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Review Article

Understanding Anchorage in Orthodontics -A Review Article

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1. Abstract

Before starting active treatment of any orthodontic case, anchorage must be planned well to get rid of the problems that might accompanied the treatment procedures. This article reviewed the anchorage from all aspects starting from the definition, sources, types, planning, anchorage loss and how to avoid it.

2. Definition

According to the third law of Newton, for every action there is a reaction equals in amount and opposite in direction. This can be applied in orthodontics simply when retracting canine against posterior teeth. The expected thing is distalization of the canine in the first premolar extraction site against mesial (forward) movement of the posterior teeth which called anchorage unit.

According to Graber[1], the term anchorage is referred as "the nature and degree of resistance to displacement offered by an anatomic unit when used for the purpose of affecting tooth movement", while Gardiner et al.[2]defined it as "the site of delivery from which a force is exerted". On the other hand, Lewis [3] defined anchorage simply as "the resistance to unwanted tooth movement".

3. Sources of Orthodontic Anchorage

Basically, the sources of orthodontic anchorage can be summarized as[4-7]:

A. Intra-oral sources

1. Teeth

2. Alveolar bone

3. Cortical bone

4. Basal jaw bone

5. Musculature

B. Extra-oral sources

1. Cranium

- Occipital bone
- Parietal bone

2. Facial bones

- Frontal bone
- Mandibular symphysis

3. Back of the neck (cervical bone)

A. Intra-oral sources of anchorage

1. Teeth: In orthodontics, teeth themselves are the most frequently used anchorage unit to resist unwanted movement. Forces can be exerted from one set of teeth to move certain other teeth. Many factors related to the teeth can influence the anchorage like: the root form, the size (length) of the roots, the number of the roots, the anatomic position of the teeth, presence of ankylosed tooth, the axial inclination of the teeth, root formation, contact points of teeth and their intercuspation.

1.1.Root form

Generally, the root in cross section can be either round, flat (mesio-distally) or triangular. The distribution of the periodontal fibers on the root surface aid in anchorage.The more the fibers, the better the anchorage potential. The direction of attachment of the fibers also affects the anchorage offered by a tooth. Round roots have only half their periodontal fibers stressed in any given direction, hence offer the least anchorage. Mesio-distally flat roots are able to resist mesiodistal movement better as compared to labio-lingual movement as more number of fibers are activated on the flatter surfaces as compared to the relatively narrower

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labial or lingual surfaces.

Triangular roots, like those of the canines are able to provide greater anchorage. Their flatness adds to resistance.

The tripod arrangement of roots like that seen on maxillary molars also aids in increasing the anchorage. The round palatal root resists extrusion and the two flat buccal roots resist intrusion and the mesio-distal stresses.

1.2. Size (length) of the roots

The larger or longer the roots, the more is their anchorage would be. The maxillary canines, because of their long roots can be the most difficult teeth to move in certain clinical circumstances.

1.3. Number of roots

The greater the surface area of the root, the greater the periodontal support and hence, greater the anchorage potential. Multi-rooted teeth provide greater anchorage as compared to single rooted teeth with similar root length.

1.4. Anatomic position of the teeth

Sometimes the position of the teeth in the individual arches also helps in increasing their anchorage potential. As in the case of mandibular second molars, which are placed between two ridges-the mylohyoid and the external oblique, they provide an increased resistance to mesial movement.

1.5. Presence of ankylosed teeth

Orthodontic movement of such teeth is not possible and they can therefore serve as excellent anchors whenever possible.

1.6. Axial inclination of the tooth

When the tooth is inclined in the opposite direction to that of the force applied, it provides greater resistance or anchorage.

1.7. Root formation

Teeth with incomplete root formation are easier to move and are able to provide lesser anchorage.

1.8. Contact points

Teeth with tight intact and/ or broad contacts provide greater anchorage.

1.9. Intercuspation

Good intercuspation leads to greater anchorage potential. This is mainly because the teeth in one jaw are prevented from moving because of the contact with those of the opposing jaw, this is especially true for teeth in the posterior segment which also show the presence of attrition facets.

2. Alveolar bone

The investing alveolar bone around the roots offer resistance to tooth movement up to a certain amount of force, exceeding which there will be bone remodeling. Less dense alveolar bone offers less anchorage. More mature bone increases anchorage. This takes place because of two factors—one, the bone becomes more calcified and dissolution takes time and two, the regenerative capacity of the bone decreases. Forces that are dissipated over a larger bone surface area offer increased anchorage.

3. Cortical bone

Ricketts floated the idea of using cortical bone for anchorage. The contention being that the cortical bone is denser with decreased blood supplies and bone turnover. Hence, if certain teeth were torqued to come in contact with the cortical bone, they would have a greater anchorage potential. The idea as such remains controversial as tooth roots also show resorption in such conditions and the risk of non-vitality of such teeth is also more.

4. Basal jaw bone

Certain areas of basal jaw bone such as hard palate and lingual surface of anterior mandible can be utilized in order to enhance the intra-oral anchorage. Nance palatal button uses the anchorage provided by the hard palate to resist the mesial movement of maxillary molars.

5. Musculature

Under normal circumstances, the peri-oral musculature plays an important part in the growth and development of the dental arches. Hypotonicity of the peri-oral musculature might lead to spacing and flaring of the anterior teeth. The hypertonicity of the same muscles has the reverse effect. Lip bumper is an appliance that makes use of the tonicity of the lip musculature and enhances the anchorage potential of the mandibular molars preventing their mesial movement.

B. Extra-oral sources of anchorage

1. Cranium

Headgears derived anchorage from occipital or parietal regions of the cranium. These are used along with a face bow to resist the growth of maxilla or to move the maxillary teeth distally.

2. Facial bones

The frontal bone (forehead region) and mandibular symphysis (chin area) are used as resistance units during face mask therapy so as to protract the maxilla.

3. Back of the neck (cervical bone)

The cervical headgears derived anchorage from back of the neck or cervical region. They are also used to bring about changes in the maxilla or maxillary teeth.

4. Classification of Anchorage

Generally, anchorage could be classified[8]:

I. According to the manner of force application:

1. Simple anchorage
2. Stationary anchorage
3. Reciprocal anchorage

II. According to jaws involved:

1. Intra-maxillary anchorage
2. Inter-maxillary anchorage

III. According to the site of anchorage:

1. Intra-oral anchorage
2. Extra-oral anchorage:
   - Cervical
   - Occipital
   - Cranial
   - Facial
3. Muscular anchorage

IV. According to the number of anchorage units:

1. Single or primary anchorage
2. Compound anchorage
3. Multiple or reinforced anchorage.

V. According to anchorage demands[5,9-10]:

1. Maximum anchorage (Type A anchorage).
2. Moderate anchorage (Type B anchorage).
3. Minimum anchorage (Type C anchorage).
4. Absolute anchorage (direct and indirect anchorage).

Gardiner et al. [2] classified anchorage into six categories as followed:

1. Simple
2. Stationary
3. Reciprocal
4. Reinforced
5. Intermaxillary
6. Extra-oral.

5. According to the Manner of Force Application

5.1. Simple Anchorage

In this type, the manner and application of force is such that it tends to change the axial inclination of the anchor tooth or teeth in the plane of space in which the force is being applied. In other words, the resistance of the anchorage unit to tipping is utilized to move another tooth or teeth. In this type of anchorage, the appliance usually engages a greater number of teeth than are to be moved within the same dental arch. Ideally, the combined root surface area of the anchor teeth should be two times that of the teeth to be moved. The amount of force on each anchor tooth in simple anchorage is equal to the total moving force component of the appliance divided by the number of anchored teeth.

5.2. Stationary Anchorage

It is defined as dental anchorage in which the manner of application of force tends to displace the anchorage unit bodily in the plane of space in which this force is being applied. In this type of anchorage, the resistance of anchor teeth to bodily movement is utilized to move other teeth. Stationary anchorage provides greater resistance than simple anchorage to unwanted tooth movement.

5.3. Reciprocal Anchorage

The reciprocal anchorage refers to the resistance offered by two malposed units, when the dissipation of equal and opposite forces tends to move each unit towards a more normal occlusion. In some treatment procedures, it is desirable to move teeth or groups of teeth of equal anchorage potential in opposite directions. In such cases, it is possible to utilize their anchorage forces as moving forces to achieve the desirable changes. A frequently used form of reciprocal anchorage is known as intermaxillary traction in which, the forces used to move the whole or part of one dental arch in one direction are anchored by equal forces by moving the opposite arch in opposite direction, thus, correcting discrepancies in both the dental arches, also seen in cases of correction of midline diastema, bilateral symmetrical expansion and correction of single tooth crossbite.

6. According to Jaws Involved

6.1. Intra-maxillary Anchorage

Intra-maxillary anchorage is the anchorage in which the resistance units are situated within the same jaw. If appliances are placed only in maxillary or mandibular dental arches, they are considered intra-maxillary resistance units. Class I elastic stretched from first molar to canine teeth in either of the dental arches is an example.

6.2. Inter-maxillary Anchorage (Baker's anchorage)

Inter-maxillary anchorage is the anchorage in which the units situated in one jaw are used to affect tooth movement in the other jaw. Class II elastic stretched from upper canine to lower molar to affect correction of class II malocclusion and Class III elastic stretched from upper molar to lower canine to correct class III malocclusion are good examples.

7. According to the Site of Anchorage

7.1. Intra-oral Anchorage

When intra-oral structures such as teeth and other anatomic areas are used as anchor units it is called intra-oral anchorage. Mini-screws can be considered as an absolute intra-oral anchorage.

7.2. Extra-oral Anchorage

Extra-oral anchorage is the anchorage established from extra-oral structures. It included:

1. Cervical region: Use of cervical pull headgear.

2. Occipital region: Use of occipital pull headgear.

3. Forehead and chin: Use of reverse pull headgear.

7.3. Muscular Anchorage

Peri-oral musculature may be used as anchorage units in certain cases. For example, the lip bumper utilizes the force exerted by lower lip musculature to bring about distalization of mandibular first molar.

8. According to the Number of Anchorage Units

8.1. Single or Primary Anchorage

Single or primary anchorage is defined as the resistance provided by a single tooth with greater alveolar support to move another tooth with lesser alveolar support, e.g. retraction of a premolar using a molar tooth.

8.2. Compound Anchorage

It is the type of anchorage where more than one tooth with greater anchorage potential are used to move a tooth/group of teeth with lesser support.

8.3. Reinforced Anchorage/Multiple Anchorage

It frequently happens that the teeth available for simple anchorage are not sufficient in number or in size to resist the forces necessary for orthodontic treatment and that reciprocal anchorage is not appropriate to the type of treatment to be carried out. In such circumstance, it is necessary to reinforce the anchorage to avoid unwanted movements of the anchor teeth. Anchorage is said to be reinforced when more than one type of resistance units are utilized.

9. According to Anchorage Demands

9.1. Maximum anchorage (Type A anchorage)

A situation in which the treatment objectives require that very little anchorage can be lost.

9.2. Moderate anchorage (Type B anchorage)

A situation in which anchorage is not critical and space closure should be performed by reciprocal movement of both the active and the anchorage segment.

9.3. Minimum anchorage (Type C anchorage)

A situation in which, for an optimal result, a considerable movement of the anchorage segment (anchorage loss) is desirable, during closure of space.

9.4. Absolute anchorage

In this type of anchorage, mesial migration of the anchor unit is avoided conserving 100% of the extraction site space. In the last years, titanium temporary skeletal anchorage devices (TSAD) like mini-implants have been used in orthodontic treatment in order to provide absolute anchorage without patient compliance. These mini-screws are small enough to be placed in different areas of the alveolar bone. This type of anchorage can be divided into direct anchorage when the TSAD is used directly to move a tooth and indirect anchorage when a tooth or group of teeth are connected to TSAD that acts as periodontal-skeletal anchorage unit allowing for anchor tooth or group of teeth to be moved against this stabilized unit[10].

10. Planning of Anchorage in Orthodontic Cases

At the time of determining the space requirement to resolve the malocclusion in a given case, it is essential to plan for space that is likely to be lost due to the invariable movement of the anchor teeth. The anchorage requirement depends on[3,9]:

1. The number of teeth to be moved; the greater the number of teeth being moved, the greater is the anchorage demand. Moving teeth in segments as in retracting the canine separately rather than retracting the complete anterior segment together will decrease the load on the anchor teeth.

2. The type of teeth to be moved; teeth with large flat roots and/or more than one root exert more load on the anchor teeth, hence, it is more difficult to move a canine as compared to an incisor or a molar as compared to a premolar.

3. Type of tooth movement; moving teeth bodily requires more force as compared to tipping the same teeth.

4. Periodontal condition of the dentition; teeth with decreased bone support or periodontally compromised teeth are easier to move as compared to healthy teeth attached to a strong periodontium.

5. Duration of tooth movement; prolonged treatment time places more strain on the anchor teeth. Short term treatment might bring about negligible amount of change in the anchor teeth whereas the same teeth might not be able to withstand the same forces adequately if the treatment becomes prolonged.

6. Space requirements; the amount of crowding or spacing should be assessed as part of treatment planning. This can be done using visual assessment or more formally using a space analysis. Maximum anchorage support is required when all or most of the space created, most commonly through tooth extraction, is required in order to achieve the desired tooth movements.

7. Aims of treatment; the fewer teeth that need to be moved to achieve the aims of treatment then the lesser anchorage demand, however, if treatment is complex and multiple teeth are to be moved there will be a greater anchorage demand. The aims of treatment should be clear. In cases with a Class II molar relationship, anchorage needs will be greater if a Class I molar (and canine) relationship is to be achieved rather than a Class II molar (and Class I canine) relationship. The need to achieve a Class I canine relationship is essential for the success of all treatment, anchorage planning should therefore focus not only on the intended molar movements but also importantly on the required movements of the canines to achieve this goal.

8. Growth rotation and skeletal pattern; an increased rate of tooth movement has been associated with patients who have an increased vertical dimension or backward growth rotation. It has been suggested that space closure or anchorage loss may occur more rapidly in these high angled cases. Conversely in a patient with reduced vertical dimensions or a forward growth rotation, space loss or anchorage loss may be slower. A possible explanation that has been proposed for this observation is the relative strength of the facial muscles, with reduced vertical dimensions having a stronger musculature.

9. The angulations and position of the teeth; usually, in cases where there is bi-protrusiveness or excessive proclination ofthe anterior teeth, a total control of anchorage will be necessary. This way we can take complete advantage of the extraction spaces.

10. The mandibular plane angle (high or low). The inclination of this angle may be modified with different extra-oral anchorage appliances (High Pull, Head Gear, and Face Bow).

11. Spee curve depth.

12. Age of the patient. Depending on this we must take the growth factor of the patient into consideration for anchorage type selection.

13. Patient profile. In biprotrusive type patients we will need very good posterior anchorage in order to modify this type of profile.

14. Surrounding bone characteristics; when teeth are located within trabecular bone, they pose less resistance to move. But, when they are located in cortical bone,their anchorage quantity increases because this bone is denser, laminated and much more compact, with a very limited blood supply. Blood supply is the key factor in dental movement because the physiologic resorption process and the osseous apposition are delayed, so dental movement is slower.

11. Anchorage with Fixed Appliance

Many methods had been listed to increase anchorage value with the fixed appliance; these included[5,9]:

1. Banding or bonding the second molars.

2. Decreasing number of teeth to be moved at a given time.

3. Moving the apices of anchor teeth close to the cortex

4. Stopper in the wire in front of the molars

5. Retro-ligature (figure of 8 ligation).

6. Toe-in and Tip back bends [Anchor bends for posterior anchorage] and "Apical torque" [for anterior anchorage] in archwire.

7. Use of combined Nance bottom with trans-palatal arch in the upper and lingual arch in the lower.

8. Managing the timing of extraction.

9. Managing the friction between the bracket's slot and archwire.

10. Inter-maxillary elastics.

11. Extra oral traction – occipital, occipital-cervical or cervical.

12. Lip bumper.

13. Tipping the molars and premolars distally prior to retraction of the anterior teeth according to Tweed philosophy to increase the anchorage value of the posterior segments, allowing further retraction of the canines and incisors with less anchorage loss.

14. Utilizing dental implants or ankylosed teeth

15. Mini-screws and mini-plates.

12. Anchorage with the Removable and Myofunctional Appliances

Removable appliances can be used alone or to reinforce anchorage in conjunction with a fixed appliance. By virtue of their palatal coverage they increase anchorage. Other design features which reinforce anchorage include[3]:

• Anteroposteriorly – by colleting around the posterior teeth with acrylic; inclined bite-blocks, palatal bows or the use of incisor capping.

• Transversely – the pitting of one side of the arch against the other can reinforce transverse anchorage, typically seen where an expansion screw or coffin screw is used for increasing the palatal transverse dimension.

• Vertically – by either reducing the vertical dimensions during treatment of a high angle patient by intruding the posterior teeth, or increasing the vertical dimension by allowing differential eruption with the use of an anterior bite-plane.

All of these three dimensional features can be incorporated into functional appliances, which additionally can be used to gain anchorage in the anteroposterior direction to aid in the treatment of a Class II malocclusion.

13. Anchorage Loss

Anchorage loss is the movement of the reaction unit or the anchor unit instead of the teeth to be moved[4,5].

14. Causes of Anchorage Loss [4,5]

1. Not wearing the appliance adequately.
2. Too much activation of springs or active components
3. Presence of acrylic or any obstruction on the path of tooth movement
4. Poor retention of appliance.
5. Anterior bite plane: as this withdraws the occlusal interlock.
6. Anchor root area not sufficiently greater than the root area of tooth or teeth to be moved.
7. If appliance encourage tipping movement of anchor teeth and bodily movement of the teeth to be moved.
8. Using heavy force in moving teeth.
9. Poor anchorage planning.

15. Signs of Anchorage Loss [4,5]

1. Mesial movement of molars.
2. Closure of extraction space by movement of posterior teeth.
3. Proclination of anterior teeth.
4. Spacing of teeth.
5. Increase in overjet.
6. Change in molar relations.
7. Buccal cross bite of upper posteriors.

16. Means to Detect Anchorage Loss [5]

1. Relating the position of other teeth to the teeth in the same and opposite arch.
2. Increase in overjet.
3. Checking the fitness of the removable appliance in the mouth.
4. Measurements of the distance of anchor teeth from midline.
5. Measurements from palatal rugae and frenum.
6. Observation of the spacing mesial/distal to the anchor teeth.
7. Inclination of the anchor teeth.

Radiological examination (cephalometric radiograph).

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