

REVIEW

## Micro-Implants: Innovative Anchorage Concepts in Orthodontics

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### ABSTRACT:

Mini-implants are increasingly popular in clinical orthodontics to effect skeletal anchorage. The mode of anchorage facilitated by these implant systems has a unique characteristic owing to their temporary use, which results in a transient, albeit absolute anchorage. The foregoing properties together with the recently achieved simple application of these screws have increased their popularity, establishing them as a necessary treatment option in complex cases that would have otherwise been impossible to treat. The aim of this comprehensive review is to present and discuss the development, clinical use, benefits, and drawbacks of the miniscrew implants used to obtain a temporary but absolute/skeletal anchorage for orthodontic applications.

**Key words:** *Micro-implant; orthodontic anchorage; skeletal anchorage*

### INTRODUCTION

Orthodontic anchorage is defined as resistance to undesired tooth movement.<sup>1</sup> It is a prerequisite for the orthodontic treatment of dental and skeletal malocclusions.<sup>2,3</sup> Micro-implants have become very popular in the orthodontic community in recent years for providing anchorage.<sup>4-8</sup> They are an excellent alternative to conventional orthodontic anchorage systems such as intraoral dental anchoring units and extra-oral headgear devices. Micro-implants are especially useful in adults with an incomplete dentition as well as in adolescents when noncompliance during treatment is likely. Other advantages include their relatively small size which results in minimal anatomical limitations, user-friendly protocol, immediate loading potential, adaptability to biomechanics in effecting orthodontic and orthopedic forces, high

success rate, low cost and most importantly patient acceptability.<sup>9-11</sup>

### HISTORICAL DEVELOPMENT

The idea of using screws fixed to bone to obtain absolute anchorage goes back to 1945, when Gainsforth and Higley<sup>12</sup> placed vitallium screws in the ascending ramus of 6 dogs to retract their canines. The first clinical use reported in the literature came in 1983 when Creekmore and Eklund<sup>13</sup> used a Vitallium bone screw inserted in the anterior nasal spine to treat a patient with a deep overbite. However, the use of miniscrew implants for orthodontic anchorage was not immediately embraced. Thereafter, a number of papers focused on the use of other means to obtain skeletal anchorage for orthodontic tooth movement, such as dental implants,<sup>14-16</sup> onplants,<sup>17</sup> and palatal implants.<sup>18</sup> In 1997, Kanomi<sup>19</sup> described a mini-implant specifically made for orthodontic use, and in 1998, Costa et al.<sup>20</sup>

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presented a screw with a bracket like head. Several other miniscrew implants have been introduced since then, each presenting different designs and features. Further, during the last decade, other means of bone anchorage have also been proposed, including zygoma wires,<sup>21</sup> miniplates,<sup>22,23</sup> and zygoma anchors.<sup>24</sup>

## CLASSIFICATION

Skeletal anchorage devices can be classified into 2 main categories, based on their origin.<sup>25</sup> The first category has its origins in osseointegrated dental implants and includes the orthodontic mini-implants, the retromolar implants, and the palatal implants. The second category finds its origin in the surgical mini-implants, such as the one used by Creekmore and Eklund<sup>13</sup> and those described later by Kanomi<sup>19</sup> and Costa et al.<sup>20</sup> In a similar manner, Cope classified the current available methods of skeletal anchorage as either biocompatible or biologic in nature<sup>26</sup>.

In a more thorough classification of implants used for orthodontic anchorage, Labanauskaite et al.<sup>27</sup> suggested the following classification:

- according to the shape and size
  - \_ conical (cylindrical)
  - miniscrew implants
  - palatal implants
  - prosthodontic implants
    - \_ miniplate implants
    - \_ disc implants (onplants);
- according to the implant bone contact
  - \_ osseointegrated
  - \_ nonosseointegrated;
- according to the application
  - \_ used only for orthodontic purposes (orthodontic implants)
  - \_ used for prosthodontic and orthodontic purposes (prosthodontic implants).

Currently, there are a number of commercially available miniscrew implant systems for orthodontic use (**Table I**)

## TYPES OF ANCHORAGE

The miniscrew implants can provide 2 different types of anchorage: direct and indirect. When used for indirect anchorage, they are connected through bars or wires to the reactive unit, whereas when used for direct anchorage, they directly receive the reactive forces by acting as an anchor unit.

## CLINICAL APPLICATIONS

In general, the various miniscrew implant systems can be used in cases where the support of dental units is quantitatively or qualitatively compromised, as in partial edentulous patients or periodontally involved teeth. In addition, an absolute indication is the requirement for minimum undesired reactive forces.<sup>28</sup> Melsen<sup>25</sup> suggested using miniscrew implants as anchorage for tooth movements that could not otherwise be achieved, such as in patients with insufficient teeth for the application of conventional anchorage, in cases where the forces on the reactive unit would generate adverse side effects, in patients with a need for asymmetrical tooth movements in all planes of space, and finally in some cases as an alternative to orthognathic surgical procedure. During the past few years, the application of miniscrew implants has been expanded to include a wide array of cases, including the correction of deep over bites,<sup>29,30</sup> closure of extraction spaces,<sup>31-33</sup> correction of a canted occlusal plane,<sup>29</sup> alignment of dental midlines,<sup>29</sup> extrusion of impacted canines,<sup>34</sup> extrusion and uprighting of impacted molars,<sup>35-47</sup> molar intrusion, maxillary molar distalization, distalization of mandibular teeth,<sup>47</sup> en-masse retraction of anterior teeth,<sup>48</sup> molar mesialization,<sup>49,50</sup> upper third molar alignment, intermaxillary anchorage for the correction of sagittal discrepancies,<sup>48</sup> and correction of vertical skeletal discrepancies that would otherwise require orthognathic surgical procedure.

## IMPLANT SITE SELECTION

Selecting the proper implant site can be an important factor in the overall success of this treatment approach. Five factors are important in determining an adequate site for implantation.

1. Indication, system used, and required mechanics. When placing an orthodontic mini-

implant, the treatment objective and how long the implant will remain in situ are of paramount importance. Mechanics should be as simple and fail-safe as possible, but the future tooth movement must be anticipated to avoid any interference with the implant.

2. The implant site should ideally provide sufficient attached gingiva for placement of the mini implant. This prevents patient discomfort, tissue overgrowth, and micro jiggling that can lead to long-term implant failure.

3. Sufficient interradicular distance. The implant must be placed where roots are wide enough apart so that no damage is inflicted. Periapical radiographs or 3-dimensional cone-beam computed tomography are essential tools for evaluating potential implant sites. If the preferred implant site is obstructed by root proximity, some preparatory root uprighting might be necessary.

4. Avoiding other anatomical structures. Other anatomical structures can interfere with the placement of an orthodontic mini-implant: eg, inferior alveolar nerve, artery, vein, mental foramen, maxillary sinus, and nasal cavity. Again, 3-dimensional digital imaging can help evaluate the anatomical relationships.<sup>51</sup>

5. Adequate cortical bone thickness. Cortical bone thickness is an important factor in mini-implant stability.<sup>52</sup> Placing the implant in areas of favorable bone thickness ensures better primary stability and long-term success.

#### **CLINICAL PROCEDURES OF IMPLANT INSERTION**

Miniscrew implant placement procedures are usually available in the product brochure. Some basic guidelines follow: (1) A small amount of local anesthesia is usually sufficient for the placement of miniscrew implants, and it is advocated not to achieve profound anesthesia of the teeth but only of the soft tissue.<sup>50</sup> (2) In case of non—self-drilling miniscrew implants, a pilot hole is necessary. Pilot drilling should be done in a surgical environment, and if necessary, by an oral surgeon. Firstly, soft tissue from the site of the placement is either incised or removed using a soft tissue punch. Thereafter, a pilot hole is drilled using a drill rotating no more than 1000

rpm. The pilot drill is usually 0.2 to 0.3 mm thinner than the miniscrew implant.<sup>53</sup> The miniscrew implant is then screwed in place by using an appropriate screwdriver. (3) In case of self-drilling miniscrew implants, no incision or soft tissue removal is necessary. Infection control is similar to that for an extraction. After selecting the appropriate site, the miniscrew implant, and the corresponding site of placement, it is inserted in place.

#### **LOADING AND ANCHORAGE CONSIDERATIONS**

In contrast to dental implants, orthodontic miniscrews are loaded immediately, and most authors suggest the use of light forces early on.<sup>54</sup> Only a few studies, mostly on animals, have dealt with the investigation of tissue reaction to immediate loading of miniscrew implants.<sup>55-57</sup> In a study using finite element analysis, it was found that immediate loading should be limited to 50 cN of force in a 2 mm diameter miniscrew implant.<sup>30</sup> In another study on 51 patients in which 134 titanium screws of 3 types (1.0 mm, 1.5 mm, and 2.0 mm in diameter) and 17 miniplates were used, no significant association was found between the success rate and immediate loading, and it was concluded that immediate loading is possible if the applied force is less than 2 N.<sup>58</sup> The ability of orthodontic miniscrews to provide absolute anchorage was shown by a recent study comparing canine retraction anchorage loss with the use of miniscrew implants and with conventional molar anchorage.<sup>59</sup> However, it is questionable if the miniscrew implants remain stationary throughout their period of loading. In fact, Liou et al.<sup>60</sup> found that miniscrew implants might move according to orthodontic loading in some patients, and it is therefore advised to allow 2 mm of safety clearance between the miniscrew implant and dental roots of the adjacent teeth.

#### **CLINICAL PROCEDURES OF IMPLANT REMOVAL**

Usually, miniscrew implant removal is uneventful, and the wound does not require any special treatment. The removal procedure can be achieved without the use of anesthesia,<sup>61,62</sup> but topical or local anesthesia can be used—especially when there is tissue covering the miniscrew implant.<sup>61,63</sup> The miniscrew implant is unscrewed using the screwdriver of the corresponding manufacturer. In

the event it cannot be removed, it is advised to wait 3 to 7 days after the initial attempt of its removal, because it is believed that microfractures or bone remodeling as a result of the initial attempt will cause the screw to loosen.<sup>63</sup> If the miniscrew implant fractures during removal, a small surgical procedure to remove it may be necessary.

## COMPLICATIONS

As with any treatment, several potential complications are associated with orthodontic mini-implants. A common complication is failure of the miniimplant. Currently, approximately 10% of orthodontic mini-implants fail.<sup>64,65</sup> This rate is slightly higher than that for dental implants and can be attributed to the fact that the orthodontic mini-implant is not designed to osseointegrate. Osseointegration would complicate implant removal and is therefore not desired. The reasons for reduced implant success are improper implant site selection, overheating of the bone when drilling a pilot hole, lack of primary stability, gingival inflammation around the implant, trauma, poor oral hygiene, and idiopathic factors. Implant failure might delay treatment time. Some systems offer mini-implants of significantly larger diameter that can be placed immediately in the site of the failed implant. Extreme caution must be used to prevent damage of the adjacent roots. A healing time of 2 to 3 months before placing a new implant of the same diameter in the same location is necessary to allow for the bone to fill in. The greatest danger of mini-implant failure is aspiration if the implant becomes completely dislodged from the appliance. Damage to adjacent structures can occur even though orthodontic mini-implants and pilot drills are specifically designed to not cut into roots. Therefore, damage of the root proper is rare, but it is possible to damage the structures of the periodontal ligament. Damage of the periodontal ligament should be carefully avoided by proper implant planning and placement. The minimal space requirement between roots is 0.5 mm mesial and distal to the implant, or 1 mm more than the implant diameter (Table).<sup>62</sup> Theoretically, other structures such as the inferior alveolar nerve or the maxillary sinuses are also at risk, but they can usually be avoided by proper treatment planning. Patient

feedback when using only topical anesthetic is helpful for avoiding important structures.

Implant fractures during implant placement are rare and can be almost completely prevented by not applying excessive torque moments. Therefore, systems including a torque control ratchet are preferred (Table I).

## CONCLUSION

Mini-implants and specifically the Ortho Implant system, are an excellent adjunct to provide stable, bone based anchorage for the application of orthodontic biomechanical force systems. The Ortho Implant is valuable in treating a wide variety of malocclusions due in large part to the small dimensions that permit placement in most intraoral locations. Hence, mini-implant enhanced mechanics can become a routine application in the modern orthodontic office.

## REFERENCES

1. Daskalogiannakis J. Glossary of orthodontic terms. Leipzig: Quintessence Publishing Co.; 2000.
2. Turley PK, Kean C, Schur J, Stefanac J, Gray J, Hennes J, et al. Orthodontic force application to titanium endosseous implants. *Angle Orthod* 1988;**58**:151-162.
3. Papadopoulos MA. Overview of the intra-maxillary non-compliance appliances with absolute anchorage. In: Papadopoulos MA, editor. *Orthodontic treatment for the Class II non-compliant patient: current principles and techniques*. Edinburgh: Elsevier, Mosby; 2006. p. 341-344.
4. Kanomi R. Mini-implant for orthodontic anchorage. *J Clin Orthod* 1997;**31**:763—767.
5. Costa A, Raffaini M, Melsen B. Miniscrews as orthodontic anchorage: a preliminary report. *Int J Adult Orthodon Orthognath Surg* 1998;**13**:201—209.
6. Ohmae M, Saito S, Morohashi T, Seki K, Qu H, Kanomi R, et al. A clinical and histological evaluation of titanium mini-implants as anchors for orthodontic intrusion in the beagle dog. *Am J Orthod Dentofacial Orthop* 2001;**119**:489—497.
7. Kyung HM, Park HS, Bae SM, Sung JH, Kim IB. Development of orthodontic micro-implants for intraoral anchorage. *J Clin Orthod* 2003;**37**:321—328.
8. Fritz U, Ehmer A, Diedrich P. Clinical suitability of titanium microscrews for orthodontic anchorage-preliminary experiences. *J Orofacial Orthop* 2004;**65**:410—418.
9. Kanomi R, Takada K. Application of titanium mini-implant system for orthodontic anchorage. In: Mah J, Davidovitch Z, editors. *Biological mechanisms of tooth movement and craniofacial adaptation*. Birmingham (AL): EBSCO Media; 2000. p. 253—258.

10. Buchter A, Wiechmann D, Koerdt S, Wiesmann HP, Piffko J, Meyer U. Load-related implant reaction of mini-implants used for orthodontic anchorage. *Clin Oral Impl Res* 2005;**16**:473—479.
11. Park HS, Lee SK, Kwon OW. Group distal movement of teeth using microscrew implant anchorage. *Angle Orthod* 2005;**75**:602—609.
12. Gainsforth BL, Higley LB. A study of orthodontic anchorage possibilities in basal bone. *Am J Orthod Oral Surg* 1945;**31**:406-416.
13. Creekmore TD, Eklund MK. The possibility of skeletal anchorage. *J Clin Orthod* 1983;**17**:266-269.
14. Douglass JB, Killiany DM. Dental implants used as orthodontic anchorage. *J Oral Implant* 1987;**13**:28-38.
15. Roberts WE, Helm FR, Marshall KJ, Gongloff RK. Rigid endosseous implants for orthodontic and orthopedic anchorage. *Angle Orthod* 1989;**59**:247-256.
16. Roberts WE, Marshall KJ, Mozsary PG. Rigid endosseous implant utilized as anchorage to protract molars and close an atrophic extraction site. *Angle Orthod* 1990;**60**:134-152.
17. Block MS, Hoffman DR. A new device for absolute anchorage for orthodontics. *Am J Orthod Dentofacial Orthop* 1995;**107**:251-258.
18. Wehrbein H, Glatzmaier J, Mundwiler U, Diedrich P. The Orthosystem: a new implant system for orthodontic anchorage in the palate. *J Orofac Orthop* 1996;**57**:142-153.
19. Kanomi R. Mini-implant for orthodontic anchorage. *J Clin Orthod* 1997;**31**:763-767.
20. Costa A, Raffaini M, Melsen B. Miniscrews as orthodontic anchorage: a preliminary report. *Int J Adult Orthodon Orthognath Surg* 1998;**13**:201-209.
21. Melsen B, Petersen JK, Costa A. Zygoma ligatures: an alternative form of maxillary anchorage. *J Clin Orthod* 1998;**32**:154-158.
22. Nagasaka H, Sugawara J, Kawamura H, Kasahara T, Umemori M, Mitani H. A clinical evaluation on the efficacy of titanium miniplates as orthodontic anchorage. *Orthod Waves* 1999;**58**:136-147.
23. Umemori M, Sugawara J, Mitani H, Nagasaka H, Kawamura H. Skeletal anchorage system for open-bite correction. *Am J Orthod Dentofacial Orthop* 1999;**115**:166-174.
24. De Clerck H, Geerinckx V, Siciliano S. The Zygoma Anchorage System. *J Clin Orthod* 2002;**36**:455-459.
25. Melsen B. Mini-implants: where are we? *J Clin Orthod* 2005;**39**:539-547.
26. Cope J. Temporary anchorage devices in orthodontics: a paradigm shift. *Semin Orthod* 2005;**11**:3-9.
27. Labanauskaite B, Jankauskas G, Vasiliauskas A, Haffar N. Implants for orthodontic anchorage. Meta-analysis. *Stomatologija* 2005;**7**:128-32.
28. Fortini A, Cacciafesta V, Sfondrini MF, Cambi S, Lupoli M. Clinical applications and efficacy of miniscrews for extra-dental anchorage. *Orthod* 2004;**1**:87-98.
29. Carano A, Velo S, Leone P, Siciliani G. Clinical applications of the Miniscrew Anchorage System. *J Clin Orthod* 2005;**39**:9-24.
30. Ohnishi H, Yagi T, Yasuda Y, Takada K. A mini-implant for orthodontic anchorage in a deep overbite case. *Angle Orthod* 2005;**75**:444-52.
31. Park H, Bae S, Kyung H, Sung J. Micro-implant anchorage for treatment of skeletal Class I bialveolar protrusion. *J Clin Orthod* 2001;**35**:417-28.
32. Park Y, Chu J, Choi Y, Choi N. Extraction space closure with vacuum-formed splints and miniscrew anchorage. *J Clin Orthod* 2005;**39**:76-9.
33. Yun S, Lim W, Chun Y. Molar control using indirect miniscrew anchorage. *J Clin Orthod* 2005;**39**:661-4.
34. Park HS, Kwon OW, Sung JH. Micro-implant anchorage for forced eruption of impacted canines. *J Clin Orthod* 2004;**38**:297-302.
35. Park H, Kyung H, Sung J. A simple method of molar uprighting with micro-implant anchorage. *J Clin Orthod* 2002;**36**:592-596.
36. Giancotti A, Muzzi F, Santini F, Arcuri C. Miniscrew treatment of ectopic mandibular molars. *J Clin Orthod* 2004;**37**:380-383.
37. Park HS, Kwon OW, Sung JH. Uprighting second molars with micro-implant anchorage. *J Clin Orthod* 2004;**38**:100-103.
38. Park Y, Lee SY, Kim DH, Jee SH. Intrusion of posterior teeth using miniscrew implants. *Am J Orthod Dentofacial Orthop* 2003;**123**:690-694.
39. Paik C, Woo Y, Boyd R. Treatment of an adult patient with vertical maxillary excess using miniscrew fixation. *J Clin Orthod* 2003;**37**:423-428.
40. Chang YJ, Lee HS, Chun YS. Microscrew anchorage for molar intrusion. *J Clin Orthod* 2004;**38**:325-330.
41. Yao CC, Lee JJ, Chen HY, Chang ZC, Chang HF, Chen YJ. Maxillary molar intrusion with fixed appliances and miniimplant anchorage studied in three dimensions. *Angle Orthod* 2005;**75**:754-760.
42. Bae SM, Kyung HM. Mandibular molar intrusion with miniscrew anchorage. *J Clin Orthod* 2006;**40**:107-108.
43. Chung K, Kim SH, Kook Y. C-orthodontic microimplant for distalization of mandibular dentition in class III correction. *Angle Orthod* 2005;**75**:119-128.
44. Kyung H, Park H, Bae S, Sung J, Kim I. The lingual plain-wire system with micro-implant anchorage. *J Clin Orthod* 2004;**38**:388-395.
45. Chung KR, Kim SH, Kook YA. The C-orthodontic micro implant. *J Clin Orthod* 2004;**38**:478-486.
46. Lee J, Park HS, Kyung H. Micro-implant anchorage for lingual treatment of a skeletal class II malocclusion. *J Clin Orthod* 2001;**35**:643-647.
47. Bae S, Park H, Kyung H. Clinical application of micro-implant anchorage. *J Clin Orthod* 2002;**36**:298-302.
48. Kyung SH, Choi JH, Park YC. Miniscrew anchorage used to protract lower second molars into first molar extraction sites. *J Clin Orthod* 2003;**37**:575-579.
49. Giancotti A, Greco M, Mampieri G, Arcuri C. The use of titanium miniscrews for molar protraction in extraction treatment. *Prog Orthod* 2004;**5**:236-247

50. Kyung HM, Park HS, Bae SM, Sung JH, Kim IB. Development of orthodontic microimplants of intraoral anchorage. *J Clin Orthod* 2003;**37**:321-328.
51. Cevidanes LH, Styner MA, Proffit WR. Image analysis and superimposition of 3-dimensional cone-beam computed tomography models. *Am J Orthod Dentofacial Orthop* 2006;**129**:611-618.
52. Tseng YC, Hsieh CH, Chen CH, Shen YS, Huang IY, Chen CM. The application of mini-implants for orthodontic anchorage. *Int J Oral Maxillofac Surg* 2006;**35**:704-707.
53. Carano A, Lonardo P, Velo S, Incorvati C. Mechanical properties of three different commercially available miniscrews for skeletal anchorage. *Prog Orthod* 2005;**6**:82-97.
54. Ohashi E, Pecho OE, Moron M, Lagravere MO. Implant vs. screw loading protocols in orthodontics: a systematic review. *Angle Orthod* 2006;**76**:721-727.
55. Ohmae M, Saito S, Morohashi T, Seki K, Qu H, Kanomi R, et al. A clinical and histological evaluation of titanium mini-implants as anchors for orthodontic intrusion in the beagle dog. *Am J Orthod Dentofacial Orthop* 2001;**119**:489-497.
56. Buchter A, Wiechmann D, Koerdt S, Wiesmann HP, Piffko J, Meyer U. Load-related implant reaction of mini-implants used for orthodontic anchorage. *Clin Oral Implants Res* 2005;**16**:473-479.
57. Chen YJ, Chen YH, Lin LD, Yao CC. Removal torque of miniscrew used for orthodontic anchorage: a preliminary report. *Int J Oral Maxillofac Implants* 2006;**21**:283-289.
58. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. *Am J Orthod Dentofacial Orthop* 2003;**124**:373-378.
59. Thiruvengkatachari B, Pavithranand A, Rajasigamani K, Kyung HM. Comparison and measurement of the amount of anchorage loss of the molars with and without the use of implant anchorage during canine retraction. *Am J Orthod Dentofacial Orthop* 2006;**129**:551-554.
60. Liou EJ, Pai BC, Lin JC. Do miniscrews remain stationary under orthodontic forces? *Am J Orthod Dentofacial Orthop* 2004;**126**:42-47.
61. Herman R, Cope JB. Miniscrew implants: IMTEC Mini Ortho Implants. *Semin Orthod* 2005;**11**:32-39.
62. Maino BG, Mura P, Bednar J. Miniscrew implants: the Spider Screw Anchorage System. *Semin Orthod* 2005;**11**:40-46.
63. Melsen B, Verna C. Miniscrew implants: the Aarhus Anchorage System. *Semin Orthod* 2005;**11**:24-31.
64. Tseng YC, Hsieh CH, Chen CH, Shen YS, Huang IY, Chen CM. The application of mini-implants for orthodontic anchorage. *Int J Oral Maxillofac Surg* 2006;**35**:704-707.
65. Cheng SJ, Tseng IY, Lee JJ, Kok SH. A prospective study of the risk factors associated with failure of mini-implants used for orthodontic anchorage. *Int J Oral Maxillofac Implants* 2004;**19**:100-106.

**Table I. Currently available systems approved by the Food and Drug Administration**

System	Lomas	Tomas	Ortho Implant
Manufacturer	Mondeal, Tuttlingen, Germany	Dentaurum, Ispringen, Germany	Imtec, Ardmore, Okla
US distributor	GAC/Dentsply, Bohemia, NY	Dentaurum, Newtown, PA	3M Unitek, Monrovia, Calif
Screw shape	Cylindrical	Cylindrical	Conical
Screw type (thread)	Self-drilling Self-tapping	Self-tapping Self-drilling	Self-drilling Self-tapping
Diameter (mm)	1.5 2.0 2.3	1.6	1.8
Length (mm)	7 9 11	6 8 10	6 8 10
Screw head	Rectangular, .018X.025-in and .022 X.025-in tube and slot	Hexagonal, .022-in universal cross slot and patented undercut	Hexagonal, O-ball & .030-in hole, O-cap
Packaging	Sterile	Sterile	Sterile
System components	Autoclavable tray Pilot drill Ø 1.0 and 1.5 mm Torque wrench Socket driver handle Socket blade Finger socket driver Hand piece socket	Teflon tray Tissue punch Locator Round drill Ø 1.0 mm Standard pilot drill Ø 1.2 mm Pilot drill Ø 1.1 mm Applicator wheel Torque ratchet Driver	MDI tray Tissue punch Pilot drill Ø 1.1 mm O-driver O-cap Mucosa marker Optional #2 round bur Ratchet wrench with adapters