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Biomechanics Of Mini Screw-Assisted Orthodontic Tooth Movement: A Review On Absolute Anchorage And Centre Of Resistance

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Abstract

Mini screw-assisted orthodontics has become a cornerstone of contemporary practice, offering enhanced control over anchorage and more predictable tooth movements. This review explores the biomechanics of Mini screw-assisted orthodontic treatment, with a focus on absolute anchorage and the role of the centre of resistance (CRes). We examine screw placement, force vector mechanics, finite element studies, and clinical considerations that influence treatment outcomes. Understanding these principles is essential for optimizing Mini screw usage and minimizing side effects such as undesired tipping, anchorage loss, or screw failure.

Keywords:

Mini-screw anchorage, orthodontic biomechanics, absolute anchorage, centre of resistance, tooth movement control, skeletal anchorage system.

Introduction

Anchorage control is a key factor in successful orthodontic treatment. Traditional anchorage systems often rely on reactive tooth units or extraoral devices, which can be limited by unwanted movement or patient non-compliance. The introduction of temporary anchorage devices (TADs), particularly Mini screws, has revolutionized this landscape by offering **absolute anchorage**—a biomechanical situation where the anchoring unit remains stable under orthodontic force without reciprocal movement. +

At the heart of biomechanical control is the **centre of resistance (CRes)**, a critical point in a tooth or segment that determines the nature of its movement. Force vectors that pass through or near the CRes produce bodily movement, while those that deviate produce moments resulting in tipping or rotation.

This article reviews the biomechanical basis, clinical applications, and evidence-based considerations involved in using Mini screws for optimal orthodontic outcomes.

Absolute Anchorage and Mini screws

Definition and Importance

Absolute anchorage refers to a situation in which no movement occurs in the anchoring unit during the application of orthodontic force. Mini screws achieve this by anchoring directly into alveolar bone, thereby bypassing the limitations of dental anchorage, including periodontal ligament flexibility and root resorption susceptibility.

Mini screws:

- Eliminate reliance on patient compliance.
- Enable complex movements such as en-masse retraction or molar intrusion.
- Provide versatile placement options (buccal, palatal, infra zygomatic crest, retromolar area).

Biomechanical Advantages

- They provide stationary anchorage points that can redirect force systems.
- Allow high force application without compromising adjacent teeth.
- Offer multiple sites of placement, enabling custom force vectors.

Centre of Resistance and Tooth Movement Mechanics

Concept of Centre of Resistance (CRes)

The **CRes** is the point in a tooth or group of teeth where a single force will cause pure translation. The location varies:

- For a single-rooted tooth, it's approximately 1/3 of the root length apical to the alveolar crest.
- For multi-rooted teeth or tooth groups, it depends on the overall root support and bone levels.

Influence of Force Vector on Movement

To achieve controlled tooth movement:

- The force vector must align with or pass near the CRes.
- Force vectors that pass below the CRes induce **tipping**.
- Force vectors above the CRes may induce **intrusion and rotation**.
- Use of lever arms and vertical hooks can help align force vectors closer to the CRes.

Finite element method (FEM) studies have demonstrated that precise placement of force relative to the CRes significantly influences the resulting tooth movement pattern (tipping vs translation vs intrusion).

Biomechanics of Mini Screw-Assisted Tooth Movement

Force Application and Control

- Mini screws provide an immobile point from which force can be applied.
- Connecting elements such as Niti coil springs or elastomeric chains allow directional force application.
- By adjusting Mini screw height and hook length, clinicians can manipulate the force vector to control movement.

Role of Centre of Rotation (CRot)

- The **centre of rotation (CRot)** is affected by the force-moment system applied to the tooth.
- FEM studies show consistent trajectories of CRot among patients when force systems are standardized.
- Combining force with a controlled couple allows manipulation of CRot for desired movement (e.g., controlled tipping vs root movement).

Factors Affecting Miniscrew Anchorage and Stability

Screw Design and Insertion

Factor	**Clinical Effect**
Length	Longer screws (8–10 mm) provide more mechanical retention and are preferred in low-density bone.
Diameter	Wider screws may enhance stability but increase risk of root proximity.
Thread shape	Influences insertion torque and primary stability.
Insertion angle	Perpendicular (90°) insertion offers better resistance to tipping and mobility than oblique angles.

Bone Quality and Cortical Thickness

- Higher cortical bone thickness and density correlate with greater Mini screw stability.
- Mandibular bone generally provides better stability than maxillary bone due to its higher density.

Loading Protocol

- **Immediate loading** is generally safe, especially when primary stability is achieved.
- Excessive force (>200 cN) may increase risk of screw loosening.
- Recommended forces range from **50–150 cN** depending on the tooth movement required.

Site Selection and Complications

- **Ideal sites**: between the second premolar and first molar, palate, infrazygomatic crest.
- Complications include screw fracture, soft tissue inflammation, and root proximity injuries.

Clinical Applications

En-masse Retraction

- Mini screws placed between second premolars and first molars support anterior segment retraction.
- Using anterior retraction hooks (ARH) to adjust the height of force vector reduces tipping.

Molar Intrusion

- Palatal or buccal Mini screws can deliver intrusive forces on over erupted molars.
- Prevents bite deepening and helps manage anterior open bite.

Midline and Asymmetry Correction

- Unilateral Mini screw placement enables asymmetric force application to correct midline discrepancies.

Crossbite and Transverse Discrepancies

- Palatal Mini screws can support trans palatal expansion or selective movement of posterior segments.

Future Directions and Research Gaps

- **Individualized biomechanics**: More accurate localization of patient-specific CRes via CBCT or AI-guided simulations.
- **Mini screw reuse**: Further research into mechanical degradation of reused screws.
- **Screw mobility monitoring**: Development of non-invasive tools to detect early screw failure.
- **Smart materials**: Investigating coatings or surface treatments that enhance osseointegration without compromising removability.

Conclusion

Mini screws have redefined orthodontic anchorage, allowing for high-precision tooth movements that were previously difficult or impossible. Their ability to deliver **absolute anchorage** depends on proper biomechanical planning—particularly the alignment of force vectors with the **centre of resistance**. Success requires careful attention to screw design, insertion angle, bone quality, and force direction. With appropriate application, Mini screws can facilitate efficient, predictable, and minimally invasive orthodontic care.

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