MPAS and the nearest

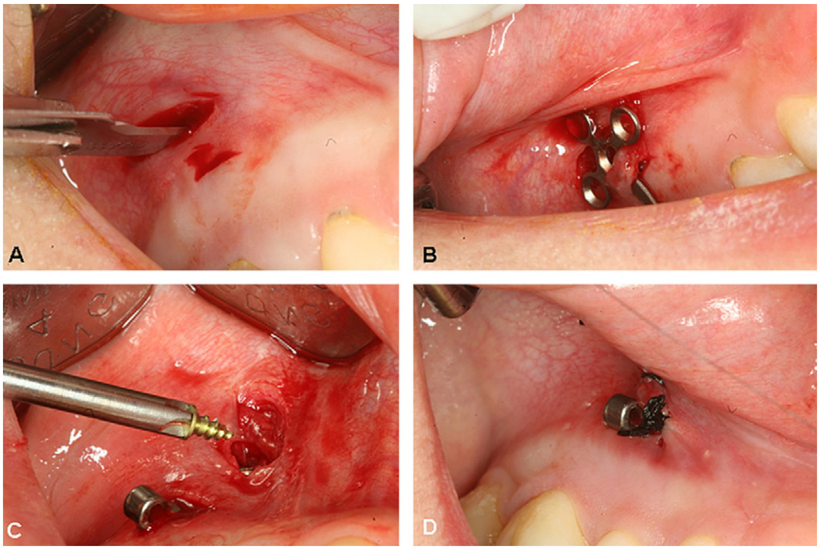

**Fig 2.** Placement protocol of the C-tube miniplate: **A,** double incision with #15 surgical blade; **B,** cross-type C-tube placed at the incised area; **C,** self-drilling miniscrew (diameter, 1.5 mm; length, 4 mm) is placed with a manual hand driver; **D,** orthodontic C-tube is exposed after miniplate placement.

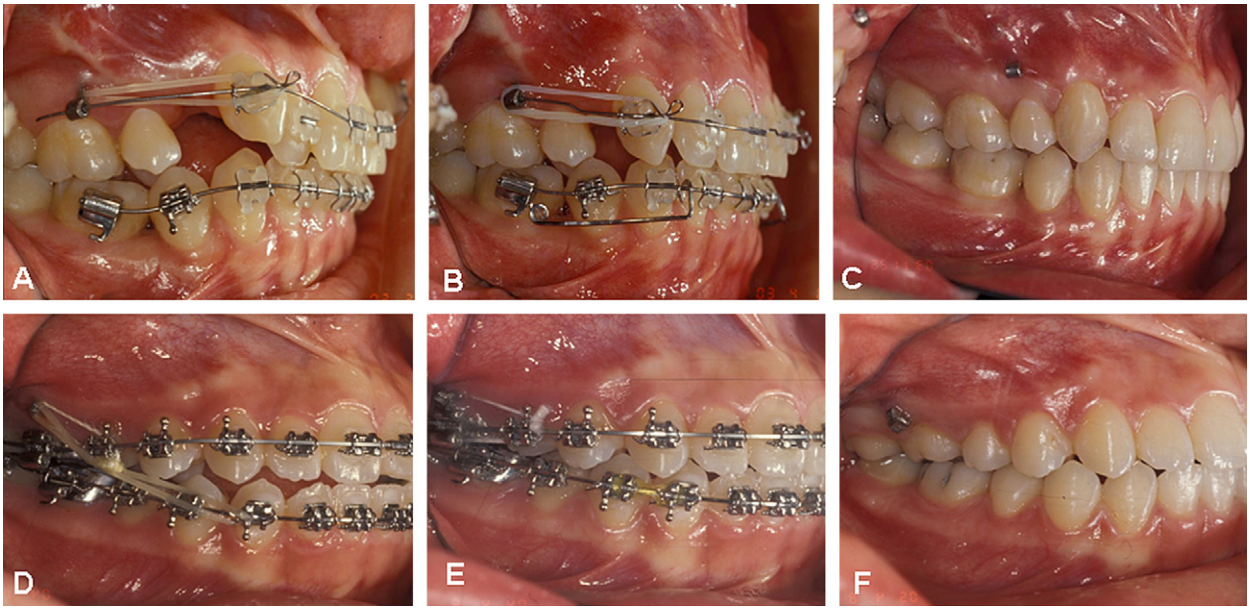

**Fig 3.** Use of the C-tube: **A-C,** independent appliance for en-masse retraction; **D-F,** hook for intermaxillary elastics and maxillary posterior intrusion.

root surface was measured (Figs 6-8). No value was assigned if there was barely contact. A negative value was assigned if there was root penetration, and a positive value was given if the root was not in contact.

An axial plane was constructed passing through each MPAS of the miniplate. By using postplacement CBCT images as a guide, the MPAS in this study were divided into 3 groups according to RP: group 1, no RP (Fig 6); group 2, minimal RP (Fig 7); and group 3, root penetration (Fig 8). Sagittal and frontal plane images were used to identify any maxillary sinus penetration of the MPAS (Fig 9). Additionally, cortical bone depth was measured in the areas of penetration following the MPA's placement direction.

### Statistical analysis

To test for intrarator reliability, CBCT data sets from 6 patients were randomly selected and remeasured by using the same defined parameters 2 weeks after the initial data analysis. These results showed high reproducibility (Pearson correlation coefficient, 0.77-0.94; $P$ <0.001).

The means and standard deviations of PH were calculated from the CBCT data. The PDs of MPAS in the CBCT images were recorded and compared by using paired $t$ tests to evaluate the differences between the left and right sides. There were variations in the numbers of MPAS in patients. The difference between the sexes was disregarded.

Differences in PH and PD were analyzed according to MPAS position. Analysis of variance (ANOVA) was used to determine whether there was a difference in means between the 2 groups. If a difference in means was observed, the Duncan multiple comparison was performed. ANOVA and a multivariable comparison with the Duncan multiple range test were used to compare differences between the PH and PD groups according to MPAS position.

The Fisher exact test was used to determine root contact and sinus involvement according to the MPAS position, and the chi-square test was also used. All statistical calculations were made with SAS software (version 8.0, SAS Korea, Seoul, Korea).

## RESULTS

Tables II and III shows the means and standard deviations of PH, PD, and RP. There was no statistically significant difference between the right and left sides. A significant difference was found in PH between position 3 and positions 1, 2, and 4 with ANOVA. However, no significant difference was found in the PH between positions 1, 2, and 4. The average PD of MPAS was 2.48 ± 0.52 mm, and there was no significant difference in PD according to the various placement sites (Table III). Forty-eight of 74 MPAS were placed in edentulous areas, with 26 in dentulous areas. Fourteen were placed in interradicular areas, and 4 were away from the adjacent roots (Table IV). However, of the 9 MPAS showing RP, 7 had root penetration: 2 had root penetration at position 1, and position 2 had 5 incidents of root penetration.

In this clinical study, 39 maxillary sinus involvements by MPAS (left, 19; right, 20) were observed on the CBCT images (Fig 9, Table IV). No MPAS had

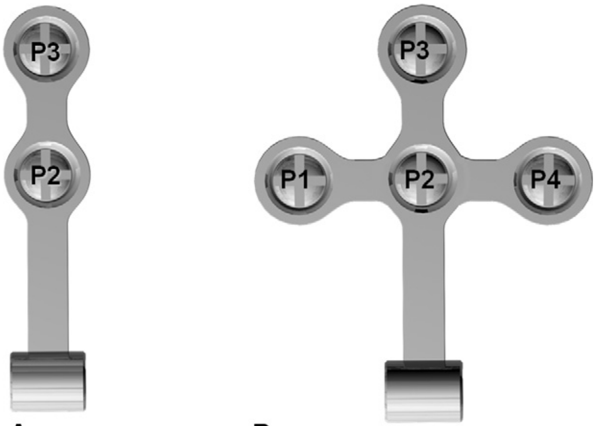


**Fig 4.** Schematic illustration showing the types of miniplates and associated miniscrew positions: **A,** I-type miniplate; **B,** cross-type miniplate.

a clinical complication. The miniplates were maintained only by the maxillary sinus wall. The mean cortical bone depth of the sinus wall was 1.36 mm, and the mean PD of the MPAS with sinus involvement was 2.66 mm when there was sinus penetration. The mean penetration length of MPAS was 1.31 ± 0.72 mm. There was no statistically significant difference between PD and thickness of the maxillary sinus wall or between the right and left sides. The coefficient of correlation between the PD of MPAS and the sinus wall cortical bone depth was $P = 0.6716$ for sinus involvement.

## DISCUSSION

The CBCT technology used in this study (0.15 $mm^3$ voxel size) has been used to provide 3D images enabling more detailed 3D visualization and quantification of mini-implant status in the posterior maxilla.[14-16] This study is, however, the first to analyze actual postplacement positions of miniplates, MPAS, and related risk factors such as root damage and sinus penetration. This type of 3D assessment cannot be made with conventional 2-dimensional dental radiographs.

The goals of this study were to analyze the postplacement status of anchoring screws used to secure miniplates in the posterior maxilla and to evaluate their effects on adjacent root structures and the maxillary sinus. The orthodontic miniplate primarily used in this study was the C-tube because its design and size are more favorable in the posterior maxilla than in the zygomatic buttress areas.[11-13] In addition, because MPAS of C-tubes can be placed much higher than a mini-implant makes it more attractive when interradicular space is limited because of dilacerated roots, expanded maxillary sinus, or severe alveolar ridge resorption. In these

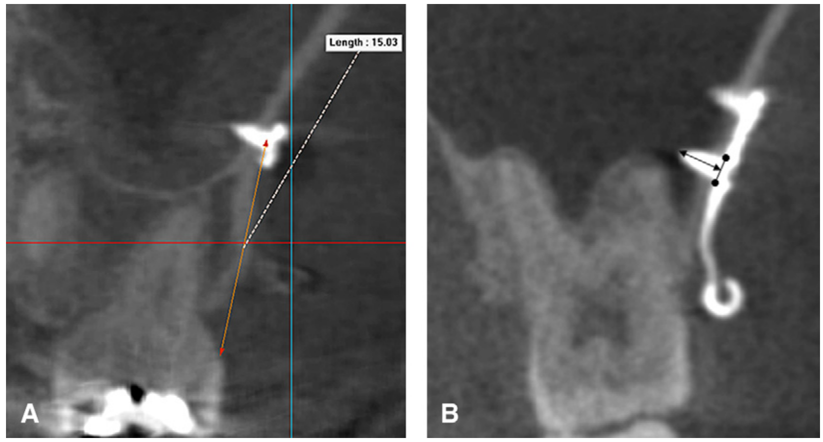


**Fig 5.** CBCT images of frontal view of the miniplate: **A,** vertical distance from the CEJ to the center of the miniscrew (PH); **B,** PD of the miniscrew from the cortical surface to the apex of the miniscrew.

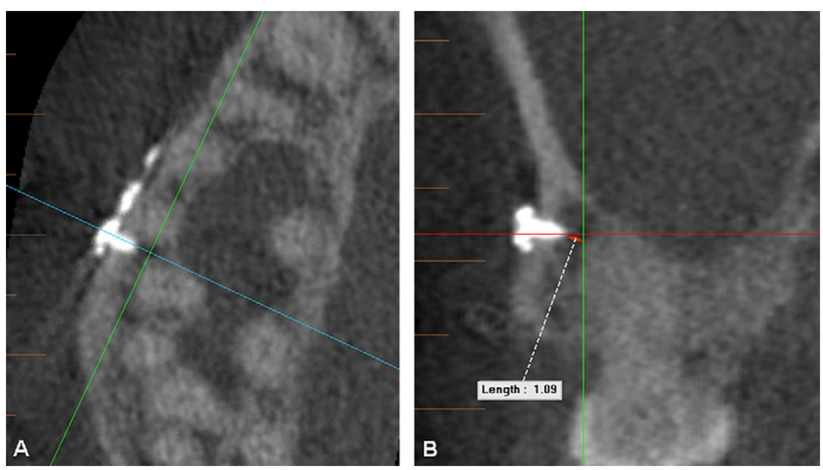


**Fig 6.** CBCT view of the miniplate with no root contact with the miniscrew: **A,** axial view; **B,** frontal view.

cases, an insecurely placed mini-implant might not be the best skeletal anchorage option for the biomechanics associated with ideal orthodontic tooth movement.

In the study by Kuroda et al,[7] RP was identified as a major risk factor for mini-implant failure. On the other hand, Kim et al[15] reported that the CBCT evaluation of orthodontic patients showed that 1-side RP and sinus perforations with initial primary stability might not be major risk factors for osseointegration-based mini-implant failures.

The MPAS in this study were 4 mm long, the shortest self-drilling miniscrews available. The small length and diameter of MPAS are also believed to contribute to minimizing potential damage to adjacent roots. Even with reduced size, however, 26 of 74 MPAS showed some root involvement after placement. Of the 9 MPAS with RP, 7 had root penetration, and 2 had root contact. Fourteen MPAS were placed in interradicular spaces, and 4 were placed far from the roots and had no effect on the roots. The 7:26 root penetration ratio was further analyzed as follows: 5 MPAS were placed at position 2, and 2 at position 1. Position 2 is usually the first place on a miniplate for an MPAS. Deviation in this position by unstable drilling technique often occurs and damages the roots. Therefore, this position needs special attention during MPAS placement.

Several authors have studied root damage by mini-implant placement and its consequences.[17-19] An animal study by Chen et al[17] showed that the iatrogenic lesion on the root caused by mini-implant placement was repaired with a narrow zone of mineralized tissue deposited on the root surface (most likely cellular cementum) and was

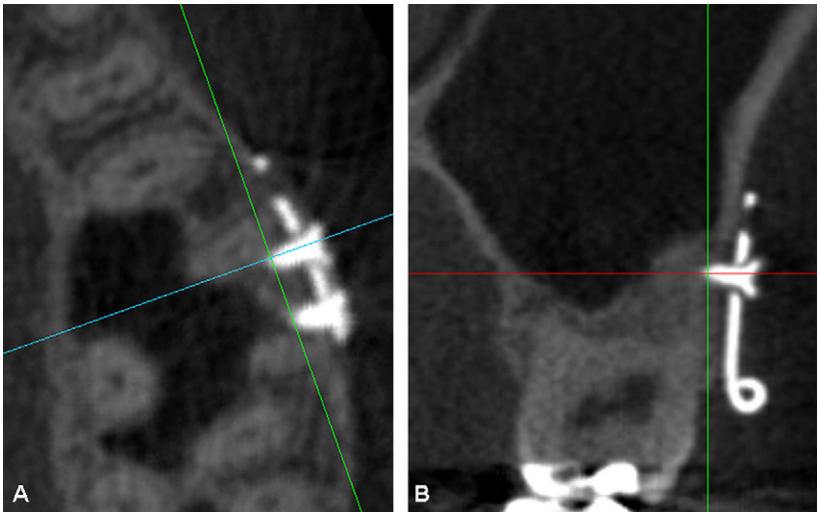


**Fig 7.** CBCT view of the miniplate confirming root contact with the miniscrew: **A,** axial view; **B,** frontal view.

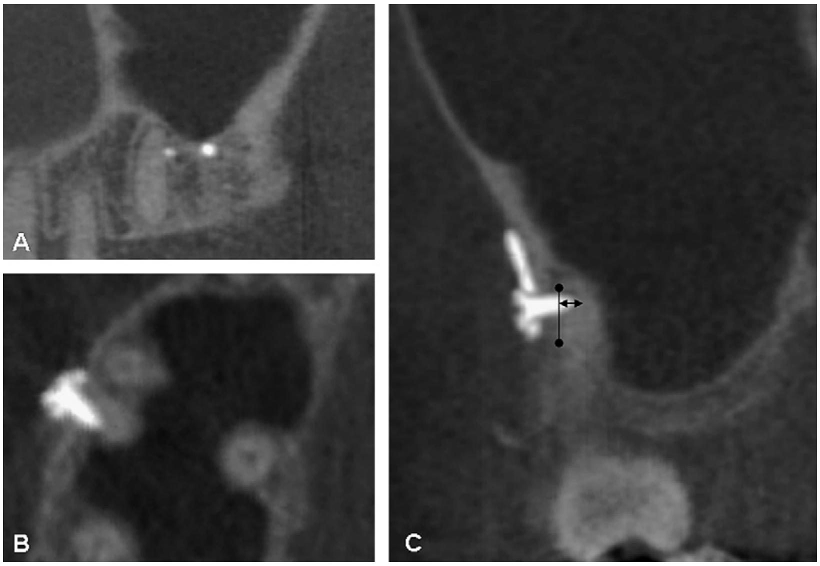


**Fig 8.** CBCT view of the miniplate showing root penetration of the miniscrew: **A,** sagittal view; **B,** axial view; **C,** frontal view.

mainly filled with alveolar bone, with the periodontal ligament space maintained. A human study by Maino et al[19] confirmed that damaged root surfaces recovered well after removal of the miniscrews. In this study, most patients were treated with a systemized orthodontic treatment technique with the archwire engaged through the C-tube of the miniplate without fixed appliances on the posterior dentition.[20-22] Since no appliance was applied to the penetrated root, there was no active movement of these teeth from root penetration; this might be why the mini-implant with root penetration was still stable during orthodontic treatment.

However, the surface of 1 MPAS used in posterior intrusion for anterior open-bite correction was believed to be damaged during molar intrusion. In this study, no patient had pain or discomfort during or after placement of the miniplates, and there was no evidence to suggest damage to tooth vitality. Therefore, root penetration by MPAS or possible related pulpal damage was not evaluated in this study.

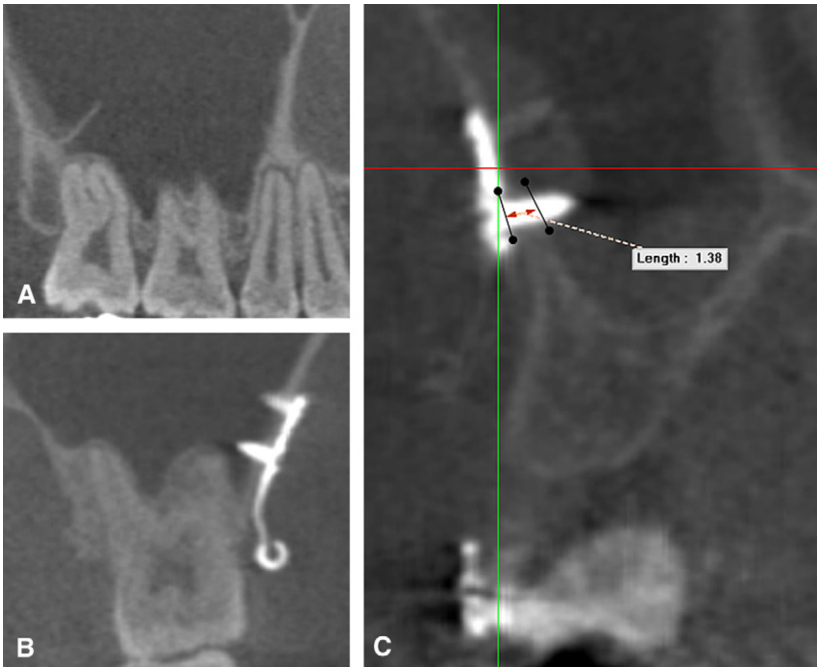


**Fig 9.** CBCT view of the miniplate showing sinus penetration of the miniscrew: **A,** sagittal view; **B and C,** frontal view.

**Table II.** PH and PD of miniscrews (mean ± SD and range in millimeters)

| | | *PH* | | *PD* | |
|---|---|---|---|---|---|
| *(NS)* | *NP* | *Mean ± SD* | *Range* | *Mean ± SD* | *Range* |
| Total | 31 (74) | 13.05 ± 2.54 | 5.87-20.35 | 2.48 ± 0.52 | 1.28-3.99 |
| Side | | | | | |
| Left | 16 (38) | 12.88 ± 2.29 | 9.06-19.26 | 2.46 ± 0.51 | 1.42-3.88 |
| Right | 15 (36) | 13.23 ± 2.80 | 5.87-20.35 | 2.49 ± 0.53 | 1.28-3.99 |

*NP,* Number of miniplates; *NS*, number of miniscrews; *PH,* vertical distance from the CEJ to the center of screw; *PD*, distance from the cortical bone surface to the miniscrew apex through the long axis of the miniscrew.

Although the length of MPAS was 4 mm, the length of MPAS in full-depth placement was measured only to have a mean of 2.48 mm in the CBCT images. Position 3 showed significant variations in position and PH. Since position 3 was the supercentral position, this much variation in vertical distances was not unexpected. In this study, there were no statistically significant differences of MPAS placed horizontally in positions 1, 2, or 4. This was because the horizontal position was determined by the exposed area of the miniplate, and there was no specific influence of anatomic structure (zygomatic buttress). There was no statistically significant difference in PD of MPAS or in root contacts in the various placement positions.

Thirty-nine of 72 MPAS had sinus involvement. Some MPAS were placed so that miniplates could

**Table III.** Comparison of PH and PD of miniscrews according to position in millimeters

| | | *PH* | | | *PD* | | |
|---|---|---|---|---|---|---|---|
| *Miniscrew position* | *NS* | *Mean* | *SD* | P *value* | *Mean* | *SD* | P *value* |
| 1 | 9 | 12.72[b] | 1.22 | | 2.13 | 0.48 | |
| 2 | 31 | 12.04[b] | 2.24 | <0.0001 | 2.50 | 0.41 | >0.05 |
| 3 | 12 | 16.53[a] | 2.49 | | 2.68 | 0.64 | |
| 4 | 22 | 12.70[b] | 1.70 | | 2.47 | 0.55 | |

*NS,* Total number of miniscrews; *PH,* vertical distance from the CEJ to the center of the miniscrew; *PD,* distance from the cortical bone surface to the miniscrew apex through the long axis of the miniscrew; *1*, miniscrew placed in the mesial hole of the miniplate; *2*, miniscrew placed in the center hole of the miniplate; *3*, miniscrew placed in the supercenter hole of the miniplate; *4*, miniscrew placed in the distal hole of the miniplate. Superscript letters indicate area with no statistically significant difference.

**Table IV.** Comparison of root proximity and maxillary sinus penetration according to screw position (%)

| Screw position | NS | Root Proximity: IDS | + | 0 | — | % | P value | Sinus penetration: n | % | P value |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 1 | 0 | 0 | 2 | 66.67 | | 4 | 44.44 | |
| 2 | 14 | 7 | 2 | 0 | 5 | 35.35 | 0.0719 | 15 | 48.39 | 0.1398 |
| 3 | 1 | 1 | 0 | 0 | 0 | 0.00 | | 10 | 83.33 | |
| 4 | 8 | 5 | 1 | 2 | 0 | 25.00 | | 10 | 45.45 | |

*NS*, Total number of miniscrews; *IDS,* miniscrew placed in interdental space; +, positive distance between miniscrew apex to root surface; *0*, root contact; —, root penetration; *1*, miniscrew placed in mesial hole of the miniplate; *2*, miniscrew placed in the center hole of the miniplate; *3*, miniscrew placed in the supercenter hole of miniplate; *4*, miniscrew placed in the distal hole of the miniplate.

obtain better retention from the sinus wall. The mean PD of MPAS with sinus involvement was 2.6 mm, and the mean cortical bone depth of the sinus wall at the involvement area was 1.36 mm. There was no significant interrelationship between the thickness of the maxillary sinus wall of MPAS placement and PD of MPAS, since the MPAS was placed flush with the plate regardless of sinus wall thickness.

Several studies reported that perforation of the maxillary sinus membrane during dental implant placement is not significant in causing postsurgical clinical complications.[23-25] In the study by Jung et al,[23] a dental implant that penetrated less than 2 mm through the mucosa of the sinus floor resulted in spontaneous recovering of the mucosal membrane over the implant. They suggested that the tearing of the maxillary sinus membrane caused by the dental implant was unrelated to the postsurgical sinus complications in animal experiments.

The sinus involvement in this study was defined as penetration of the Schneiderian membrane that often occurs when the thin lateral wall of the sinus is infractured from the buccal side.[26,27] In cases of sinus involvement by orthodontic mini-implants, it is recommended to monitor patients for potential development of sinusitis and mucoceles. Miniplates, however, can be easily placed in pneumatized regions of the maxilla without slippage considerations or damage to the sinus because of the small size of MPAS for the miniplates.[27] Our study showed that MPAS with sinus involvement had a mean depth of 1.31 ± 0.72 mm, and only 3 of 39 MPAS showed more than 2 mm of sinus penetration (2.37, 2.95, and 3.41 mm). None of these showed loosening or other postplacement complications such as sinusitis, swelling, or inflammation from MPAS involvement in the maxillary sinus membrane.

## CONCLUSIONS

In this study, miniplates were successfully maintained with 4-mm MPAS. If the successful placement of an independent mini-implant is doubtful because of a complex anatomic environment, such as limited interradicular space or severe alveolar bone resorption, a miniplate is a reliable alternative to achieve a high rate of successful stability for a temporary skeletal anchorage device in orthodontic treatment. Although the smallest commercially available MPAS was used (length, 4 mm; diameter, 1.5 mm), there can still be damage to the adjacent roots. The results of this study suggest the following guidelines for safe and secure placement of MPAS for miniplate stabilization.

1. The primary placement site for MPAS is the interradicular space. Since 5 of 7 root-penetrated screws were in position 2, this area should be more carefully examined when determining the location of miniplates and deciding on the final location of MPAS.
2. Clinicians should pay extra attention to avoid slippage or path-of-insertion angulation error during positioning of MPAS that might interfere with precisely placing the miniplate at the targeted position.
3. MPAS at positions 1, 2, and 3 that are placed intraradicularly should not be completely screwed into the hole but, instead, should be left relatively loose. Alternatively, MPAS at these positions can be placed obliquely relative to the direction of the roots instead of strictly perpendicular to the hole of the miniplate. When MPAS is placed in an oblique direction, more retention can be obtained from greater contact of the surface area to the cortical bone, and the risk of damage to adjacent roots can also be minimized. Geometrically, if an MPAS with 4 mm of bone contact is placed 30° to the dental axis, the distance equals the product of 4 mm of actual screw length times cosine 30°. Total contact distance is, of course, calculated with varying degrees of angulation.[14]
4. When placing near the maxillary sinus, an MPAS should be perpendicular to the external surface of the sinus wall with light force so as not to damage or strip the cortical bone of the sinus wall. RP of an MPAS to several roots and sinus perforation

without primary stability seem to be major risk factors for miniplate failure.

With limited literature to date, additional studies of miniplates as temporary skeletal anchorage device are required to determine standard guidelines for safe placement.

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