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EXTRA-RADICULAR IMPLANTS - REDEFINING SKELETAL ANCHORAGE IN ORTHODONTICS: A REVIEW ARTICLE

Orthodontics

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ABSTRACT

Anchorage control remains a central challenge in orthodontic treatment, and conventional appliances are often limited by dependence on patient compliance and the risk of unwanted reciprocal tooth movement. Extra-radicular implants (ERIs) have emerged as a skeletal anchorage solution that engages dense cortical bone outside the alveolar housing, most commonly at the infrazygomatic crest (IZC), mandibular buccal shelf (MBS), and palatal regions. Unlike inter-radicular temporary anchorage devices (TADs), ERIs largely avoid root proximity, offering higher primary stability, greater load-bearing capacity, and versatile three-dimensional force application. This review outlines the biomechanical basis of ERI function, classifies implant types by anatomical site, and summarizes clinical applications including molar distalization, en masse retraction, molar intrusion, asymmetric tooth movement, maxillary protraction, and surgical and non-surgical open bite correction. Advantages such as absolute anchorage and reduced compliance dependence are weighed against limitations including technique sensitivity, soft-tissue irritation, and the need for CBCT-based planning. Emerging innovations — digital surgical guides, 3D-printed implants, minimally invasive insertion, and AI-driven planning — point toward a more precise, personalized future for skeletal anchorage.

KEYWORDS

Extra-radicular implants, Skeletal anchorage, Infrazygomatic crest, Temporary anchorage devices (TADs)

INTRODUCTION

Reliable anchorage control is a fundamental determinant of successful orthodontic treatment. Conventional appliances have well-known drawbacks: heavy dependence on patient cooperation, biomechanical inefficiency, and the risk of unwanted reciprocal tooth movement or root resorption (1). Skeletal anchorage devices were developed to overcome these problems, and ERIs have become a particularly valuable option within this category.

Unlike inter-radicular TADs, which sit between the roots of adjacent teeth, ERIs are inserted outside the alveolar housing altogether, in regions where cortical bone is thicker — mainly the IZC, MBS, and areas of the palate (2). Because they avoid the interdental space, ERIs largely sidestep the root-proximity problems that commonly compromise inter-radicular screws.

This extra-alveolar placement has opened new possibilities for complex tooth movement, including maxillary molar distalization, molar intrusion, and asymmetric force application. Strong engagement with high-density cortical bone gives ERIs superior primary stability, allowing high-force application without anchor loss (3), which makes them well suited to non-extraction plans and difficult Class II/III malocclusions. Achieving good outcomes depends on careful case selection, sound anatomical knowledge, and precise surgical technique, since poor placement can cause soft-tissue irritation, mobility, or overload failure.

BIOMECHANICAL BASIS

Anchorage quality. Dense cortical engagement at IZC and MBS sites allows genuine "absolute anchorage" — tooth movement without reciprocal displacement of the anchor (4), with lower failure rates than inter-radicular miniscrews due to superior stability and reduced micromovement (5).

Force direction and magnitude. Extra-alveolar placement gives access to force vectors inter-radicular screws cannot offer. IZC screws permit posterior and superior-directed forces useful for distalizing or intruding maxillary molars (6), while MBS screws support strong distal and intrusive forces in Class III camouflage (7), with minimal interference from surrounding dental structures.

Avoiding root proximity. Root contact is a leading cause of miniscrew failure and resorption. ERIs largely eliminate this risk by design, allowing safer use of larger, longer screws for added retention (8).

Load capacity. Larger dimensions, greater thread surface area, and thicker surrounding bone give ERIs higher load capacity, torque resistance, and resistance to loosening under sustained force (9).

Three-dimensional control. Together, these properties support precise vertical intrusion, transverse expansion, and sagittal control, while reducing dependence on patient compliance.

Types Of Extra-radicular Implants (table 1)

Infrazygomatic crest (IZC) implants are placed above the maxillary molar roots and below the zygomatic buttress (Fig 1a), a site offering thick cortical bone and ample space without interfering with dental roots (15). They typically measure 10–14 mm in length with a diameter of 2.0 mm or more, indicated for maxillary arch distalization, molar intrusion, and total arch retraction, with reported success rates exceeding 90% at 55–70° insertion angulation.

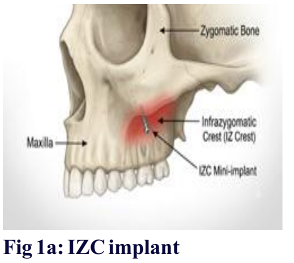

Fig 1a: IZC implant


Fig 1b: Buccal shelf implant

Mandibular buccal shelf (MBS) implants (Fig 1b) are inserted distal to the mandibular first and second molars, on the external oblique ridge — a site providing dense cortical bone suitable for heavy loading (12). They are used for mandibular molar protraction or distalization, Class III correction, and en masse retraction, typically placed at 30–45° to the buccal surface to ensure bicortical engagement.

Palatal extra-radicular implants, placed in the posterior lateral palatal vault, cause minimal soft-tissue interference and offer high patient comfort, useful for molar intrusion, maxillary expansion, and indirect anchorage, and can be connected with rigid bars or transpalatal arches for enhanced biomechanical control.

Zygomatic anchorage screws are longer (14–18 mm) and engage the zygomatic buttress itself, indicated for severe skeletal discrepancies requiring heavy force application, such as maxillary protraction (14). Their surgical complexity and need for CBCT-based planning mean they are typically placed by oral surgeons, often with bone-anchored maxillary protraction (BAMP) appliances.

Nasal floor and canine fossa screws are a less-established option, explored mainly when IZC or MBS placement is contraindicated; thin cortical bone and perforation risk limit their broader use (15).

Table 1. Comparison of Extra-Radicular Implant Types by Anatomical Site, Indication, and Key Advantage

Type	Site	Primary Use	Key Advantage
IZC	Posterior maxilla	Arch retraction, molar intrusion	Thick cortical bone, root clearance
MBS	Posterior mandible	Molar protraction, Class III correction	High force capacity, safe placement
Palatal	Mid-palate/lateral	Expansion, intrusion, indirect anchorage	Comfort, low soft-tissue irritation
Zygomatic	Zygomatic buttress	Severe skeletal anchorage	Deep insertion, high stability
Nasal floor/Canine fossa	Anterior maxilla	Experimental anchorage	Proximity to anterior teeth

CLINICAL APPLICATIONS

Molar distalization. IZC implants enable bodily distal movement of maxillary molars without tipping (6), while MBS screws achieve comparable mandibular distalization in Class III camouflage treatment (7), eliminating the need for extraoral appliances or elastics.

En masse retraction. In non-extraction or maximum-anchorage cases, ERIs anchor retraction of the six anterior teeth, minimizing posterior anchorage loss — particularly useful for convex or protrusive profiles.

Vertical control and molar intrusion. Vertical forces from IZC or palatal implants enable molar intrusion (10), inducing favorable mandibular autorotation that closes anterior open bites, without the flaring or extrusion seen with conventional intrusion mechanics.

Asymmetric tooth movement. Unilateral, extra-arch placement allows asymmetric forces without affecting the contralateral side — useful for midline correction and differential distalization or intrusion.

Maxillary protraction. In growing Class III patients, IZC implants combined with protraction facemasks improve control over maxillary advancement and mandibular growth redirection (11,14), supporting skeletally based expansion protocols.

Surgical orthodontics. ERIs assist presurgical decompensation and postsurgical stabilization, allowing precise control of incisor inclination and transverse arch coordination (14).

Non-surgical open bite correction. Intruding posterior teeth via IZC or palatal implants can reduce vertical dimension and facilitate autorotation into functional occlusion, with documented long-term stability given adequate retention.

Advantages

- **Absolute anchorage without root interference:** Extra-alveolar placement eliminates the risk of root contact common with inter-radicular TADs (2,8).
- **Greater loading capacity:** ERIs can withstand higher orthodontic loads — often 500–1000 grams of force — with buccal shelf screws showing greater resistance to failure than inter-radicular miniscrews (9,12).
- **Minimal dependence on patient compliance:** ERIs reduce or eliminate the need for compliance-based appliances such as headgear, elastics, or facemasks.
- **Versatility in biomechanics:** ERIs allow a wide range of force vectors, facilitating three-dimensional control without transpalatal support or auxiliary arms (16).
- **Fewer insertion site limitations:** ERIs can be placed in broader regions such as the zygomatic buttress or external oblique ridge, sites with significantly greater cortical thickness than inter-radicular zones.

LIMITATIONS

- **Technique sensitivity and learning curve:** Deeper insertion and specific angulation requirements demand surgical precision; improper placement can lead to cortical perforation, sinus penetration, or nerve injury, with higher failure rates during the early learning phase, particularly without CBCT guidance (8).
- **Soft tissue irritation and inflammation:** ERIs, especially at the MBS, often perforate thick, movable mucosa, causing irritation, inflammation, or mucosal overgrowth.
- **Limited placement in growing patients:** Due to incomplete skeletal maturation, ERI use in younger patients (under about 13 years) is limited, as high insertion torque and ongoing bone remodeling can compromise stability (13).
- **Potential for screw fracture or loosening:** Excessive force or poor angulation may cause fracture, micromovement, or premature loosening, with a reported 5–10% incidence in high-stress regions lacking bicortical engagement (17).
- **Need for CBCT-based planning:** Accurate placement near anatomically sensitive zones like the maxillary sinus often requires CBCT imaging, increasing cost and planning complexity (18).

FUTURE DIRECTIONS

- **Digital planning and navigation systems:** CBCT and intraoral scanning enable precise virtual planning, with static surgical guides and dynamic navigation systems supporting safe, reproducible placement at sites like the IZC and MBS (19).
- **Customized implant design via 3D printing:** Additive manufacturing enables fully customized implants based on a patient's CBCT data, improving cortical bone engagement and reducing insertion torque and soft-tissue irritation.
- **Minimally invasive placement techniques:** Flapless insertion, piezosurgery, and ultrasonic bone preparation aim to reduce trauma and shorten healing time while maintaining primary stability.
- **Integration with clear aligners:** As aligner therapy expands, ERIs increasingly provide fixed skeletal support for movements aligners alone cannot easily achieve.
- **Biomechanical simulation and AI-driven planning:** Finite element analysis and machine learning allow clinicians to visualize stress distribution and optimize force systems before clinical application, with AI increasingly trained to recommend implant sites from CBCT data (20).

CONCLUSION

Extra-radicular implants have significantly expanded what is biomechanically achievable in orthodontics, offering strong, root-safe anchorage for movements difficult to achieve with conventional appliances. Each implant type — IZC, MBS, palatal, zygomatic, or the less common nasal floor/canine fossa options — offers distinct advantages, and selection should be tailored to treatment goal, patient anatomy, and clinician experience, with CBCT remaining essential to safe placement. Digital planning, 3D printing, minimally invasive insertion, and artificial intelligence are set to transform ERI placement into an increasingly data-driven, personalized procedure.

REFERENCES

1. Papadopoulos MA, Tarawneh F, Karamouzos A. Skeletal anchorage in orthodontics: A review of current concepts. World J Orthod. 2012;13(1):123-30.
2. Lin JC, Roberts WE, Huang C. The application of extra-radicular miniscrews for orthodontic anchorage. J Clin Orthod. 2017;51(5):287-95.
3. Suzuki EY, Suzuki B, Ruellas ACO. Infrazygomatic crest and buccal shelf screws for maxillary and mandibular anchorage in Class III treatment. Semin Orthod. 2019;25(1):30-40.
4. Chang CH, Roberts WE. A new protocol for orthodontic mini-implant anchorage in the infrazygomatic crest. J Clin Orthod. 2016;50(5):285–94.
5. Antoszewska-Smith J, Sarul M, Lyczek 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):440–55.
6. Park HS, Lee SK, Kwon OW. Group distal movement of teeth using microscrew implant anchorage. Angle Orthod. 2005;75(4):602–9.
7. Sugawara J, Kanzaki R, Takahashi I, Nagasaka H, Nanda R. Distal movement of maxillary molars in nongrowing patients with the skeletal anchorage system. Am J Orthod Dentofacial Orthop. 2006;129(6):723–33.
8. Poggio PM, Incorvati C, Velo S, Carano A. "Safe zones": A guide for miniscrew positioning in the maxillary and mandibular arch. Angle Orthod. 2006;76(2):191–7.
9. Chang JZC, Liu SS, Roberts WE. Primary stability, placement torque and bone density with orthodontic mini-implants: Overview and clinical relevance. Int J Orthod Implantol. 2015;39:17–34.
10. Sherwood KH, Burch JG, Thompson WJ. Closing anterior open bites by intruding molars with titanium miniplate anchorage. Am J Orthod Dentofacial Orthop. 2002;122(6):593–600.
11. Liou EJW, Tsai WC. A new protocol for maxillary protraction in Class III patients: Alternating rapid maxillary expansion and constriction using mini-implants. J Clin Orthod. 2005;39(11):675–85.
12. Chang C, Roberts WE. A retrospective study of the mandibular buccal shelf implant site: Bone quality and quantity. Int J Orthod Implantol. 2012;27(4):13-25.
13. Melsen B, Verna C. Miniscrew implants: The ideal anchorage? Semin Orthod. 2007;13(1):75-83.
14. De Clerck H, Cornelis MA, Cevidanes LHS, Heymann G, Tulloch CJ. Orthopedic traction of the maxilla with miniplates: A new perspective for treatment of midface deficiency. J Oral Maxillofac Surg. 2009;67(10):2123-9.
15. Nanda R, Uribe F. Temporary Anchorage Devices in Orthodontics. 2nd ed. St. Louis: Elsevier; 2022.
16. Roberts WE, Nelson CL, Goodacre CJ. Rigid anchorage with corticotomy-enhanced anchorage devices: 3D biomechanics. Clin Orthod Res. 2005;8(3):205–10.

17. Cope JB, Graham JW. Miniscrew implants: The orthodontist's answer to skeletal anchorage. Ortho Tribune. 2007;2(5):12–7.
18. Deguchi T, Nasu M, Murakami K, Yabuuchi T, Kamioka H, Takano-Yamamoto T. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. Am J Orthod Dentofacial Orthop.2006;129(6):721.e7–721.e12.
19. Alikhani M, Raptis M, Zoldan B, Sangsuwon C, Lee YB, Alyami B, et al. Effectiveness of static surgical guides for miniscrew placement in orthodontics. Am J Orthod Dentofacial Orthop. 2018;153(4):504–12.
20. Montasser MA, El-Bialy T. 3D finite element analysis of forces and stresses produced by different designs of mini-screw implants. Prog Orthod. 2018;19(1):7.