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Review Article

A descriptive review on the use of skeletal anchorage in orthodontics (Part II)

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ABSTRACT

This is the continuation of the first part of our article and includes the design and function of screw-type orthodontic mini-implants, placement sites, surgical procedures, loading approaches and a little about biocortical and resorbable implants.

1. Introduction

In the first part of our article, we had discussed about the history and different means of skeletal anchorage present.[1] In this part we will further proceed with the most commonly used screw type mini-implants, their design, function, placement sites and other intricacies along with the biocortical and resorbable implants.

Cope[2] recommended the phrase "miniscrew implants" for those having a diameter of less than 2.5mm. He classified temporary anchorage devices as Biological TADs and Biocompatible TADs.

A classification of implants used in orthodontics was given by Labanauskaite et al[3] in 2005 as

1. Conical, Miniplate implants and Disc implants according to the shape and size.
2. Osseointegrated and Nonosseointegrated according to the implant bone contact and
3. Orthodontic implants and Prosthodontic implants according to the application.

2. Types and Properties

Miniscrews mainly differ in their composition, size, and design based upon the alloy or metal used for their fabrication, the diameter of threaded portion, the length of the implant, and the design of the head and the threaded portion.

The implant alloy used must be nontoxic, biocompatible which possess excellent mechanical properties and provides resistance to stress, strain, and corrosion.

The commonly used materials for implants are:[4]

1. Biotolerant (stainless steel, chromium-cobalt alloy).
2. Bioinert (titanium, carbon).
3. Bioactive (vetroceramic apatite hydroxide, ceramic oxidized aluminum).

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2.1. Head design

The head designs of various miniscrews differ based upon the need to use either direct or indirect anchorage or both as well as to avoid tissue irritation. Most frequently used is the button-like design with a sphere, double sphere or hexagonal shape. A bracket like design also exists.

2.2. Self-drilling versus self-tapping

The thread design of miniscrews can either be self-tapping or self-drilling. For the self-tapping implants, the placement is preceded by pilot drilling to prepare a hole for the implant placement. This procedure in itself has potential dangers, such as damage to tooth roots, drill-bit breakage, overdrilling, and thermal necrosis of bone especially in the interradicular region. On the contrary, self-drilling screws don't need pilot drilling and can be placed conveniently in narrow interdental areas.

Yan Chen[5] in 2008 compared the influences of Self-drilling versus self-tapping microimplants on the surrounding tissues biomechanically and histologically in dogs and found that the percentage of bone-to-implant contact values was greater in the self-drilling group. They concluded that for use in the maxillary segment as well as in areas of mandible which have thin cortical bone, self-drilling type is better recommended.

2.3. Conical versus cylindric designs

Wilmes et al[6] in 2008 concluded that there is higher primary stability in conical miniimplants than the cylindrical designs and Yano[7] in 2006 suggested that tapered miniscrews induce bone-screw cohesion following immediate loading and hence advocated their use in comparison to the cylindric designs.

2.4. Length and diameter of the miniscrew implant

The dimensions of the miniscrew are variable based upon the site of placement in the jaws. The average thread diameter ranges from 1.2 to 2.0 mm while the length from 4.0 to 12.0 mm. Few companies also provide a length of 14,17 or even 21 mm.[8] Thinner diameter screws also provide an added advantage of ease of insertion in the interradicular area without the risk of root contact.

Miyawaki et al[9] in 2003 reported an increase in rate of mobility and failure of the screw at a diameter of 1.0 mm or less. Lin et al[10] and Dalstra[11] documented an increased chance of fracture with diameters less than 1.2 mm. Although studies unanimously agree upon safety in using screws with length 6 - 8 mm and diameter 1.2- to 1.5-mm.

2.5. Osseointegration

Upon usage in orthodontics, complete osseointegration of screws is a bane as it complicates the removal process. Hence, most of these devices are manufactured with a smooth surface, that minimizes osseointegration in ordinary conditions and in the absence of special surface treatment regimens.[2] Chaddad[12] in 2008 upon evaluation of the clinical performance of various types of miniscrews found that SLA mini-implants presented a higher level of osseointegration at the time of removal, which was evident by the higher amount of torque necessary for its removal when compared with smooth machined titanium implants. Hence, surface treated (SLA) implants should be used in areas of poor bone quality, and their loading should be delayed for 6 to 8 weeks when initial osseointegration has occurred.

3. Clinical Applications of TADs

The clinical applications of temporary anchorage devices can be broadly classified for three categories viz. skeletal, dental and soft tissue.[13,14]

3.1. Skeletal

1. TADs can be used during conventional orthopedic corrections for skeletal anchorage preparations.
2. To prevent secondary eruption during growing phase to yield more horizontal growth in vertical growers.
3. For intrusion of posterior dentition in vertical growers hence enabling counterclockwise rotation of the mandible.
4. For intrusion of the entire dental arch in cases of maxillary alveolar hyperplasia to reduce the gummy smile.
5. To obtain true skeletal expansion of the maxilla and prevent undesirable dental tipping.

3.2. Dental

1. For space closure in cases of extraction, congenitally missing or lost teeth, thus eliminating the need for prosthetic rehabilitation.
2. During enmasse retraction of anterior and prevent loss of anchorage of posterior unit.
3. For uprighting tipped molars.
4. For torque control during retraction.
5. In cases of asymmetric correction of Class II or III dental relation.
6. In correction of tilt of occlusal plane.
7. In borderline cases.
8. In deep bite cases for intrusion anteriors.
9. In intrusion of overerupted teeth.
10. For extrusion of submerged tooth.

11. In unilateral cross-bite cases for movement of single segment.

3.3. Soft tissue

1. For space closure by posterior protraction to maintain the incisor position for optimal lip support.
2. For space closure by anterior retraction thus reducing lip protrusion.
3. To eliminate lip incompetency by decreasing lower-face height.

4. Possible Sites for Placement of Miniscrew Implant

4.1. Maxilla

1. Inferior to anterior nasal spine.
2. On the palatine process of maxilla.
3. Infrazygomatic crest.
4. Maxillary tuberosities.
5. Alveolar process (both buccally and palatally) between the roots of the teeth.

4.2. Mandible

1. Mandibular symphysis or parasymphysis
2. Inter radicular area on the alveolar process.
3. Retromolar area.

Poggio et al.[15] suggested an order of sites available in the interradicular spaces based on safety for maxilla and mandible.

4.3. Maxillary sites

1. Between the second premolar and the first molar on the palate 2-8mm away from alveolar crest.
2. In the interradicular space palatally between the first and second molar 2-5 mm from the alveolar crest.
3. In the interradicular space between the canine and second premolar both buccally and palatally 5-11 mm from the alveolar crest.
4. On the buccal side, in the interradicular space between the first molar and second premolar, from five to eight mm from the alveolar crest.
5. In the maxilla, the more anterior and the more apical, the safer the location becomes.

4.4. Mandibular sites

1. Interradicular spaces between the central incisor to second molar buccally at approx. 6-11mm from the alveolar crest.
2. The least amount of bone was between the first premolar and the canine.

4.5. Safety Distance

Safety distance:[16] Diameter of the implant + PDL space (normal range 0.25 mm ± 50%) minimal distance between implant and tooth (1.5 mm)

Example: Safety distance (mm) of mini-implants when inserted between roots 1.2+(0.25 + 50%) + (1.5 +1.5) = 4.575. Therefore, the distance between roots needs to be at least 4.6 mm to reduce the risk.

4.6. Safety distance modified

The safety distance was modified by Gautam P and Valiathan A as:[17]

Safety distance = Diameter of the implant + 2 × [PDL space (normal range 0.25 mm ± 50%)] minimal distance between implant and tooth (1.5 mm)

5. Surgical Procedure for Placing a Mini Implant

1. The patient rinse with a chlorhexidine mouthwash
2. Local anesthesia at the selected site is administered
3. Mucosa at the center of the loop is indented with a punch,dental probe or round bur.
4. Use a round bur 1-1.2 mm to indent the cortical plate at the center of the surgical site.
5. Insert the mini-screw slowly by a screw driver
6. When the implant is almost completely seated, take a radiograph to verify the implant position relative to the adjacent roots.

Minor adjustments to the insertion depth and screw head projection are made if needed. Since contact of the miniscrew implants to the root surfaces of the adjacent teeth should be avoided, taking an intraoral radiograph with a surgical guide made from a rectangular wire bonded to teeth or Surgical guide or stent in the region where a miniscrew implant is to be placed, can significantly help for a more accurate identification of that region.

6. Post-Surgical Instructions

Patients should be given standard surgical postoperative instructions emphasizing the importance of inflammation control and cautioned not to brush or touch the implant for a week. Ibuprofen or its equivalent is adequate for discomfort, and antibiotics are rarely necessary. A chlorhexidine rinse is usually prescribed for 7 to 14 days, but no other post-surgical care is required. Patients with miniscrew implants should return to the orthodontic office as soon as possible for loading, preferably within 1 week.

7. 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,

but topical or local anesthesia can be used—especially when there is tissue covering the miniscrew implant.[18,19] 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.[18] If the miniscrew implant fractures during removal, a small surgical procedure to remove it may be necessary.

8. Loading and Anchorage Considerations

Clinically, there are 2 types of loading patterns for implants as orthodontic anchorage.

1. Albrektsson et al[20] & Roberts et al[21] stated that first type is to allow the implant to heal before the application of orthodontic force and to achieve osseointegration at the bone implant interface. After osseointegration, bone quality as much as bone quantity are important factors, because of the necessity for long-term maintenance of the stability of the bone-implant interface.
2. Miyawaki[9] stated that second type of loading pattern, for miniscrews, the force can be loaded immediately, because implant stability might be achieved by mechanical interdigitation rather than by osseointegration at the early stage of implant healing. Therefore, bone quantity seems to be the major factor in the stability of miniscrews.

9. Complications of Orthodontic Miniscrews

These can occur at various stages.[22]

9.1. During insertion

1. PDL or root trauma.
2. Slipup of the microimplant.
3. Neural damage.
4. Perforation of nasal and maxillary sinus air spaces.
5. Miniscrew deformation or breakage.

9.2. During orthodontic loading

1. Failure of the screw.
2. Migration of the microimplant.

9.3. Soft-tissue complications

1. Ulcers of the mucosa.
2. Soft-tissue coverage.
3. Soft tissue inflammation
4. Peri-implantitis.

9.4. During removal

1. Miniscrew deformation or breakage.
2. Partial osseointegration.

10. Bicortical Microimplant

Wu et al[23] in 2007 described bicortical microimplant with 2 anchorage heads. They used it for mesial movement of posterior tooth in the beagle dog. Since microimplant provides only 1 anchorage unit for unilateral orthodontic anchorage, so rotation control of the tooth is needed; this increases the friction force and extends the total treatment time. Also, in patients with large spaces to be closed, the antirotation lever arm does not work well because of distortion caused by occlusal forces. A bilateral orthodontic force system applied to the center of resistance of the active molar is preferred to unilateral force in mesiodistal displacement of teeth.

Theoretically, to obtain optimal bilateral force applied to the center of resistance of the active molar of the mandible, we can place 2 microscrews, 1 on the buccal side and another on the lingual side, but it is difficult to place the lingual one in the correct place because of the limitation of the anatomy of the oral cavity. Hence Jian-chao Wu designed a new bicortical microimplant with 2 anchorage units for applying bilateral forces. The microimplants were 12 to14 mm long with a diameter of 1.15 mm, in a cylindrical shape with 1 slot on each head. Mesial displacement of posterior teeth without rotation in beagle dogs was achieved by bilateral orthodontic force. Hence, they suggested that bicortical microimplants with 2 anchorage units can function as anchors for mesial movement of posterior teeth.

11. Resorbable Screws for Orthodontic Anchorage

The risks associated with metallic micro fixation devices used in pediatric craniofacial surgery and the need of a subsequent removal operation has given a rise to the development of biodegradable mini-osteosynthesis devices. Devices made of polylactic acid (PLA) and polyglycolic acid (PGA) and their copolymer have been used in the internal fixation of fractures and osteotomies in orthopaedic surgery since 1980s. The obvious biocompatibility of certain resorbable materials and the need of alternative methods to metallic fixation led to a rapid change over to biodegradable fixation in non-loaded osteosyntheses in the child neurocranium after 1995.

Absorbable screws are made of a resorbable copolymer, a polyester derivative of L-lactic and glycolic acids. Poly L-lactic/polyglycolic acid copolymer degrades and resorbs in vivo by hydrolysis into L-lactic and glycolic acids which are then metabolized by the body.[24] The material is non-toxic, non-irritating and 100% amorphous, metabolizing to caron-di-oxide and water. The potential advantages of

bioresorbable implants include less stress shielding of the bone that would be expected with metallic implants, less interference with modern imaging techniques, and elimination of the need for subsequent operations to remove the implant.

12. Discussion

Skeletal orthodontic anchorage has mainly changed the possibilities and paradigms in orthodontic treatment. The scientific basis of the implant bone integration in maxillofacial surgery and implantology has become part of interdisciplinary research in the field of orthognatic treatment. The Skeletal orthodontic anchorage obviates the need for significant patient compliance, particularly with regard to extraoral appliances, which allows more predictable treatment results. This also allows an overall decrease in the number of nonextraction and orthognathic surgery cases. Because the Skeletal orthodontic anchorage is rigidly fixed to bone, molars can be moved in any direction without taxing anchorage and the occlusal plane can be controlled by orthodontists, without the need for surgery.

13. Conclusions

The Skeletal orthodontic anchorage is quite effective biomechanics for adult patients, retreatment cases, and patients with complex orthodontic problems.

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15. Conflict of Interest

None.

References

1. Singh NB, Nagar A, Shukla P, Gupta S. A descriptive review on the use of skeletal anchorage in orthodontics (Part I). *IP Indian J Orthod Dentofacial Res*. 2023;9(2):77–82.
2. Cope JB. Temporary Anchorage Devices in Orthodontics: A Paradigm Shift. *Semin Orthod*. 2005;11(1):3–9.
3. Labanauskaite B, Jankauskas G, Vasiliauskas A, Haffar N. Implants for orthodontic anchorage. Meta-analysis. *Stomatologija*. 2005;7(4):128–32.
4. Favero L, Brollo P, Bressan E. Orthodontic anchorage with specific fixtures: Related study analysis. *Am J Orthod Dentofacial Orthop*. 2002;122(1):84–94.
5. Chen Y, Shin HI, Kyung HM. 5.Yan Chen, Hong-In Shin, and Hee-Moon Kyung. Biomechanical and histological comparison of self-drilling and self-tapping orthodontic microimplants in dogs. Am J Orthod Dentofacial Orthop 2008;133:44-50. *Am J Orthod Dentofacial Orthop*. 2008;133(1):44–50.
6. Wilmes B, Ottenstreuer S, Su YY, Drescher D. Impact of Implant Design on Primary Stability of Orthodontic Mini-implants. *J Orofac Orthop*. 2008;69(1):42–50.
7. Yano S, Motoyoshi M, Uemura M, Ono A, Shimizu N. Tapered orthodontic miniscrews induce bone-screw cohesion following immediate loading. *Eur Jou Orthod*. 2006;28(6):541–6.
8. Melsen B. Mini-implants: where are we? *J Clin Orthod*. 2005;39(9):539–47.
9. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T, et al. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. *Am J Orthod Dentofacial Orthop*. 2003;124(4):373–8.
10. Lin JC, Liou EJ. A new bone screw for orthodontic anchorage. *J Clin Orthod*. 2003;37(12):676–81.
11. Dalstra M, Cattaneo PM, Melsen B. Load transfer of miniscrews for orthodontic anchorage. *Orthod*. 2004;1:53–62.
12. Chaddad K, Ferreira AFH, Geurs N, Reddy MS. Influence of surface characteristics on survival rates of mini-implants. *Angle Orthod*. 2008;78(1):107–13.
13. Mcguire MK, Scheyer ET, Gallerano RL. Temporary anchorage devices for tooth movement: a review and case reports. *J Periodontol*. 2006;77(10):1–12.
14. Shukla P, Thakral R, Gupta S, Nagar A. Borderline cases in orthodontics-A review. *IP Indian J Orthod Dentofacial Res*. 2019;5(3):78–83.
15. Poggio P, Incorvati C, Velo S, Carano A. "Safe zones": a guide for miniscrew positioning in the maxillary and mandibular arch. *Angle Orthod*. 2006;76(2):191–7.
16. Huang LH, Shotwell JL, Wang HL. Dental implants for orthodontic anchorage. *Am J Orthod Dentofacial Orthop*. 2005;127(6):713–22.
17. Gautam P, Valiathan A. Implants for anchorage. *Am J Orthod Dentofacial Orthop*. 2006;129(2):174. doi:10.1016/j.ajodo.2005.12.018.
18. Melsen B, Verna C. Miniscrew implants: the Aarhus Anchorage System. *Semin Orthod*. 2005;11(1):24–31.
19. Herman R, Cope JB. Miniscrew implants: IMTEC Mini Ortho Implants. *Semin Orthod*. 2005;11(1):32–9.
20. Albrektsson T, Branemark PI, Hansson HA, Lundstrom J. Osseointegrated titanium implants. Requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man. *Acta Orthop Scand*. 1981;52(2):155–70.
21. Roberts WE, Smith RK, Zilberman Y, Mozsary PG, Smith RS. Osseous adaptation to continuous loading of rigid endosseous implants. *Am J Orthod*. 1984;86(2):95–111.
22. Neal D, Kusnoto B. Kravitz and Budi Kusnoto Risks and complications of orthodontic miniscrews. *Am J Orthod Dentofacial Orthop*. 2007;131(4 Suppl):S43–51.
23. Wu JC, Huang JN, Zhao SF. Bicortical microimplant with 2 anchorage heads for mesial movement of posterior tooth in the beagle dog. *Am J Orthod Dentofacial Orthop*. 2007;132(3):353–9.
24. Aoki T, Ogawa K, Miyazawa K, Kawai T, Goto S. The use of bioabsorbable implants as orthodontic anchorage in dogs. *Dent Mater J*. 2005;24(4):628–35.

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