MH cortical screws, a revolutionary orthodontic TADs design

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Abstract

OBJECTIVE: MH cortical screws were designed to combine the advantages of thick mini-implants with the versatility of micro-screws while avoiding the disadvantages of both.

MATERIALS AND METHODS: An MH cortical screw (MH is an abbreviation for the author’s name) was made from titanium material. The screw has a 3 mm-long amphora-shaped shank of 2 mm thickness at its thinnest and 3 mm at its thickest part. Uniform 4 mm diameter threads blend into a 1 mm cutting tip. An external hexagonal head with side retentive ligature holes and a central hole for attachments was fabricated on a saucer-shaped gingival collar. Multiple attachments have been prepared for amending to the central hole.

RESULTS: The shank design allowed cortical plate retention. The uniform threads and the amphora design provided maximum primary and secondary stability, respectively. The self-drilling tip allowed for a flapless technique, while the hexagonal head with side holes facilitated screwdriver control and allows for ligature wire anchorage. Cleats and buttons facilitated the use of elastics and springs, together with bracket-heads and eyelets for titanium molybdenum alloy and nickel-titanium wires inclusion. Adjustable hooks and chains provided versatility of line of action. Cover screws to retain extra-tissue mini-plates applied skeletal anchorage and long-term retention with flapless manipulations.

CONCLUSION: MH cortical screws are a novel and important introduction to orthodontic anchorage. They combine primary and secondary stability with avoidance of root damage together with insertions into attached gingiva only. Multiple and versatile attachments allow for the application of biomechanical techniques according to the clinician’s preferences. Extra-tissue mini-plates facilitate maximum anchorage for skeletal control and long-term retention without surgery.

Keywords: Anchorage, attachments, MH cortical screws, mini-implants, mini-plates, primary stability, secondary stability, skeletal retention, TADs

Introduction

Temporary anchorage devices (TADs) are defined as structures applied to the bone for a temporary period to provide skeletal anchorage sufficient for tooth movement.1 Generally, modern TADs are manufactured from titanium, while older TADs were formed from stainless steel. The idea of dental implants was first introduced into the prostodontics branch by Branemark in 1960.2 Later, with the shift from prostodontics to orthodontics, multiple uses for TADs were developed. The modern TADs were developed in 1997 and have gained popularity since then. These device types include midpalate implants, onplants, mini-plates, and mini-screws.3

Midpalate implants were the smallest length classic prosthodontic implants that allowed for insertion into the anterior part of the palate and were used after the period of osseointegration for orthodontic anchorage. These implants had the advantage of good retention and stability and could withstand heavy multidirectional forces. Their drawbacks included surgery for site preparation and fixture placement and the need for complex wire designs for indirect
anchorage. A second surgery to remove the implant with a large flap and left-over socket after removal was not favorable for most patients. Further, high cost and the possibility of root damage were critical flaws of these devices.\[4,5\]

Onplants, by contrast, were designed to be attached to the cortical plate of the palatal bone. The thick palatal gingiva was used as a hold-and-support until the onplant was fully osseointegrated with the bone surface. The appliances designed and attached to onplants were used as indirect anchorage methods which required a skilled lab to reach the desired goals. Onplants had the advantage of requiring less extensive surgery for removal, and they provided enough anchorage for regular orthodontic movements. However, onplants required large flap reflection in placement and removal together with bone surface negotiation to allow for osseointegration. High cost and patient discomfort were added disadvantages.\[6\]

Mini-implants were produced to address the drawbacks of previous TADs. The diameter of the mini-implants was 2–2.5 mm, similar to the mini-implants used in prosthodontics for the support of temporary crowns in arch spaces. Mini-implants were aimed at osseointegration which allowed for good support during applied forces of orthodontic movements.\[7\] The main drawbacks were that sufficient space was needed for placement to avoid root damage. At least 1 mm of bone should encircle the mini-implants in all directions for stability and osseointegration. Thus, many mini-implants were placed after, rather than before, leveling and alignment.\[8\] That was a problem because the loss of anchorage started and progressed earlier during leveling and alignment phase due to the built-in angulation. Later, micro-screws were developed with a diameter of 1.4 mm. That fine diameter was intended to allow safe placement between the roots of teeth from the beginning of treatment to secure the anchorage. Unfortunately, the micro-screws had an high rate of fracture during placement and removal.\[9\]

Mini-plates were derived from the surgical plates used for the rigid fixation of bony fractures. The plates came in different shapes: L, T, C, and I. These plates were originally manufactured from stainless steel, then titanium, and finally self-resorbing materials. They were fixed into bone using surgical bony screws that penetrated the cortical plates in different lengths. Modifications were applied to those plates to amend hooks, T-attachment bars, and extension arms that penetrated the mucosa to appear in the oral cavity. However, flaps were required for placement and removal, and a small window in the flap had to be designed to allow for retentive-arm penetration into the oral cavity. Patients were instructed to keep those sites as clean as possible to avoid inflammation or tissue deterioration. High cost, together with double surgical steps were the primary disadvantages of mini-plates in orthodontics.\[10\]

As noted, the development of TADs progressed in phases, with each advancement addressing drawbacks of previous devices. Designers tried to avoid complicated surgical steps. For dental implants, onplants, and mini-plates, flaps still had to be raised and restored, either for placement or removal. For mini-implants and micro-screws, flaps were not needed in placement or removal. Size of TADs dictated the site of placement. Thin TADs were placed between the roots or in the basal bone but with caution to avoid fracture; whereas, thick TADs were placed into basal bone only, with a low risk of fracture.\[11\]

TADs could also be classified according to their mode of insertion. Mini-plates, for example, required pre-drilling with the TAD attached by surgical screws. Other TADs needed pre-drilling but had self-tapping threads for screwing into the drilled hole. Most of these self-tapping devices were mini-implants. Finally, there were self-drilling screws with sharp cutting tips. The clinician simply placed the screw into position, twisted the screwdriver, and the screw drilled its hole and fixed itself in place. Self-drilling devices meant ease of placement and a flapless technique.\[12\] Sizes and diameters were presented as 2 mm thickness with 10 mm length for the onplants; mini-implants had a 2 mm thickness with 6 mm, 8 mm, 10 mm, 12 mm, or even 14 mm length. Micro-screws were only 1.4 mm in diameter, with 6 mm, 8 mm, or 10 mm lengths. The materials used for manufacturing TADs were either titanium or stainless steel. Titanium allowed for osseointegration but carried the risk of fracture due to its brittle nature, while stainless steel had the ability to bend and adapt to the bony surfaces, allowed for resilience, and avoided fractures, but did not allow for osseointegration.\[13\]

In this article, the authors introduce a novel design of screws that allow for safe placement and a wide range of applications without fear of root damage or TADs fracture. Versatility and case-friendly options have been adapted to provide the clinician with maximum benefit and best performance.

### Materials and Design

The MH screw (MH is an abbreviation for the author’s name) is made from titanium material. Our novel approach specifically considers the design of all aspects of the device: the screwhead, changeable head attachments, gingival collar, shaft, threads, and cutting tip.
Screwhead
The head of the screw has an external hexagonal design that allows for better engagement of the driver to secure the screw into the bone. The width of the hexagon is 5 mm, allowing for an extra 1 mm clearance from the head to the circular edge of the gingival collar. The head is 3 mm thick with 1 mm holes placed in the center of each side to allow for attachment of ligature wires. The center of the hexagon has a central hole of 1.5 mm depth with threads to receive different attachments. A hole depth of 5 mm extends through the head and the gingival collar’s whole thickness [Figure 1].

Changeable head attachments
The MH screw allows for different accessory attachments to be amended to the design that was made from stainless steel material. If needed, the clinician can attach a wire, elastic, power chain, or even plate on top of the screw. Attachments are secured by a flat end threaded shaft of 5 mm length and 1.5 mm thickness that fits the central hole in the screwhead and collar. Different attachment designs of button and cleat shapes have been produced for elastics and springs, respectively [Figure 2]. Eyelet- and bracket-shaped attachments have been developed to anchor nickel-titanium (NiTi) wires and titanium molybdenum alloy wires (TMA), respectively [Figure 3]. Attachments of chains and hooks allow a change in the point of force application from the bracket head to another desired location [Figure 4]. Chains and hooks can be shortened using conventional orthodontic cutters as desired by the clinician. The clinician simply selects the desired shape and attaches it to the screw after insertion by hand twisting. Cover screws are provided to attach mini-plates above the tissues on top of the MH screws. Different designs of plates can be selected and amended to increase anchorage enforcement [Figure 5].

Gingival collar
The gingival collar has been designed to show a smooth surface. This allows for adaptability of the gingival tissues to the collar, avoids irritation, and facilitates tissue health. The design of the collar is saucer-shaped to prevent gingival tissue enlargement on top of the collar with poor oral hygiene. The collar is 2 mm thick with a width of 3 mm at the narrowest point and 7 mm at the thickest [Figure 6].

Shaft
The shaft design mimics a Greek amphora shape for stability and adaptability. The shaft has a pointed end that allows the screw to be self-drilled into the bone. The hourglass body allows for maximum bone adaptability and interlocking after healing, providing the best anchorage enforcement.
mechanical retention of the screw. The top of the shank is the beginning of the gingival collar. The thickest area of the shaft is 3 mm and the thinnest area is 2 mm, which provides strength and reduces the chances of fracture during insertion and removal [Figure 7].

**Threads**
The threads were formulated with a uniform 4 mm width through the length of the shaft with a tapered tip. The design allows for maximum primary stability after drilling and uniform threading during insertion and removal. The threads are repeated every 0.5 mm along the shaft’s length [Figures 6 and 7].

**Cutting tip**
The tip is self-drilling, and the edge blends with the other threads allowing for a smooth transition of the screw through the bone with little resistance. The 1-mm-long tip is sharp enough to cut through the cortical plate [Figure 8].

**Discussion**
Screws have been an important and popular part of orthodontic treatment for many years. Yet, many clinicians suffered problems with selection and placement. The main options were to prioritize strength and size to prevent fracture, which limited locations of insertion, or to use thin screws that fit almost anywhere but suffered multiple fractures during insertion and removal.[14] Additionally, placement in attached gingiva was limited to thin screws that fit between the roots of teeth, which resulted in many cases of root injury due to narrow space or inexperience of clinicians. Moreover, those thin screws were unable to withstand increased loads and many were dislodged early in treatment. Larger, thicker, and longer mini-implants were strong enough to be placed into the depth of the sulcus within the movable mucosa and provided stability, strength, and unimpeded tooth movements as no interference between the roots and the implants was anticipated. However, pain, inflammation, and tissue overgrowth, especially with deteriorated oral hygiene, were detected. Minor tissue incisions or flaps were usually needed for the insertion and removal of those implants which further complicated the process.[15] Clinicians had to choose between simplicity with multiple screw failures and changing locations or stability with complexities and irritations.

In the current design of MH cortical screws, the authors aimed to combine the advantages of thin screws with
the strong points of thicker and larger mini-implants to provide a novel design that allows for best clinical practice. The concept of limiting the screw length to 3 mm with a 1 mm cutting tip aimed to limit the placement into the cortical plates only. Cortical plates usually vary in thickness from 1.5 mm to 3 mm. Hence the screw would not reach the roots of teeth and would not interfere with any kind of tooth movement or cause injury or damage. There is no need to relocate screws for distalization or intrusion due to root approximation. Once placed, the screw should maintain its location for the whole duration of treatment. This allows the safe placement of the MH screws into the attached gingiva only, which spares the patient and clinician all the disadvantages of inflammation, irritation, and tissue overgrowth anticipated with other placements into the movable mucosa.

The size of the screw was designed to gain maximum stability in the cortex of bone. Bone histology is composed of a thick buccal cortical plate, the cancellous soft bone underneath, and a lingual–palatal cortical plate on the other side. Cortical plates are of compact bone type, with thick and well-adapted trabeculae that provide maximum stability. Thus, securing the screw to the cortical plate using a smart amphora design with adequate width was more important than providing long and thin screws that penetrated the soft cancellous bone without much added benefit. The screw length is sufficient to engage the whole thickness of the cortical plate and gain maximum retention. The amphora-shaped shaft provides an hourglass design for the cortical plate to heal and adapt, allowing for long-term stability throughout treatment [Figure 7]. The 2 mm thickness at the shaft’s thinnest part allows enough strength to avoid fracture during insertion or removal even by inexperienced clinicians. The cutting-edge tip is designed to allow for self-drilling through the bone [Figure 8]. The tip edge is blended with cutting threads of 4 mm uniform thickness to allow for better insertion and primary stability until the bone heals and adapts to the amphora shaft [Figure 6]. As noticed, the MH screws can be placed palatally or facially into the buccal or labial gingiva. Moreover, lingual placement within the lingual gingiva was possible as the penetration was limited to the cortical plate only.

The part of the screw in contact with the gingiva is the gingival collar; it has two important features that enhance its function. First, the saucer-shaped design began with a 3 mm diameter at the bone surface and expanded to a 5 mm diameter at the top with a total thickness of 2 mm smooth progression. This design prevents tissue overgrowth onto the screwhead even in cases of poor oral hygiene. The second feature is the smoothness of the surface which allowed for maximum tissue health and adaptation to the collar. In summary, the collar was designed to begin at the bone surface and end just above the gingival surface with a total thickness of 2 mm [Figures 6 and 7]. On top of the collar, the screwhead emerges to show an external hexagon shape. This design is one of the best for mechanical stability and handling for insertion and removal using screwdrivers. The diameter from one side to the opposite side of the hexagon is 5 mm, which allows for a 1 mm clearance between the head and the collar. This acts as a stopper for the screwdriver during manipulation. The head is 3 mm thick to withstand the forces of the screwdriver and allow for the 1 mm side holes placed safely into the opposite walls of the hexagon to secure ligature wires. The side holes are more than sufficient for securing teeth with ligatures for direct anchorage plans [Figure 1].

Many situations require the clinician to attach wires, elastics, and springs to screws in different directions and vertical levels. The MH screw has an internal vertical-threaded hole of 1.5 mm diameter that penetrates through the head and the collar with a total depth of 5 mm. This central hole is designed to receive different attachments that can be amended, removed, or changed during the course of treatment [Figure 1]. Attachments can be threaded or removed by hand through the central hole in clockwise/anti-clockwise rotations. Attachments could include a bracket design with vertical and horizontal slots to attach accessory TMA archwire or an eyelet to attach a NiTi archwire [Figure 3]. This design is important for clinicians who decide to use loop mechanics with TMA anchored to the screw or aligning an impacted tooth using a piggyback NiTi attached to the eyelet. Other attachment designs include buttons or cleats that allow the anchor of intraoral elastics or power chains for retraction and NiTi coil springs for push–pull mechanics [Figure 2]. In many situations, the clinician needs to extend the point of force application away from the screw to provide a better line of force for specific directional movements. This can be performed by attaching chains or hooks which can be shortened by measuring the required length and cutting the excess using wire cutters according to the clinician’s needs [Figure 4].

Mini-plate applications have been important throughout the last few decades. Orthodontists used surgical mini-plates with added retentive heads to apply heavy forces that ordinary screws could not withstand. Application of heavy intermaxillary elastics and/or fixed functional appliances required mini-plates for success and stability. Many cases of skeletal class 2 or 3 or even skeletal open bites that required total double jaw molar intrusion were chosen for mini-plates anchorage. Long-term force applications for retention
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MH cortical screws are excellent for achieving the desired aims of treatment without jeopardizing the health of the tissue. MH cortical screws provide the required stability through cortical anchorage together with a wide diameter and amphora design that allows for maximum primary and secondary stability. The short length confined to the cortical plate allows for the preservation of the roots without endangering their stability. Moreover, this preserves unnecessary screw-relocating procedures or interference with tooth movements.

Conclusions

- MH cortical screws are excellent for achieving the desired aims of treatment without jeopardizing the health of the tissue.
- MH cortical screws provide the required stability through cortical anchorage together with a wide diameter and amphora design that allows for maximum primary and secondary stability.
- The short length confined to the cortical plate allows for the preservation of the roots without endangering their stability. Moreover, this preserves unnecessary screw-relocating procedures or interference with tooth movements.
- The novel design allows for freedom of insertion into the facial, lingual, and palatal attached gingiva, without fear of root injury or tissue inflammation.
- The saucer-shaped gingival collar allows for better tissue health and prevents any tissue overgrowth.
- The hexagonal head with lateral ligature holes provides maximum integration with the screwdrivers together with sufficient anchorage using ligature wires.
- The central threaded hole in the head and collar allows for multiple attachments to be placed, changed, and interchanged through the treatment.
- Attachments have been designed for TMA and NiTi wires as bracket-shaped and eyelets, respectively, facilitating complex mechanics and enhanced teeth movement control.
- Buttons and cleats facilitate the attachment of elastics and NiTi coil springs to provide push–pull mechanics according to the clinician’s preferences.
- Chains and multileveled hooks are provided as attachments with the ability for the clinician to cut and adjust to the required dimensions. These types are important if the orthodontist decides to change the orientation of the line of force for better movement control.
- Stainless steel plates with cover screws are provided to be attached on top of four to six MH screws, away from tissues and without any need for flaps reflection. This opens the door for heavier force applications to control skeletal anteroposterior and vertical problems either during treatment phases or retention phases until the patient reaches twenty years of age. The screw-retained plates with detachable design allow for removal, cleaning, and re-attaching the plates when needed, with repairs, adjustments, and modifications to be performed.
- The concept of MH cortical screws together with the ability to amend and change the attachments on top are paramount for facilitating the treatment protocols and achieving the goals of complex treatment plans with ease and safety.

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Conflicts of interest

There are no conflicts of interest.

References

1. Khlef HN, Hajeer MY, Ajaj MA, Heshmeh O, Youssef N, Mahaini L. The effectiveness of traditional corticotomy vs
flapless corticotomy in miniscrew-supported en-masse retraction of maxillary anterior teeth in patients with Class II Division 1 malocclusion: A single-centered, randomized controlled clinical trial. Am J Orthod Dentofacial Orthop 2020;158:e111-20.

2. Kia C, Antonacci CL, Wellington I, Makanji HS, Esemente SM. Spinal implant osseointegration and the role of 3D printing: An analysis and review of the literature. Bioengineering (Basel) 2022;9:108.

3. Becker K, Rauch N, Brunello G, Azimi S, Beller M, Hufner M, et al. Bone remodelling patterns around orthodontic mini-implants migrating in bone: An experimental study in rat vertebrae. Eur J Orthod 2021;43:708-17.

4. Cornelis MA, Scheffler NR, Mahy P, Siciliano S, De Clerck HJ, Tulloch JF. Modified miniplates for temporary skeletal anchorage in orthodontics: Placement and removal surgeries. J Oral Maxillofac Surg 2008;66:1439-45.

5. Hasan HS, Kolemen A, Elkolaly M, Marya A, Gujjar S, Venugopal A. TAD’s for the Derotation of 90° rotated maxillary bicuspids. Case Rep Dent 2021;2021:4285330.

6. Carano A, Velo S, Leone P, Siciliani G. Clinical applications of the Miniscrew Anchorage System. J Clin Orthod 2005;39:9-24; quiz 29-30.

7. Afrashtehfar KI. Patient and miniscrew implant factors influence the success of orthodontic miniscrew implants. Evid Based Dent 2016;17:109-10.

8. Hasan HS, Elkolaly MA. Updating the orthodontic envelope of discrepancy: Canines transposition. Int J Orthod Rehabil [serial online] 2021;12:140-7.

9. Garfinkle JS, Cunningham LL Jr, Beeman CS, Kluemper GT, Hicks EP, Kim MO. Evaluation of orthodontic mini-implant anchorage in premolar extraction therapy in adolescents. Am J Orthod Dentofacial Orthop 2008;133:642-53.

10. Cornelis MA, De Clerck HJ. Maxillary molar distalization with miniplates assessed on digital models: A prospective clinical trial. Am J Orthod Dentofacial Orthop 2007;132:373-7.

11. Mohd YQ, Reddy S, Sinha R, Agarwal A, Fatima U, Abdulllah M. Three-dimensional miniplate: For the management of mandibular parasymphysis fractures. Ann Maxillofac Surg 2019;9:333-9.

12. Singh K, Kumar D, Jaiswal RK, Bansal A. Temporary anchorage devices - Mini-implants. Natl J Maxillofac Surg 2010;1:30-4.

13. Joseph R, Ahmed N, Younus A Abrar, R Bhat KR. Temporary anchorage devices in orthodontics: A review. IP Indian J Orthod Dentofacial Res 2020;6:222-8.

14. Meeran NA. Iatrogenic possibilities of orthodontic treatment and modalities of prevention. J Orthod Sci 2013;2:73-86.

15. Cornelis MA, Tepedino M, Cattaneo PM, Nyssen-Behets C. Root repair after damage due to screw insertion for orthodontic miniplate placement. J Clin Exp Dent 2019;11:e133-8.

16. Kim HJ, Yu SK, Lee MH, Lee HJ, Kim HJ, Chung CH. Cortical and cancellous bone thickness on the anterior region of alveolar bone in Korean: A study of dentate human cadavers. J Adv Prosthodont 2012;4:146-52.

17. Elkolaly MA, Hasan HS, Foda MY. MHM bracket design on the path of Dr Andrews of true straight wire technique, prototype study design. J Orthodont Sci 2022;11:e133-8.

18. Pandey RK, Panda SS. Drilling of bone: A comprehensive review. J Clin Orthop Trauma 2013;4:15-30.

19. Cornelius CP, Ehrenfeld M. The use of MMF screws: Surgical technique, indications, contraindications, and common problems in review of the literature. Cranio-maxillofac Trauma Reconstr 2010;3:55-80.

20. Hasan HS, Al Azzawi AM, Kolemen A. Pattern of distribution and etiologies of Midline diastema among Kurdistan-region Population. J Clin Exp Dent 2020;12:e938-43.

21. Mishra N, Thakkar N, Kar I, Baig SA, Sharma G, Kar R, et al. 3-D Miniplates versus conventional miniplates in treatment of mandible fractures. J Maxillofac Oral Surg 2019;18:65-72.