

# Replacing a failed mini-implant with a miniplate to prevent interruption during orthodontic treatment

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**Introduction:** When mini-implants fail during orthodontic treatment, there is a need to have a backup plan to either replace the failed implant in the adjacent interradicular area or wait for the bone to heal before replacing the mini-implant. We propose a novel way to overcome this problem by replacement with a miniplate so as not to interrupt treatment or prolong treatment time. **Methods:** The indications, advantages, efficacy, and procedures for switching from a mini-implant to a miniplate are discussed. Two patients who required replacement of failed mini-implants are presented. In the first patient, because of the proximity of the buccal vestibule to the mini-implant, it was decided to replace the failed mini-implant by an I-shaped C-tube miniplate. In the second patient, radiolucencies were found around the failed mini-implants, making the adjacent alveolar bone unavailable for immediate placement of another mini-implant. In addition, the maxillary sinus pneumatization was expanded deeply into the interradicular spaces; this further mandated an alternative placement site. One failed mini-implant was examined under a scanning electron microscope for bone attachment. **Results:** Treatment was completed in both patients after replacement with miniplates without interrupting the treatment mechanics or prolonging the treatments. Examination under the scanning electron microscope showed partial bone growth into the coating pores and titanium substrate interface even after thorough cleaning and sterilization. **Conclusions:** Replacement with a miniplate is a viable solution for failed mini-implants during orthodontic treatment. The results from microscopic evaluation of the failed mini-implant suggest that stringent guidelines are needed for recycling used mini-implants. (*Am J Orthod Dentofacial Orthop* 2011;139:849-57)

The most commonly used temporary skeletal anchorage device (TSAD) is a mini-implant because of its compact size for the interradicular space, low cost, and various screw-head designs favorable for

orthodontic archwire engagement.<sup>1-7</sup> The success rates of these mini-implants and screws, however, vary from 75.2% to 93.6%.<sup>8-11</sup> When mini-implants loosen during active orthodontic treatment, the best recommended alternative is to immediately replace them at adjacent interradicular spaces with better alveolar bone mass. The unexpected loosening of mini-implants at any stage of treatment can easily jeopardize the entire original orthodontic treatment plan, especially when the treatment biomechanics require continuous anchorage support.<sup>12,13</sup>

To date, there are no recommendations in the literature on how to sustain the original treatment mechanics when the conditions of the adjacent areas do not guarantee better stability after replacement of failed mini-implants. These preexisting anatomic conditions might include severe pneumatization of the maxillary sinus, extremely narrow interradicular space, insufficient amount of attached gingiva, unfavorable frenal attachment, or abnormal distribution of nerve and blood vessels.

Since contemporary orthodontic treatment planning now commonly includes many types of mini-implants

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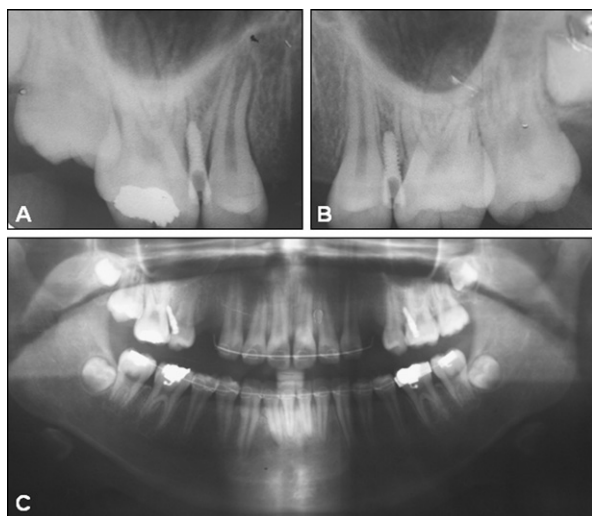
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**Fig 1.** Patient 1, radiographs taken immediately after placement of mini-implants: **A** and **B**, periapical radiographs; **C**, panoramic radiograph.

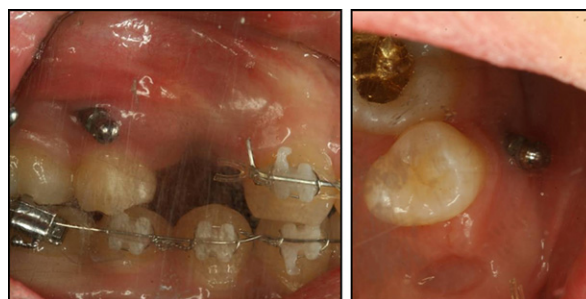
as critical components of biomechanics for a patient's successful orthodontic treatment, the plan should also incorporate a backup plan that would allow the clinician to continue the original treatment mechanics with no delay. This will enable clinicians to use mini-implants in any situation and be confident of the clinical outcome, eventually leading to more extensive and universal uses of TSADs in orthodontics in the long term.

This report suggests a novel way of ensuring the continuity of treatment mechanics despite the failure of a mini-implant during comprehensive orthodontic treatment. The case reports also emphasize the importance of restricting the reuse of mini-implants to the same patient based on the scanning electron microscope (SEM) evaluation of the failed mini-implant's surface.

## CLINICAL APPLICATIONS

### Patient 1

A 14-year-old girl with a chief complaint of bimaxillary protrusion agreed to an orthodontic treatment plan based on the philosophy of biocreative therapy.<sup>5,12-15</sup> The treatment goals were to perform en-masse retraction of the maxillary anterior teeth and reduce her facial convexity while maintaining the preexisting Class I posterior occlusal relationship (Fig 1). Therefore, a 2-component orthodontic mini-implant (C-implant, Cimplant Co, Seoul, Korea) of 1.8 mm in diameter and 8.5 mm in length was placed bilaterally between the maxillary second premolar and the first molar.<sup>5,7</sup> This mini-



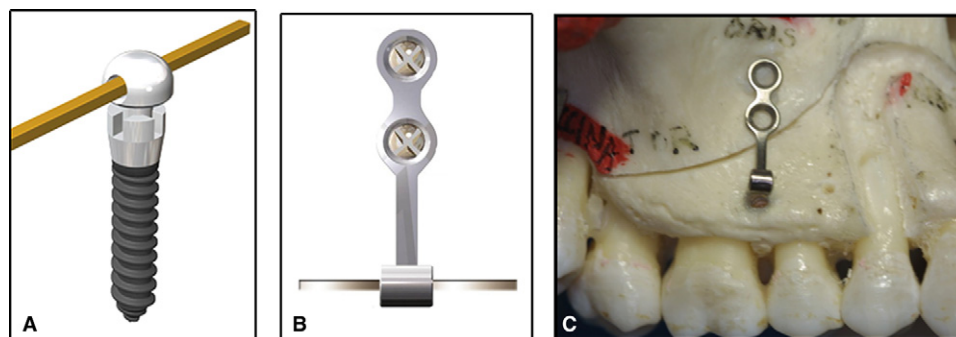
**Fig 2.** Patient 1, intraoral photograph of loosened mini-implant 4 weeks after loading.

implant served as an independent orthodontic anchor and excluded the molars from use as anchorage. During the fourth week of active en-masse retraction, the mini-implant on the right side loosened (Figs 1, A, and 2), and the active en-masse retraction could no longer be continued against the loose mini-implant. At this stage, there was still significant extraction space, and the treatment was far from reaching the initial goal.

To sustain the initially planned biocreative therapy (C-therapy) mechanics without delay and to avoid occlusal canting that can result from bilateral en-masse retraction with different points of force application relative to the center of resistance of the retracted segment, it was desirable to maintain the point of force application of the orthodontic anchor at the same place. In addition, the proximity of the patient's buccal vestibule to the mini-implant site indicated that the immediate relocation of the loose mini-implant farther apically would not be desirable. More importantly, there was no guarantee of stability of the replanted mini-implant at the same location even with 1 or 2 months of healing after removal of the loose mini-implant.

With all these factors taken into consideration, we decided to remove the loose mini-implant and place a different type of temporary skeletal anchorage device at the same patient appointment. The treatment of choice was an I-shaped miniplate with a tube-shaped head (C-tube, Jin Biomed Co., Bucheon, Korea) (Fig 3).<sup>14,15</sup> This I-shaped C-tube is a titanium miniplate with 2 anchoring holes and a .0036-in diameter tube-shaped head serving as the point of orthodontic force application. This modification accommodates the same biomechanics for the C-therapy and also achieves much higher stability during active en-masse retraction. The details of the switching procedure are as follows.

The failed mini-implant was removed with a screwdriver or a Weingart plier. After local anesthesia was applied submucosally around the mini-implant screw-body area and below its mucogingival junction, the screw



**Fig 3.** Schematic illustrations: **A**, C-implant; **B** and **C**, C-tube miniplate.

body was taken out with a hand screwdriver by rotating it counterclockwise. The hole left after the screw body was removed served as the entry point of the I-shaped C-tube miniplate. Then a 3-mm long horizontal incision was made with a number 15 surgical scalpel approximately 2 mm apical to the screw-body removal site (Fig 4, A and B), and this incision was the access point for securing the miniplate with miniplate anchoring screws (MPAS). The alveolar bone under the 2-mm wide mucosal-periosteal tissue needs to be properly exposed by gross dissection with a periosteal elevator (Fig 4, C). The side of the miniplate with the anchoring holes was placed through the mucosal hole left after the screw body was removed, leaving the C-tube (the head part of the miniplate) exposed to the oral cavity at the same location as the failed mini-implant (Fig 4, D). Once the miniplate was placed under the lifted 2-mm wide mucogingival-periosteal tissue, then the anchoring side of the miniplate needed to be better adapted to the contour of the exposed bony surface by molding the miniplate against the bony surface with direct pressure from the dull end of a periosteal elevator. When the anchoring side of the miniplate was adequately adapted, it was fixed into place with 2 self-drilling MPAS (diameter, 1.5 mm; length, 4 mm) (Fig 4, E). A single stitch with 4-0 silk on the incision was used for placement of the MPAS to facilitate soft-tissue closure and healing (Fig 4, F). Analgesics or antibiotics can be prescribed, but most over-the-counter painkiller medications should be sufficient to alleviate the postsurgical discomfort. With adequate oral hygiene and the use of chlorhexidine gluconate for a week after the procedure, this small incision site tends to heal quickly with no subsequent medical complications. The suture material is removed a week after this procedure.

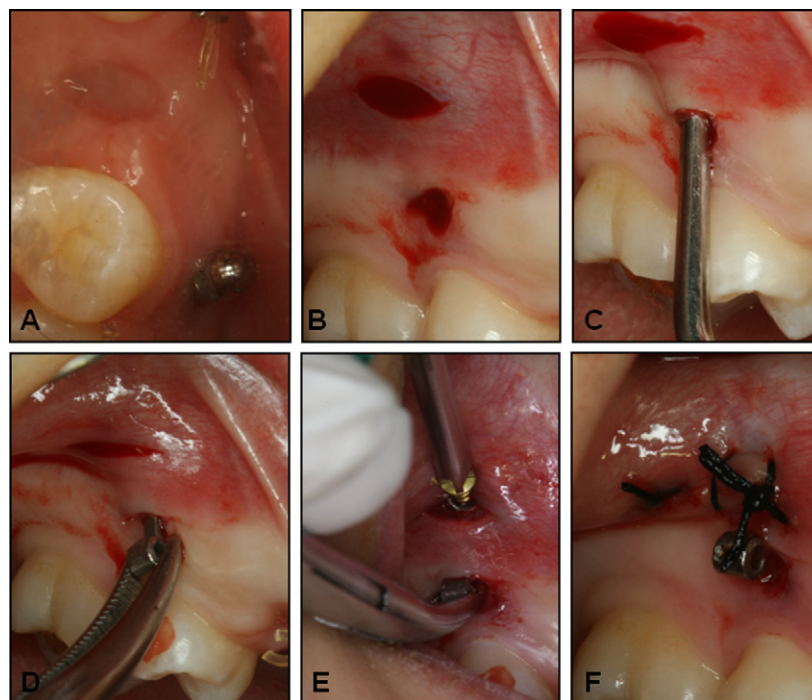
After switching from the loose mini-implant to an I-shaped miniplate on the same day, the full retraction force used to achieve active en-masse retraction was loaded on the miniplate on the right side and on the

existing mini-implant on the left side (Fig 5). The procedure for switching from a loose mini-implant to an I-shaped miniplate is simple enough for an orthodontist who is already familiar with the placement of mini-implants in interradicular spaces.

When the miniplate was no longer needed for orthodontic treatment, a single small vertical incision was made above the miniplate restricted to the area of the 2 MPAS, providing easy access to the MPAS. After the 2 MPAS were unscrewed, the miniplate could be removed by pulling it out through the hole where the C-tube was exposed to the oral cavity. This removal procedure can be performed by using slight local anesthesia, and minimum suture was required after it was removed. Again, with adequate oral hygiene and the use of chlorhexidine gluconate for a few days after this procedure, the small incision site tends to heal quickly with no further medical complications.

#### Patient 2

A 16-year-old girl with a Class I malocclusion and bimaxillary dentoalveolar protrusion was planned for extraction of the maxillary first premolars and en-masse retraction of the maxillary incisors with biocreative therapy. Figure 6 shows the placement of mini-implants between the maxillary left and right second premolars and the first molars. The mini-implants were left unloaded for 4 weeks to allow partial osseointegration and secure their stability. Meanwhile, the patient was referred to an oral surgery for extraction of the maxillary first premolars. The patient returned 4 weeks after the extractions, and both mini-implants were found to be loose with obvious radiolucencies around them, making the adjacent alveolar bone unavailable for immediate placement of another mini-implant. In addition, the maxillary sinus pneumatization was expanded deeply into the interradicular spaces; this further mandated a higher level of anchoring system to



**Fig 4.** Patient 1, switching procedure: **A**, loosened mini-implant; **B**, mini-implant was removed, and a horizontal incision was made; **C**, the periosteum was detached; **D**, I-shaped C-tube was placed through the removal site of the mini-implant; **E**, fixation of the miniplate; **F**, finished state after suture.

ensure the stability of the alternative TSAD. It was decided to switch the failed mini-implants with a cross-shaped miniplate with a tube-shaped head (C-Tube, KLS Martin, Tuttlingen, Germany) with 4 MPAS placement holes (instead of the I-shaped miniplate with only 2 MPAS). The switching procedure was similar to that described previously, except that the tube-shaped head was placed through the incision apical to the mini-implant removal site, sliding down under the lifted mucoperiosteal tissue and exposed to the oral cavity through the hole left after the mini-implant was removed (Fig 7). The cross-shaped anchoring side of the miniplate was also placed through the same incision. After the miniplate was placed, it was passively adapted to the contour of the lateral wall of the maxillary sinus before placing the first MPAS. The dull end of a periodontal elevator was useful for this adaptation procedure. Although placement with 4 MPAS is ideal, 3 MPAS should be sufficient to fully secure the stability of the miniplate if the maxillary sinus pneumatization seems excessively large. After its placement, the miniplate was immediately loaded for the en-masse retraction of the maxillary anterior teeth (Fig 8).

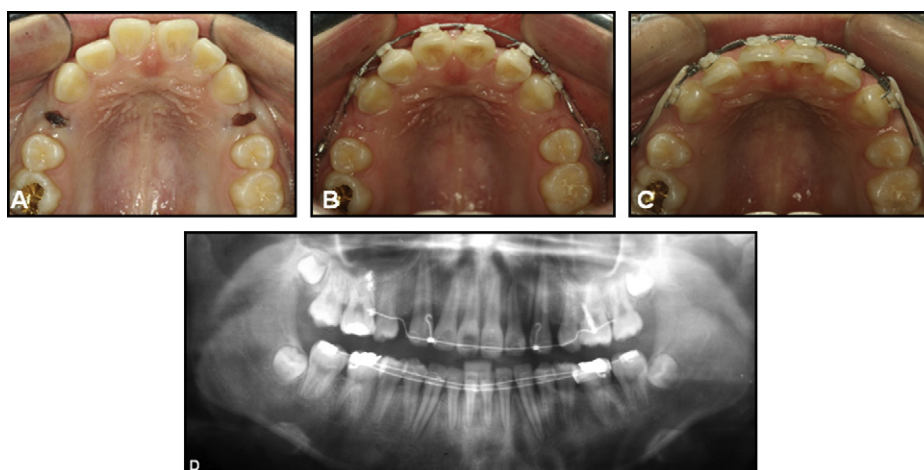
Immediately after the switching procedure, the removed mini-implant was cleaned many times, sterilized, and inspected under the SEM by using the focused ion

beam (FIB) technique of Giannuzzi et al<sup>16</sup> (Fig 9). FIB mills is a thin specimen section that can be more precisely inspected by SEM; this technique has been shown to be effective in characterizing the bone-dental implant interface.

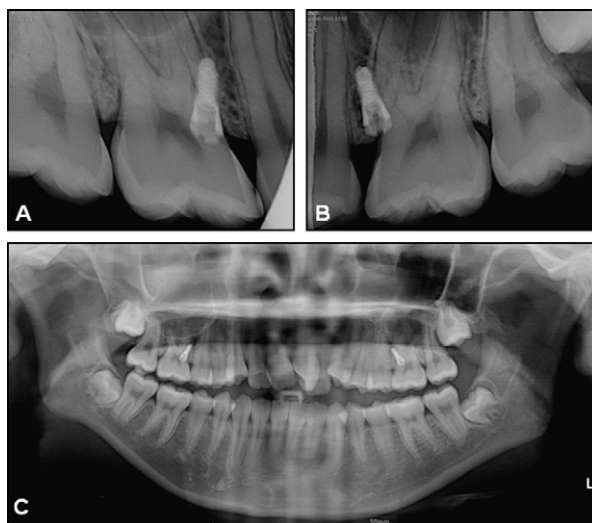
The low-magnification image of the mini-implant surface under the secondary SEM showed that bone-like organic material still remained on the screw surface even after thorough cleaning and sterilization (Fig 9, B). In addition, the backscattered electron SEM image of the same area also showed partial bone growth into the coating pores and the titanium substrate interface as reported by Giannuzzi et al<sup>16</sup> (Fig 10; photograph published with permission).

## DISCUSSION

The clinical application of TSADs has advanced to a stage where the anchorage considerations of an entire orthodontic biomechanics treatment plan can be effectively achieved by using a TSAD as the sole source of orthodontic anchorage.<sup>5,6,14,15,17,18</sup> This is a new concept for orthodontics, since now we can achieve ideal results without having to factor in potential anchorage loss, especially in patients requiring maximum retraction of the maxillary anterior segment. Using creative methods



**Fig 5.** Patient 1, treatment progress intraoral photographs with biocreative therapy: **A**, immediately after maxillary first premolar extraction; **B**, 1 week later; **C**, 10 months after the switching procedure; **D**, panoramic radiograph taken at 11 months after the switching procedure.



**Fig 6.** Patient 2, radiographs taken immediately after placement of the mini-implants: **A** and **B**, periapical radiographs; **C**, panoramic radiograph.

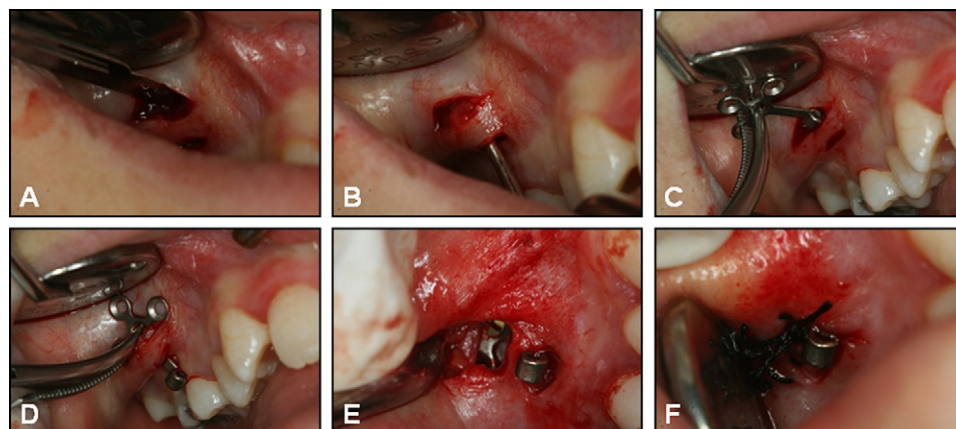
of applying TSADs, we can eliminate unnecessary and complicated dental anchorage preparation involving the first and second molars as orthodontic anchors. This novel treatment concept has been advocated and clinically applied in Korea by Chung<sup>19</sup> since 1999 and has been named biocreative therapy (also called C-therapy) by Chung et al<sup>12,13</sup> since 2008. Biocreative therapy provides simplified orthodontic biomechanics and significantly reduced adjustment time during each visit and is well tolerated by patients primarily due to the increased comfort as a result of limited fixed

orthodontic appliances only on the anterior teeth for most of the treatment duration.

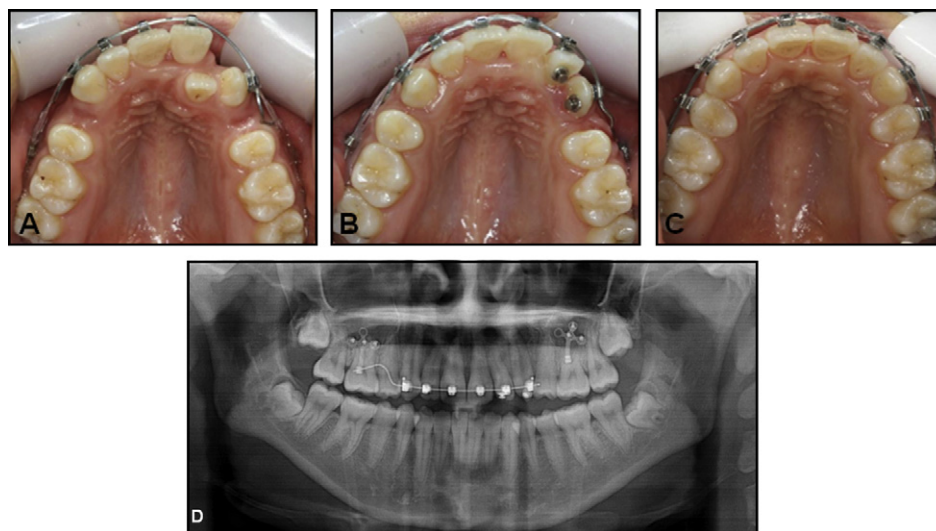
When the orthodontic mechanics rely solely on the use of TSADs, their stability and reliability become major factors in determining the efficiency of the entire treatment. In this report, therefore, we aimed to demonstrate an effective alternative that can be implemented immediately as soon as the initially placed mini-implant, the clinician's initial treatment of choice for a TSAD, shows questionable stability during active orthodontic treatment so that the initially planned biomechanics will not be altered or delayed in any way.

The average success rate of a restorative dental implant is consistently reported as over 90% because of the improvement of its design and surface modification strategies.<sup>20-22</sup> The success rate of an orthodontic mini-implant is, however, relatively lower than that of restorative dental implants. Factors attributed to the lower success rates of mini-implants include type of mini-implant, placement procedure, implant-root proximity, general oral hygiene, amount of biofilm around the mini-implant, amount of keratinized gingiva around the mini-implant, bone density difference between the maxilla and the mandible, skeletal pattern, and age.<sup>8-11,23,24</sup>

The failure of the mini-implants in these 2 patients was mainly because of the proximity to the root of the adjacent tooth. The periapical and panoramic radiographs clearly showed that a significant amount of screw surface of the failed mini-implant was directly exposed to the periodontal ligament space, and radiolucency around the mini-implant was evident. As suggested by Kuroda et al<sup>23</sup> and Motoyoshi et al,<sup>25</sup> micromovement



**Fig 7.** Patient 2, switching procedure: **A**, the mini-implant was removed, and a horizontal incision was made; **B**, the periosteum was detached; **C-E**, cross-shaped C-tube was placed through the removal site of the mini-implant in the opposite direction to the I-shaped miniplate; **F**, fixation of miniplate and suture.

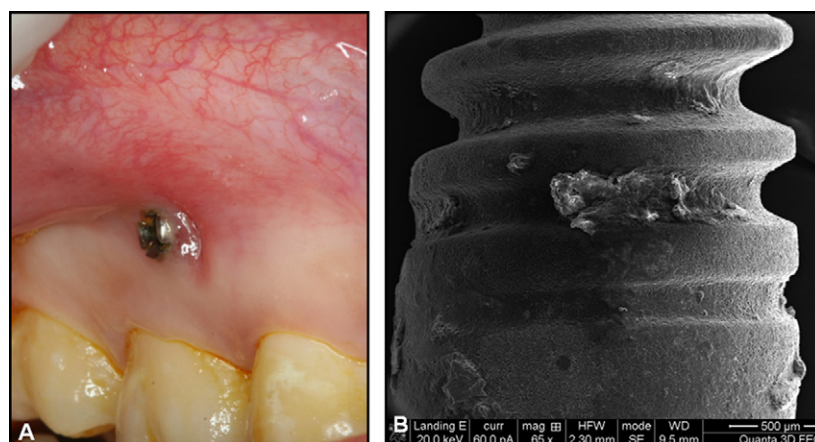


**Fig 8.** Patient 2, treatment progress intraoral photographs with biocreative therapy: **A**, 1 week; **B**, 5 months; and **C**, 10 months after the switching procedure; **D**, panoramic radiograph taken 10 months after the switching procedure.

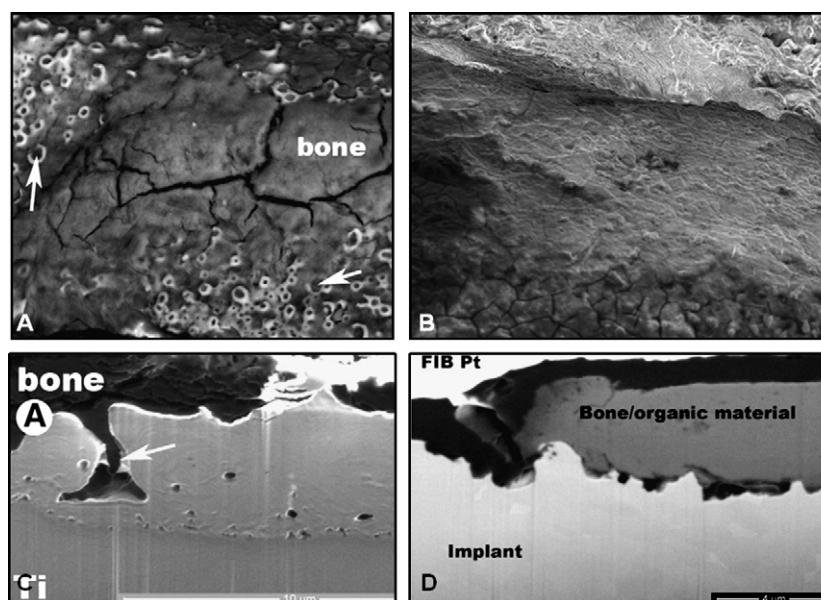
of a tooth in the periodontal-ligament spaces during mastication might significantly compromise the initial osseointegration process that is critical for the long-term stability of mini-implants.

When 1 bilaterally placed mini-implant fails during active orthodontic tooth movement, there are a few treatment alternatives. First, we can try to immediately relocate the loose mini-implant to an adjacent site in the alveolar bone. However, most of the time, the adjacent alveolar bone of the failing mini-implant shows signs of questionable bone quality for a newly repositioned mini-implant because of inflammation from

the failing mini-implant. Also, a change of mini-implant location requires a change of biomechanical strategy, since the point of force application of the newly positioned mini-implant will affect the relationship of the center of resistance of the moving segments relative to the point of anchor in all 3 dimensions. A second alternative is to remove the failed mini-implant and suspend active orthodontic treatment for 4 to 6 weeks while the mini-implant site heals.<sup>26</sup> A new mini-implant can then be placed at the same location of the previous mini-implant, with better placement results (eg, no contact with adjacent roots, better engagement



**Fig 9.** Patient 2: **A**, intraoral photograph of the failed mini-implant; **B**, low-magnification secondary SEM image of the mini-implant.



**Fig 10.** Backscattered SEM images of an implant surface: **A**, from Gianuzzi et al<sup>16</sup>; **B**, failed mini-implant (patient 2); **C**, secondary electron FIB image of implant (from Gianuzzi et al<sup>16</sup>); **D**, failed mini-implant (patient 2). The FIB images show bone and organic material coating the mini-implant’s surface.

of cortical bone, and so on). However, this alternative is risky, since it does not guarantee a more ideal positioning of the mini-implant the second time. This option also extends the total orthodontic treatment duration to accommodate the healing time. The third alternative is to continue the orthodontic treatment by using the molars as the source of anchorage instead of relying on the mini-implant. This effectively changes the treatment plan from skeletal anchorage to dental anchorage

and will require major changes of the initial treatment plan, biomechanics, and goals. New caveats and compromises during treatment might not always be a pleasant experience between the clinician and the patient.

Our proposed alternative method that switches from a failed mini-implant to a miniplate has several clinical benefits.<sup>14,15,17,18,27-29</sup> It does not require changes in treatment plan, biomechanics, or related archwire auxiliaries because the technique maintains the same

point of force application with much better long-term stability. Since the location of MPAS is completely disengaged from the interradicular area while the head part of the miniplate remains at the same place as the previous mini-implant, there is almost no restriction of miniplate placement as an alternative to a prematurely failing mini-implant. In patients with extensive maxillary sinus pneumatization, this anatomic difficulty in the placement of a miniplate can be easily addressed by using a miniplate with many holes for the placement of MPAS.<sup>30</sup> In addition, the average success rate of a miniplate is reported to be over 90%, which is much higher than that of a mini-implant.<sup>8-10,31</sup> The stability of an orthodontic miniplate with immediate loading is well documented in the literature.<sup>8,9,32</sup>

The use of a C-tube miniplate as an orthodontic TSAD provides several advantages: (1) maximum reliability and stability for orthodontic procedures resulting from multiple MPAS applications; (2) minimal mucosal irritation around the miniplate after placement since the tube-shaped head of the miniplate is, most of the time, exposed to the oral cavity through the attached gingiva (the screws are placed under mobile oral mucosa); and (3) the location of MPAS rarely interferes with orthodontic tooth movement or frenum attachment, since they are usually placed above the apices of the teeth.

However, there are other important factors to consider when choosing a miniplate as an orthodontic TSAD: (1) postoperative care can be complicated if the patient already has an allergy to commonly prescribed antibiotics or the patient's postoperative soft-tissue healing is expected to be slow; (2) the patient has emotional distress caused by fear of surgery; (3) bony and fibrotic tissue overgrowth around MPAS might require extensive soft-tissue reflection for the removal of the miniplate, implying a more complicated surgical procedure than for mini-implants or miniscrews.

Therefore, the decision on the use of a miniplate as an orthodontic TSAD should be primarily based on the patient's anatomic and physiologic conditions rather than on the clinician's preference. In this report, we suggest that clinicians should use 1-piece single miniscrews if the purpose of the TSAD is auxiliary use only. If the treatment plan follows biocreative therapy principles, a partial osseointegration-based 2-piece mini-implant (C-implant) is recommended. Finally, a C-tube miniplate is incorporated into the biomechanical strategy when the patient's anatomic and physiologic conditions do not allow stable and reliable placement of an orthodontic mini-implant, or when a mini-implant is failing prematurely during active treatment.

In this report, we used FIB technology to prepare the cross-sectional specimen of the prematurely failed mini-implant screw to inspect it with the SEM. The microscopic images show that the bony and organic tissues formed on the surface of the prematurely failed mini-implant screw had mechanically locked into the implant surface and were not easily removed even after many cleanings and sterilizations. Since it was a cross-section specimen of a failed implant, the amount of bony and organic debris retained on the mini-implant screw surface was minimal. As shown by Vande Vannet,<sup>27</sup> the degree of osseointegration is much higher when the screw is clinically retained in position for a long time. This indicates that we can expect greater osseointegration-related debris that is mechanically locked into the screw surface of mini-implants with greater clinical longevity. Therefore, a more stringent guideline seems to be needed regarding recycling used mini-implants for another patient.

## CONCLUSIONS

A miniplate with a tube-shaped head makes an excellent treatment alternative that allows the initial treatment plan and biomechanical strategy to be continued without prolonging treatment duration when a mini-implant prematurely fails during active orthodontic therapy. In addition, results from the microscopic evaluation suggest that more stringent guidelines are needed for recycling a used mini-implant for another patient.

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