

Orthodontics: Is a specialty of dentistry that is concerned with the study and treatment of malocclusions (improper bites), which may be a result of tooth irregularity, disproportionate jaw improved bite (*occlusion*).

The orthodontic can be divided into three categories based on the nature and time of procedures:-

1. **Preventive orthodontics**
2. **Interceptive orthodontics**
3. **Corrective orthodontics**

Preventive orthodontics:

It is the action taken to preserve the integrity of what appears to be normal occlusion at a specific time.

The preventive measures may include:

1. Anatomical dental restoration,
2. Space maintenance. →



Interceptive orthodontics:

It is phase of orthodontics that used to recognize and eliminate potential irregularities and malpositions in the developing dentofacial complex. For example:

1. Space regaining, →



Corrective orthodontics:

Find the extension of the condition and determine technical procedures to reduce or eliminate the problem.

1. Mechanical: removable or fixed appliances
2. Functional: myofunctional appliance
3. Surgical.

Necessary terms:

Overjet: Is defined as the horizontal overlap of the incisors. (or) The relationship between upper and lower incisors in the horizontal plane.

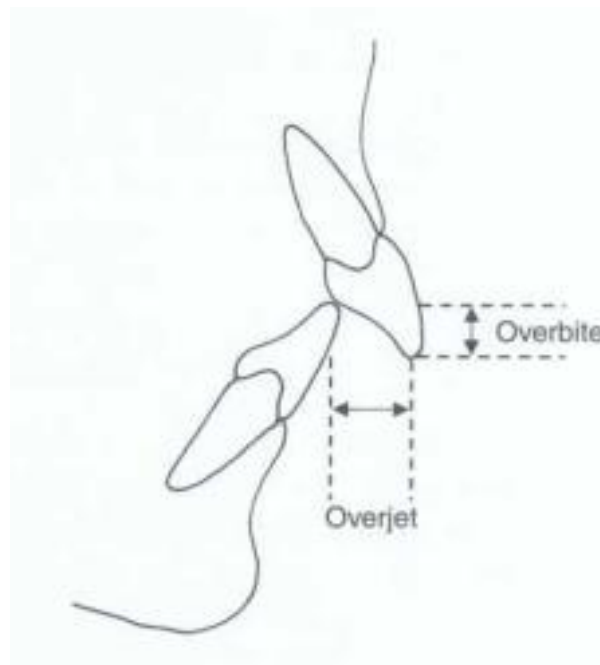
Normally the incisors are in contact with the upper incisors in front of the lower by 2-3 mm

Increased overjet - more than 3 mm.

Reduced overjet - less than 2 mm

Negative or reverse overjet – the lower incisors are in front of the upper incisors

Overbite: Is defined as vertical overlap of the incisors. (or) The overlap of the lower incisors by the upper incisor in the vertical plane. Normally the lower incisor edges contact the lingual surface of the upper incisors at or above the cingulum.



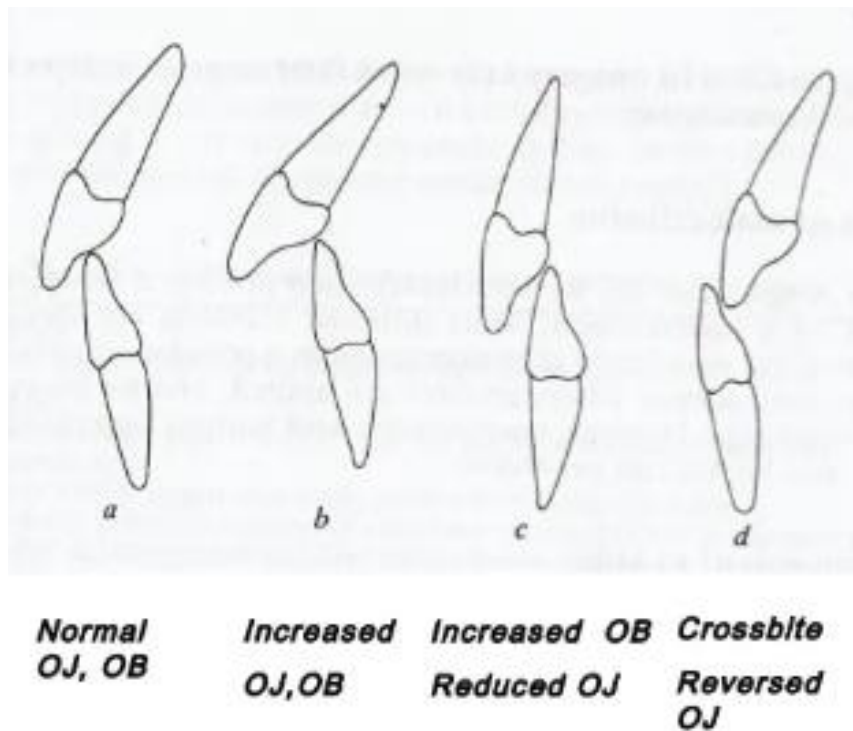
Normal overbite – 2 - 3 mm

Increased or Deepbite – more than 3 mm

Reduced overbite – less than 2 mm.

Complete overbite – An overbite in which the lower incisors contact either the upper incisors or the palatal mucosa.

Incomplete overbite –An overbite in which the lower incisors contact neither the upper incisors nor the palatal mucosa.



Occlusion: It is any contact between teeth of opposing dental arches, usually referring to contact between the occlusal surfaces.

Ideal occlusion: A theoretical occlusion based on the morphology of the teeth, (or) The ideal relationship of the teeth.



Normal occlusion: An occlusion which satisfies the requirements of function and aesthetics but in which there are minor irregularities of individual teeth.

Malocclusion: Can be defined as any deviation from the ideal that may be considered aesthetically or functionally unsatisfactory, (or) An occlusion in which there is a mal-relationship between the arches in any of the planes of space or in which there are anomalies in tooth position beyond the limits of normal.



Anterior openbite: The lower incisors are not overlapped in the vertical plane by the upper incisors and do not occlude with them, (or) When the patient is viewed from the front and the teeth are in occlusion, a space can be seen between the upper and lower incisor edges.



Crossbite - A deviation from the normal bucco- lingual relationship; may be anterior / posterior / or unilateral / bilateral .

Anterior crossbite –This can either be anterior in such case, one or more upper incisors are in lingual occlusion the lower incisors.

Posterior crossbite - A transverse discrepancy in arch relationship . The lower arch is wider than the upper so that the buccal cusps of the lower teeth occlude outside the buccal cusps of the corresponding upper teeth.



Procline: The upper and lower incisors are proclined labially to a greater degree than normal.



Retroclined: The upper and lower incisors are incline palatally / lingually to a greater extent than normal.



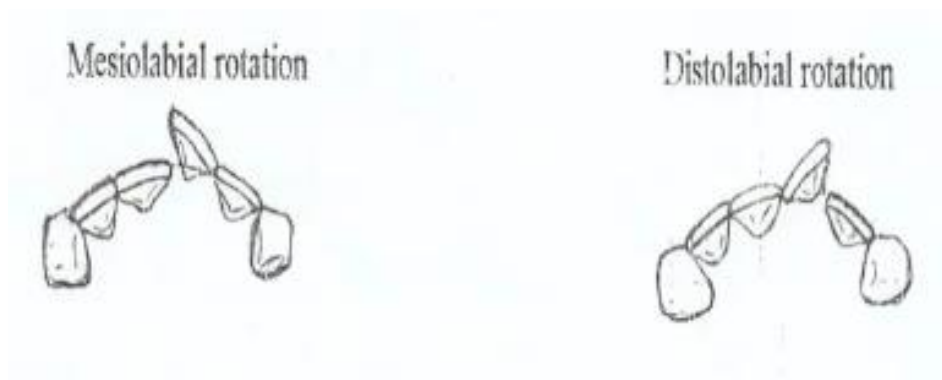
Imbrication: The overlapping of incisor teeth in the same direction.



Rotation: Rotation of teeth around their long axis.

Mesiolabially rotated: If the mesial aspect is out of the line of the arch .

Distolabially rotated: If the distal aspect is out of the line of the arch.



Angulation: Mesio-distal tip of tooth within the dental arch. Or, an expression of the degree of tip in the mesiodistal plane.



Inclination: The labio-palatal, labio-lingual, bucco-palatal or bucco-lingual tip of a tooth within the dental arch.



Palatally inclined



Lingually inclined

Spacing: Is a term refer to gaps between the teeth. Spacing can range from noticeable to severe.



Crowding : When the size of the dentition is greater than the space available to accommodate the teeth in good general alignment then crowding may be said to occur.



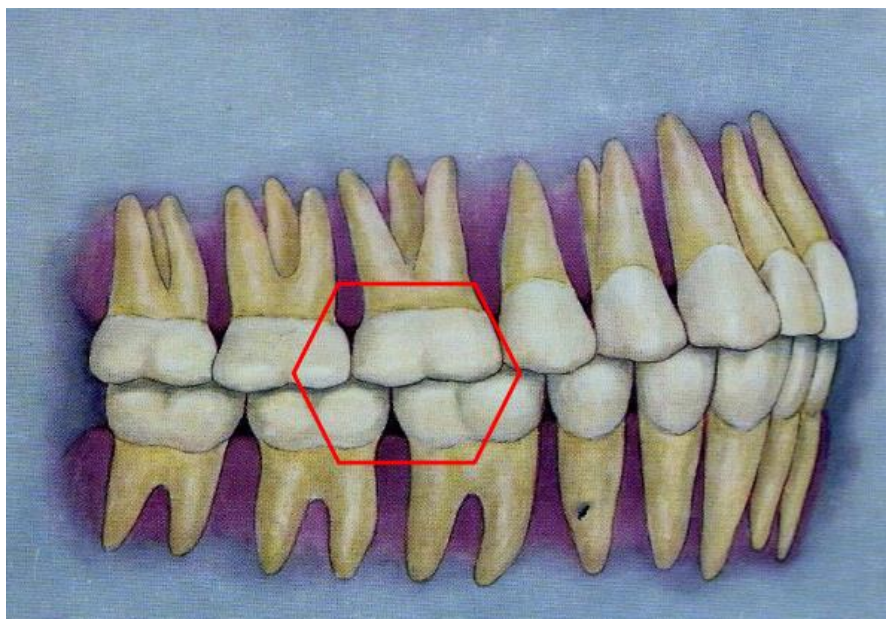
Six keys of normal occlusion

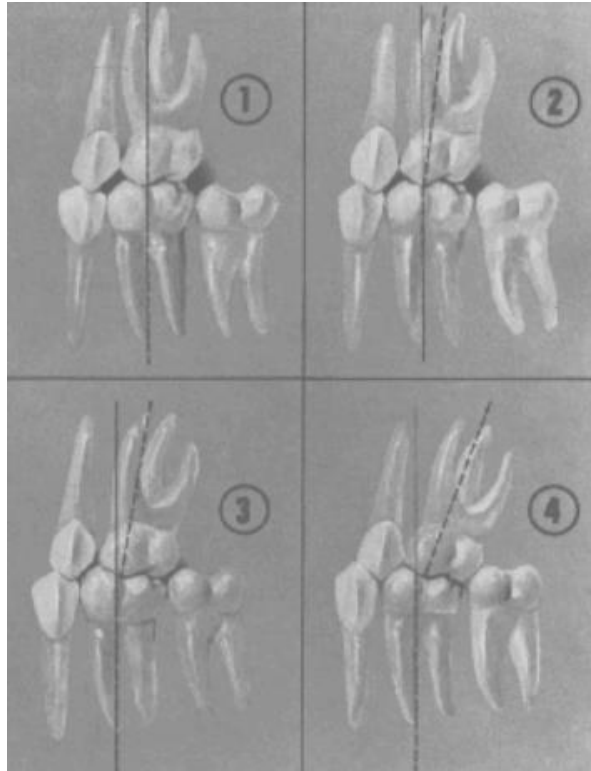
Andrews described six keys to normal occlusion:

1. Molar relationship.
2. Crown angulation (tipping).
3. Crown inclination (torque).
4. Absence of rotation.
5. Tight contact.
6. A flat occlusal plane or slight curve of Spee.

Key I. Molar relationship

1. The mesiobuccal cusp of the upper first molar should occlude within the mesiobuccal groove of the lower first molar.
2. The mesiolingual cusp of the upper first molar should occlude in the central fossa of the lower first molar.
3. The crown of the upper first molar must be angulated so that its distal marginal ridge occludes with the mesial marginal ridge of the lower second molar.
4. Molars and premolars cusp embrasure buccally cusp fossa lingually, The tip of maxillary canine occlude slightly mesially to the embrasure between lower canine and premolar (canine rise concept).

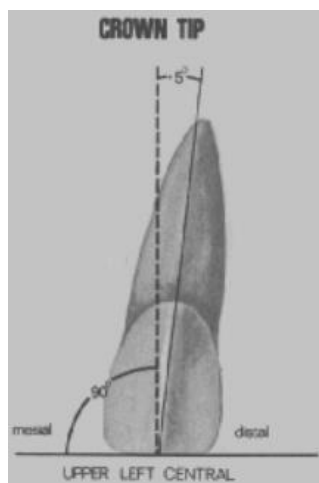




In the figure up: 1, Improper molar relationship. 2, Improved molar relationship. 3, More improved molar relationship. 4, Proper molar relationship.

Key II. Crown angulation (tipping)

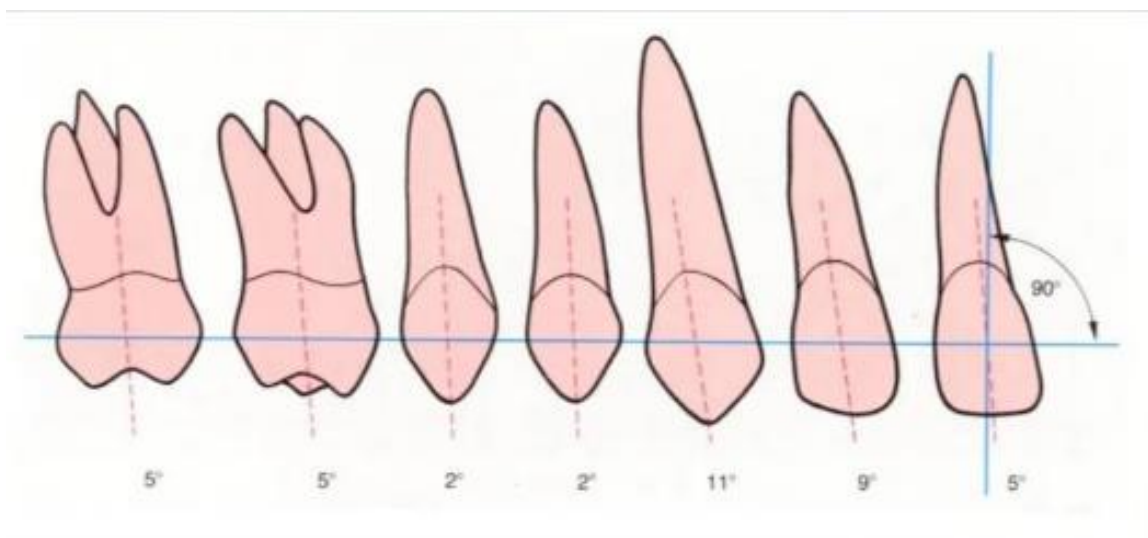
It's the mesiodistal tip of the long axis of the crown, or, the degree of crown tip is the angle between the long axis of the crown (as viewed from the labial or buccal surface) and a line bearing 90 degrees from the occlusal plane. **Normally:** The gingival portion of the long axes of all crowns was more distal than the incisal portion.





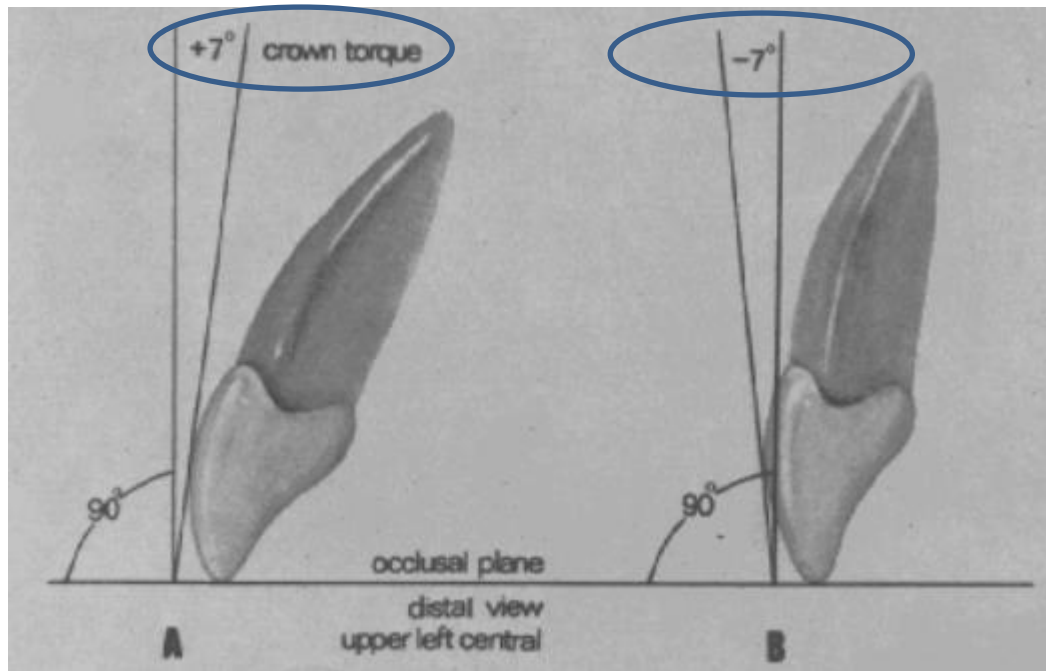
A "positive reading" is assigned when the gingival portion of the long axis of the crown is distal to the incisal portion.

A "negative reading" is assigned when the gingival portion of the long axis of the crown is mesial to the incisal portion.



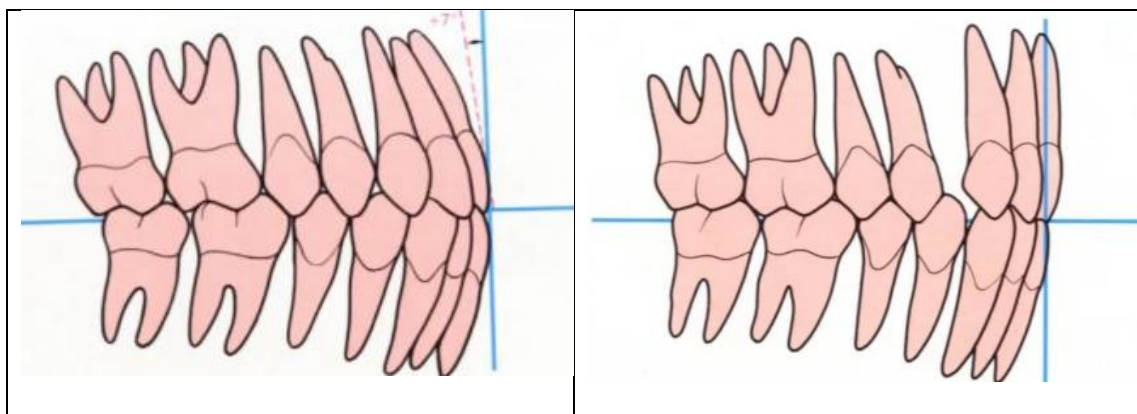
Key III. Crown inclination (labiolingual or buccolingual inclination)

Crown inclination refers to the labiolingual or buccolingual inclination of the long axis of the crown. Or its angle formed between the facial long axis of the crown and a perpendicular to the occlusal plane. (viewed from proximal surface)



When the gingival portion of the long axis of the crown is more lingual to the incisal portion, the crown inclination is **positive**. When the gingival portion of the long axis of the crown is more labial to the incisal portion, the crown inclination is **negative**.

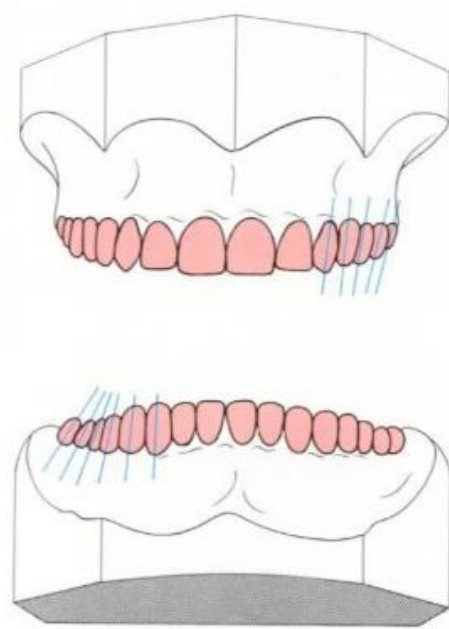
Incorrect crown torque and occlusal findings will happen if the upper anterior teeth be in a too upright position (the labiolingual crown inclinations of the upper incisors have negative values), then, the occlusion will be unstable. The canine guidance is insufficient and there is a risk that the posterior teeth will drift toward the mesial.



Key IV. Labiolingual inclination of the teeth in optimal occlusion

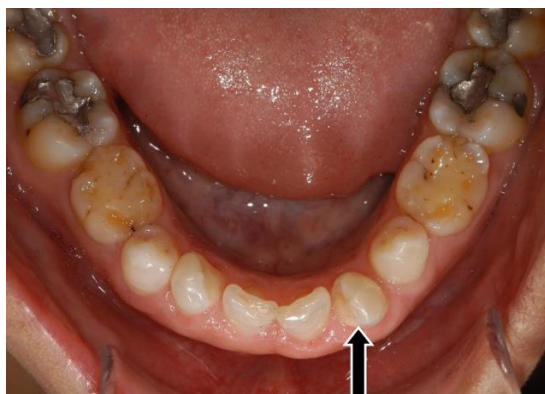
In normal occlusion, the crown inclination for all teeth was negative except maxillary central and lateral incisors. A minimal lingual crown inclination generally occurs in normally occluded upper posterior crowns. The inclination is constant from the canines through the second premolars and slightly increased in the molars. The

lingual crown inclination of normally occluded lower posterior teeth progressively increases from the canines through the second molars.



Key IV. Absence of rotation

The fourth key to normal occlusion is that the teeth should be free of undesirable rotations. Because if the tooth rotated, would occupy more space than normal, creating a situation unreceptive to normal occlusion. Rotated molars and premolars occupy more space in the dental arch than normal. Rotated incisors may occupy less space than those correctly aligned. Rotated canines adversely affect esthetics and may lead to occlusal interferences.



Key V. Tight contacts

The fifth key is that the contact points should be tight (no spaces).

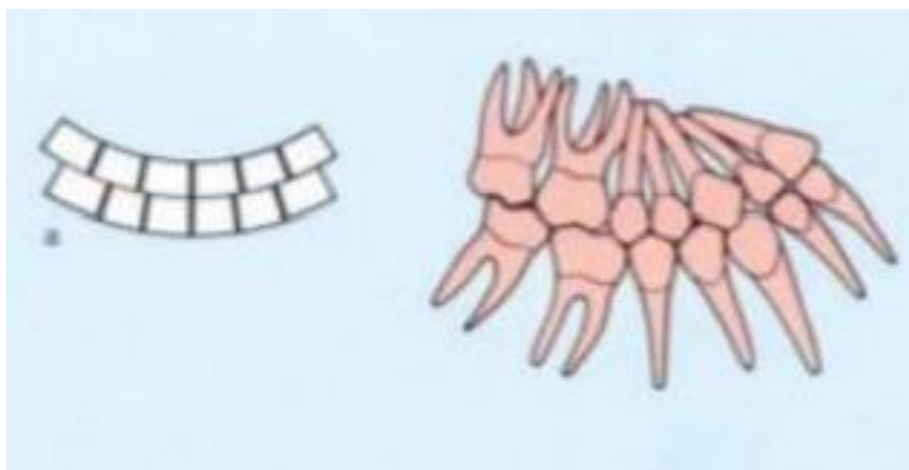


Key VI. Occlusal plane

Occlusal plane: is the imaginary plane on which the teeth meet in occlusion. In normal occlusion, the occlusal plane should be flat or nearly flat.

Curve of Spee:

An excessive curve of Spee restricts the amount of space available for the teeth, which must then move toward the mesial and distal, thus preventing correct intercuspation.



Normal occlusion has a flat occlusal plane (according to Andrews, the mandibular curve of Spee should not be deeper than 1.5 mm).



Reverse curve of Spee creates excessive space in the upper jaw, which prevents development of a normal occlusion.



GENERALLY:

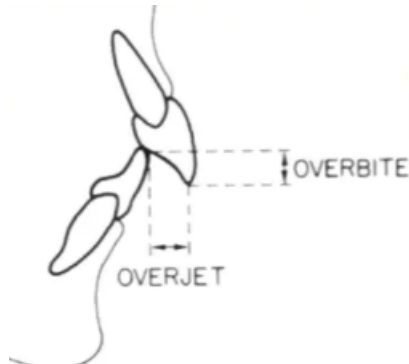
Every upper tooth occludes against two opposite teeth except lower centrals. ,spaces and crowding are not present. The neighbouring teeth are aligned without rotation or malposition.



Maxillary midline coincides with mandibular midline. Overbite is $\frac{1}{3}$ the crown heights of the lower incisors.



Overbite is one third the crown height of the lower incisors and overjet is about the thickness of the incisal edges of the upper incisors in normal.



Types of orthodontic appliances

Orthodontic appliances can be defined as devices, which create and/or transmit forces to individual teeth/a group of teeth and/or maxillofacial skeletal units so as to bring about changes within the bone with or/without tooth movement which will help to achieve the treatment goals of functional efficiency, structural balance and esthetic harmony.

Broadly the appliances can be classified into two groups:

1. Mechanical appliances

- Removable
- Fixed.

2. Functional appliances

- Removable
- Fixed.

Orthodontic appliances can be also classified as **mechanical or functional**, based on the way they generate or transmit forces. Based on the patient's ability to remove them, they can be sub-classified **as removable or fixed**. The simplest classification is probably based on the patient's ability to remove the orthodontic appliance. Based on this premise the appliances can be classified as-removable, semi-fixed or fixed.

Mechanical orthodontic appliances

Mechanical orthodontic appliances possess active components, which are themselves capable of generating forces. These appliances are capable of generating forces that can move individual teeth, group of teeth and / or the jaws. Mechanical appliances may be fixed or removable.

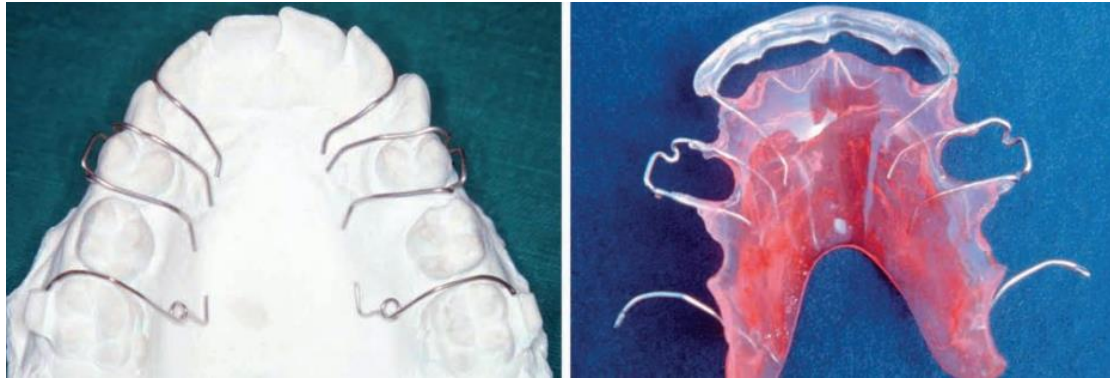
1. Removable orthodontic appliances

As the name suggests, these appliances can be removed from the mouth by the patient. The patient can insert and remove these appliances without the intervention of a clinician. They may be active or passive, depending upon their capability to exert/generate forces.

Active removable appliances :Active removable appliances are designed to achieve tooth movement (mainly tipping) by means of active components, e.g. wire springs, screws etc. They are capable of generating tooth moving forces.

Passive removable appliances :Passive removable appliances are designed to maintain teeth in their designated or present position, e.g. space maintainers, retainers etc.

Removable orthodontic appliances are those that can be removed by the patient, e.g. Howley's retainer.



2. Semi-fixed orthodontic appliances

Semi-fixed orthodontic appliances have some part of the appliance fixed on to the tooth surfaces which the patient cannot remove but the rest of the appliance can be removed, e.g. lip bumper.



3. Fixed orthodontic appliances

Fixed orthodontic appliances includes those appliances which the patient cannot remove. These appliances are capable of bringing multiple movements with limited patient co-operation, e.g. the pre-adjusted edge-wise appliance.

Fixed appliances also considered as devices in which attachments are fixed to the teeth and forces are applied by arch wires or other auxiliaries via these attachments. These can be further classified as active and passive, depending upon their ability to generate forces.



Banding

A metal ring that is usually placed on your teeth to hold on parts of your braces. Banding involves the use of thin stainless steel strips called bands that are pinched tightly around the teeth and then cemented to the teeth. The stainless steel tape is available in different widths and thicknesses to suit different teeth. While the molar band material is wide and stiffer, the anterior band material is relatively thinner and narrower in width. The outer surface of the band material is smooth and glossy while the inner surface is comparatively rough and dull, so as to aid in retention of the cement.

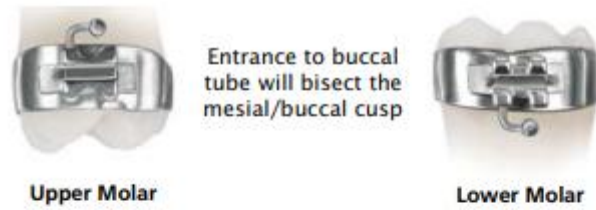
Types of Bands

1. Custom made bands
2. Preformed bands.



Custom Made Bands: Based on which tooth is being banded; the band material of appropriate thickness and width is selected.

Preformed Bands: Preformed bands are available in various sizes. Proper size of band should be selected by trial and error method by placing the bands on the models till they fit snugly.



Lingual Cleat Attachments Centered on Molar Bands



Active Fixed Appliances

Active fixed appliances are attached (fixed) onto the tooth surface and are capable of generating forces which are capable of bringing about tooth movements.

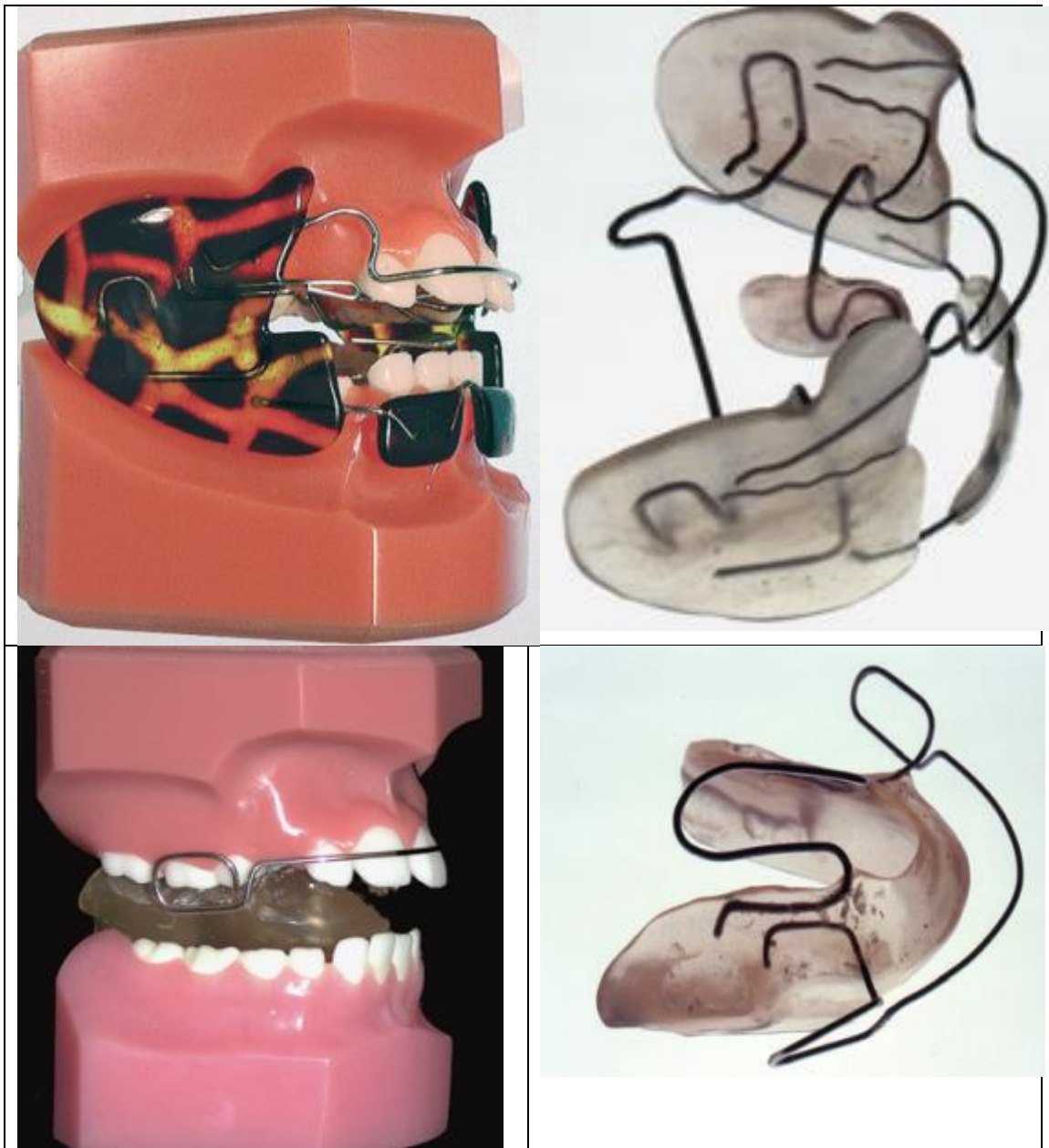
Passive Fixed Appliances

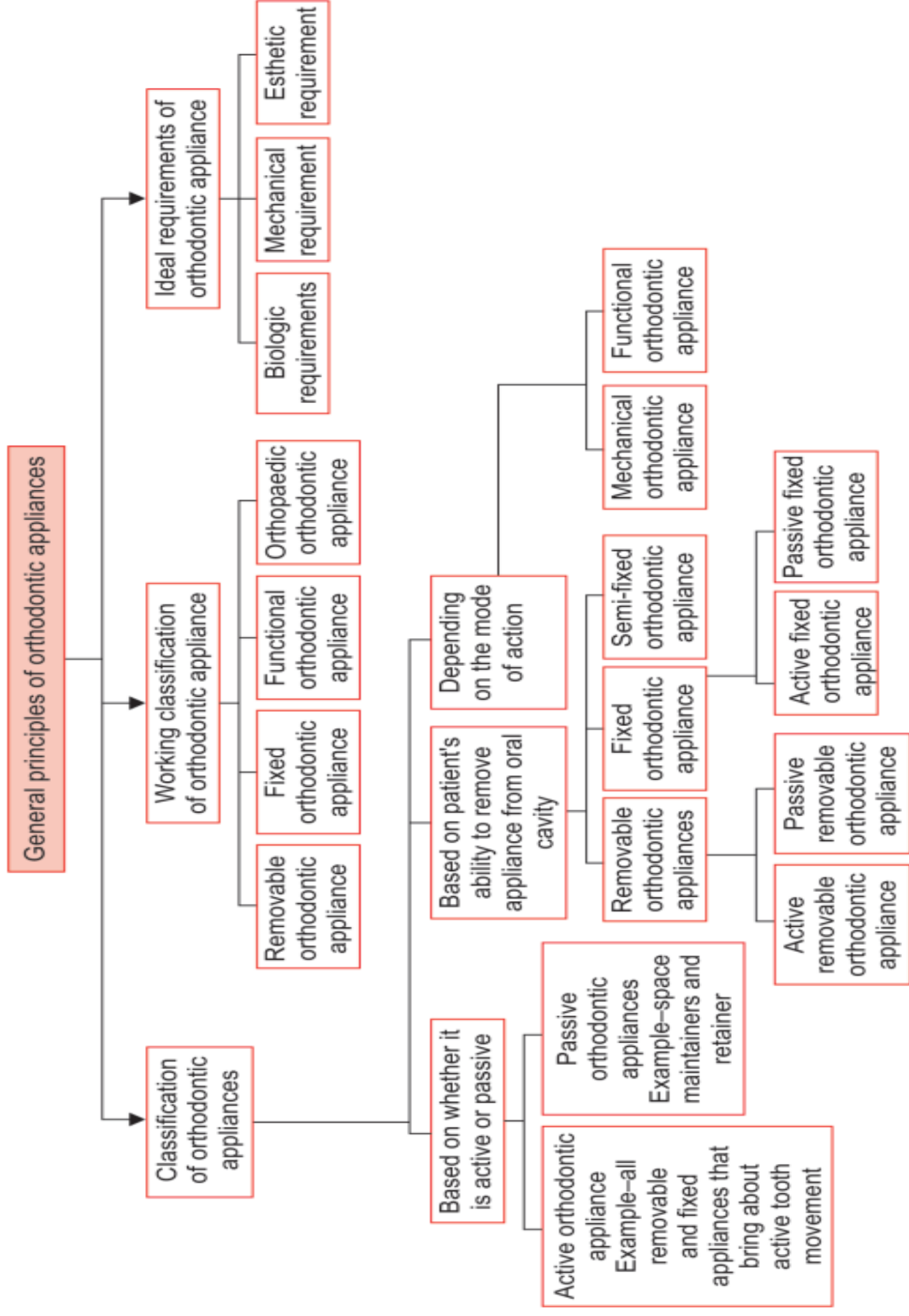
Passive fixed appliances do not generate forces and are responsible for maintaining the attained position of the teeth, e.g. fixed retainer fixed space maintainers, etc.



Functional orthodontic appliances

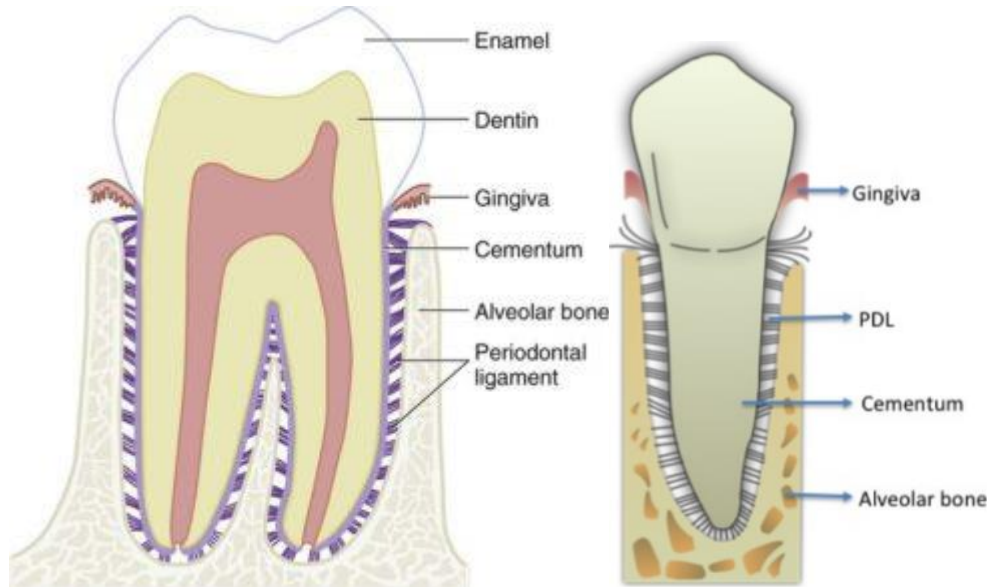
These are appliances which engage both arches and act principally by holding the mandible away from its resting position, they harness and transmit the natural forces of the circum oral musculature to the teeth and/ or alveolar bone. These appliances generally cause a change in the surrounding soft tissue envelope of the teeth thereby leading to a more harmonious relationship of the jaws to each other and to the other bones of the facial skeleton, e.g. the Frankel appliance.





Mechanical basis of tooth movement

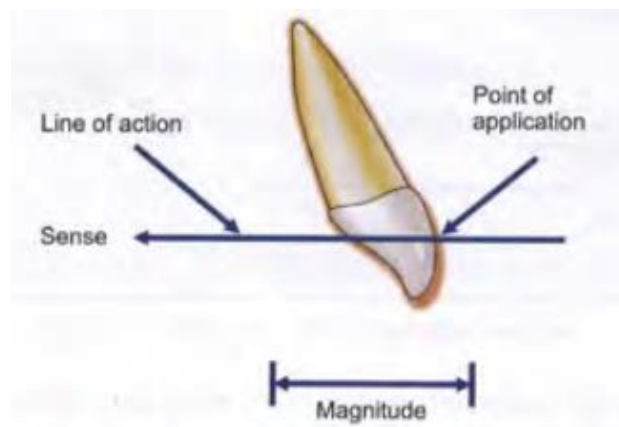
Orthodontic tooth movement is produced by the force system that delivered to the teeth and mediated through the orthodontic appliance and the biological response it induces.



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Force:

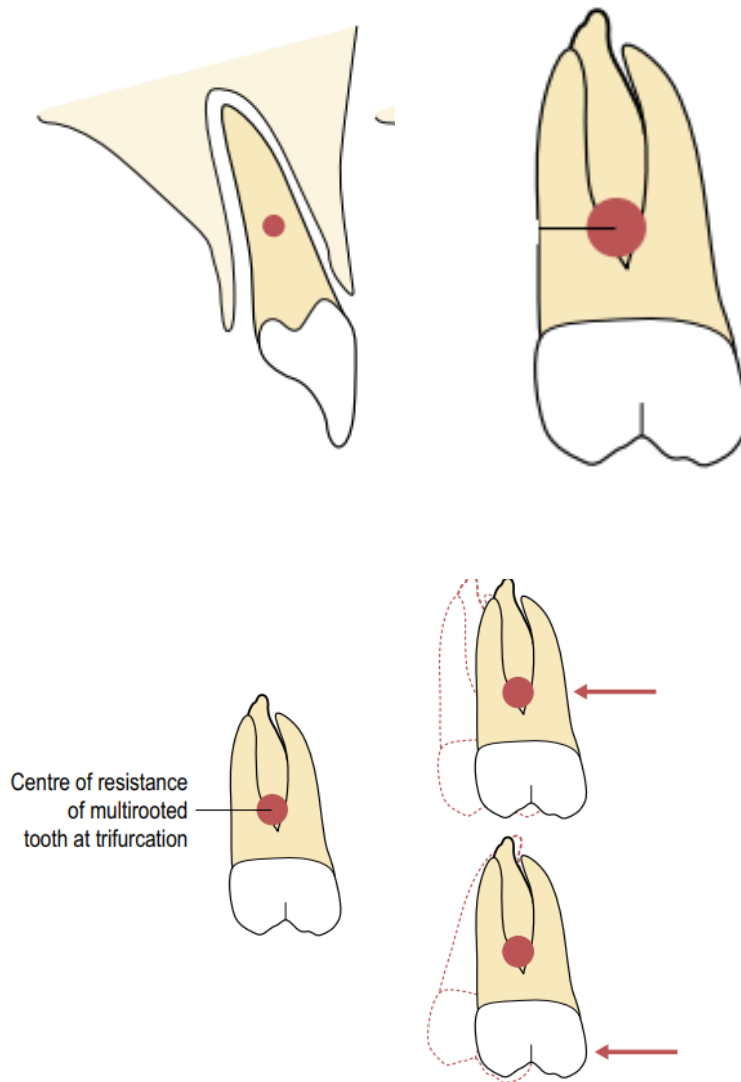
A load applied to an object that has both magnitude and direction. Forces can be represented visually by vectors. also, the point of application must be taken into account and has great significance from an orthodontic perspective.



Centre of resistance:

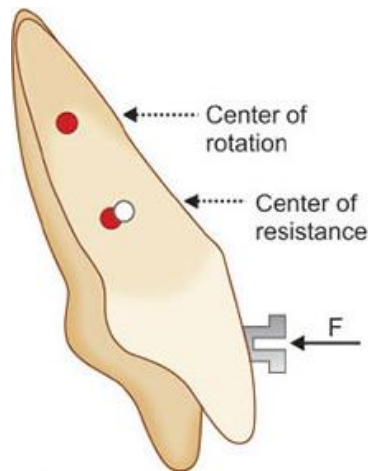
The point at which bodily movement or translation of an object will result along the line of the force application. The center of resistance of a single-rooted tooth is on the long axis of the tooth, probably between one third and one half of the root of single-

rooted teeth or found at a point located at a distance of 33-42% of the root length, when measured from the alveolar crest. For a multi-rooted tooth, the center of resistance is probably between the roots, 1 or 2 mm apical to the furcation.



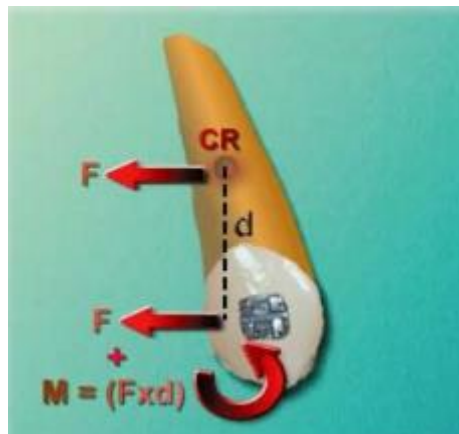
Center of rotation:

What is the Center of Rotation: Any point around which the tooth is rotate. It may be at the center of resistance, apical, or incisal to it .



Moment:

The moment of the force is the tendency for a force to produce rotation. It is determined by multiplying the magnitude of the force by the perpendicular distance of the line of action to the center of resistance. It is measured in gm-mm.



Couple:

This represents two equal and opposite forces. A couple cannot produce force to bodily move a tooth, as the forces are opposite in direction and cancel each other out. A couple acting alone on a tooth will produce a purely rotational movement.

Optimum Orthodontic Force:

The optimum orthodontic force is the one, which moves teeth most rapidly in the desired direction, with the least possible damage to tissues and with minimum patient discomfort. The optimum force for tooth movement was one that induced a pressure of around $20\text{-}26 \text{ gm/cm}^2$ of root surface.

The optimum orthodontic force has the following clinical characteristics:

- It produces rapid tooth movement,
- Causes minimal patient discomfort. Orthodontic Tooth Movement ,
- Lag phase of tooth movement is shorter,
- The tooth being moved does not become loosened in its socket.

The Orthodontic Force can be classified:

1-According to magnitude into:

Light force: The force must be light in beginning of treatment because this will permits the proliferation of cells which is very necessary of tooth movement and less discomfort and pain to the patient.

Heavy force: Heavy force is not preferable in orthodontic tooth movement for the following causes:

- Delay tooth movement.
- Risk of root resorption.
- Pain and discomfort for the patient.
- Loss of tooth vitality.
- Increased mobility of tooth due to removal of a great amount of supporting bone.

2-According to the duration of force application into:

- Continuous: Force maintained at somewhat considerable level of the original from one patient visit to the next
- Interrupted: Force levels decline to zero between activations

Both continuous and interrupted forces can be produced by fixed appliances that are constantly present.

- Intermittent: Force levels decline abruptly to zero intermittently when the orthodontic appliance is removed by the patient or perhaps when a fixed appliance is temporarily deactivated, and then return to the original level some time later. Intermittent forces are produced by all patient-activated appliances, such as removable appliances.

Forces generated during normal function (chewing, swallowing, speaking, etc.) can be viewed as a special case of intermittently applied forces.

- According to site from which they exerted:

Intra-oral force: Force generated by an element of an orthodontic or orthopedic appliance located inside oral cavity and this placed by springs, elastics, bows, screws and arch wires.

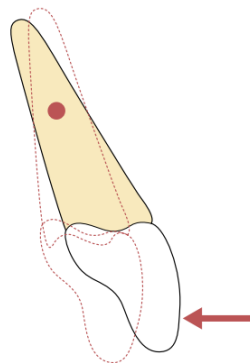
Extra-oral force: Force generated by (elastically) deforming an activating element of an orthodontic or orthopedic appliance, located outside the oral cavity.

Types of tooth movement

Tooth movement can be described in many ways. The basic types of tooth movement are (i) tipping, (ii) translation, (iii) root movement and (iv) rotation.

1. Tipping

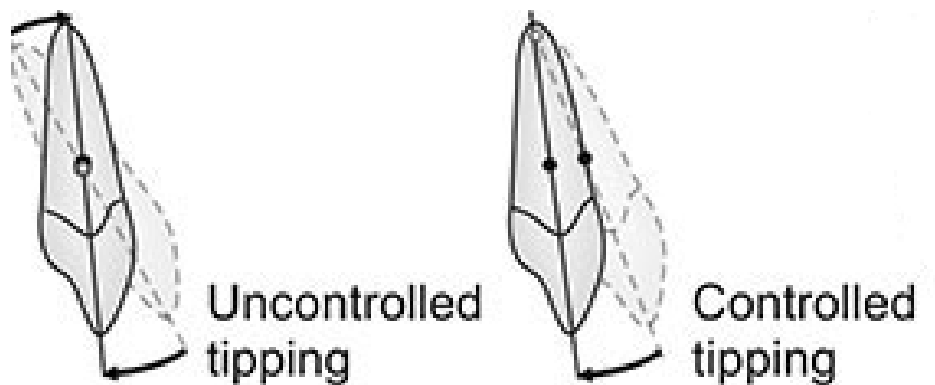
Tipping is the simplest tooth movement and the one easily carried out. In tipping, there is greater movement of the crown than that of the root. There are two types of tipping:



Uncontrolled tipping: It is produced when a single force is applied to the crown of a tooth. Crown moves in one direction and the root moves in opposite direction. Centre of rotation between the centre of resistance and apex of the root. Force required: 35–60 g. Uncontrolled tipping is useful when incisors have to be proclined.

Controlled tipping: It is a desirable tooth movement when compared to uncontrolled tipping. Crown moves in one direction and there is minimal or no movement of the root in opposite direction. Centre of rotation is at the root apex. Force required: 35–

60. Controlled tipping is useful in retraction of excessively proclined incisors when roots are normally positioned.



Uncontrolled inclination



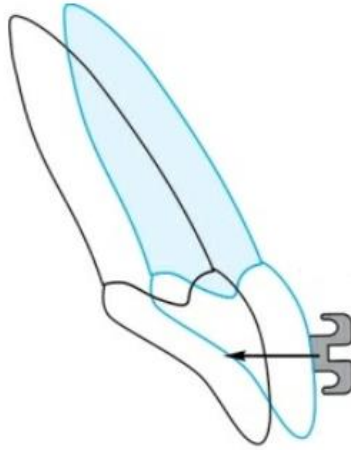
Controlled inclination

2. Translation

Pure translation of a tooth occurs when two forces are applied simultaneously to the crown of the tooth. In translation, crown and root move the same distance in the same direction. Applied force passes through the center of resistance. Pure translation is of three types: (a) bodily movement, (b) intrusion and (c) extrusion.

a. Bodily movement

This is the most desirable type of tooth movement. In bodily movement, crown and root move the same distance either lingually or labially. Centre of rotation is at infinity. Force applied: 70–120 g.

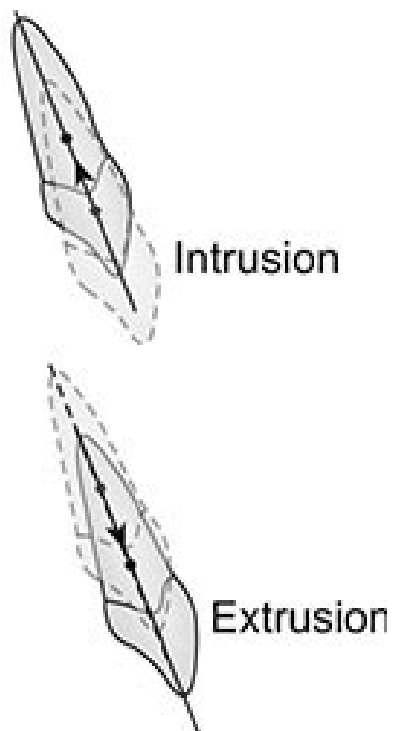


b. Intrusion

This is defined as the axial movement of the tooth along the long axis towards the apex of the root. Intrusion is the tooth movement which requires minimum force. Centre of rotation; Force passes through the centre of resistance. Force required: 10–20 g.

c. Extrusion

Extrusion is defined as the axial movement of the tooth along the long axis towards the coronal part. Force required: 35–60 g.

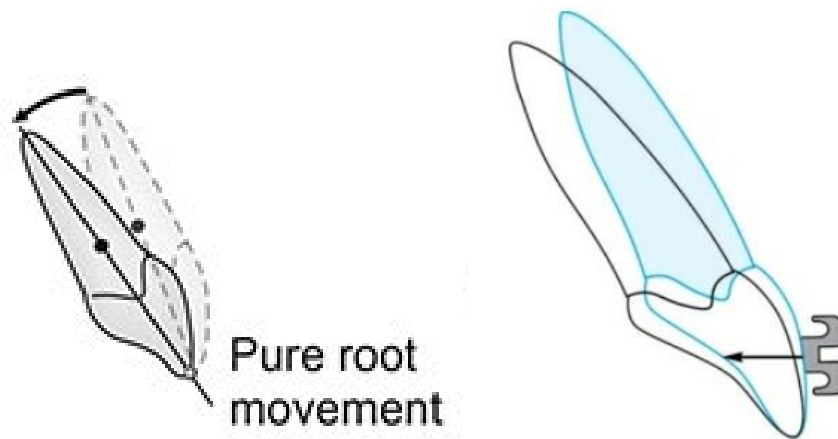


3. Root movement

This is the opposite of crown tipping. Crown of a tooth is kept stationary, while the root moves labiolingually or mesiodistally. There are two types of root movement:

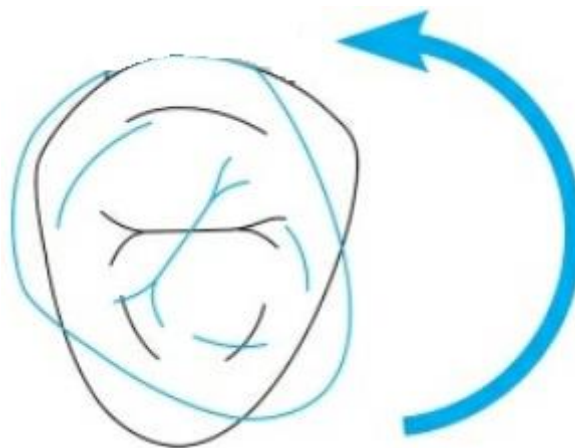
- a. Torque: Labiolingual root movement
- b. Uprighting: Mesiodistal root movement.

Centre of rotation: At incisal edge. Force required: 50–100 g. Root movement is used to torque the incisor and upright tipped teeth.



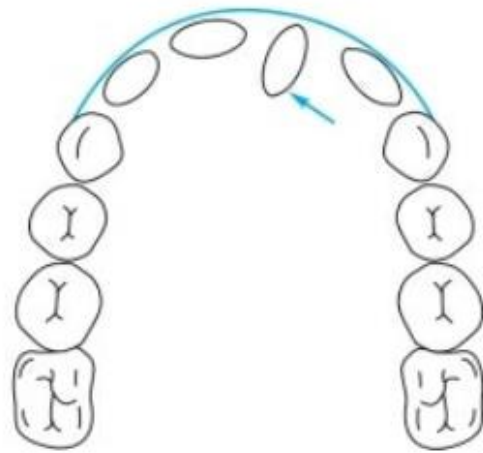
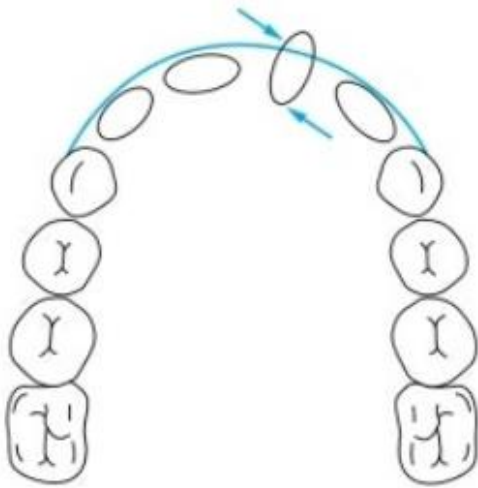
4. Rotation

Rotation can be defined as the turning of the tooth around its long axis. Rotation can be achieved by applying a couple. The forces get reversed and only moment exists which causes rotation. Force required for rotation correction: 35–60 g.



Rotation can be achieved by two ways:

1. By using a couple force
2. By using a single force and a stopper.



Properties of Orthodontic Wires:

For orthodontic purposes, three major properties are critical in defining their clinical usefulness:

Strength, stiffness and range: Each represents, in different way, the maximum load that the material can resist.

$$\text{Strength} = \text{Stiffness} \times \text{Range}$$

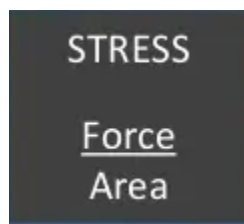


Diagram showing the formula for Stress:

$$\text{STRESS} = \frac{\text{Force}}{\text{Area}}$$



Diagram showing the formula for Strain:

$$\text{STRAIN} = \frac{\text{Change in length}}{\text{Original length}}$$

- Stress: Internal distribution of load.
- Strain: Internal distortion produced by the load.

Important terms:

1. Tough

It is the property of being difficult to break, tougher the material, stronger it is.

2. Stiffness

This is the force magnitude delivered by an appliance. Low stiffness provides with the ability to apply lower forces and more constant force over time.

3. Deflection rate

Refers to the amount of force produced for every unit of activation of an orthodontic wire. Factors influencing load-deflection rate:

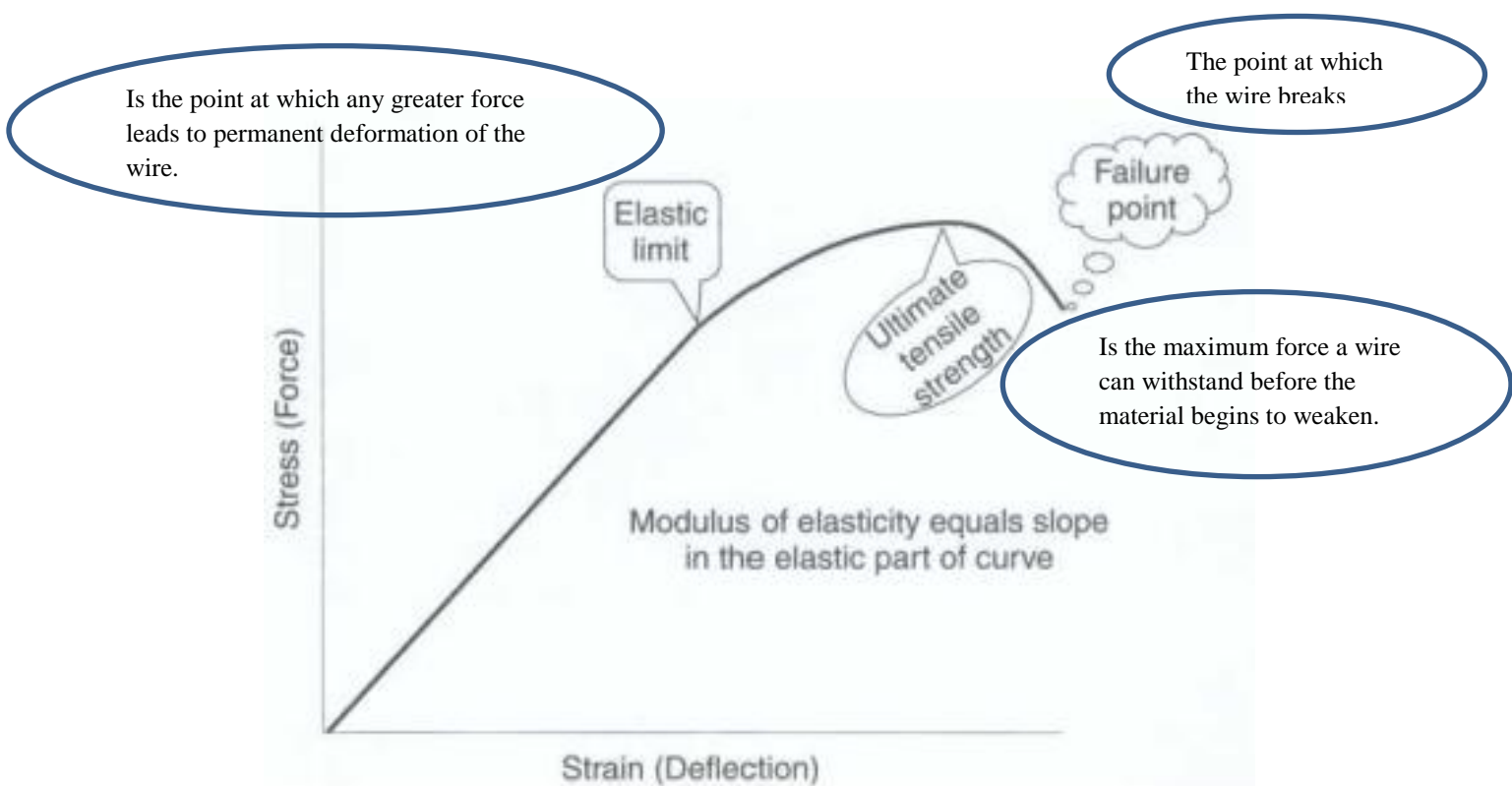
- 1) length & cross-section of wire,
- 2) manner of loading,
- 3) mechanical properties of the metal.

4. Elasticity

Is defined as the ability of stressed material to return to its original form.

5. Elastic range

The amount of deflection that a wire can withstand before permanent deformation. A high elastic range in a wire enables activation of a wire to a greater extent with a lesser chance of undergoing permanent deformation. On the other hand, the ability to permanently deform a material beyond its elastic limit enables the clinician to place bends in the wire.



6. Range

Is defined as the distance that the wire will bend elastically before permanent deformation occurs. For orthodontics, this distance is measured in millimeters. If the wire is deflected beyond this point, it will not return to its original shape,

7. Spring Back

It is also a measure of how far a wire can be deflected without causing permanent deformation. Higher spring back values provide the ability to apply large activations with a resultant increase in working time of the appliance.

5. Elastic range

The amount of deflection that a wire can withstand before permanent deformation reflects an appliance's elastic range. A high elastic range in a wire enables activation of a wire to a greater extent with a lesser chance of undergoing permanent deformation. On the other hand, the ability to permanently deform a material beyond its elastic limit enables the clinician to place bends in the wire.

8. Resilience

It represents the energy storage capacity of the wire, which is a combination of strength and springiness.

9. Formability

Is the amount of permanent deformation that a wire can withstand before failing. It represents the amount of permanent bending the wire will tolerate (while being formed into a clinically useful spring, for instance) before it breaks. A wire with an extended plastic range is more formable, which means it can be bent several times without undergoing failure. High formability provides the ability to bend a wire into desired configurations such as loops, coils .etc. without fracturing the wire.

10. Friction

The preferred wire material for moving teeth should produce the least amount of friction. Excessive friction usually accompanied by little or no tooth movement.

11. Biocompatibility and environmental stability

Biocompatibility includes resistance to corrosion and tissue tolerance to elements of the wire. Environmental stability ensures the maintenance of desirable properties of the wire for an extended period of time after manufacture.

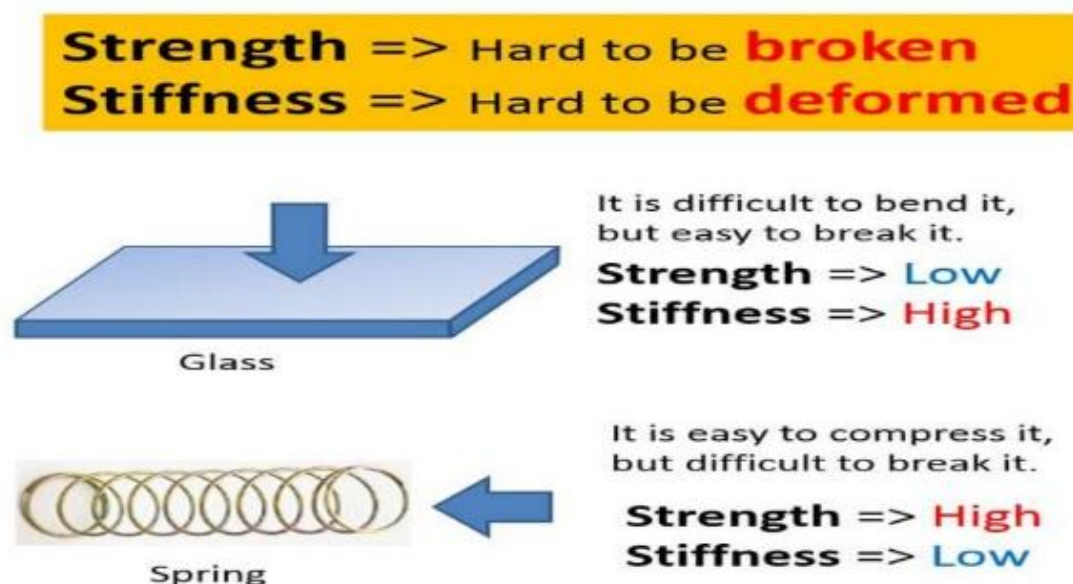
12. Capability to be welded or soldered to auxiliaries and attachments. This increases the utility of the wire since more auxiliaries can be fixed onto it.

13. Shape memory

Refers to the ability of the material to remember its original shape after being plastically deformed.

Characteristics of orthodontic wires, which are considered desirable for optimal performance during treatment include:

1. Large spring back: Good spring back values provide with greater range of activation, increased working time of the appliance and a fewer changes and adjustments are required in the arch wire.
2. Low stiffness: Wire stiffness or elastic force delivery depends on the composition and structure of the wire alloy, and the wire segment geometry, that is, the cross section, shape and the size of the wire. The stiffness of an arch wire is inversely proportional to the segment length. So that, if the length is doubled the wire flexibility will be doubled for the same applied force.



3. High formability: It provides the ease in bending the wires into loops, coils and stops without fracture.

4. High stored energy
5. Low surface friction
6. Biocompatibility and environmental stability: There should be resistance to corrosion for maintenance of desired properties. There should be increased tissue tolerance.
7. Capability to be welded or soldered to auxiliaries and attachments.
8. Bio-host-ability: It is the simplicity with which the material will culture bacteria, spores or viruses. Therefore wire should be poor bio-host, i.e. neither actively nurtures nor passively acts as a substrate for growth of microorganism, which will smell foul, cause colour change or compromise in mechanical properties.

Factors That Influence the Load Deflection Rate of an Appliance

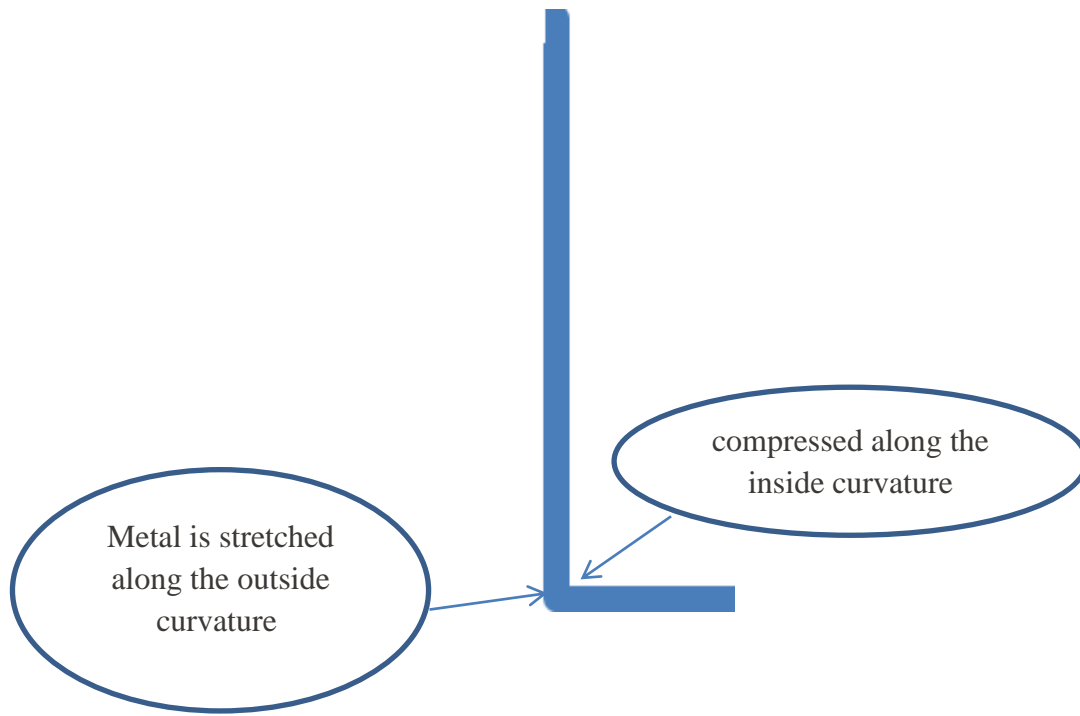
There are some factors that the clinician has control over that can reduce the load deflection rate:

1. Use of low modulus wires(Describe the relative stiffness or rigidity of the material), Changing the wire material: Stainless steel is the stiffest material used in orthodontics. If steel were given an arbitrary modulus of elasticity of 100, titanium/molybdenum alloys would be 35% as stiff as steel and nitinol would be 17% as stiff as steel,
2. Reducing the wire cross section,
3. Placing loops in the arch wire,

Decreasing the cross section of the wire: Doubling the diameter of the wire decreases springiness of a wire by 16 times and half the range. Doubling the diameter increase its strength 8 times.

- 1- Round
- 2- Square
- 3- Rectangular
- 4- Multi stranded





Types of Orthodontic Wires Materials:

Stainless Steel Wires

Stainless steel is the most popular wire alloy used in orthodontics because of an outstanding combination of:

1. mechanical properties,
2. corrosion resistance,
3. and cost.

The wires used in orthodontics are generally known as “18-8” Stainless steels, so designated because of the percentages of chromium and nickel in the alloy. The chromium in the stainless steel forms a thin, adherent passivating oxide layer that provides corrosion resistance by blocking the diffusion of oxygen to the underlying bulk of the alloy. The chromium, carbon, and nickel atoms are incorporated into the solid solution formed by the iron atoms. The nickel atoms are not strongly bonded to form some intermetallic compound, so nickel alloy releases from the alloy surface, which may interfere with the biocompatibility of the alloy.

Stainless steel produces higher forces that dissolve over shorter periods therefore requires frequent activations. **Heat treatment of the wire causes decrease in residual stress and increase in resilience.** Heat treatment of stainless steel wires at above 650 C° must be avoided because rapid recrystallization of the wrought structure takes place, with deleterious effects on the wire properties. Heating stainless steel to a temperature between 400 to 900 C° causes reaction of the Chromium and carbon to form chromium carbide precipitate at the grain boundaries. Loss of **chromium** from the iron solid solution matrix results in reduction of chromium content which in turn causes the stainless steel alloy to become **susceptible to inter-granular Corrosion**. Join-ability with stainless steel is possible. They can be fused together by soldering and welding. Friction experienced with the stainless steel wires is comparatively low.

<i>Composition</i>
Iron—71%
Chromium—18%
Nickel—08%
Carbon less than—0.2%

1. Advantageous properties:
High stiffness
High yield strength- 1400MPa approx.
High resilience

Good formability
Good environmental stability
Good join-ability
Adequate spring back
Biocompatible
Corrosion resistant, except at weld sites
Economical.

2. Disadvantageous properties:

Soldering is difficult

Lower spring back than Nickel-titanium alloys.

High modulus of elasticity.

More frequent activations are required to maintain the same force levels.

Heating to temperatures of 400-900 C° causes the release of nickel and chromium, thereby decreasing the corrosion resistance of the alloy.

Cobalt Chromium

These wires are very similar to stainless steel wires in appearance, mechanical properties, and joining characteristics, but have a much different composition and considerably greater heat response. They are also known as Elgiloy. The advantage of these wires over stainless steel wires includes the greater resistance to fatigue and distortion. In most respect the mechanical properties are similar to that of stainless steel so the stainless steel wires can be used instead of cobalt chromium wires. They have a high modulus of elasticity. The elastic modulus of Elgiloy ranges from about 160-190 GPa when under tension, while after heat treatment it increases to range from about 180-210 GPa. Similarly the yield strength ranges from 830-1,000 MPa under tension, and 1,100-1,400 MPa after heat treatment. The clinical use of Elgiloy is fabrication of fixed lingual quad-helix appliance, which produces slow maxillary expansion in the treatment of maxillary constriction.

<i>Composition</i>	
Cobalt	—40%
Chromium	—20%
Nickel	—15%
Iron	—15.4%
Molybdenum	—07%
Manganese	—02%
Beryllium	—0.4%
Others	—0.05%

Nickel-Titanium alloy

Nickel-Titanium alloy is useful in clinical orthodontics because of its exceptional springiness. The generic name **Nitinol** which is applicable to this group of nickel titanium alloy originates from (Ni-nickel, Titanium, NOL-Naval Ordnance Laboratory). Shape memory is one of the remarkable properties of the NiTi alloys.

There are two major NiTi phases in the nickel-titanium wires. The **austenitic** phase and the **martensitic** phase that forms at low temperatures and high stresses.

The shape memory characteristics of the nickel titanium alloys are associated with a reversible transformation between the austenitic and martensitic phases. In order for a nickel titanium arch wire to possess shape memory, the transformation of the phases must be completed at the temperature of the oral environment.

Nickel-titanium arch wires with Ion-implanted surfaces have been introduced to reduce the arch wire friction. As provided for orthodontic use, Nitinol is exceptionally springy and quite strong but have poor formability. The advantages of these wires can be numbered as fewer arch wires are required to achieve the desired changes, less chair side time, and less patient discomfort. **Placing bends in the wire adversely affects the spring back property of the wire.** Clinical disadvantage of these alloys are that permanent bends cannot readily be placed in the wires and that the wires cannot be soldered.

1. Advantageous properties:
 1. High spring back
 2. High stored energy
 3. High elasticity.
2. Disadvantageous properties:
 1. High friction as compared to stainless steel.
 2. Low stiffness cannot be used at the completion stages of orthodontic treatment.
 3. Fractures easily if bent over a sharp edge.
 4. Very limited bending is possible.
 5. Cannot be welded or soldered.
 6. Expensive as compared to stainless steel wires.



Composition
Nickel—55%
Titanium—45%

Beta-titanium orthodontic alloy

A beta-titanium orthodontic alloy, also called as TMA, which represents "Titanium-molybdenum alloy". The wire has a potential for delivering lower biomechanical forces compared to stainless steel and cobalt-chromium-nickel alloy. Beta titanium alloy wires have excellent formability. The TMA alloy has the elastic force delivery ranging from about 62-69 GPa, which is less than that of stainless steel wires. Another clinical advantage of the alloy is that it possesses true weldability. Welded joints that are fabricated from stainless steel and cobalt-chromium-nickel alloys must be built up with the use of solders to maintain adequate strength. The excellent corrosion resistance of the wire is due to the presence of a thin, adherent, passivating surface layer of Titanium oxide.

The beta titanium wires are generally the most expensive of the orthodontic wire alloys, but their advantages like excellent formability, intermediate force delivery, and weldability when fabrication of more complex appliances makes them to be used widely in orthodontics. It has been shown that TMA wires have high surface roughness.

1. Excellent formability,
2. Possesses true weldability,
3. Excellent corrosion resistance,
4. Absence of nickel.

<i>Composition</i>	
Titanium	—79%
Molybdenum	—11%
Zirconium	—06%
Tin	—04%

Study model

Orthodontic study models are essential diagnostic records, which help to study the occlusion and dentition from all three dimensions. They are accurate plaster reproductions of the teeth and their surrounding soft tissues.

Ideal requirements of orthodontic study models

1. Models should accurately reproduce the teeth and their surrounding soft tissues.
2. Models are to be trimmed so that they are symmetrical and pleasing to the eye and so that an asymmetrical arch form can be readily recognized.
3. Models are to be trimmed in such a way that the dental occlusion shows by setting the models on their backs.
4. Models are to be trimmed such that they replicate the measurements and angles proposed for trimming them.
5. Models are to have clean, smooth, bubble-free surfaces with sharp angles where the cuts meet.
6. The finished models should have a glossy stain proof finish.

Importance of study models

1. They are invaluable in planning treatment, as they are the only three dimensional records of the patient's dentition.
2. Occlusion can be visualized from the lingual aspect.
3. They provide a permanent record of the inter-maxillary relationships and the occlusion at the start of therapy; this is necessary for medico-legal considerations.
4. They are a visual aid for the dentist as he monitors changes taking place during tooth movement.
5. Help motivate the patient, as the patient can visualize the treatment progress.
6. They are needed for comparison at the end of treatment and act as a reference for post treatment changes.
7. They serve as a reminder for the parent and the patient of the condition present at the start of treatment.
8. In case the patient has to be transferred to another clinician, study models are an important record.

Uses of study models

Assess and record dental anatomy

Assess and record inter-cuspal relation

Assess and record arch form

Assess and record the curves of occlusion

Evaluate occlusion with the aid of articulators

Measure progress during treatment

Detect abnormality, e.g. localized enlargements, distortion of arch form, etc.

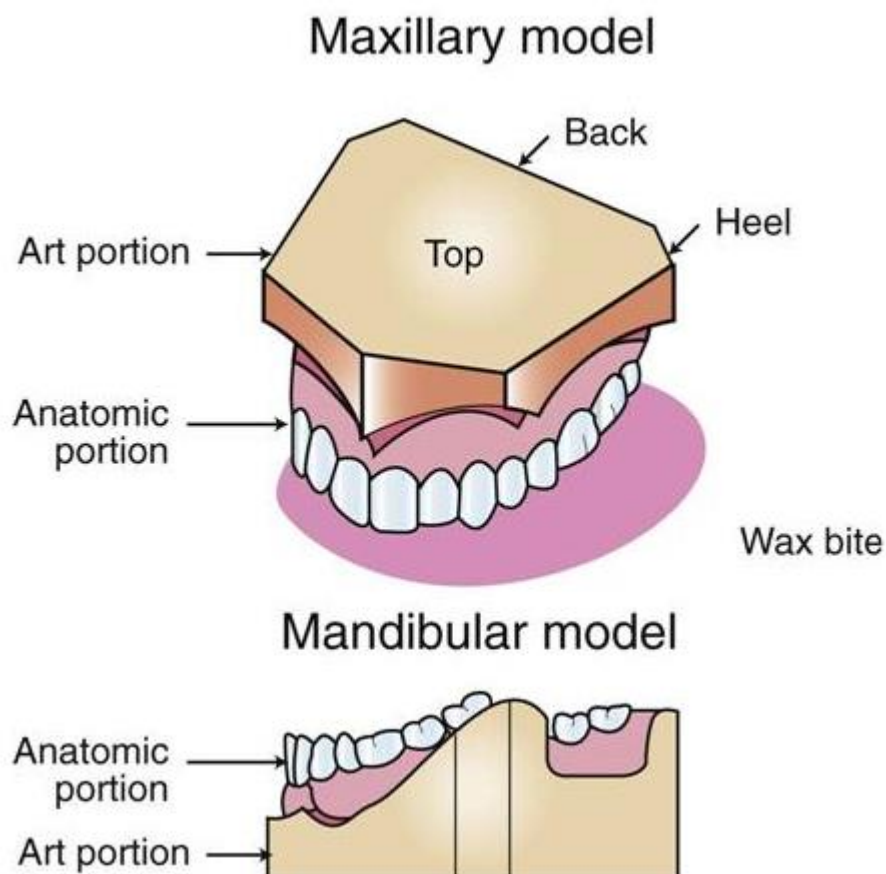
Calculate total space requirements/discrepancies

Provide record before, immediately, after and several years following treatment for the purpose of studying treatment procedures and stability.

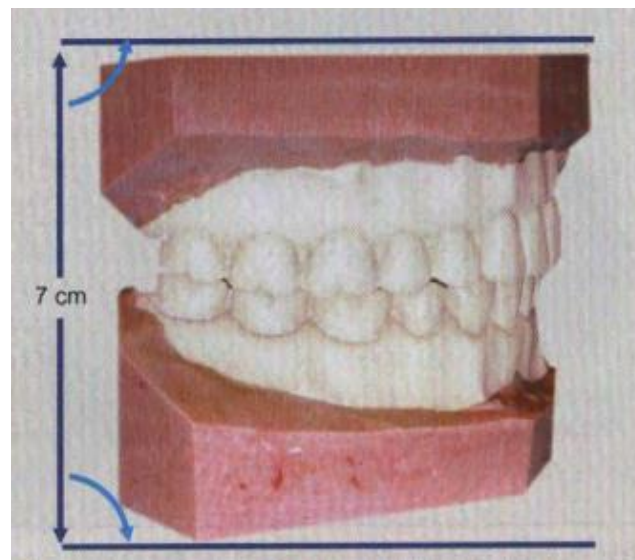
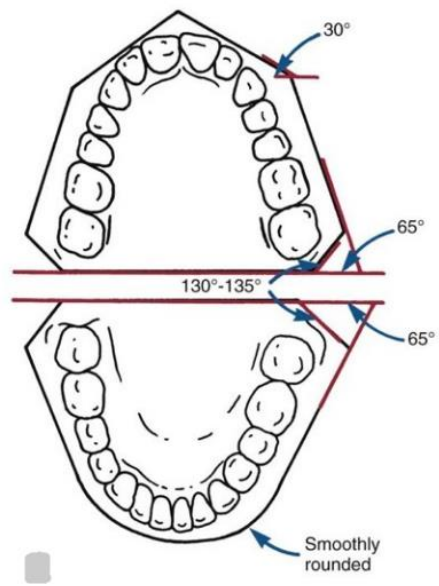
Parts of the study models

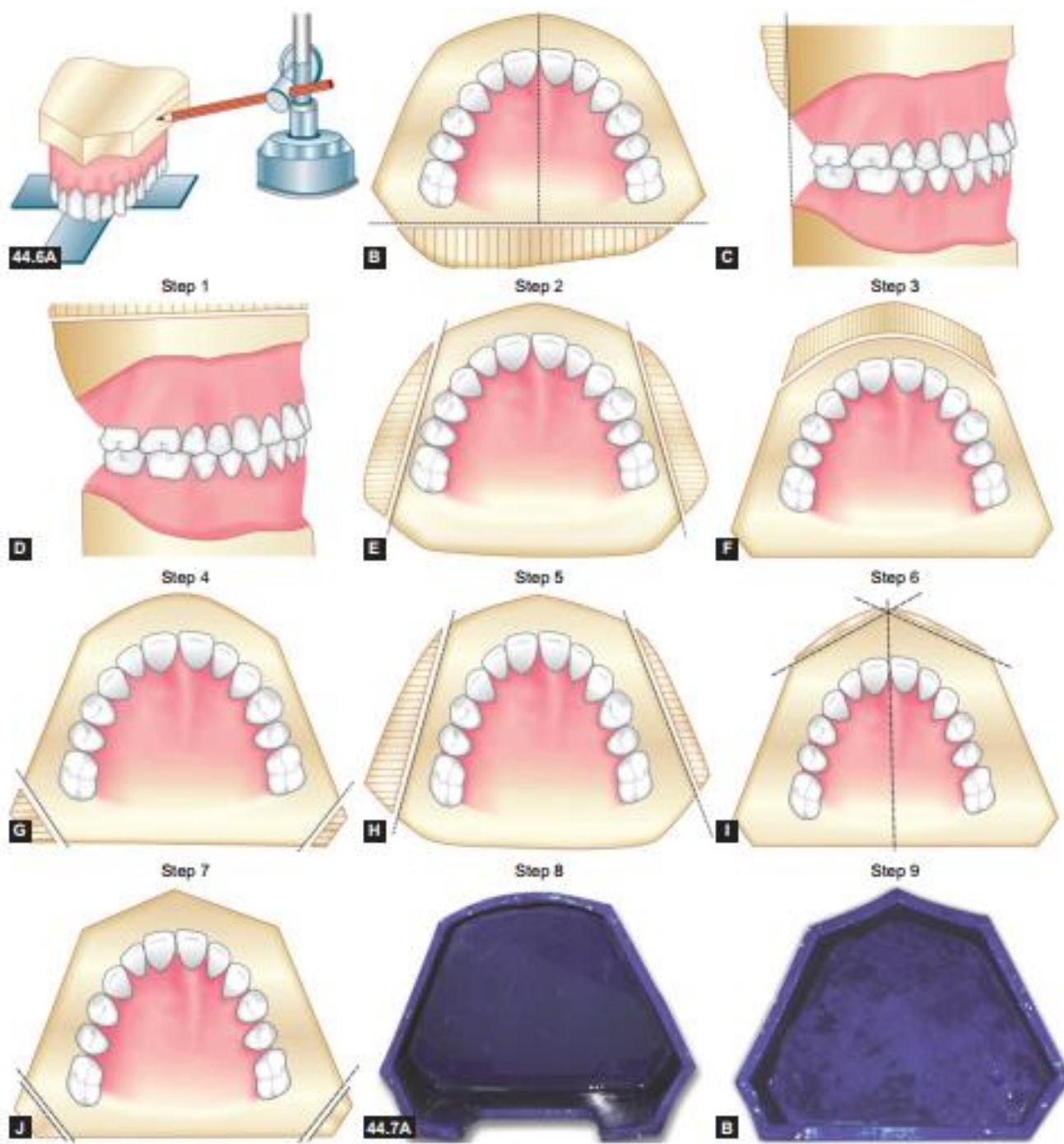
The study models can be divided into two parts for the purpose of description:

- The anatomic portion is that part which is the actual impression of the dental arch and its surrounding soft tissue structures. This is the part, which must be preserved when trimming the model.
- The artistic portion is the stone base supporting the anatomic portion. This portion is trimmed in a manner, which depicts, in a general way, the dental arch form and is pleasing to the eye.



Orthodontic casts have traditionally been trimmed with symmetric bases. The backs are trimmed perpendicular to the mid-sagittal line, most easily visualized as the mid-palatal raphe for most patients. The angles shown for the casts are suggested values; symmetry is more important than the precise angulations'.





Digital study models technologies

Digital technology started to make its way into dental and orthodontic offices with the introduction of Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM). CAD/CAM software is used to design and manufacture prototypes, finished products, and production runs of products.

CAD/CAM Components

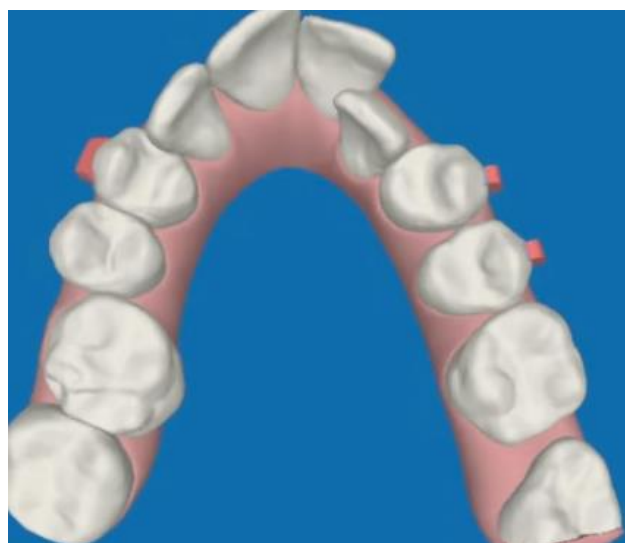
CAD/CAM systems are composed of three major parts: First, a data acquisition unit, which collects the data from the area of the preparation, adjacent and opposing structures. Then converts them to virtual impressions through intraoral scanners (in-office CAD/CAM or in-office CAD or image acquisition systems) or indirectly using a stone model generated through making a conventional impression. Second, the software used for designing virtual restorations on a virtual working cast and then computing the milling parameters. Third, a computerized milling device used for manufacturing the restoration from a solid block of restorative material or additive manufacturing.

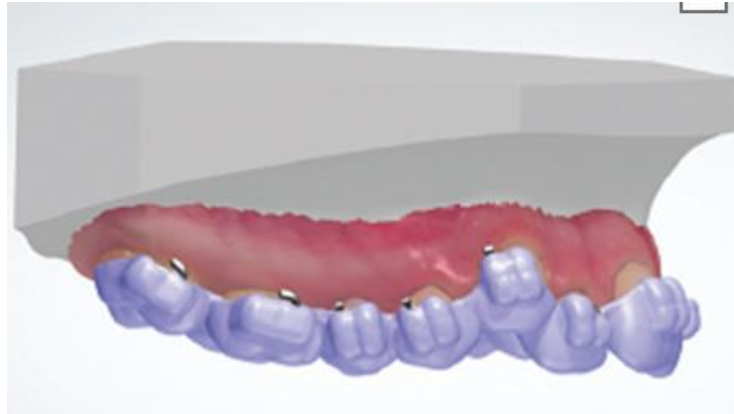
Intraoral scanners can offer significant advantages, such as:

Reduced patient discomfort, time efficiency, simplification of clinical procedures, and the benefit of capturing and storing highly accurate information.

Their use in the area of orthodontics is growing wider in recent years due to:

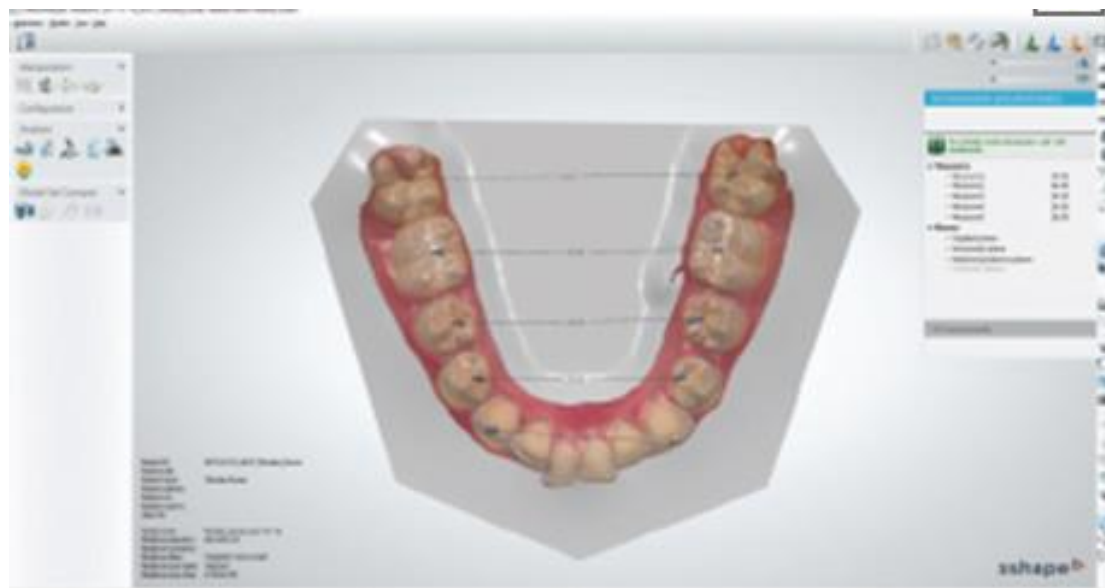
Their potential to perform full arch scanning, indirect bonding, and digitally fabricate fixed orthodontic appliances. They also facilitate orthodontic diagnosis and treatment planning, offering easy and fast electronic transfer of data, immediate access, and reduced storage space requirements.

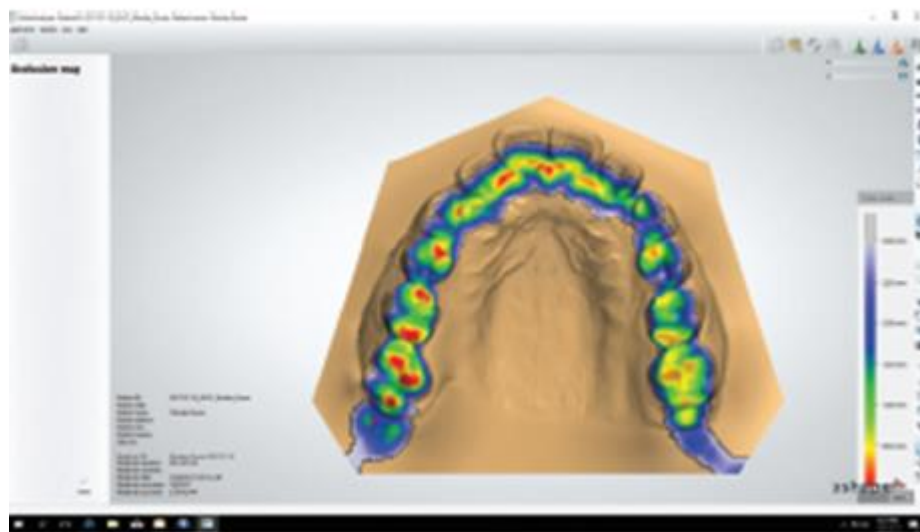




Intraoral scanners provide the orthodontist with numerous applications, such as:

Measurements of arch width and length, tooth size, transverse dimensions, Bolton discrepancy, overjet, and overbite, which are obtained with a remarkable accuracy and efficiency. The user can also create a digital diagnostic set-up, and simulate a proposed treatment plan, giving the opportunity to establish a more substantial relationship between patient and orthodontist.





Initial Consultation	Diagnosis	Treatment Plan	Treatment	Retention
Digital records (photos, X-ray/cone-beam computed tomography, intraoral scanning)	Analysis (radiographs, scan data)	<ul style="list-style-type: none"> - Virtual setup - Surgical treatment simulation 	<ul style="list-style-type: none"> - Indirect bonding - Clear aligners - Customized brackets - Appliances 	<ul style="list-style-type: none"> - Retainers - Outcome, follow-up comparison