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A Stent-Guided Mini-Implant System

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Precise positioning of miniscrews is critical to their success. Insertion too close to adjacent tooth roots increases the risk of implant failure, especially in the mandible.[1] Poor placement may also interfere with planned tooth movements.

The use of a guidance apparatus can facilitate accurate miniscrew placement.[2] The Infinitas mini-implant system,* as described in this article, allows easy fabrication of a customized stent for direct, three-dimensional insertion guidance (Fig. 1).

Mini-Implant Design

The Infinitas mini-implant (Fig. 2) is fabricated from surgical-grade 5 titanium alloy (Ti-6Al-4V). Its head has a multifunctional design (patent pending), combining cross-slots and external and internal undercuts on a single vertical plane (Fig. 3). In contrast to conventional screw head designs, the Infinitas head has a low profile that still allows direct attachment of various types of traction auxiliaries and archwires with dimensions as large as .021" × .025". For example, a standard nickel titanium coil spring can be attached to one corner of

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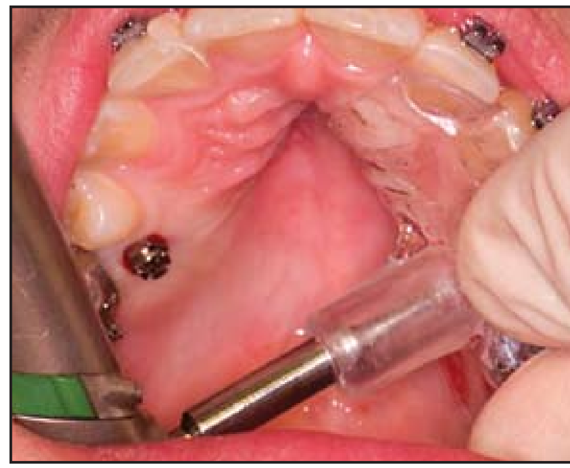

Fig. 1 Palatal insertion of Infinitas mini-implant* using three-dimensional stent.

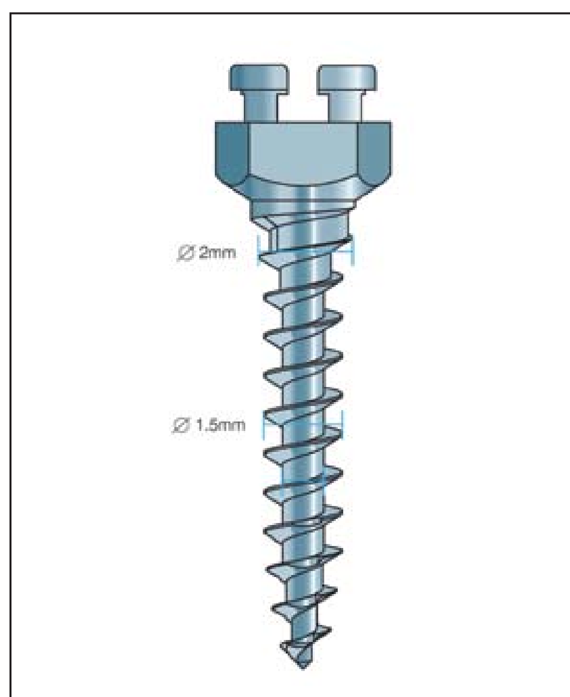

Fig. 2 Mini-implant with 1.5mm tapered body diameter, 9mm body length, and short neck.

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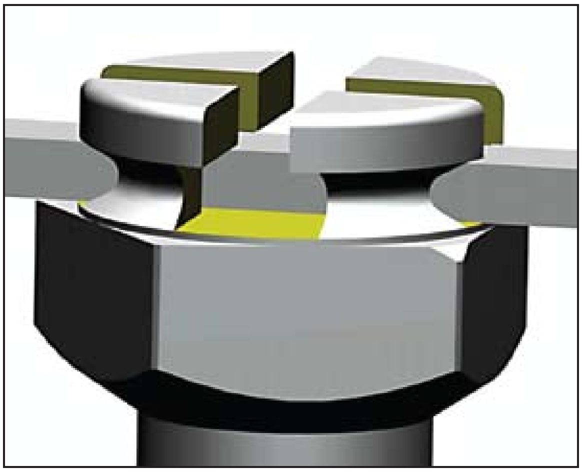

Fig. 3 Single-level head combining cross-slots (one with engaged rectangular wire) and internal and external undercuts above pentagonal neck segment.

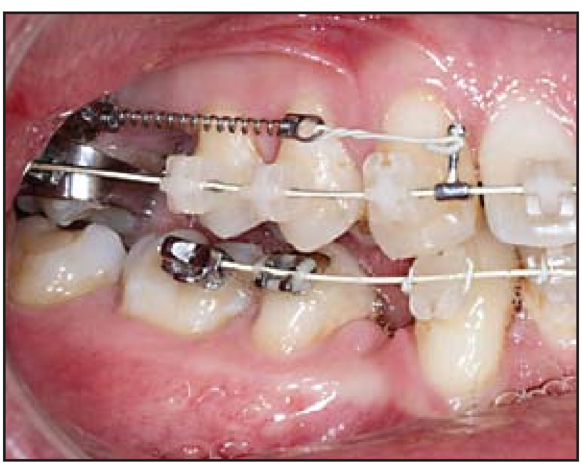

Fig. 4 Coil spring attached directly to one corner of mini-implant head above maxillary right molar, where indirect spring ligation would be difficult.

the bracket-like head within the internal undercut (Fig. 4). The screw head's low profile not only improves patient comfort, but reduces the risk of undesirable tipping moments by limiting the ratio of the head and neck length to the body length.[3]

The coronal part of the Infinitas neck has a pentagonal shape that closely matches the internal contours of the insertion screwdriver (Figs. 2,3).

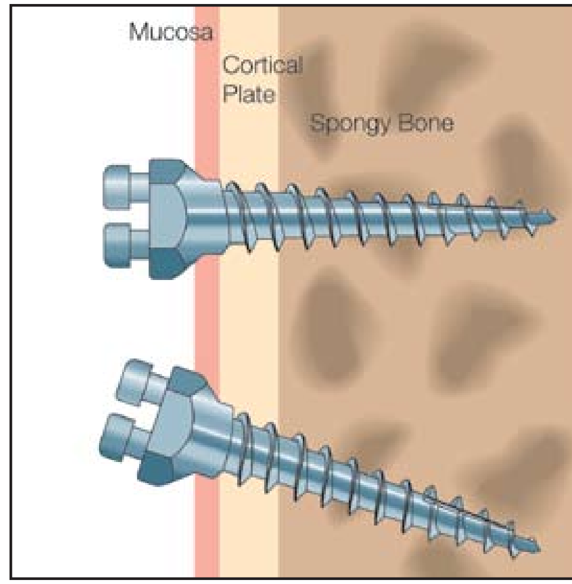

Fig. 5 Tapered neck (within mucosa) and tapered body section (within cortical plate) allow both perpendicular and oblique insertion inclinations.

Because the screw head is small, the screwdriver engages only the neck, which helps avoid breakage. The apical part of the neck is tapered to enable mini-implant insertion at both perpendicular and oblique angles to the cortical plate, with only slight compression of the adjacent mucosa (Fig. 5). Recent research indicates that an oblique insertion angle of about 25° provides the highest insertion torque values for self-drilling miniscrews.[4]

The Infinitas mini-implant is available with two different neck lengths, 1.5mm and 2.5mm, to accommodate typical buccal and palatal mucosal depths, respectively.[5] Although buccal insertions are routinely performed with a direct transmucosal technique, a customized, reusable circular mucotome (soft-tissue punch) is available to remove loose or thick mucosa, especially at palatal insertion sites. The Infinitas body comes in diameters of 1.5mm and 2.0mm and lengths of 6mm and 9mm, for a total of four size combinations. With the two neck lengths and universal head design, there are only five different configurations for all alveolar and palatal insertions, simplifying inventory control (Table 1).

TABLE 1
INFINITAS CONFIGURATIONS AND INSERTION SITES

Diameter	Body Length	Neck Length	Typical Insertion Sites
1.5mm	9mm	Short	Maxilla: buccal
1.5mm	6mm	Short	Mandible, anterior maxilla
1.5mm	9mm	Long	Maxilla: palatal
2.0mm	6mm	Long	Midpalate
2.0mm	9mm	Long	Edentulous areas, temporary abutments

All the screw-body variations are self-drilling, with asymmetrical, modified buttress threads and tips (Fig. 2), thus preserving more original bone than with screws requiring pilot drilling.[6,7] Investigators have found that the cortical plate is the principal source of primary stability and that body diameter is an important factor.[4,8-11] Engagement of the cortical plate is maximized by two specific Infinitas design features: First, the thread continues to the coronal end of the body, which provides full seating in the bone. Second, the 1.5mm-diameter-body version widens coronally, beginning 1.5mm from the head, with the thread (and body-core) diameter gradually reaching 2mm at the junction with the neck (Figs. 2,5). This results in a clinically noticeable increase in torque during the final stage of insertion—a phenomenon that has been described in the literature comparing tapered and cylindrical screw-body designs.[9,11-14] While the additional torque may improve primary stability, the extra screw width at the coronal section greatly enhances strength in this critical area, considering that a .2mm increase in the diameter of a screw can increase its strength by 50%.[15] Therefore, the risk of fracture with the Infinitas mini-implant is lower than with narrow, predrilled implants, which have been reported to break in 4% of insertions.[16,17] Because the distance between the external cortical bone surface and most root surfaces is 4mm on average,[18] the risk of contact with adjacent roots is not increased, provided the interproximal space is normal.

Studies have suggested that although low torque is associated with poor primary stability, excessive torque may lead to failure due to bone-pressure necrosis.[4,8-11] This is more likely in the mandible, where the cortical density is higher[19] and failed miniscrews have been shown to have significantly higher torque than successful ones.[8] Wilmes and colleagues demonstrated that pilot drilling reduces torque, especially within the first 2mm of drilling depth, and recommended it in sites with high cortical density.[9] Pilot drilling may be disadvantageous, however, if it requires a low-speed surgical handpiece and saline irrigation to avoid heat necrosis. The ideal situation seems to be a direct perforation of dense cortical bone to avoid excessive torque while avoiding penetration of the cancellous bed. The Infinitas system includes an easily customized cortical bone punch that perforates dense cortical bone and mucosa with a slow manual clockwise rotation, up to a maximum depth of 2mm (Fig. 6). This punch is recommended for all mandibular and midpalatal insertion sites, and it can also be used to notch the cortex to prevent mini-implant slippage during oblique insertion.

Fig. 6 Cortical bone punch used to perforate dense cortical sites before insertion of self-drilling mini-implant.


Fig. 7 Guidance kit (left to right): analog, guidance cylinder, and abutment.


Fig. 8 Analog inserted into plaster cast at planned vertical and mesiodistal angles.


Fig. 9 Abutment fitted onto analog head.

Mini-Implant Guidance System

A stent that can reliably transfer a three-dimensional prescription from the planning to the insertion stages would facilitate mini-implant placement and minimize contact with tooth roots. When used with a self-drilling miniscrew, the stent should accurately guide the insertion instrument and thus the screw itself. Cousley and Parberry have developed such a stent, but its fabrication requires time-consuming laboratory work.[2] In contrast, the Infinitas mini-implant guidance kit consists of three simple components—a mini-implant analog, an abutment, and a guidance cylinder (Fig. 7)—that fit together precisely on a vacuum-formed base plate.

Fabrication of the stent consists of six simple steps, which can be performed either by an orthodontist with access to a vacuum-forming machine or by a laboratory technician following the orthodontist's prescription. The procedure is as follows:

1. Plan the insertion process using a dental cast and radiographs. The optimal position and insertion angles of each mini-implant are determined by mentally superimposing the radiographic information, such as a periapical view of root positions, onto a plaster cast. It is much easier to visualize the insertion angles on a cast than intraorally, because the surface contour of the cast will highlight the insertion space as a concave indentation between roots.
2. Drill a pilot hole in the cast at the planned vertical and mesiodistal insertion angles, using a plaster drill and a straight or contra-angle dental handpiece.
3. Insert the mini-implant analog into the cast (Fig. 8).
4. Manually fit the abutment onto the analog head to amplify the insertion angles (Fig. 9). If the 3D position of the analog appears unsatisfactory, remove it from the cast, fill in the plaster hole as needed, and repeat the insertion process at a different location or with different angles.
5. Slide the guidance cylinder over the abutment (Fig. 10).
6. Form the base plate from a 1.5mm thermoplastic blank by placing the assembled cast, abutment,

and guidance cylinder in a pressure-forming machine (Fig. 11). Trim the base plate incorporating the guidance cylinder to the desired size.

All three Infinitas insertion instruments (the soft-tissue and bone punches and the screwdriver) fit inside the guidance cylinder as precisely as the abutment does. In addition to physically guiding the instruments, the stent offers several other benefits. First, it provides a stable insertion point, preventing slippage of the mini-implant tip across the cortical surface during oblique insertion. Second, it reduces directional variation, minimizing any flaring of the insertion bed and reducing the risk of fracture of the self-drilling tip. Third, it minimizes radiation exposure of the patient, since the stent fabrication requires no additional radiographs.

Fig. 10 Guidance cylinder placed over abutment.

Fig. 11 Finished stent with guidance cylinder incorporated into base plate.

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