ANCHORAGE IN ORTHODONTICS: CONCEPTS, CLASSIFICATIONS, AND CLINICAL APPLICATIONS

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ABSTRACT

Anchorage in orthodontics refers to the resistance to unwanted tooth movement during orthodontic treatment. Effective anchorage control is crucial in achieving desirable treatment outcomes, particularly in cases requiring significant tooth movement. With advancements in orthodontic techniques and materials, various anchorage strategies, including traditional intraoral methods and modern skeletal anchorage systems, have evolved. This article provides an in-depth understanding of anchorage, its types, clinical considerations, and its role in enhancing orthodontic success.

Keywords: Orthodontics, anchorage, movement, headgear, TADs

INTRODUCTION

In orthodontics, anchorage is a delicate concept and difficult to maintain. To simplify the anchorage concept, it can be considered analogous to bending a larger tooth against another smaller tooth, or against two smaller teeth.

The role of anchorage in orthodontic treatment has been appreciated since the 18th century, as prominent orthodontists such as Gunnell, Desirabode, and Angle realized the limitations of moving teeth against other teeth used for anchorage, introducing ideas such as the use of occipital, stationary, and occlusal anchorage.

Every orthodontic appliance consists of two rudiments: an active component and a resistance component. The active corridor of the orthodontic appliance is concerned with tooth movements, while the resistance units provide resistance (anchorage) that makes tooth movements possible.

Initially, in 1923, Louis Ottofy defined anchorage as "the base against which orthodontic force or reaction of orthodontic force is applied." According to W.R. Proffit, it is "resistance to unwanted tooth movement." Resistance to reaction forces is generally handled by other teeth or, occasionally, by the palate, head, or neck (via extraoral force), or implants in bone.

T.M. Graber defined anchorage as the nature and degree of resistance to displacement offered by an anatomic structure for the purpose of effecting tooth movement. Nanda defined anchorage as "the amount of movement of posterior teeth (molars, premolars) to close extraction space in order to achieve selected treatment goals."

According to the 3rd law of Newton, for every action there is a reaction equal in amount and opposite in direction. This can be applied in orthodontics when retracting a canine against posterior teeth. The tooth movement that occurs in the reactive member is termed anchorage loss, which is undesirable in most instances.

To exemplify, mesial anchorage loss refers to unwanted mesial movement of molars during retraction/pull of anterior teeth using the buccal segment. Harvold has shown that a Class II molar correction can be obtained almost completely through vertical manipulation. If the upper molar is not allowed to erupt while the lower molar is encouraged to erupt, the molar relation correction can be aided immensely when the goal is to obtain maximum skeletal change. For instance, Tweed's method took lower incisor length into account but averaged close to 1 mm additional arch length for each degree of lingual tipping.

Definition of Anchorage

According to Proffit et al. (2019), anchorage is defined as "resistance to unwanted tooth movement." It refers to the method by which force is directed to achieve a desired movement without unwanted reciprocal effects.

Classification of Anchorage

Anchorage can be classified based on various parameters:

1. Based on Site

- **Intraoral Anchorage:** Anchorage derived from teeth within the mouth.
  - **Dental anchorage:** Using teeth alone (e.g., molars).
  - **Muscular anchorage:** Using muscles of mastication.
  - **Periodontal anchorage:** Using the periodontal ligament and alveolar bone.
- **Extraoral Anchorage:** Utilizes headgear or other

external appliances.

- **Skeletal Anchorage:** Involves anchorage from bone using temporary anchorage devices (TADs), mini-implants, or plates.

2. Based on Number of Units

- **Simple anchorage:** One tooth or a small group of teeth.
- **Compound anchorage:** A larger group of teeth.
- **Reinforced anchorage:** Additional teeth or structures used to increase anchorage.

3. Based on Reaction

- **Stationary anchorage:** Movement involves bodily movement of teeth.
- **Reciprocal anchorage:** Equal and opposite forces move two units toward or away from each other.
- **Absolute anchorage:** No movement of the anchorage unit (commonly achieved with TADs).

4. Based on Type (Min-Max)

- **Maximum Anchorage (Type A):** Anterior moves more, posterior minimal movement ≥ 2:1 (Bimaxillary protrusion, TADs, headgear).
- **Moderate Anchorage (Type B):** Equal anterior and posterior movement 1:1 (Mild crowding, normal appliance).
- **Minimum Anchorage (Type C):** Posterior moves more, anterior minimal movement ≤ 1:2 (Class III camouflage, stops, bite plane).

Anchorage Value

Anchorage value refers to the resistance offered by a tooth or a group of teeth to displacement when orthodontic forces are applied. It determines how effectively a tooth or unit can serve as a stable anchor during tooth movement.

The concept was introduced by Louis Ottofy in orthodontic literature to classify teeth based on their anchorage potential.

Basis of Anchorage Value

Anchorage value is influenced by several factors:

1. **Root Surface Area (RSA):** Larger root surface area → greater resistance to movement. Molars have higher anchorage value compared to premolars and incisors.
2. **Root Morphology:** Multi-rooted teeth (molars) have greater anchorage than single-rooted teeth.
3. **Periodontal Health:** Healthy periodontal ligament and alveolar bone increase anchorage value.
4. **Bone Density:** Denser bone provides greater anchorage resistance.
5. **Number of Teeth in Anchorage Unit:** The more teeth included in an anchorage unit, the greater the combined anchorage value.

Anchorage Value of Different Teeth (from highest to lowest):

- Maxillary first molar
- Maxillary second molar
- Mandibular molars
- Premolars
- Canines
- Incisors (lowest anchorage value)

Relative Anchorage Value – Ottofy's Classification

Ottofy classified anchorage values of teeth by assigning numerical values based on root surface area:

Tooth TypeAnchorage Value*Maxillary 1st Molar100 Maxillary 2nd Molar100Mandibular Molars~ 90–95 Maxillary 1st Premolar~70Mandibular 1st Premolar~ 65Canines~60Maxillary Incisors~50Mandibular Incisors~45*Values are approximate and used for relative comparison.

Anchorage Reinforcement Based on Value

When anchorage value is insufficient, reinforcement can be achieved using:

1. Additional teeth in the anchorage unit
2. Extraoral devices (headgear)
3. Intraoral appliances (Nance appliance, transpalatal arch)
4. Skeletal anchorage (TADs, mini-plates)

Anchorage value is a fundamental concept in orthodontics that influences every stage of treatment planning and biomechanics. Understanding the relative resistance of different teeth ensures efficient force application, minimizes anchorage loss, and improves treatment outcomes.

Anchorage in Different Malocclusions

- **Class I:** Moderate anchorage demands for space closure.
- **Class II:** Requires maximum anchorage to retract anterior teeth.
- **Class III:** Often requires distalization and strong anchorage in posterior segments.

Methods to Augment Anchorage

1. Intraoral Appliances (Fig. 1)

- Banding or bonding more teeth
- Using transpalatal arch (TPA)
- Nance holding arch
- Lingual arch

Fig. 1: Intraoral Appliances

2. Extraoral Appliances (Fig. 2)

- Cervical pull headgear: Applies distal and downward force
- High-pull headgear: Applies upward and distal force
- High-Pull Headgear
- High-pull headgear applies distal and upward force for vertical control.
- Combination Pull
- Combines both effects of cervical and high-pull forces.

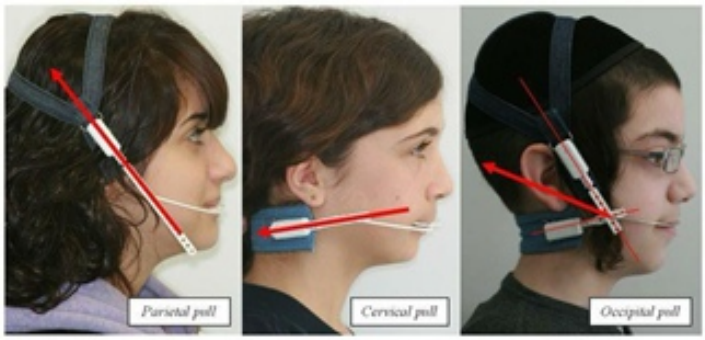


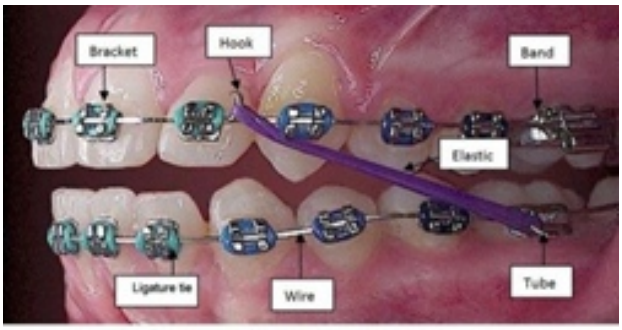
Fig. 2: Extraoral Appliances

3. Skeletal Anchorage

- Mini-implants (TADs)
- Titanium screws placed in alveolar bone.
- Mini-plates
- More invasive but provide absolute anchorage.
- Zygomatic Anchorage
- Used for orthopedic and severe anchorage demands.
- Temporary Anchorage Devices (TADs)
- Temporary Anchorage Devices (TADs) are small, screw-like biocompatible devices placed temporarily into bone to provide absolute anchorage for orthodontic tooth movement.
- They have revolutionized orthodontics by eliminating dependence on patient compliance and minimizing unwanted reciprocal tooth movements.
- Composition and Structure
- Material: Titanium or titanium alloy (biocompatible, corrosion-resistant).
- The metal should be non-destructive and biodegradable, with exceptional physical and mechanical properties, including tolerance to tension, deformation, and rusting.
- Materials used can be classified as:
- Bio-resistant materials — stainless steel, chrome-cobalt alloy.
- Bio-inert materials — titanium, carbon.
- Biologically active materials — hydroxyapatite, oxidizedaluminum with ceramics.
- Due to its properties (no allergic or immunological reactions and no tumor growth), titanium is considered an excellent material and is most commonly used.
- Implant Dimensions
- Implant accessories should accomplish primary stability and withstand mechanical loads. The bone–implant interface determines most of the load.
- Different sizes of implants are available to extend anchorage — from "small implants" (6 mm length, 0.6 mm radius) to "traditional implants" used in dentistry (6–15 mm length, 1.5–2.5 mm radius).
- Types of Skeletal Anchorage
- Mini-screws (most common)
- Mini-implants
- Mini-plates
- Size: Varies in diameter (1.2–2.3 mm) and length (6–12 mm), depending on placement site.
- Mechanism of Action
- TADs are inserted into alveolar or extra-alveolar bone, serving as fixed points of anchorage.
- Orthodontic forces are applied directly from the TAD to the tooth or appliance, bypassing the need to rely on other teeth for anchorage.
- Forces can be applied immediately or after short healing, depending on primary stability.
- Indications
- Maximum Anchorage Requirements
- Retraction of anterior teeth after premolar extraction without mesial movement of molars.
- Molar Intrusion or Distalization
- Deep bite correction and open bite management.
- Vertical Control

- Intrusion of posterior teeth to close anterior open bites.
- Asymmetric Tooth Movement

- Midline correction or unilateral space closure.
- Space Management
- Protraction of posterior teeth to close edentulous spaces.
- Traction of Impacted Teeth
- Especially maxillary canines and premolars.
- Advantages
- Provides absolute anchorage without relying on other teeth.
- No patient compliance required (unlike headgear).
- Can be placed in various intraoral sites (buccal, palatal, interradicular, infrazygomatic crest, mandibular buccal shelf).
- Minimally invasive and relatively easy to insert/remove.
- Allows versatile mechanics and reduces treatment time.
- Limitations and Risks
- Failure risk due to mobility or loss of stability.
- Soft tissue irritation or inflammation (peri-implantitis).
- Proximity to roots if placed incorrectly.
- Limited placement sites in patients with poor bone quality.
- Clinical Protocol
- Diagnosis & Planning
- CBCT or periapical radiographs to assess bone quantity and root proximity.



- Sterilization&Anesthesia
- Local anesthesia and aseptic technique.
- Placement
- Self-drilling or pre-drilling technique depending on bone density.
- Force Application
- Immediate or delayed loading depending on primary stability.
- Removal
- Done after required tooth movement is complete; site heals spontaneously.
- Examples of Use
- En-masse anterior retraction with TADs between second premolars and first molars.
- Posterior intrusion with TADs placed in the palate for open bite closure.
- Molar distalization using infrazygomatic crest TADs.
- TADs have transformed orthodontic biomechanics by offering a reliable, non–compliance-dependent source of anchorage.
- Their versatility in managing complex tooth movements makes them an indispensable tool in modern orthodontics.
- Clinical Applications of Anchorage in Orthodontics
- Anchorage plays a critical role in ensuring controlled tooth movement while minimizing undesired reciprocal movements.
- Its applications extend to various orthodontic procedures and treatment goals:
- 1. Space Closure
- Premolar Extraction Cases: Anchorage is vital in retracting anterior teeth into extraction spaces without unwanted mesial movement of posterior teeth.
- Maximum Anchorage Situations: Skeletal anchorage devices such as TADs, palatal implants, or mini-plates are used to preserve molar position during retraction.
- 2. Molar Distalization
- Used to correct Class II molar relationships or relieve anterior crowding without extractions.
- Extraoral anchorage (headgear) or intraoraldistalizing appliances (Pendulum, Distal Jet) utilize anchorage to move molars distally without shifting anterior teeth forward.
- 3. Intrusion of Teeth

- In deep bite correction, posterior anchorage prevents extrusion of molars while anterior teeth are intruded.
- Skeletal anchorage ensures efficient force application without unwanted reciprocal effects.

4. Protraction of Posterior Teeth

- Required in cases of anterior open bite closure, space gaining, or closing posterior edentulous spaces.
- Anchorage helps avoid mesial drift of other teeth during space management.

5. Correction of Midline Discrepancies

- Anchorage assists in asymmetric mechanics, preventing unwanted movements on the unaffected side while shifting the midline to correct occlusion.

6. Orthopedic Corrections

- In growing patients, anchorage is used in conjunction with functional appliances (e.g., Class II or III correctors) to control skeletal and dental changes.

- Skeletal anchorage minimizes unwanted vertical or transverse changes during orthopedic expansion or protraction.

7. Open Bite & Deep Bite Management

- For open bite, posterior intrusion using skeletal anchorage helps rotate the mandible upward and forward.
- For deep bite, anterior intrusion is achieved with minimal molar extrusion, reducing the risk of increasing vertical dimension.

8. Impacted Tooth Traction

- Anchorage is required to apply traction forces to impacted canines or premolars without causing adverse movements of other teeth.

9. Segmental Mechanics in Orthodontics

- In segmented arch techniques, anchorage is necessary to isolate forces for intrusion, extrusion, or retraction of a particular segment without disturbing the rest of the dentition.
- Recent Advances in Anchorage
- 3D planning of TAD placement using CBCT imaging.
- CAD/CAM customized anchorage systems.
- Robotically assisted wire bending and precise biomechanics.
- Bioadaptive materials for sustained force delivery.

Conclusion

- Anchorage is a foundational concept in orthodontic treatment planning and execution.
- With innovations like skeletal anchorage and TADs, clinicians can now achieve more predictable, efficient, and patient-friendly outcomes.
- A thorough understanding of anchorage principles, proper diagnosis, and judicious selection of anchorage methods are essential to ensure successful orthodontic treatment.

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