Orthodontic miniplate with tube as an efficient tool for borderline cases

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An orthodontic miniplate tube device, the C-tube, was designed for use in patients for whom a conventional miniscrew is not suitable, such as those with narrow interradicular spaces, extended maxillary sinuses, dilacerated roots, or severe alveolar bone loss. After local anesthesia, 2 parallel horizontal incisions are made in the area of placement, and the perioisteum is elevated. The C-tube is slipped under the mucosal flap and fixed with self-drilling miniscrews (diameter, 1.5 mm; length, 4 mm). Because the screws are short, there is adequate retention in the alveolar plate, and the clinician can avoid the increased morbidity of anchoring to the zygomatic buttress. This makes placement possible with superficial anesthesia. A small rolled tube at the head part can act as an orthodontic tube and accommodate archwires or as a hook to attach orthodontic elastics. However, in some patients with pneumatization or systemic diseases, such as diabetes mellitus, or in heavy smokers, cross-type C-tubes with longer miniscrews are recommend for better stability. This new type of orthodontic miniplate can be an effective alternative to conventional 1-component screws or miniplates in complex situations. (Am J Orthod Dentofacial Orthop 2011;139:551-62)

Recently, a number of case reports with skeletal anchorage as orthodontic anchorage have been presented.1-9 Several types of skeletal anchorage devices, including miniscrews, onplants, and miniplates, have been introduced, and the most popular is the miniscrew.5,6 Miniscrews are reasonably cost low, easy to place and remove, and small, and can be implanted in many locations in the oral cavity. These strong points might be the reasons for their popularity. But their placement is usually between the dental roots; this renders them an obstacle to many desired tooth movements.10-12 To overcome this weak point, clinical trials to place miniscrews apart from the dental apparatus—eg, the palatal area—have been performed.13,14 But this location complicates the biomechanical design and is usually limited to the maxilla.

There have been previous reports about surgical miniplates as orthodontic anchorage.15-17 These miniplates do not interfere with tooth movement and can withstand heavier and more dynamic forces than miniscrews because of multi-screw retention. However, the surgical miniplate is not ideal for orthodontic purposes because its shape is not designed for orthodontic use, and placement is not easy.

Still, miniplates are useful when the anatomic situation prevents the use of a miniscrew. Several designs are suitable for orthodontic purposes.7-9 Sugawara et al developed a new design of miniscrew anchored to the zygomatic buttress and named it the “skeletal anchorage system.” De Clerck and Cornelis8 showed patients treated with miniplates and various additive components. But these systems still require relatively longer retentive screws and are placed in deeper anatomic sites, requiring invasive surgery. Simpler designs might encourage orthodontists to place the device.

The C-tube was developed exclusively for orthodontic purposes with the concept of simple design and small size for easy placement.9,18-20 Clinical experiences have proved that this system can work as a good auxiliary orthodontic appliance and also as an appliance to partly replace orthodontic brackets. The purposes of this article were to introduce the C-tube primarily when miniscrews are not applicable and to show the various principles of clinical applications.

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C-TUBE AND ORTHODONTIC MECHANICS

C-tubes are titanium miniplates with a 0.036-in diameter hole in the tube. They have 2 to 4 holes (diameter, 1.5 mm) and lengths of 4 to 7 mm; they are self-drilling miniscrews (KLS Martin, Tutlingen, Germany, Jin Biomed Co., Bucheon, Korea) (Fig 1).

The C-tube is anchored to the cortical bone near the posterior teeth, instead of the zygomatic buttress. C-tube placement requires a minimum of dissection compared with the buttress site.

Two types of C-tube have developed: I and cross.19 The I-type C-tube is fixed with 2 drill-free miniscrews and applied in the posterior maxillary area if there are narrow interradicular spaces or dilacerated roots, or in the anterior maxilla with a prominent labial frenum (Fig 1, A-C).20 Cross-type C-tubes are used when there is severe pneumatization of the maxillary sinus or when distalization of the dentition is planned. The cross-type C-tube is fixed with 2 to 4 drill-free 4-mm miniscrews according to the quality of bone and the direction of the orthodontic force vector. Although a 4-mm miniscrew might seem short, the use of several screws gives good stability to the miniplate even in thin cortical bone. Also, these miniscrews are short enough not to touch dental roots and not to interfere with tooth movement. The C-tube can be placed in various region of the oral cavity and is valuable where absolute anchorage is needed (Fig 2).

A C-tube in the posterior maxillary area can be used for intrusion and distalization of posterior teeth (Fig 2, A) and also for intrusion of anterior teeth (Fig 2, B and C). In the maxillary area of the mental foramen, it can be used for intrusion or distalization of the mandibular posterior teeth and intrusion of anterior teeth (Fig 2, D-F). Also, it is applicable for lingual orthodontics and can be placed on the retromolar pad with the rolled tube exposed in the oral cavity (Fig 2, G-I).

Usually, the C-tube is placed in alveolar bone between the dental roots or in cortical bone above the alveolar bone (Fig 3). These areas are much lower and more accessible than the zygomatic buttress where a conventional miniplate is usually placed. The intraoral exposure part of the C-tube is placed at the border between attached and movable mucosa. The head part of the C-tube should be adjusted with care so that it will not be covered by the mucosa.

1. Inject local anesthesia and wait for 10 minutes for complete diffusion of the anesthesia.
2. Make a horizontal incision with a number-15 blade where the head of C-tube is to be exposed and then

![Fig 1. A, Schematic illustration of I-type C-tube; B and C, preplacement and postplacement of the C-tube retained by 2 drill-free screws 1.5 × 4 mm (width × length), recommended for a narrow interradicular space; D, cross-type C-tube: E, frontal and F, sagittal cone-beam computed tomography views of a C-tube in a patient with an enlarged maxillary sinus.](image-url)
make another 3-mm long horizontal incision 2 mm apical and parallel to the first one (Fig 3, A).
3. Lift the periosteum carefully with a periosteal elevator (Fig 3, B).
4. Conform the C-tube to the exposed bony surface with a bending pliers.
5. Place the C-tube on the bone surface through the second horizontal incision (Fig 3, C), expose the tube part to the oral cavity, and then fix the C-tube with self-drilling miniscrews (diameter, 1.5 mm; length, 4 mm) placed through the second horizontal incision (Fig 3, D and E).
6. Suture the incised area with 4-0 silk (Fig 3, F).
7. Prescribe nonsteroidal anti-inflammatory drugs and antibiotics for 3 days. Remove the suture material 1 week later.

The removal procedure includes the following steps.
1. After local anesthesia, make a vertical incision on the miniscrew area with a number 15 blade.
2. Unscrew the miniscrews and remove the C-tube through the incision. Sometimes it is necessary to increase the opening for the head part to slip through the tissue.
3. Suture the incision area with 4-0 silk.
4. Prescribe nonsteroidal anti-inflammatory drugs and antibiotics for 3 days. Remove the suture material 1 week later.

CLINICAL APPLICATIONS OF THE C-TUBE

The C-tube can be used for en-masse retraction without posterior appliances. The C-tube is applied on the maxillary anterior teeth without attached appliances to the posterior dentition in maximum anchorage cases. It can replace brackets on the posterior dentition through accommodation of the posterior part of the archwire into its tube without losing control of the anterior teeth. It resists heavy and dynamic loads because of several miniscrews. Also, various elastics, power chains, and archwires can be easily applied to the 0.9-mm diameter hole in the tube.20

A 30-year-old woman visited our orthodontic clinic complaining of lip protrusion. After a complete analysis,
she was diagnosed as having Class II bidentoalveolar protrusion; the treatment plan included extraction of the 4 first premolars and temporary skeletal anchorage devices TSADs to enable en-masse retraction (Figs 4 and 5). A sand-blasted with large grit and acid-etched surface-treated mini-implant (C-implant, Cimplant Co.,

**Fig 3.** Surgical procedure of cross-type C-tube placement: A, make a horizontal incision with a number-15 blade where the head of the C-tube is to be exposed and then make another 3-mm long horizontal incision 2 mm apical to the first one; B, carefully lift the periosteum with a periosteal elevator; C and D, place the C-tube on the bone surface through the second horizontal incision and expose the tube part to the oral cavity; E, fix the C-tube with self-drilling miniscrews placed through the second horizontal incision; F, suture the incised area with 4-0 silk.

**Fig 4.** Patient 1. A C-tube was used for anterior retraction instead of bonded or banded appliances on the maxillary posterior dentition. A, Treatment progress panoramic radiograph shows the mini-implant on the right side and an I-type C-tube on the left side. This patient had a narrow interradicular space and an enlarged maxillary sinus on the maxillary left posterior dentition. B, Axial cone-beam computed tomography image of the C-implant between the maxillary right second premolar and the first molar. C, Frontal cone-beam computed tomography image (version 4.0, Invivodental, Anatomage, San Jose, Calif) of I-type C-tube in the left posterior maxilla.
Seoul, Korea) was implanted between the maxillary right second premolar and first molar, but, on the left side, a narrow interradicular space and extended maxillary sinus contraindicated the use of the C-implant (Fig 4, A and B). Instead, an I-type C-tube was placed with 2 self-drilling miniscrews (Fig 4, C). The miniscrew and the C-tube eliminated any need for bracketed appliances on the maxillary posterior dentition. The archwire passed through the head of the C-tube. After 19 months, resolution of anterior protrusion and closure of extraction space were achieved (Fig 5).

The C-tube can be used in the same way with lingual appliances (Fig 6).

C-tubes can be used for vertical correction. I-type C-tubes can be used for intrusion of the maxillary incisors (Fig 7). A 34-year-old woman with a deep anterior overbite and a lingually blocked maxillary left lateral incisor was treated with an I-type C-tube (Fig 7, A and B). Her blocked lateral incisor was extracted, and the C-tube was placed between the maxillary right central and lateral incisors. Intrusion force was applied with elastic chain between the C-tube and the archwire. Intrusion

**Fig 5.** Patient 1. A, Anterior retraction initiated; B, after 15 months of retraction; C, after 19 months of retraction without posterior bonded or banded appliances.

**Fig 6.** Patient 2. C-tube application for lingual orthodontics: A, initial stage; B, after 2 months of retraction; C, after 5 months of retraction; D, after 8 months of retraction; E, posttreatment occlusal view. The total treatment period was 12 months.
took 4 months; this allowed bracket to be placed on the mandibular anterior teeth (Fig 7, C and D). The total treatment period was 15 months.

Another patient required intrusion of the mandibular anterior teeth. A 32-year-old man was diagnosed with a Class II anterior deepbite malocclusion with anterior spacing. We placed 2 miniscrews on the maxillary teeth and an I-type C-tube on the mandibular anterior teeth (Figs 8 and 9). The maxillary miniscrews (C-implants: diameter, 1.8 mm; length, 8.5 mm) were used for anterior retraction, and a C-tube on the mandibular anterior teeth was used for intrusion. The C-tube was fixed to cortical bone under the mucosa, avoiding the roots of the incisors, and the head of the C-tube was exposed through the attached gingiva. This minimized inflammation. Four millimeters of intrusion occurred after 3 months of active intrusion (Fig 9).

A 16-year-old girl came with a deep anterior overbite caused by extrusion of the maxillary and mandibular anterior teeth. We simultaneously intruded both the maxillary and mandibular anterior teeth using maxillary and mandibular anterior I-type C-tubes (Figs 10 and 11). After 2 months of treatment, a significant reduction of anterior overbite was achieved; this allowed placement of appliances on the mandibular anterior teeth (Fig 11). As expected, the force vector caused some incisor flaring.

Intrusion of posterior teeth and resolution of anterior openbite are also possible with a cross-type C-tube placed in the maxillary posterior region (Fig 12). A 25-year-old woman with an anterior open bite visited our clinic. We planned to intrude her maxillary posterior teeth against C-tube anchorage. A transpalatal arch was included to prevent buccal tipping of the molars during intrusion. Improvement of the anterior overjet was noted after 7 weeks of intrusion of the maxillary molars (Fig 12, A-D). After the maxillary posterior intrusion, distalization of the full maxillary dentition was performed simultaneously, and a normal overjet and overbite relationship was achieved after 18 months of treatment (Fig 12, E and F).

The C-tube device can endure orthodontic forces of various directions and intensities. We placed an I-type C-tube in a 27-year-old woman with a Class III intermaxillary relationship and an anterior open bite. The C-tube provided anchorage to both intrude the posterior teeth and retract the mandibular anterior teeth. After 11 months of treatment, improved overjet and overbite were achieved (Fig 13).

Distalization of the full mandibular dentition can be achieved with an I-type C-tube placed on the retromolar pad. If the third molar is not present, there is no risk of damaging roots (Fig 14).

A 30-year-old woman with a Class III occlusal relationship on the left side visited our clinic, and a nonextraction treatment plan including distalization of the mandibular left dentition was established (Fig 15, A-C). The I-type C-tube was placed on the left retromolar pad and fixed with 2 self-drilling miniscrews (diameter, 1.5 mm; length, 5 mm). The mandibular left dentition was distalized with an 0.018 × 0.025-in stainless steel sliding jig with force applied with
Fig 8. Patient 4. Intrusion of mandibular anterior teeth: A-C, intraoral photographs and panoramic radiographs at pretreatment; D-F, after 3 months of intrusion, 4 mm of intrusion was obtained.

Fig 9. Patient 4. Lateral cephalograms: A, pretreatment; B, after 3 months of intrusion; C, superimposition.

Fig 10. Patient 5. Pretreatment intraoral photographs.
Fig 11. Patient 5. A and B, Maxillary and mandibular intrusion was started after placement of 2 I-type C-tubes; C and D, after 2 months of intrusion.

Fig 12. Patient 6. Intrusion of the maxillary molars by elastic thread from a cross-type C-tube: A and B, intraoral photographs of initial force application; C and D, after 7 weeks of intrusion; E and F, posttreatment.
a nickel-titanium coil spring (Forestadent Co., Pforzheim, Germany) (Fig 15, D-I). The total treatment period was 10 months, and a Class I occlusal relationship with normal anterior overjet and overbite was achieved (Fig 15, J-L).

**DISCUSSION**

Various kinds of skeletal anchorage situations have been described that permit the orthodontist to treat certain malocclusions that are impossible to manage with traditional methods.\(^{21}\) Surgical miniplates are the typical treatment tool. These plates are used for the treatment of facial bone fractures and stabilization of osteotomy segments. The materials used for miniplates have proven to be stable and biocompatible through long usage. Many authors showed that miniplate systems have fewer failures compared with orthodontic miniscrews.\(^{22-26}\) Chen et al\(^{26}\) stated that an advantage of miniplates is to keep the anchorage screws out of the way of tooth movement and, thus, to increase the possible range of

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**Fig 13.** Patient 7. Intrusion of the maxillary posterior teeth and mandibular retraction with I-type C-tubes: A-C, pretreatment intraoral photographs; D-F, treatment progress; G-I, posttreatment intraoral photographs. The total treatment period was 11 months.

**Fig 14.** C-tube application for mandibular molar distalization. The arrow shows the retromolar area of the mandible.
movement. They found that placement and removal of miniplates are minimally invasive, with mild postoperative discomfort and few risks. We are orthodontists who are not practiced in surgical procedures. Nevertheless, we place and remove C-tubes by ourselves without the help of surgeons.

Most orthodontic miniplates described in the international journals are placed on the zygomatic buttress or the basal bone area after a 2-cm vestibular incision. To support the rather long arm that extends into the oral cavity, several miniscrews (diameter, 2 mm; length, 5-10) are usually used.

C-tubes also can be placed on the zygomatic buttress like other miniplates, but, for most patients, the alveolar cortical bone adjacent to the interradicular space is preferred, since it is a simpler and less invasive procedure. Not much surgical training is needed for these procedures. Although C-tubes are fixed with several screws, these screws are of 4 mm in length to minimize the possibility of dental root damage. They are placed without a pilot hole. Using several screws to fixate the device provides good stability against the application of heavy and dynamic forces.

The tube part of the fixture offers improved biomechanical options. Specifically, it can accommodate archwires, and so the device can replace posterior brackets and tubes. Surgical procedures for C-tube placement are easier than for conventional miniplates but more complicated than miniscrews. However, the C-tube does not interfere with tooth roots during molar distalization or intrusion. C-tubes can be successfully used in young growing patients.

The patients presented in this article had 6 treatment situations: (1) interradicular spaces too narrow for conventional miniscrews, (2) severe pneumatization of the maxillary sinuses, (3) dilacerated roots that made
interradicular spaces unavailable for miniscrews, (4) narrow interradicular spaces and distalization of the entire dentition, (5) need for a TSAD on the retromolar pad, and (6) severe loss of alveolar bone that compromised the placement of miniscrews.

In the case of severe pneumatization, when the maxillary buccal cortical bone is usually too thin, the use of a cross-type C-tube fixed with more than 3 miniscrews (diameter, 1.5 mm; length, 4 mm) is recommended.

Although minor sinus perforations can occur, they might not be a concern. Reports suggest that perforation of the sinus membrane is the most common complication during the sinus floor elevation procedures for prosthetic implants. Research showed that perforations were not related to increased loss of implants, and only 5% of patients showed signs of sinusitis. The sinus mucosa will usually regenerate across the immobilized bone graft during normal healing. Berengo et al showed that small membrane perforations during the osteotomy are compatible with clinically healthy postoperative sinus conditions.

Even though the C-tube has numerous advantages compared with mini-implants and orthodontic miniplates, there are some details to consider. When applying orthodontic elastics to the C-tube, open the rolled tube and (6) severe loss of alveolar bone that compromised the placement of orthodontic anchorage. Angle Orthod 2008;78:737-44.

In a patient with a systemic disease patient (especially diabetes mellitus), a longer miniscrew should be used for better mechanical retention of the C-tube. Even though the 4-mm long miniscrew is short compared with conventional miniscrews, clinicians should nevertheless take care to avoid contact with tooth roots during placement.

**CONCLUSIONS**

The typical anatomic site for the placement of a C-tube is in the anterior or posterior facial alveolar bone. Whereas placement of a C-tube miniplate involves screw placement closer to roots than a miniscrew attached to the zygomatic buttress, the use of short screws moderates the risk of root contact. Further study will develop additional biomechanic protocols for the C-tube, discover any risk factors, including effects on the neighboring roots and maxillary sinuses, and establish the best anatomic sites for placement.

**REFERENCES**