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Review Article

Basic principles of anchorage: a review

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ABSTRACT

During orthodontic treatment, teeth are subjected to various forces and moments, which generate reciprocal forces of equal magnitude but opposite direction. To prevent unwanted tooth movements and ensure successful treatment outcomes, it is essential to effectively manage these reciprocal forces. Numerous studies have explored different anchorage systems in terms of their application, function, and effectiveness. However, practitioners often find it challenging to interpret these findings due to the diversity in study designs, sample sizes, and methodologies. A solid understanding of anchorage principles is crucial for applying them effectively. Anchorage control is a critical factor in designing orthodontic appliances. While extraoral devices can provide stable anchorage, their effectiveness heavily relies on patient cooperation. In contrast, intraoral anchorage tends to be less stable, often necessitating complex appliances and sometimes the extraction of teeth. Nonetheless, intraoral systems have the advantage of requiring less patient compliance. To achieve treatment objectives, it is vital to establish a biomechanical setup that delivers the appropriate type and magnitude of force. This foundational understanding of anchorage principles will enhance the effectiveness of orthodontic treatments.

Keywords: Orthodontic treatment, Anchorage, Reciprocal forces

INTRODUCTION

Orthodontic anchorage, defined as the ability to counteract unwanted reactive tooth movements from various sources, including adjacent teeth, the palate, the head or neck, or dental implants embedded in the bone.[1,2] In orthodontic treatment, anchorage loss can occur as a side effect of mechanotherapy and is a significant contributor to treatment failures. This issue is often attributed to various factors, including the site of extraction, the type of appliance used, patient age, dental crowding, and the amount of overjet present.[3-5] Over the years, clinicians have sought biomechanical solutions to enhance anchorage control. Pioneers like Tweed, Begg, Holdaway, and Merrifield created various anchorage systems aimed at improving treatment effectiveness.[6-8] Ideally, intraoral anchorage should remain stable and utilize a source that lacks periodontal membrane, as this membrane typically responds to tension and pressure, facilitating movement within the bone.[9-11]

CLASSIFICATION

Moyers according to the manner of force application: Simple anchorage: resistance to tipping, stationary anchorage and resistance to bodily movement.[4]

Reciprocal anchorage

Two or more teeth moving in opposite directions and pitted against each other by the appliance.

According to the jaws involved: Intra-maxillary: Anchorage established in the same jaw. Inter-maxillary: Anchorage distributed to both jaws (Baker's anchorage 1904). According to the site of anchorage: Intra oral: Anchorage established within the mouth. Extra oral: Anchorage obtained outside the oral cavity. a) Cervical: Neck straps, b) Occipital: head gears; c) Cranial: High pull headgears and d) Facial: Face masks. Muscular: Anchorage derived from action of muscles e.g. vestibular shields.

According to the number of anchorage units: Single or primary anchorage: Anchorage involving only one tooth. Compound anchorage: Anchorage involving two or more teeth. Reinforced anchorage: Addition of non-dental anchorage sites. e.g. Mucosa, muscle, head, etc.

According to Nanda: A anchorage: critical / severe (75% or more of the extraction space is needed for anterior retraction). B anchorage: moderate [Relatively symmetric space closure (50%)]. C anchorage: mild / non critical (75% or more of space closure by mesial movement of posterior teeth).[3]

According to Burstone: Group A arches, group B arches and group C arches.[11]

Natural anchorage

Natural anchorage is derived from the resistance provided by the dental arch, based on the application of forces between individual teeth or groups of teeth.

Simple anchorage: It refers to the way forces are applied, which can lead to the displacement or alteration of the axial inclination of the teeth that serve as the anchorage unit in the direction of the force. Essentially, the resistance of the anchorage unit to tipping is used to facilitate the movement of other teeth.

Reciprocal anchorage: This involves opposing two teeth or groups of teeth with equal anchorage value to create reciprocal tooth movement. For example, when closing a diastema, the two central incisors can be used against each other in this manner.

Stationary anchorage: Dental anchorage that involves the application of force resulting in the bodily displacement of the anchorage unit within the plane of the force is known as stationary anchorage.[12] This concept refers to the benefit gained by using the bodily movement of one group of teeth to counteract the tipping of another group.

Reinforced anchorage

This involves strengthening the anchorage or resistance area by increasing the number of resistance units or employing additional aids. A straightforward method for reinforcing anchorage is to place bands on the second molars. Other methods include using a transpalatal arch (T.P.A.), a Nance holding arch, or a lower lingual arch. Additionally, tissue anchorage, such as that provided by a lip bumper, can effectively distalize molars.[13]

Prepared anchorage

Prepared anchorage involves positioning the teeth at a distoaxial inclination, significantly enhancing their resistance to displacement. This technique is particularly effective for controlling anchorage when it is crucial for treatment success.[14]

Active root thrust

This concept, introduced by Dr. Calvin Case in 1908, involves enhancing bodily resistance in the anchorage area by using extensions that are affixed to the bands of the molar teeth.

Cortical anchorage

Cortical bone is more resistant to resorption compared to medullary bone, and the concept of cortical anchorage leverages this property. Ricketts suggested that torquing the roots of buccal teeth outward against the cortical plate can help prevent their mesial movement.[10] Torquing movements are restricted by the facial and lingual cortical plates. If a root is consistently pressed against the cortical plate, tooth movement is significantly hindered, leading to a higher risk of root resorption and, in some cases, potential penetration of the cortical bone.

Graber has classified anchorage as: Intra- maxillary anchorage and inter-maxillary anchorage.[1,12]

Intramaxillary anchorage refers to a situation where all resistance units are located within the same jaw. Appliances placed solely in either the maxillary or mandibular arch are classified as intramaxillary resistance units.

Intermaxillary anchorage involves using resistance units in one jaw to facilitate tooth movement in the opposite jaw. To effectively utilize the space created by extractions, a more logical classification of anchorage can be beneficial. In the mandibular arch, anchorage can be categorized into three classes: minimum, moderate, and maximum.[14-16]

Minimum anchorage mechanics rely on reciprocal forces between the posterior and anterior teeth without attempting to maintain a moment on the anchorage area. This approach is chosen when the mandibular posterior teeth are allowed to move mesially into half or more of the extraction site.

Moderate anchorage involves applying an active root thrust or moment on the anchorage teeth, resulting in bodily resistance in that area. This method is used when the mandibular posterior teeth are allowed to advance into one fourth to one half of the extraction site.

Maximum anchorage mechanics focus on strengthening the anchor teeth by utilizing all available resources and minimizing the workload on the anchorage area by generating forces outside the mandibular arch as much as possible. This approach is used when the mandibular posterior teeth are permitted to advance into no more than one fourth of the extraction site.

It's important to recognize that, regardless of the case classification, anchorage needs will be influenced by the total workload and available space, and the mechanics used in each case will be similar.

BIOLOGICAL ASPECTS OF ANCHORAGE

Factors affecting anchorage

Number of roots: a greater number of roots, anchorage is more, shape, size and length of each root: conical roots offer more anchorage than cylindrical. Multi rooted >single rooted; Longer rooted >shorter rooted; triangular shaped root >conical or ovoid root; larger surface area >smaller surface area. Cortical anchorage: cortical bone vs medullary bone. Muscular forces: horizontal growers vs. vertical growers. Relation of contiguous teeth. Forces of occlusion. Age of the patient and individual tissue response.[17-20]

ANCHORAGE LOSS

Anchor loss can occur in all 3 planes of space.[1,2,21-23]

Sagittal plan: Mesial movement of molars and proclination of anteriors.

Vertical plane: Extrusion of molars and bite deepening due to anterior extrusion.

Transverse plane: Buccal flaring due to over expanded arch form and unintentional lingual root torque and lingual dumping of molars.

PRINCIPLES OF ANCHORAGE CONSERVATION

Class I, class II, and class III cases may have minimum, moderate, or maximum anchorage requirements, as well as variations in class II cases with different mandibular plane angles, such as low and high. Minimum anchorage needs are seldom observed in class II skeletal issues, while maximum anchorage requirements are infrequently seen in class II cases with a low mandibular plane angle.[2,3]

MINIMUM ANCHORAGE

In class I minimum anchorage scenarios, the primary tasks typically involve aligning and distally tipping the canines and anterior teeth. Anchorage is often obtained from the mandibular buccal teeth, with forces applied reciprocally within the arch to the mandibular canines and anterior teeth. A force system can be chosen to limit the forces to these teeth, either individually or as a group.

In class II cases, the demand on the mandibular anchorage increases as the work load is increased in the form of: Retraction of maxillary canines and incisors, correction of class II molar relation, workload is further increased if it is skeletal class II, retraction of mandibular anterior teeth, a minimum or moderate anchorage class II case remains so if: Retraction in maxillary arch can be carried out by inter-arch mechanics, retraction of mandibular anteriors is minimal and it also depends on the class II correction and if it is dental or dental and skeletal.

If cervical or occipital forces are not applicable, the classification shifts from minimum to moderate, as the mandibular arch must handle more load. In this scenario, it's acceptable for the mandibular molars to shift forward into the available space. However, applying bodily thrust is essential to enhance resistance and prevent the mandibular molars from advancing too quickly, which could compromise their anchorage potential. The additional force from class II elastics can accelerate the mesial tipping of the mandibular molars, while the bodily thrust works to counteract this tipping and reduce the rate of their movement.[3]

MODERATE ANCHORAGE

In a moderate anchorage scenario, mandibular molars can be allowed to shift into one-fourth to one-half of the extraction site. However, it is crucial to maintain bodily resistance consistently to prevent forward tipping of the mandibular molars and bicuspids. This resistance not only slows the movement of the buccal segments but also provides the necessary support for the forces needed to move canines and anterior teeth distally into half or more of the extraction site. By carefully balancing the forces in both the anchorage and working areas, these goals can be effectively achieved.

In a class I moderate anchorage situation, bodily resistance in the anchorage area is employed to counterbalance the forces in the working area. Space closure in the maxillary arch is accomplished through mechanics within the arch itself. If the anchorage space is depleted, mandibular anchorage will be unavailable for retracting the anterior teeth. In such instances, class III elastics combined with extraoral anchorage in the maxillary arch can facilitate the movement of the mandibular anterior teeth. Additionally, extraoral anchorage helps resist forces applied to the maxillary anterior teeth.

In class II cases, the mechanics used are consistent whether the classification is purely dental or involves a combination of dental and skeletal factors. The additional workload for retracting the maxillary anteriors and canines in class II dental cases, and an even greater workload in class II dental and skeletal cases, necessitates torque control for the bodily displacement of the maxillary anteriors. This level of control is typically not achievable from moderate anchorage in the mandible, particularly if there are specific anchorage needs in that area. If class II correction is introduced into a moderate anchorage situation in the mandibular arch, it will remain moderate only if the required adjustments in the maxillary arch do not depend on the mandibular arch for anchorage.

Relationship of tooth movement to force

To achieve effective tooth movement, it's essential to concentrate the applied force at the desired site while dissipating the reaction force across multiple adjacent teeth. This approach minimizes the pressure in the periodontal ligament (PDL) of the anchorage teeth. An ideal scenario occurs when the pressure remains below a certain threshold, ensuring that no reaction is generated and allowing for optimal anchorage control. This means it's only necessary to ensure that the force applied does not exceed the threshold for initiating movement in the teeth within the anchorage unit.[1]

Amount of tooth movement and magnitude of pressure, up to a point

Once the optimal threshold is reached, the amount of tooth movement becomes independent of the pressure magnitude. The ideal orthodontic force is the lightest one that elicits a near-maximum response. While forces greater than this optimal level can still be effective, they can cause unnecessary trauma and stress to the anchorage.[24,25]

Anchorage value

The anchorage value of a tooth is generally proportional to its root surface area. In each arch, the surface area of the molars and second premolars is roughly comparable to that of the incisors and canines.[2]

ANALYSIS AND TREATMENT PLAN CHART

Analysis and treatment plan chart were treatment time for each step, length of time class II and class III elastics were worn, type of head gear & length of time worn, length of time palatal bars were worn and high/ low mandibular plane angle.

PURPOSE OF FILLING ANALYSIS CHART

The purpose to visualize how to treat the malocclusion and establishes a definite goal and reveals which teeth to extract.

CONCLUSION

Anchorage plays a crucial role in orthodontics, especially when forces are applied solely to the teeth, for several reasons: It reflects the resistance needed to prevent unwanted tooth movement while allowing desired movement to occur. It provides insight into the resistance that specific teeth will offer, indicating the type of movement that can be anticipated. It influences the selection of the appliance required to achieve the desired tooth movement.

All orthodontic forces are reciprocal in nature. For true reciprocity to occur, teeth with equal resistance must be engaged against one another, with the expectation that all teeth experiencing the force will move an equal distance toward the desired position.

There are three main methods to enhance the resistance of teeth: The connector between the tooth and the force-generating mechanism can be designed to be stationary, ensuring that any movement of the tooth occurs in a bodily manner rather than through tipping. The arch wire can be shaped to facilitate bodily movement of the tooth instead of tipping. Incorporating more teeth in the section of the dental arch where movement is not intended, compared to the area where movement is desired, can also increase resistance.

Anchorage control is a critical factor in the design of all orthodontic appliances. While extraoral devices can provide stable anchorage, their effectiveness often relies on patient cooperation. In contrast, intraorally derived anchorage tends to be less stable, which can lead to the need for more complex and sometimes inefficient appliances, often resulting in the extraction of teeth. However, a key advantage of these intraoral appliances is that they require less extensive cooperation from the patient.

If there were reliable intraoral anchor points that remained stable throughout treatment and were comfortable, biocompatible, and minimally intrusive, it would significantly simplify and enhance appliance design. Effectively conserving anchorage in the right areas and at the appropriate times is one of the most challenging yet crucial tasks in orthodontics. Establishing the correct biomechanical setup to deliver the appropriate type and magnitude of force is essential to meet treatment goals.

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