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Orthodontic Mini-Implants (Temporary Anchorage Devices): Types, Designs, and Clinical Applications - A Narrative Review

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Abstract

The introduction of temporary anchorage devices (TADs) has significantly expanded the biomechanical possibilities in orthodontics by providing stationary anchorage independent of patient compliance. Among these, orthodontic mini-implants are the most widely used due to their minimal invasiveness, versatility, and cost-effectiveness. This narrative review aims to classify orthodontic mini-implants based on design, dimensions, site of placement, method of insertion, and clinical function, while highlighting their indications, advantages, and limitations in contemporary orthodontic practice.

Keywords: Orthodontic mini-implants; Temporary anchorage devices; Skeletal anchorage.

Introduction

Anchorage control is a cornerstone of successful orthodontic treatment, directly influencing treatment efficiency, outcomes, and long-term stability. Traditionally, orthodontic anchorage has relied on intraoral dental units, extraoral appliances such as headgear, or intermaxillary elastics. While these methods have been effective in selected cases, they are often limited by unwanted reciprocal tooth movements, dependence on patient compliance, esthetic concerns, and biomechanical constraints. These limitations are particularly evident in adult patients, patients with compromised dentition, and cases requiring complex or asymmetric tooth movements.[1,7,11]

The concept of skeletal anchorage was introduced to overcome these challenges by providing a stationary anchorage source independent of the dentition. Among the various skeletal anchorage systems developed, orthodontic mini-implants commonly referred to as temporary anchorage devices (TADs) have emerged as the most widely adopted due to their relatively simple placement, minimal surgical invasiveness, and broad clinical applicability.[1,8,12] Unlike conventional osseointegrated dental implants, orthodontic mini-implants are designed for temporary use, rely primarily on mechanical retention rather than osseointegration, and can be loaded immediately or shortly after placement.[1,9,12] (Figure 1)

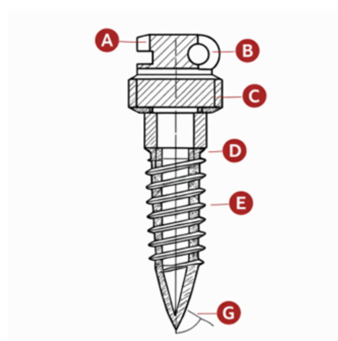

Figure 1: 2D Cross-Sectional schematic of orthodontic mini-implant (TAD) geometry.

Head (A, B, C); Neck/ Transgingival section (D); Threads/Intra-osseous section (E) ;Tip (G)

Since their introduction in the late 1990s, orthodontic mini-implants have undergone continuous refinement in terms of design, dimensions, surface characteristics, and insertion protocols.[2,9,12] These developments have resulted in improved primary stability, higher success rates, and broader indications.[12,14] However, despite their widespread use, failure rates and complications such as loosening,

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inflammation, root proximity, and fracture still occur, underscoring the importance of proper case selection, anatomical assessment, and understanding of implant characteristics.[12,16,19, 21]

Given the diversity of commercially available orthodontic mini-implants and the expanding range of clinical applications, a clear and structured understanding of their classification is essential for clinicians. Classifying mini-implants based on design features, dimensions, placement sites, head configuration, and functional biomechanics facilitates appropriate selection and optimizes clinical outcomes.[2,9,12] Therefore, this narrative review aims to provide a comprehensive overview of the various types of orthodontic mini-implants, with emphasis on their classification and relevance to contemporary orthodontic practice.

Methodology

A narrative literature review was conducted using electronic searches in PubMed, Scopus, and Google Scholar from database inception to 2025. Search terms included *orthodontic mini-implants*, *temporary anchorage devices (TADs)*, *miniscrews*, and *skeletal anchorage*, combined using Boolean operators. Relevant full-text articles in English (original studies and reviews) addressing design, placement, biomechanics, indications, and complications were included. Reference lists were hand-searched. Findings were synthesized narratively.

2. Classification of Orthodontic Mini-Implants

Orthodontic mini-implants exhibit considerable variation in design, dimensions, insertion technique, and clinical application. This diversity reflects attempts to optimize primary stability, minimize complications, and adapt to different anatomical sites and biomechanical demands.[2,12,14,18] A systematic classification of mini-implants allows clinicians to make informed decisions regarding selection and placement, thereby improving clinical success rates.[12,14]

2.1 Classification Based on Design

Design characteristics directly influence insertion torque, primary stability, risk of fracture, and ease of placement and removal. Based on insertion mechanics, orthodontic mini-implants are broadly classified into self-drilling and self-tapping types.[1,14]

2.1.1 Self-Drilling Mini-Implants

Self-drilling mini-implants are designed with a sharp, cutting apical tip and fluted threads that enable direct insertion into bone without the need for a pilot hole. This design simplifies the clinical procedure, reduces chairside time, and minimizes soft tissue trauma.[1,14] The absence of pre-drilling preserves bone density around the implant threads, which may contribute to enhanced primary stability, particularly in areas with thin cortical bone.[16]

These implants are widely used in routine orthodontic practice, especially in the maxillary alveolar bone where bone density is relatively low.[3,9] However, self-drilling mini-implants require careful control of insertion torque. Excessive torque, particularly in areas of dense cortical bone such as the posterior mandible or extra-alveolar sites, may increase the risk of implant fracture or microdamage to surrounding bone.[16,18] Additionally, the lack of a pilot hole may result in increased heat generation during insertion, which can negatively affect bone vitality if not adequately controlled.[16]

2.1.2 Self-Tapping Mini-Implants

Self-tapping mini-implants require the preparation of a pilot hole prior to insertion. The pre-drilled hole reduces insertion resistance, allowing for controlled placement in areas with thick or dense cortical bone. This design is particularly advantageous in the mandible, infrazygomatic crest, or buccal shelf regions, where bone density is high.[16,21] The use of a pilot hole decreases the risk of implant fracture and allows more precise angulation during placement. It also reduces insertion torque and operator-dependent variability, making it a preferred option in anatomically challenging sites.[16]

Despite these advantages, self-tapping mini-implants involve an additional surgical step, increasing chairside time and the potential for patient discomfort. Improper pilot hole preparation, such as excessive drilling diameter or depth, may compromise primary stability and increase the risk of early implant failure.[14,16]

2.2 Classification Based on Dimensions

The dimensions of orthodontic mini-implants specifically diameter and length play a critical role in determining mechanical stability and anatomical compatibility.[12,16]

2.2.1 Diameter-Based Classification

Mini-implant diameters typically range from 1.2 mm to 2.0 mm. Smaller diameter implants are preferred in interradicular areas where root proximity is a concern. Their reduced size minimizes the risk of root damage and facilitates placement in narrow spaces. However, smaller diameters are associated with lower fracture resistance and reduced stability under heavy orthodontic loads.[16,21] Larger diameter mini-implants provide greater mechanical strength and enhanced primary stability, making them suitable for extra-alveolar anchorage or high-force applications. The increased diameter, however, requires sufficient bone width and careful soft tissue management.[12,16]

2.2.2 Length-Based Classification

Mini-implant lengths commonly range from 6 mm to 12 mm. Shorter implants are indicated in areas with limited bone depth, such as the maxillary posterior interradicular region, where sinus proximity may restrict implant length. While easier to place, shorter implants may exhibit reduced stability if cortical bone engagement is inadequate.[17,22] Longer implants engage a greater volume of cortical and cancellous bone, thereby improving primary stability. These are frequently used in extra-alveolar sites such as the infrazygomatic crest and buccal shelf, where increased bone thickness allows deeper insertion.[16,21]

2.3 Classification Based on Site of Placement

Anatomical placement significantly influences implant stability and clinical application.[12,21]

2.3.1 Interradicular Mini-Implants

Interradicular mini-implants are placed between adjacent tooth roots within the alveolar bone. They are commonly used for anterior retraction, molar intrusion, and space closure. Successful placement requires accurate assessment of root angulation and interradicular space using radiographs or CBCT imaging.[9,22]

Root proximity remains a major risk factor, and improper placement may result in root contact, periodontal damage, or implant failure.[21,22]

2.3.2 Extra-Alveolar Mini-Implants

Extra-alveolar mini-implants are placed outside the dental alveolus, commonly in the infrazygomatic crest (maxilla) and buccal shelf (mandible). These sites provide thick cortical bone and allow placement away from dental roots, enabling large-scale tooth movements such as total arch distalization.[12,21]

Although extra-alveolar TADs offer superior stability, they are associated with increased soft tissue irritation and require advanced surgical skill and anatomical knowledge.[12,21]

2.4 Classification Based on Head Design

The head design of orthodontic mini-implants is a critical yet often underestimated factor influencing clinical usability, biomechanical versatility, patient comfort, and soft tissue health. While the body and thread design primarily determine primary stability, the head configuration dictates how orthodontic forces are delivered and how the implant interacts with surrounding soft tissues. Variations in head design have evolved to accommodate different force systems, attachment methods, and anatomical locations.[9,12]

2.4.1 Button-Type Head Mini-Implants

Button-type head mini-implants feature a rounded, low-profile head with a smooth or slightly textured surface. This design allows easy attachment of elastomeric chains, coil springs, or ligature wires. The simplicity of the button head makes it one of the most commonly used designs in routine orthodontic practice.[9,12]

From a biomechanical perspective, button-type heads are well suited for applications requiring linear force vectors, such as anterior retraction, molar intrusion, and space closure mechanics. Their low profile reduces soft tissue irritation, particularly when placed in attached gingiva. However, in areas with thick or movable mucosa, the reduced head height may limit accessibility and increase the risk of soft tissue overgrowth.[12] Clinically, button-type heads are favored for their ease of hygiene maintenance and patient comfort. Nevertheless, their limited versatility in engaging rigid auxiliaries or archwires restricts their use in complex three-dimensional force systems.[9,12]

2.4.2 Bracket-Type Head Mini-Implants

Bracket-type head mini-implants incorporate a slot resembling a conventional orthodontic bracket, typically with dimensions compatible with standard archwires (e.g., 0.018 or 0.022-inch systems). This design enables direct engagement of orthodontic wires, allowing the mini-implant to function as a skeletal anchorage bracket.[9,12] The bracket-head configuration offers enhanced biomechanical control, particularly in cases requiring precise force direction, torque control, or multi-vector force application. It is especially useful in asymmetric mechanics, segmental orthodontics, and intrusion or uprighting movements. Additionally, the ability to incorporate the mini-implant into the archwire system reduces the need for auxiliary attachments. [14,19,20] However, bracket-type heads are bulkier than button-type designs, which may increase patient discomfort and plaque accumulation if not carefully positioned. Their prominence also increases the risk of soft tissue irritation, especially in non-keratinized mucosa. Meticulous oral hygiene and careful soft tissue evaluation are therefore essential when selecting this design.[9,12]

2.4.3 Hook-Type Head Mini-Implants

Hook-type head mini-implants are characterized by an extended projection or hook that emerges from the mucosa. This design is particularly advantageous in areas with thick soft tissue, such as the posterior maxilla or extra-alveolar sites, where a low-profile head may become submerged.[12,21]

The hook extension provides easy access for attachment of elastics, power chains, or springs without impingement on the surrounding soft tissue. Hook-type heads are commonly used in vertical control mechanics, including molar intrusion and open bite correction, as well as in distalization protocols involving heavy force application.[9,12] Despite their accessibility, hook-type heads may increase the risk of soft tissue irritation and ulceration if improperly positioned. Their extended profile also necessitates careful patient instruction to avoid trauma during mastication.[12]

2.4.4 Eyelet and Multi-Attachment Head Designs

Some mini-implants feature eyelets or multiple attachment points on the head, allowing simultaneous application of different force systems. These designs provide increased biomechanical flexibility, particularly in complex orthodontic cases requiring combined vertical, sagittal, and transverse force vectors.[12,14]

Eyelet-based designs facilitate the use of ligature wires and elastics in varied configurations, while multi-attachment heads reduce the need for multiple implants in the same anatomical region. However, the increased complexity of these designs may complicate oral hygiene and increase plaque retention.[9,12]

2.6 Classification of Orthodontic Mini-Implants Based on Material

Orthodontic mini-implants can be classified based on material composition into:

2.6.1. Titanium / Titanium Alloy Mini-Implants

Titanium and titanium alloy (e.g., Ti-6Al-4V) mini-implants are the most commonly used in clinical practice due to their excellent biocompatibility, corrosion resistance, and favorable strength-to-weight ratio. They demonstrate good primary stability and minimal adverse tissue response. Their surface characteristics are typically smooth or minimally roughened to facilitate easy removal after treatment. It has advantage of high biocompatibility, corrosion resistance, good clinical success but risk of fracture in very small diameters under high insertion torque and higher cost than SS.[9,12,16]

2.6.2 Stainless Steel Mini-Implants

Stainless steel mini-implants offer greater toughness and fracture resistance compared to titanium, making them useful in dense cortical bone or high-stress insertion sites. However, they exhibit comparatively lower biocompatibility and corrosion resistance in the oral environment, which may increase soft tissue irritation in susceptible patients. It has advantage of higher fracture resistance, lower cost but inferior biocompatibility and corrosion resistance compared to titanium.[9,12]

2.7 Classification Based on Functional Anchorage

Mini-implants may be used for direct or indirect anchorage. In direct anchorage, forces are applied directly from the implant to the teeth, offering maximal anchorage control. In indirect anchorage, the implant stabilizes a dental unit that serves as the anchorage source.[14,19, 20]

3. Clinical Indications of Orthodontic Mini-Implants

Orthodontic mini-implants have broadened the scope of orthodontic biomechanics by providing absolute or near-absolute anchorage in situations where conventional anchorage methods are inadequate or unreliable. Their clinical indications span a wide range of sagittal, vertical, and transverse discrepancies, particularly in adult patients and complex malocclusions.[1,9,12]

3.1 En-Masse Anterior Retraction

One of the most common indications for mini-implant use is en-masse retraction of anterior teeth following premolar extractions. Conventional anchorage using posterior teeth often results in anchorage loss and mesial molar movement. Mini-implants placed in the posterior interradicular region or extra-alveolar sites provide stationary anchorage, allowing bodily retraction of anterior segments with improved control over torque and vertical position. This is especially beneficial in patients with bimaxillary protrusion or lip incompetence.[1,9,12]

3.2 Molar Intrusion and Vertical Control

Vertical discrepancies such as anterior open bite and posterior dentoalveolar extrusion are challenging to manage with traditional mechanics. Mini-implants enable true molar intrusion without reciprocal extrusion of adjacent teeth. Placement in the posterior maxilla or mandible allows application of intrusive forces directly to molars, facilitating counterclockwise mandibular rotation and improvement in facial esthetics. This indication is particularly relevant in non-growing patients, where orthopedic or growth-modifying approaches are ineffective.[3,9,12]

3.3 Distalization of Posterior Teeth

Mini-implants are widely used for maxillary and mandibular molar distalization, either unilaterally or bilaterally, without the need for headgear or patient compliance. Extra-alveolar mini-implants placed in the infrazygomatic crest or buccal shelf region allow distal movement of the entire dental arch, making them useful in the correction of Class II and mild Class III malocclusions. This approach often reduces or eliminates the need for extractions or orthognathic surgery in selected cases.[9,12,21]

3.4 Space Closure and Anchorage Reinforcement

In cases with compromised posterior anchorage due to missing teeth, periodontal involvement, or reduced tooth support, mini-implants serve as an effective anchorage reinforcement tool. They stabilize the anchorage unit during space closure, preventing unwanted tooth movement and shortening treatment duration. This indication is particularly valuable in adult orthodontics and interdisciplinary cases.[1,9,12]

3.5 Correction of Asymmetries

Dental and skeletal asymmetries often require asymmetric force application, which is difficult to achieve using conventional anchorage. Mini-implants allow independent force delivery on one side of the arch, enabling controlled correction of midline discrepancies, unilateral space closure, or asymmetric intrusion or extrusion. This level of control improves precision and reduces collateral effects on the contralateral side.[14,19,21]

3.6 Management of Impacted and Ectopic Teeth

Mini-implants provide stable anchorage for the traction of impacted teeth, such as maxillary canines, without affecting adjacent teeth. Forces can be applied in controlled directions to guide the impacted tooth into the arch while maintaining anchorage integrity. This is particularly useful in cases where adjacent teeth are insufficient or undesirable as anchorage units.[9,12]

3.7 Orthodontic Treatment in Adult and Compromised Patients

Adult patients often present with reduced periodontal support, missing teeth, or restorations that limit the use of conventional anchorage. Mini-implants offer a non-dentition-based anchorage solution, enabling efficient tooth movement with minimal risk to existing restorations or periodontally compromised teeth. They are also valuable in pre-prosthetic orthodontics to optimize space and tooth position before restorative procedures.[11,12]

3.8 Adjunct to Orthognathic and Camouflage Treatment

Mini-implants are increasingly used as adjuncts in pre- and post-surgical orthodontics to facilitate decompensation, intrusion, or distalization. In borderline surgical cases, they may allow orthodontic camouflage by achieving movements that would otherwise require orthognathic intervention.[9,12]

Classification Category	Type	Description	Common Clinical Indications
Based on Design	Self-drilling	Sharp cutting tip; inserted without pilot hole; faster placement; higher insertion torque	Routine interradicular placement, maxillary alveolar bone
	Self-tapping	Requires pilot hole; controlled insertion; reduced fracture risk	Dense cortical bone, posterior mandible, infrazygomatic crest, buccal shelf
Based on Diameter	Small diameter (≈1.2 1.4 mm)	Reduced root proximity risk; lower fracture resistance	Interradicular placement, narrow spaces
	Large diameter (≈1.5 2.0 mm)	Higher mechanical strength and stability	Extra-alveolar anchorage, high-force mechanics
Based on Length	Short (≈6 8 mm)	Easier placement; less bone engagement	Maxillary posterior interradicular region
	Long (≈9 12 mm)	Greater bone engagement; increased stability	Infrazygomatic crest, buccal shelf
Based on Site of Placement	Interradicular	Placed between roots within alveolar bone	Retraction, molar intrusion, space closure
	Extra-alveolar	Placed outside alveolus (IZC, buccal shelf)	Total arch distalization, large tooth movements
Based on Head Design	Button-type	Low-profile rounded head; elastics/springs	Retraction, intrusion, space closure
	Bracket-type	Slot for archwire engagement	Segmental mechanics, torque control, asymmetric mechanics
	Hook-type	Extended projection; accessible in thick mucosa	Vertical control, distalization, heavy force
	Eyelet / Multi-attachment	Multiple force application points	Complex 3D force systems
Based on Material	Titanium / Titanium alloy	Biocompatible, corrosion-resistant, easy removal	Routine orthodontic anchorage
	Stainless steel	High fracture resistance, lower biocompatibility	Dense cortical bone, high-stress sites
Based on Functional Anchorage	Direct anchorage	Force applied directly from implant to teeth	Absolute anchorage mechanics
	Indirect anchorage	Implant stabilizes dental anchorage unit	Reinforcement of posterior anchorage

Table 1: Classification of Orthodontic Mini-Implants.

4. Advantages and Limitations of Orthodontic Mini-Implants

Orthodontic mini-implants have gained widespread acceptance due to their ability to provide reliable skeletal anchorage with minimal invasiveness[1,2,12]. However, despite their numerous advantages, their use is not devoid of limitations and potential complications[3,21]. A balanced understanding of both aspects is essential for appropriate case selection, patient counseling, and long-term success[2,12].

4.1 Advantages

4.1.1 Absolute Anchorage and Biomechanical Versatility

The primary advantage of orthodontic mini-implants is their ability to provide absolute or near-absolute anchorage[1,7,8]. By eliminating reliance on dental units or extraoral appliances, mini-implants allow orthodontists to apply forces without reciprocal tooth movement[11]. This has significantly expanded biomechanical possibilities, enabling movements such as en-masse retraction, molar intrusion, and total arch distalization with greater precision and predictability[2,12,19].

4.1.2 Reduced Dependence on Patient Compliance

Traditional anchorage systems, such as headgear and elastics, require high levels of patient cooperation[4]. Mini-implants function independently of patient compliance, making them particularly advantageous in adult patients and adolescents with poor compliance[1,2]. This contributes to more efficient treatment progression and reduced treatment time[12].

4.1.3 Minimally Invasive and Reversible

Mini-implant placement is a minimally invasive procedure that can often be performed under local anesthesia in a clinical setting[1,8]. Unlike osseointegrated dental implants, orthodontic mini-implants are temporary and can be removed easily after completion of treatment, typically without the need for surgical intervention or significant bone remodeling[5,6,9].

4.1.4 Immediate or Early Loading Capability

Most orthodontic mini-implants rely on mechanical retention rather than osseointegration, allowing them to be loaded immediately or shortly after placement[8,11]. This immediate functionality enhances treatment efficiency and reduces overall treatment duration[2,12].

4.1.5 Applicability in Compromised Dentitions

Mini-implants are particularly useful in patients with missing teeth, reduced periodontal support, or extensive restorations, where conventional anchorage options are limited[3,9]. By bypassing compromised dental units, mini-implants protect existing teeth from undesirable forces[2,12].

4.2 Limitations and Complications

4.2.1 Risk of Implant Failure and Loosening

Despite high reported success rates, mini-implant failure remains a concern[21]. Failure may occur due to insufficient primary stability, excessive orthodontic loading, poor bone quality, or improper placement technique[14,17]. Early loosening often necessitates removal and repositioning, potentially prolonging treatment[21].

4.2.2 Soft Tissue Inflammation and Peri-Implantitis

Inflammation of the surrounding soft tissues is one of the most common complications associated with mini-implants, particularly when placed in movable mucosa[15]. Poor oral hygiene, plaque accumulation around the implant head, and improper head design may exacerbate inflammation, leading to discomfort and increased risk of failure[3,9].

4.2.3 Risk of Root Damage and Anatomical Injury

Interradicular placement carries a risk of root proximity or direct root contact, which may result in root resorption, loss of tooth vitality, or implant failure[20]. Inadequate radiographic assessment and improper angulation increase this risk[19,20]. Extra-alveolar placements, while avoiding root damage, may pose risks to adjacent anatomical structures if not carefully planned[19].

4.2.4 Technique Sensitivity and Learning Curve

Successful use of mini-implants requires thorough knowledge of anatomy, biomechanics, and surgical technique[2,12]. Inadequate training or experience may increase the risk of complications[17,18]. The learning curve associated with extra-alveolar placements is particularly steep and necessitates careful case selection[20].

5. Success vs. Failure Rates of Temporary Anchorage Devices

The overall clinical performance of TADs in orthodontics is high but variable, with success and failure rates influenced by device type, anatomical location, bone quality, and clinical factors. Across studies, TAD success rates are frequently reported between 80% and >90%, indicating reliable performance in providing skeletal anchorage when correctly placed and managed. In a large scoping review, nearly half of the studies reported success rates ≥90%, with mini-plates showing higher average success (~95%) compared to mini-implants (~87%). Prospective clinical data also show success rates around 82–90% for mini-screws used under typical orthodontic loading. Single-center clinical reports have recorded miniscrew success >80% up to 12 months after placement, with longer screws (10–12 mm) showing particularly higher survival.

Failure rates vary, but many studies report overall failure between ~5% and 26%, depending on definitions used and clinical context. A classic meta-analysis found an approximate 16% failure rate for miniscrews, compared with 7–10% for palatal implants or miniplates, which often show superior stability. Retrospective data also suggest that factors such as lower bone quality and adverse habits (e.g., smoking) may increase failure risk, with some cohorts showing up to ~25% failure at 6 months.

Conclusion and future advances

Orthodontic mini-implants, commonly referred to as temporary anchorage devices (TADs), have fundamentally transformed contemporary orthodontic practice by providing reliable, compliance-free skeletal anchorage. Their introduction has expanded the boundaries of orthodontic biomechanics, enabling complex tooth movements such as en-masse retraction, molar intrusion, total arch distalization, and asymmetric corrections with a level of predictability that was previously difficult to achieve using conventional anchorage systems. The wide variety of mini-implant designs differing in insertion method, dimensions, head configuration, and placement site allows clinicians to tailor anchorage strategies to individual patient anatomy and specific biomechanical requirements. A clear understanding of these classifications is essential for optimal selection, safe placement, and effective force application. Interradicular and extra-alveolar mini-implants each offer unique advantages, and their appropriate use can reduce the need for extractions, minimize dependence on patient compliance, and, in selected cases, provide alternatives to orthognathic surgery.

Future advances in orthodontic mini-implants are expected to focus on improving primary stability, reducing failure rates, and enhancing clinical precision. Developments in surface modification and optimized thread design may enhance early stability while preserving ease of removal. Integration of digital workflows, including CBCT-based planning and 3D-printed surgical guides, is likely to improve placement accuracy and reduce anatomical complications. Advances in biomaterials and standardized loading protocols may further increase predictability and long-term clinical success.

References

1. Cope JB (2005). Temporary anchorage devices in orthodontics: A paradigm shift. *Semin Orthod* 11(1):39.
2. Kalra A, Jaggi N, Jasoria G, Shamim W, Rathore S, Manchanda M (2013). Miniscrew implants as temporary anchorage devices in orthodontics: A comprehensive review. *J Contemp Dent Pract* 14(5): 993 999.
3. Mizrahi E (2016). The use of miniscrews in orthodontics: A review of selected clinical applications. *Prim Dent J* 5(4):20 27.
4. Gainsforth BL, Higley LB (1945). A study of orthodontic anchorage possibilities in basal bone. *Am J Orthod Oral Surg* 31(8):406 417.
5. Brånemark PI, Aspegren K, Breine U (1964). Microcirculatory studies in man by high resolution vital microscopy. *Angiology* 15(8):329 332.
6. Brånemark PI, Breine U, Adell R, Hansson BO, Lindström J, Ohlsson Å (1969). Intra-osseous anchorage of dental prostheses: I. Experimental studies. *Scand J Plast Reconstr Surg* 3(2):81 100.
7. Creekmore TD, Eklund MK (1983). The possibility of skeletal anchorage. *J Clin Orthod* 17:266 269.
8. Kanomi R (1997). Mini-implant for orthodontic anchorage. *J Clin Orthod* 31:763 767.
9. Mizrahi E, Mizrahi B (2007). Mini-screw implants (temporary anchorage devices): Orthodontic and pre-prosthetic applications. *J Orthod* 34(2):80 94.
10. Labanauskaitė B, Jankauskas G, Vasiliauskas A, Haffar N (2005). Implants for orthodontic anchorage: Meta-analysis. *Stomatologija* 7:128 132.
11. Roberts WE, Helm FR, Marshall KJ, Gongloff RK (1989). Rigid endosseous implants for orthodontic and orthopedic anchorage. *Angle Orthod* 59(4):247 256.
12. Papadopoulos MA, Tarawneh F (2007). The use of miniscrew implants for temporary skeletal anchorage in orthodontics: A comprehensive review. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 103:e6 e15.
13. Muhamad A, Nezar W (2014). Miniscrews: Clinical application in orthodontics. *RRJDS* 2(3):32 43.
14. Suzuki M, Deguchi T, Watanabe H, Seiryu M, Iikubo M, Sasano T, et al (2013). Evaluation of optimal length and insertion torque for miniscrews. *Am J Orthod Dentofacial Orthop* 144(2):251 259.
15. Costa A, Pasta G, Bergamaschi G (2005). Intraoral hard and soft tissue depths for temporary anchorage devices. *Semin Orthod* 11(1):10 15.
16. Liu SS, Cruz-Marroquin E, Sun J, Stewart KT, Allen MR (2012). Orthodontic mini-implant diameter does not affect in situ linear microcrack generation in the mandible or the maxilla. *Am J Orthod Dentofacial Orthop* 142(6):768 773.
17. Holberg C, Winterhalder P, Holberg N, Rudzki-Janson I, Wichelhaus A (2013). Direct versus indirect loading of orthodontic miniscrew implants—an FEM analysis. *Clin Oral Investig* 17(8):1821 1827.
18. Holberg C, Winterhalder P, Holberg N, Wichelhaus A, Rudzki-Janson I (2014). Indirect miniscrew anchorage: Biomechanical loading of the dental anchorage during mandibular molar protraction—an FEM analysis. *J Orofac Orthop* 75(1):16 24.
19. Purmal K, Alam MK, Pohchi A, Razak NHA (2013). 3D mapping of safe and danger zones in the maxilla and mandible for the placement of intermaxillary fixation screws. *PLoS One* 8(12):e84202.
20. Fayed MMS, Pazera P, Katsaros C (2010). Optimal sites for orthodontic mini-implant placement assessed by cone beam computed tomography. *Angle Orthod* 80(5):939 951.
21. Chen YJ, Chang HH, Lin HY, Lai EH, Hung H, Yao HC, et al (2008). Stability of miniplates and miniscrews used for orthodontic anchorage: Experience with 492 temporary anchorage devices. *Clin Oral Implants Res* 19(11):1188 1196.