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Orthodontic bone screws: A comprehensive review of applications and clinical outcomes and role of pharmacists

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***Abstract*---Background:** Temporary Anchorage Devices (TADs), such as orthodontic bone screws, have revolutionized anchorage management in orthodontics. Since their introduction in 1997, TADs have been widely adopted to improve treatment outcomes, especially in complex malocclusions. Despite their efficacy, challenges such as high failure rates in inter-radicular (I-R) placement and limited clinical integration persist. **Aim:** This comprehensive review explores the clinical applications, outcomes, and barriers to adopting orthodontic bone screws, with a focus on extra-alveolar (E-A) TADs. Additionally, the role of pharmacists in optimizing patient care in orthodontic treatments involving TADs is examined. **Methods:** The review analyzes studies on TAD applications, clinical outcomes, and failure rates, emphasizing extra-alveolar sites such as the mandibular buccal shelf (MBS) and infra-zygomatic crest (IZC). It also discusses pharmacist contributions in medication management, patient education, and minimizing peri-implant inflammation. **Results:** E-A TADs demonstrated lower failure rates (7%) compared to I-R TADs (19.3%), with superior stability in IZC and MBS placements due to enhanced cortical bone contact. Pharmacists play a critical role in managing peri-implant inflammation, advising on hygiene practices, and providing medications that mitigate infection risks. **Conclusion:** TADs offer a reliable anchorage solution for complex malocclusions, with E-A placements yielding better outcomes. Pharmacists' involvement in patient education and peri-implant care significantly enhances treatment success.

***Keywords*---**orthodontic bone screws, TADs, extra-alveolar anchorage, orthodontics, pharmacist role, peri-implant care

Introduction

Effective anchorage management is pivotal for achieving orthodontic success. Temporary anchorage devices (TADs) have emerged from various experimental and clinical foundations [1-3]. In 1997, Kanomi introduced a titanium alloy (Ti) screw, originally intended to stabilize a surgical plate, as a mini-implant for orthodontic anchorage [4]. Since then, the use of other TADs has proliferated significantly [5-7]. Literature reviews consistently show that TADs are both efficacious [8-11] and exhibit relatively low failure rates under optimal conditions [12-14]. A 2014 survey revealed that 90% of TADs were inserted in inter-radicular (I-R) sites [15], where the risk of root damage exists, and failure rates can be three times higher compared to TADs placed further from adjacent roots [16-19]. Additionally, I-R TAD anchorage may impede the direction of tooth movement [20]. From both surgical and biomechanical standpoints, extra-alveolar (E-A) TADs offer a more appealing alternative [21]. The mandibular buccal shelf (MBS) and infra-zygomatic crest (IZC) have been established as reliable E-A sites for

durable stainless steel (SS) TADs, measuring 2mm in diameter, to address various anchorage needs [20, 21].

However, the integration of innovative healthcare technologies, such as TADs, into routine clinical practice has been suboptimal [22]. The knowledge-to-action (KTA) gap for TAD anchorage spans over two decades, despite numerous positive clinical outcomes [8-14, 24]. Several barriers to widespread TAD adoption have been identified [25]. Over half of the orthodontists surveyed indicated that cost, insufficient training, fear of associated risks, limited indications, and skepticism regarding additional benefits hinder the routine use of TADs [25-28]. Conversely, factors promoting the use of TAD anchorage include reduced treatment time, fewer extractions, and the lack of other viable treatment options [25, 27]. This report aims to explore contemporary strategies to overcome the barriers and leverage the facilitators for E-A TAD anchorage by highlighting: (a) effective biomechanical principles, (b) minimally invasive clinical techniques, and (c) the integration of TADs with clear aligner therapy.

Camouflage Treatment

When it comes to treating adult Class II or III malocclusions, which frequently feature asymmetrical skeletal and/or dental abnormalities and are challenging to correct with traditional therapy—even when paired with orthognathic surgery—camouflage treatment is the method utilized. Clinicians can find ways to address or conceal some of the developmental differences causing the malocclusion by determining the genesis of the condition. This practical, if not all-inclusive, approach is called camouflage treatment. By disguising or correcting the underlying skeletal difference, the selective use of extra-alveolar (E-A) osseous anchoring offers a relatively conservative approach that can produce acceptable functional and cosmetic results. For instance, substantial orthognathic surgery may be necessary for skeletal malocclusions such as Class II with an extreme overjet (>10 mm) or Class III with an anterior crossbite and/or severe open bite [29]. Patients and their families may, however, look for other solutions or second opinions if they are worried about the expense and possible side effects of surgery. Conventional options, such as extensive intermaxillary elastics or extractions, are nevertheless likely to be difficult and may not produce the best results [30]. On the other hand, severe skeletal Class II and Class III malocclusions can be effectively managed using infra-zygomatic crest (IZC) and mandibular buccal shelf (MBS) bone screws [21, 31]. E-A anchoring helps alleviate crowding without removing teeth by selectively retracting the buccal segments to lengthen the arch. This method improves anterior torque control by minimizing the requirement for intermaxillary elastics and lowering the possibility of iatrogenic incisor tipping. Retraction and posterior rotation of the arch are caused when the retractive force fails to cross the center of resistance of either the upper or lower dentition [32]. When it comes to treating anterior open-bite instances, the mechanisms of IZC and MBS bone screws work very well [32]. Since they encourage posterior rotation and lower arch intrusion, bone screws positioned in the MBS region work better for treating Class III malocclusion than those placed in the IZC [32]. Furthermore, regardless of the underlying skeletal problem, changes in the occlusal plane inclination can result in noticeable improvements in the facial profile and dental aesthetics. Bilateral MBS bone

screws offer superior anchoring for skeletal Class III malocclusions, especially when there is an anterior open bite [32], while bilateral IZC bone screws often provide the best anchorage for treating adult Class II patients.

Recovery of Impacted Teeth

Impacted teeth are among the most frequently encountered dental anomalies, with a prevalence rate of 3.9%. The ratio of maxillary to mandibular impactions is approximately 4 to 1 [33, 34]. Becker et al. [35] categorized the etiology of impactions into four distinct groups: (a) local hard tissue obstruction, (b) local pathology, (c) disruption of normal incisor development, and (d) genetic or hereditary factors. When spontaneous eruption does not occur within an appropriate timeframe by addressing the underlying cause, orthodontic guidance or surgical intervention becomes necessary [36, 37]. In general, managing impactions presents significant challenges and has long-term consequences. A 3D lever arm anchored by an infra-zygomatic crest (IZC) or mandibular buccal shelf (MBS) bone screw is particularly beneficial in addressing severely impacted teeth. The stainless steel (SS) lever arm allows for sequential movement in all three planes of space, without affecting adjacent teeth. Accurate diagnosis and understanding of the etiology are critical to developing an effective treatment plan.

Clear Aligners

The choice of orthodontic appliance depends primarily on biomechanical requirements and patient preferences. Fixed appliances apply a 'pulling' force to achieve alignment, whereas clear aligners are custom-designed to 'push' teeth into the desired position. Despite the significant advancements in clear aligner technology for treating various malocclusions [38, 39], certain conditions remain beyond the scope of efficient aligner management. For instance, managing a scissors-bite discrepancy using aligners alone poses significant difficulties due to limited pushing surfaces and insufficient occlusal clearance. Effective treatment of a full buccal cross-bite involving the entire posterior segment (either unilateral or bilateral) often necessitates orthognathic surgery, bite plates (turbos), or extensive use of temporary anchorage devices (TADs) in both arches [40-42]. A preferred approach for managing unilateral scissors-bite is to address the excessive extrusion on the contralateral side by using a glass ionomer bite turbo to open the bite, followed by intruding the teeth in cross-bite with elastic modules anchored by an MBS bone screw [43]. Once the intermaxillary relationships have been normalized with osseous-anchored screws (OBS), the occlusion can be aligned and finished using clear aligners.

During the pre-treatment consultation, it is important to discuss with patients the advantages and limitations of each type of appliance in addressing specific aspects of malocclusion. While patients may prefer clear aligner treatment, they must be informed about its limitations, particularly in the management of crowding and protrusion with the extraction of four premolars. Dai et al. [44] reported that the actual tooth movement achieved with aligners often resulted in significant loss of posterior anchorage, and posterior tipping of the upper incisors (anterior dumping) was observed, contrary to pre-treatment predictions. Even protocols like G6 along with SmartStage® cannot guarantee predictable outcomes

due to insufficient anchorage for the prescribed tooth movements [44, 45]. To address this, a four-miniscrew setup was proposed, with two 1.5 × 8-mm incisal miniscrews for incisor intrusion and counterclockwise rotation of the maxillary arch, and two 2 × 12-mm IZC bone screws to enhance posterior anchorage for en-masse retraction [46, 47]. The complementary mechanics—aligner push combined with OBS-anchored elastic pull—greatly increase the effectiveness and applicability of clear aligner therapy.

The Clinical Intervention:

iNewton, Inc., Taiwan, invented the OrthoBoneScrew (OBS), which is designed specifically for usage in the mandibular buccal shelf (MBS) and infra-zygomatic crest (IZC) regions. The base of the zygomatic ridge, palpable on the buccal surface of the maxillary first and second molar roots, is the optimal location for an IZC bone screw to be inserted. A sketch associated with cone-beam computed tomography (CBCT) scans illustrates the process for inserting the screw into the posterior maxilla's restricted bone. It is advised to place the IZC bone screw at an angle of roughly 60˚ with respect to a line that runs perpendicular to the axis of the first molar root. On the other hand, CBCT pictures show the MBS's dense cortical bone structure. Anatomically, the MBS is located above the masseter muscle fibers and anterior to the temporalis muscle insertion. It is covered in alveolar mucosa and lacks underlying muscle. With bone penetration taking place 5-7 mm inferior to the alveolar crest and angled 30˚ buccally from the long axis of the lower first molar, the optimal location for the MBS bone screw is approximately 5 mm lateral to the interproximal area between the lower first and second teeth. Both IZC and MBS bone screws are surgically inserted after local anesthetic and a mucosal site disinfectant have been applied. Finding the bone surface is usually done with a sharp dental explorer in the vicinity of the mucogingival junction. Next, a screwdriver is used to press the self-drilling OBS into the bone. It is not recommended to raise a soft-tissue flap in order to implant a bone screw. The screw head should stay 5 mm above the soft tissue level in order to preserve oral hygiene and reduce irritation of the soft tissues [21]. Regardless of whether they penetrate connected gingiva or mobile mucosa, OBSs constructed of titanium (Ti) and stainless steel (SS) have failure rates that are not significantly different (≤7.31%) [48, 49]. Nevertheless, temporary anchoring device (TAD) failure is connected to peri-implant inflammation, which is frequently caused by inadequate hygiene [14, 48]. OBSs can be loaded right away using common clinical mechanics after installation [14].

Research indicates that the mandible has a greater failure rate (19.3%) for routine inter-radicular (I-R) TADs than the maxilla (12.0%) [12, 50, 51]. On the other hand, low failure rates are shown by extra-alveolar (E-A) bone screws in the IZC (7.0%) and MBS (7.2%) regions [48, 49]. Screw fractures, mobility, uncontrolled soft-tissue inflammation, root injury, and pain are among the failure modes of I-R TADs; these problems are more common when the miniscrew contacts or enters the periodontal ligament [12, 50, 51]. If an E-A bone screw fails, which is an uncommon occurrence, the screws could come free or stop working as a reliable anchor. For non-integrated TADs, insertion torque is a crucial predictor of primary stability and a crucial component of therapeutic outcome [52, 53]. I-R TADs are recommended to have torque values between 5 and 10 Ncm [54, 55].

Higher failure rates have been associated with higher torque levels, which may indicate screw-to-root contact [56]. According to a recent assessment, E-A bone screws have a larger insertion torque than I-R devices because of their greater contact with thick cortical bone. This means that E-A bone screws are probably more stable. While young patients' cortical bone might not be thick enough to accommodate bone screws [58], E-A OBSs have an overall success rate of over 92%, which makes them the best option for the majority of TAD applications.

Orthodontic bone screws:

Orthodontic bone screws, often referred to as Temporary Anchorage Devices (TADs), are small titanium or stainless steel screws used to provide additional anchorage in orthodontic treatments. There are various types of orthodontic bone screws, classified based on their placement site, design, and specific applications. Below are the main types:

1. Inter-Radicular (I-R) Bone Screws

- **Location:** Placed between the roots of teeth in the alveolar bone.
- **Application:** Commonly used to control tooth movement in treatments like space closure, intrusion, or retraction. They are popular for their ease of placement and minimally invasive nature.
- **Features:**
    - Usually self-drilling and self-tapping.
    - Require careful placement to avoid damage to tooth roots.
- **Common Sites:** Between premolars or molars, both in the maxilla and mandible.

2. Extra-Alveolar (E-A) Bone Screws

- **Location:** Placed outside the alveolar bone, typically in non-dental areas such as the infra-zygomatic crest (IZC) or mandibular buccal shelf (MBS).
- **Application:** Used in cases requiring significant anchorage, such as for moving multiple teeth, molar intrusion, or managing severe malocclusions.
- **Features:**
    - Engage thick cortical bone, providing greater stability.
    - Are more stable and less prone to failure compared to I-R screws.
    - They can support heavy forces and are suitable for more complex movements.

Common types of E-A screws:

- **Infra-Zygomatic Crest (IZC) Bone Screws:**
    - Positioned on the buccal side of the maxilla, near the roots of the upper molars.
    - Ideal for cases that require molar retraction or open bite correction.
- **Mandibular Buccal Shelf (MBS) Bone Screws:**
    - Placed in the cortical bone of the mandibular buccal shelf.
    - Used for distalizing the lower dentition, controlling vertical dimensions, and resolving severe malocclusions.

3. Palatal Bone Screws

- **Location:** Placed in the mid-palatal region of the maxilla.
- **Application:** Commonly used for expanding the maxillary arch (palatal expansion) or as anchorage for distalizing molars.
- **Features:**

- The palate provides a stable anchorage point with dense cortical bone.
- Frequently used in conjunction with appliances like palatal expanders.

4. Miniscrews

- **Location:** Typically placed in the inter-radicular area or other small bone areas.
- **Application:** Used for minor tooth movements, such as intrusion, extrusion, or small retractions.
- **Features:**
  - Small in size (1.2–2 mm in diameter and 6–12 mm in length).
  - Provide temporary anchorage without the need for full surgical procedures.
  - Can be inserted and removed easily in a non-invasive manner.

5. Zygomatic Bone Screws

- **Location:** Placed in the zygomatic arch, near the cheekbone.
- **Application:** Used in cases requiring strong anchorage, especially in patients with missing teeth or severe occlusal issues.
- **Features:**
  - Provide extremely strong anchorage points.
  - Typically used for maxillary retraction in severe cases.

6. Cortical Bone Screws

- **Location:** Engages the dense cortical bone layer, often outside the alveolar process.
- **Application:** Used in cases where high stability and resistance to forces are required.
- **Features:**
  - High insertion torque and stability due to thick bone engagement.
  - Can be placed in areas with limited soft tissue coverage.

7. Self-Drilling vs. Self-Tapping Screws

- **Self-Drilling Screws:**
  - Designed to penetrate the bone without pre-drilling.
  - Commonly used in areas with softer bone or when fast placement is required.
- **Self-Tapping Screws:**
  - Require a pre-drilled hole for insertion.
  - Used in areas with dense bone or when precise placement is necessary.

8. Hybrid Bone Screws

- **Location:** Can be placed in multiple locations (inter-radicular, extra-alveolar).
- **Application:** Used for a combination of anchorage and tooth movement purposes.
- **Features:**
  - Versatile in placement, providing both intraoral and extraoral anchorage.
  - Often used in combination with other orthodontic devices.

Orthodontic bone screws vary in their design and function depending on the treatment objectives, the site of insertion, and the forces required. Inter-radicular and extra-alveolar screws are the most commonly used in modern orthodontic treatments, but other specialized types such as palatal or zygomatic screws may be used in more complex cases.

Role of Pharmacists

Pharmacists play a crucial role in the management of patients undergoing orthodontic treatment with bone screws, particularly in areas related to patient care, medication management, and education. Here are some key roles pharmacists can take on in such conditions:

1. Pain Management

- **Pre- and Post-Surgical Care:** Orthodontic bone screw placement can cause discomfort or pain. Pharmacists can recommend and manage over-the-counter or prescribed analgesics (e.g., ibuprofen or acetaminophen) to alleviate pain after surgical interventions.
- **Education on Medication Use:** Pharmacists ensure that patients are aware of the correct dosage, frequency, and possible side effects of pain medications, minimizing risks like overuse or underuse.

2. Infection Prevention and Control

- **Antibiotic Stewardship:** For some patients, antibiotics may be prescribed post-operatively to prevent infection at the bone screw site. Pharmacists can assist in:
    - **Selecting the Right Antibiotic:** Based on the patient's health profile, allergies, or resistance patterns.
    - **Ensuring Proper Use:** Reinforcing adherence to the prescribed antibiotic regimen and explaining the importance of completing the full course.
    - **Counseling on Side Effects:** Monitoring potential adverse reactions or interactions with other medications.

3. Management of Peri-Implant Inflammation

- **Treatment of Soft Tissue Irritation:** Bone screws can cause localized inflammation or irritation. Pharmacists can recommend topical anti-inflammatory agents (e.g., chlorhexidine mouthwash or corticosteroid creams) to manage such issues.
- **Preventive Measures:** Pharmacists may advise on oral hygiene products like antiseptic mouthwashes, antimicrobial toothpastes, or medicated gels to prevent inflammation and ensure proper maintenance of the bone screw site.

4. Oral Hygiene Counseling

- **Preventing Complications:** Proper oral hygiene is critical for the success of orthodontic bone screws. Pharmacists can educate patients on the use of specialized oral care products (e.g., soft toothbrushes, interdental brushes) to clean around the screws and prevent peri-implant diseases.
- **Reducing Infection Risk:** They can advise patients on strategies to reduce plaque buildup and prevent gum infections, which could lead to bone screw failure.

5. Monitoring and Managing Drug-Device Interactions

- **Drug Impact on Bone Health:** Certain medications (e.g., corticosteroids, bisphosphonates) may affect bone density and healing, potentially

impacting the stability of orthodontic screws. Pharmacists can monitor these interactions and collaborate with the dental or orthodontic team to adjust medication regimens.

- **Impact of Systemic Medications:** Pharmacists should review any systemic medications the patient is on to ensure they do not interfere with bone healing or the placement of screws.

6. Patient Education

- **Pre-Surgical Preparation:** Pharmacists can prepare patients for the procedure by explaining which medications to avoid before surgery (e.g., anticoagulants or aspirin) that may increase bleeding risk.
- **Post-Surgical Guidelines:** After the bone screw installation, pharmacists play a critical role in instructing patients about medication use, managing swelling, and avoiding habits that could compromise the screws (e.g., smoking, certain foods).
- **Adherence to Treatment:** Pharmacists ensure that patients understand their treatment protocols, including the duration and proper application of medications, to promote healing and prevent complications.

7. Management of Anxiety and Stress

- **Pharmacological Support:** Some patients may experience anxiety related to orthodontic treatment and surgery. Pharmacists can collaborate with the healthcare team to provide or recommend anti-anxiety medications (if necessary) and ensure these do not interfere with other medications the patient is taking.
- **Non-Pharmacological Counseling:** Pharmacists can also provide advice on relaxation techniques or over-the-counter options like herbal supplements to reduce anxiety levels before surgery.

8. Collaborative Care

- **Interdisciplinary Communication:** Pharmacists work alongside orthodontists, oral surgeons, and other healthcare providers to ensure that medication therapies are aligned with the patient's overall treatment plan.
- **Providing Feedback to Healthcare Teams:** They can report any medication-related issues (e.g., adverse drug reactions) that could influence the success of the orthodontic treatment and propose alternative solutions if needed.

Pharmacists are integral to the interdisciplinary team in orthodontic care involving bone screws. Their expertise in medication management, patient education, and infection control helps optimize treatment outcomes and enhance patient comfort. By addressing pain management, ensuring proper medication use, and providing oral hygiene guidance, pharmacists contribute to the successful integration of orthodontic bone screws in clinical practice.

Conclusion

Orthodontic bone screws, particularly extra-alveolar (E-A) Temporary Anchorage Devices (TADs), represent a breakthrough in achieving successful orthodontic outcomes for complex cases, including Class II and III malocclusions. E-A TADs, inserted in regions like the mandibular buccal shelf (MBS) and infra-zygomatic crest (IZC), have proven to offer superior stability compared to inter-radicular (I-R)

TADs, which are prone to higher failure rates and biomechanical limitations. The reliance on E-A TADs allows for improved torque control, minimal extractions, and better cosmetic outcomes, especially in adult patients seeking less invasive alternatives to orthognathic surgery. The application of TADs in managing severely impacted teeth and facilitating complex tooth movements has been instrumental in expanding treatment possibilities. For patients with significant skeletal discrepancies or open-bite malocclusions, E-A anchorage provides a conservative yet effective approach, reducing the need for more aggressive treatments like extensive intermaxillary elastics or tooth extractions. Additionally, the integration of bone screws with clear aligner therapy enhances the biomechanical control necessary for achieving optimal outcomes in cases that would otherwise pose challenges for aligners alone. Pharmacists play a pivotal role in optimizing the success of orthodontic treatments involving TADs. Their expertise is critical in managing peri-implant inflammation, a common complication associated with TAD failure. By advising on proper hygiene practices and providing medications that reduce infection risks, pharmacists help ensure long-term success. Furthermore, pharmacists contribute to patient education regarding postoperative care and medication adherence, which is essential for minimizing adverse outcomes. In conclusion, orthodontic bone screws, especially E-A TADs, are a valuable tool for addressing complex orthodontic challenges. Their strategic placement in cortical bone regions enhances stability and patient outcomes. Collaboration between orthodontists and pharmacists is vital to ensuring optimal care, reducing failure rates, and improving the overall success of orthodontic treatments.

References

1. Roberts WE, Helm FR, Marshall KJ, Gongloff RK. Rigid endosseous implants for orthodontic and orthopedic anchorage. *Angle Orthod*. 1989; **59**(4): 247-256.
2. Feldmann I, Bondemark L. Orthodontic anchorage: a systematic review. *Angle Orthod*. 2006; **76**(3): 493-501.
3. Lee K-J, Park Y-C, Hwang C-J, et al. Displacement pattern of the maxillary arch depending on miniscrew position in sliding mechanics. *Am J Orthod Dentofacial Orthop*. 2011; **140**(2): 224-232.
4. Kanomi R. Mini-implant for orthodontic anchorage. *J Clin Orthod*. 1997; **31**(11): 763-767.
5. Labanauskaite B, Jankauskas G, Vasiliauskas A, Haffar N. Implants for orthodontic anchorage. Meta-analysis. *Stomatologija*. 2005; **7**: 128-132.
6. Chen Y, Kyung HM, Zhao WT, Yu WJ. Critical factors for the success of orthodontic mini-implants: a systematic review. *Am J Orthod Dentofacial Orthop*. 2009; **135**: 284-291.
7. Reynders R, Ronchi L, Bipat S. Mini-implants in orthodontics: a systematic review of the literature. *Am J Orthod Dentofacial Orthop*. 2009; **135**(5): 564.e1-564.e19.
8. Papadopoulos M, Papageorgiou S, Zogakis I. Clinical effectiveness of orthodontic miniscrew implants: a meta-analysis. *J Dental Res*. 2011; **90**(8): 969-976.

9. Tsui WK, Chua HDP, Cheung LK. Bone anchor systems for orthodontic application: a systematic review. *Int J Oral Maxillofac Surg*. 2012; **41**(11): 1427-1438.
10. Jambi S, Walsh T, Sandler J, et al. Reinforcement of anchorage during orthodontic brace treatment with implants or other surgical methods. *Cochrane Database Syst Rev*. 2014(**8**): CD005098.
11. Antoszewska-Smith J, Sarul M, Łyczek J, Konopka T, Kawala B. Effectiveness of orthodontic miniscrew implants in anchorage reinforcement during en-masse retraction: a systematic review and meta-analysis. *Am J Orthod Dentofacial Orthop*. 2017; **151**(3): 440-455.
12. Schätzle M, Männchen R, Zwahlen M, Lang NP. Survival and failure rates of orthodontic temporary anchorage devices: a systematic review. *Clin Oral Implants Res*. 2009; **20**(12): 1351-1359.
13. Papageorgiou SN, Zogakis IP, Papadopoulos MA. Failure rates and associated risk factors of orthodontic miniscrew implants: a meta-analysis. *Am J Orthod Dentofacial Orthop*. 2012; **142**(5): 577-595.
14. Dalessandri D, Salgarello S, Dalessandri M, et al. Determinants for success rates of temporary anchorage devices in orthodontics: a meta-analysis (n>50). *Eur J Orthod*. 2013; **36**(3): 303-313.
15. Keim RG, Gottlieb EL, Vogels D III, Vogels PB. 2014 JCO study of orthodontic diagnosis and treatment procedures, part 1: results and trends. *J Clin Orthod*. 2014; **48**(10): 607-630.
16. Liou EJW, Pai BCJ, Lin JCY. Do miniscrews remain stationary under orthodontic forces? *Am J Orthod Dentofacial Orthop*. 2004; **126**(1): 42-47.
17. Hembree M, Buschang PH, Carrillo R, Spears R, Rossouw PE. Effects of intentional damage of the roots and surrounding structures with miniscrew implants. *Am J Orthod Dentofacial Orthop*. 2009; **135**(3): 280.e1-280.e9.
18. Alves M, Baratieri C, Mattos CT, de Souza Araujo MT, Maia LC. Root repair after contact with mini-implants: systematic review of the literature. *Eur J Orthod*. 2013; **35**(4): 491-499.
19. Motoyoshi M, Uchida Y, Matsuoka M, et al. Assessment of damping capacity as an index of root proximity in self-drilling orthodontic mini-implants. *Clin Oral Invest*. 2014; **18**: 321-326.
20. Chang CH, Lin JS, Yeh HY. Extra-alveolar bone screws for conservative correction of severe malocclusion without extractions or orthognathic surgery. *Curr Osteoporos Rep*. 2018; **16**: 387-394.
21. Chang CH, Lin JS, Yeh HY, Roberts WE. Insights to extraradicular bone screw applications for challenging malocclusions. In: JH Park, ed. *Temporary Anchorage Devices in Clinical Orthodontics*. New Jersey, USA: John Wiley & Sons; 2020: 433-444.
22. Straus SE, Tetroe J, Graham ID. Knowledge to action - what it is and what it isn't. In: SE Straus, J Tetroe, ID Graham, eds. *Knowledge Translation in Health Care: Moving from*
23. Grimshaw JM, Eccles MP, Lavis JN, Hill SJ, Squires JE. Knowledge translation of research findings. *Implement Sci*. 2012; **7**(1): 50-66.
24. Leo M, Cerroni L, Pasquantonio G, Condò S, Condò R. Temporary anchorage devices (TADs) in orthodontics: review of the factors that influence the clinical success rate of the mini-implants. *Clin Ter*. 2016; **167**(3): e70-e77.

25. Reynders RM, Ronchi L, Ladu L, et al. Barriers and facilitators to the implementation of orthodontic mini implants in clinical practice: a systematic review. *Syst Rev*. 2016; **5**(1): 163-183.
26. Meeran NA, Venkatesh K, Parveen MJ. Current trends in miniscrew utilization among Indian orthodontists. *J Orthod Sci*. 2012; **1**(2): 46-50.
27. Zawawi K. Acceptance of orthodontic miniscrews as temporary anchorage devices. *Patient Preference and Adherence*. 2014; **8**: 933-937.
28. Bock NC, Ruf S. Skeletal anchorage for everybody? A questionnaire study on frequency of use and clinical indications in daily practice. *J Orofacial Orthop*. 2015; **76**: 113-128.
29. Nguyen T, Proffit WR. The decision-making process in orthodontics. In: LW Graber, RL Vanarasdall, KW Vig, GJ Huang, eds. *Orthodontics: Current Principles and Techniques*, 6th edn. St. Louis: Mosby; 2017: 208-244.
30. Georgalis K, Woods MG. A study of Class III treatment: orthodontic camouflage vs orthognathic surgery. *Aus Orthod J*. 2015; **31**(2): 138-148.
31. Tseng L, Chang CH, Roberts WE. Diagnosis and conservative treatment of skeletal Class III malocclusion with anterior crossbite and asymmetric maxillary crowding. *Am J Orthod Dentofacial Orthop*. 2016; **149**(4): 555-566.
32. Roberts WE, Viecilli RF, Chang CH, Katona TR, Paydar NH. Biology of biomechanics: Finite element analysis of a statically determinate system to rotate the occlusal plane for correction of a skeletal Class III open-bite malocclusion. *Am J Orthod Dentofacial Orthop*. 2015; **148**(6): 943-955.
33. Grover PS, Lorton L. The incidence of unerupted permanent teeth and related clinical cases. *Oral Surg, Oral Med, Oral Patho*. 1985; **599**(4): 420-425.
34. Laganà G, Venza N, Borzabadi-Farahani A, Fabi F, Danesi C, Cozza P. Dental anomalies: prevalence and associations between them in a large sample of non-orthodontic subjects, a cross-sectional study. *BMC Oral Health*. 2017; **17**: 62-68.
35. Becker A, Chaushu S. Etiology of maxillary canine impaction: a review. *Am J Orthod Dentofacial Orthop*. 2015; **148**(4): 557-567.
36. Kokich V, Mathews D. Surgical and orthodontic management of impacted teeth. *Dent Clini North Am*. 1993; **37**(2): 181-204.
37. Kokich VG. Surgical and orthodontic management of impacted maxillary canines. *Am J Orthod Dentofacial Orthop*. 2004; **126**(3): 278-283.
38. Papadimitriou A, Mousoulea S, Gkantidis N, Kloukos D. Clinical effectiveness of Invisalign® orthodontic treatment: a systematic review. *Prog Orthod*. 2018; **19**: 37-60.
39. Galan-Lopez L, Barcia-Gonzalez J, Plasencia E. A systematic review of the accuracy and efficiency of dental movements with Invisalign®. *Korean J Orthod*. 2019; **49**(3): 140-149.
40. Chugh VK, Sharma VP, Tandon P, Singh GP. Brodie bite with an extracted mandibular first molar in a young adult: a case report. *Am J Orthod Dentofacial Orthop*. 2010; **137**(5): 694-700.
41. Jung M-H. Treatment of severe scissor bite in a middle-aged adult patient with orthodontic mini-implants. *Am J Orthod Dentofacial Orthop*. 2011; **139**(4): S154-S165.
42. Suda N, Tominaga N, Niinaka Y, Amagasa T, Moriyama K. Orthognathic treatment for a patient with facial asymmetry associated with unilateral scissors-bite and a collapsed mandibular arch. *Am J Orthod Dentofacial Orthop*. 2012; **141**(1): 94-104.

43. Lee S-A, Chang CH, Roberts WE. Severe unilateral scissors-bite with a constricted mandibular arch: Bite turbos and extra-alveolar bone screws in the infrazygomatic crests and mandibular buccal shelf. *Am J Orthod Dentofacial Orthop*. 2018; **154**(4): 554-569.
44. Dai F-F, Xu T-M, Shu G. Comparison of achieved and predicted tooth movement of maxillary first molars and central incisors: First premolar extraction treatment with Invisalign. *Angle Orthod*. 2019; **89**(5): 679-687.
45. Align Technology. Invisalign G6. http://www.invisalign-g6.com/en-XA.
46. Lin LY, Chang CH, Roberts WE. Mechanics and clinical significance for mini-screws in four bicuspid extraction aligner cases. *J Digital Orthod*. 2020; **58**: 94-98.
47. Lin LY, Chang CH, Roberts WE. Bimaxillary protrusion with gummy smile treated with clear aligners: closing premolar extraction spaces with bone screw anchorage. *APOS Trends Orthod*. 2020; **10**(2): 120-131.
48. Chang CH, Liu SSY, Roberts WE. Primary failure rate for 1680 extra-alveolar mandibular buccal shelf mini-screws placed in movable mucosa or attached gingiva. *Angle Orthod*. 2015; **85**(6): 905-910.
49. Chang CH, Lin JS, Roberts WE. Failure rates for stainless steel versus titanium alloy infrazygomatic crest bone screws: A single-center, randomized double-blind clinical trial. *Angle Orthod*. 2019; **89**(1): 40-46.
50. Viwattanatipa N, Thanakitcharu S, Uttraravichien A, Pitiphat W. Survival analyses of surgical miniscrews as orthodontic anchorage. *Am J Orthod Dentofacial Orthop*. 2009; **136**(1): 29-36.
51. Uesugi S, Kokai S, Kanno Z, Ono T. Prognosis of primary and secondary insertions of orthodontic miniscrews: what we have learned from 500 implants. *Am J Orthod Dentofacial Orthop*. 2017; **152**(2): 224-231.
52. Wilmes B, Su Y-Y, Drescher D. Insertion angle impact on primary stability of orthodontic mini-implants. *Angle Orthod*. 2008; **78**(6): 1065-1070.
53. Reynders RM, Ronchi L, Ladu L, Van Etten-Jamaludin F, Bipat S. Insertion torque and orthodontic mini-implants: a systematic review of the artificial bone literature. *J Engineer Med*. 2013; **227**(11): 1181-1202.
54. Motoyoshi M, Hirabayashi M, Uemura M, Shimizu N. Recommended placement torque when tightening an orthodontic mini-implant. *Clin Oral Implants Res*. 2006; **17**: 109-114.
55. Reynders RM, Ronchi L, Ladu L, van Etten-Jamaludin F, Bipat S. Insertion torque and success of orthodontic mini-implants: a systematic review. *Am J Orthod Dentofacial Orthop*. 2012; **142**: 596-614.
56. Reynders RM, Ladu L, Ronchi L, et al. Insertion torque recordings for the diagnosis of contact between orthodontic mini-implants and dental roots: protocol for a systematic review. *Syst Rev*. 2016; **5**: 50-68.
57. Marquezan M, Mattos CT, Sant'Anna EF, De Souza MMG, Maia LC. Does cortical thickness influence the primary stability of miniscrews? A systematic review and meta-analysis. *Angle Orthod*. 2014; **84**(6): 1093-1103.
58. Lee H-S, Choi H-M, Choi D-S, Jang I, Cha B-K. Bone thickness of the infrazygomatic crest area in skeletal Class III growing patients: A computed tomographic study. *Imag Sci Dent*. 2013; **43**: 261-266.

مسامير العظام في تقويم الأسنان: مراجعة شاملة للتطبيقات والنتائج السريرية ودور الصيادلة

الملخص

الخلفية :أحدثت الأجهزة المؤقتة للتثبيت(TADs) ، مثل مسامير العظام في تقويم الأسنان، ثورة في إدارة التثبيت في تقويم الأسنان. منذ إدخالها في عام ١٩٩٧، تم اعتماد هذه الأجهزة على نطاق واسع لتحسين نتائج العلاج، خاصةً في حالات سوء الإطباق المعقدة. وعلى الرغم من فعاليتها، لا تزال هناك تحديات مثل ارتفاع معدلات الفشل في مواضع التثبيت بين الجذور (I-R)والاندماج السريري المحدود.

الهدف :تستعرض هذه المراجعة الشاملة التطبيقات السريرية، والنتائج، والمعوقات التي تواجه تبني مسامير العظام في تقويم الأسنان، مع التركيز على الأجهزة ذات التثبيت خارج السنخي .(E-A) بالإضافة إلى ذلك، يتم استعراض دور الصيادلة في تحسين رعاية المرضى في العلاجات التقويمية التي تشمل الأجهزة المؤقتة للتثبيت .

الطرق :تقوم المراجعة بتحليل الدراسات حول تطبيقات الأجهزة المؤقتة للتثبيت، والنتائج السريرية، ومعدلات الفشل، مع التركيز على المواقع خارج السنخية مثل الحافة الدهليزية للفك السفلي (MBS) وقمة تحت الوجنية .(IZC) كما تناقش مساهمات الصيادلة في إدارة الأدوية، وتثقيف المرضى، وتقليل الالتهابات حول الغرسات.

النتائج :أظهرت الأجهزة ذات التثبيت خارج السنخي معدلات فشل أقل (٧٪) مقارنةً بالأجهزة بين الجذور (١٩,٣٪)، مع استقرار أفضل في مواضع قمة تحت الوجنية والحافة الدهليزية بسبب التماس المعزز مع العظم القشري. يلعب الصيادلة دورًا حيويًا في إدارة الالتهابات حول الغرسات، وتقديم المشورة حول ممارسات النظافة، وتوفير الأدوية التي تقلل من مخاطر العدوى .

الخلاصة :توفر الأجهزة المؤقتة للتثبيت حلاً موثوقًا للتثبيت في حالات سوء الإطباق المعقدة، مع تحقيق نتائج أفضل في مواضع التثبيت خارج السنخي. يسهم دور الصيادلة في تثقيف المرضى ورعاية ما حول الغرسات بشكل كبير في نجاح العلاج.

الكلمات المفتاحية :مسامير العظام في تقويم الأسنان، الأجهزة المؤقتة للتثبيت، التثبيت خارج السنخي، تقويم الأسنان، دور الصيادلة، رعاية ما حول الغرسات