Sri Aurobindo College of Dentistry

Indore, Madhya Pradesh

INDIA

MODULE PLAN

- Topic : ***BIOMECHANICS***
- Subject: Orthodontics
- Target Group: •Undergraduat Dentistry
- Mode: Powerpoint – Webinar
- Platform: Institutional LMS
- Presenter: •**Dr. Ashish Garg**

IN ORTHODONTICS, WE DEAL WITH FORCES AND REACTIONS OF TISSUES TO THESE FORCES. THE BEHAVIOR OF OBJECTS, IN RESPONSE TO THESE FORCES, IS GOVERNED BY CERTAIN LAWS OF PHYSICS. **BIOMECHANICS** DEALS WITH THESE LAWS. A CLEAR KNOWLEDGE OF BASICS OF BIOMECHANICS IS ESSENTIAL FOR THE PROPER UNDERSTANDING, AS TO HOW THE TEETH MOVE AND HOW WE CAN OPTIMIZE OUR TREATMENT FOR BEST RESULTS.

01. Centre of Mass
02. Centre of Gravity
03. Tipping movement
04. Bodily movement / Translation
05. Couple
06. Centre of Resistance
07. Centre of Rotation
08. Moment of a Force
09. Moment of a Couple
10. Moment to Force Ratio

Each body has a point in its mass, which behaves as if the whole mass is concentrated at that single point, which we call the **Centre of mass** in a gravity free environment. The same is called **Centre of gravity** in an environment where gravity is present.

When a force is applied on this body below its Centre of mass, it tips and moves forward. When another force is applied above the Centre of mass, the body will again tip and move forward.

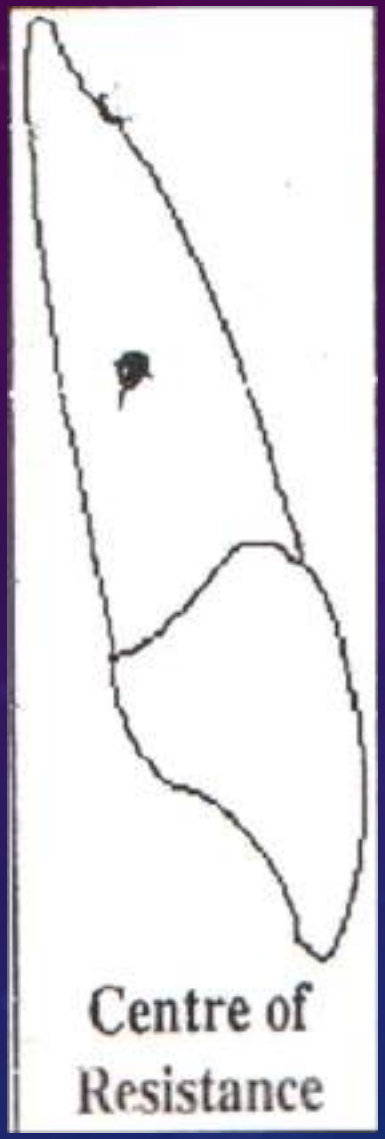
We are all familiar with the term **force**, but what exactly does it mean? Force is a load applied to an object that will move it to a different position in space. Though defined in units of **Newton's** it is usually measured in units of **grams** or **ounces.**

Further, if the same body is acted upon by two forces, one above and another below the centre of mass, which are equal in magnitude and opposite in direction, it will spin the body around its centre of mass and this situation is called a **couple.**

This couple can be either in a clockwise or counterclockwise direction.

If the force is passing through the Centre of mass, the whole body moves in a straight line, in a parallel fashion. Here all the points of the body get displaced equally from the initial position. This is called a **bodily movement or translation.**

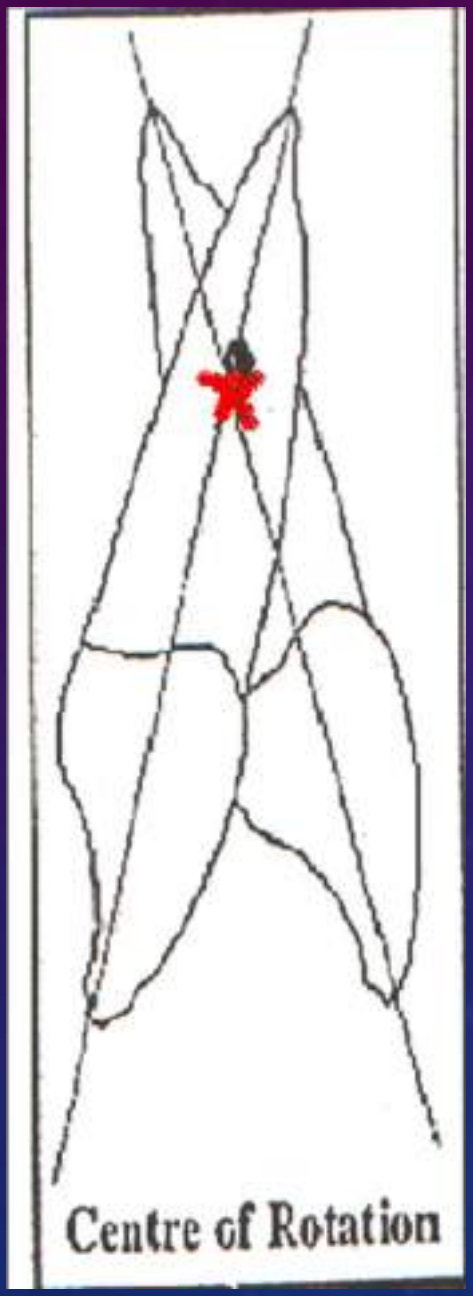
These concepts apply not only to a body but to any object including a **tooth** which is of primary concern to us. For example, a force applied below the Centre of gravity of the tooth will cause the tooth to tip and translate.



The Centre of gravity of the tooth is located more towards the crown of the tooth as the mass of the tooth is concentrated more coronally. Since the tooth is partially restrained as its root is embedded in bone, its Centre of gravity shifts apically and is then referred to as the **Centre of resistance.** This is represented by a black dot on the screen.

The Centre of resistance will be determined by the nature of the external constraints and is at the approximate midpoint of the embedded portion of the root. Centre of resistance is a point at which resistance to tooth movement is concentrated.

Now that we have understood some of the basic terms, let us see some clinical situations. Since the tooth is embedded in the alveolar bone, we can never apply a direct force on the Centre of resistance. We can only apply a force on the exposed part of the tooth which is at some distance from the Centre of resistance. Hence, the tooth tips around a point which coincides or lies close to the Centre of resistance.



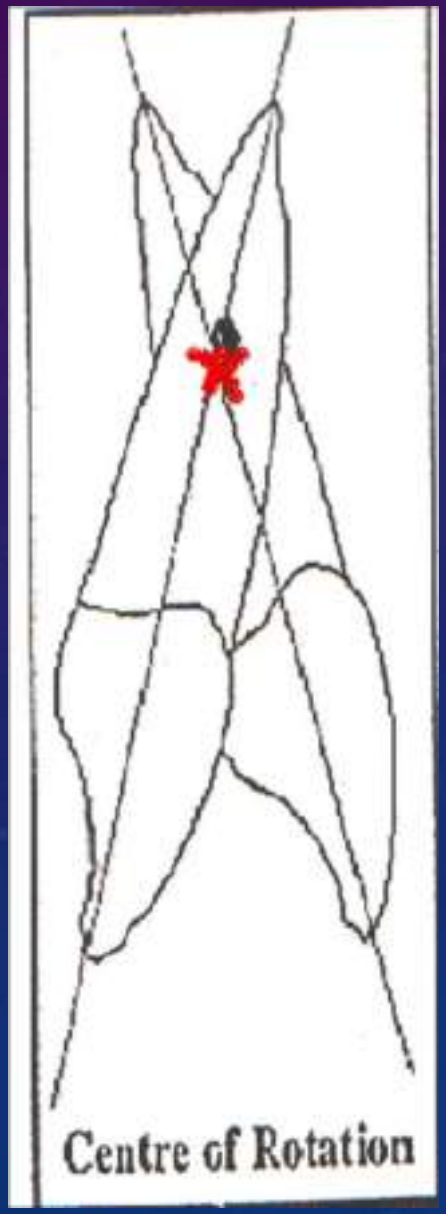
Now if you draw the long axis of the tooth in its initial and final position you will find that both these lines intersect at a point. This is the point around which the tooth rotates and is called the **centre of rotation.** This is represented by a red star on the screen.

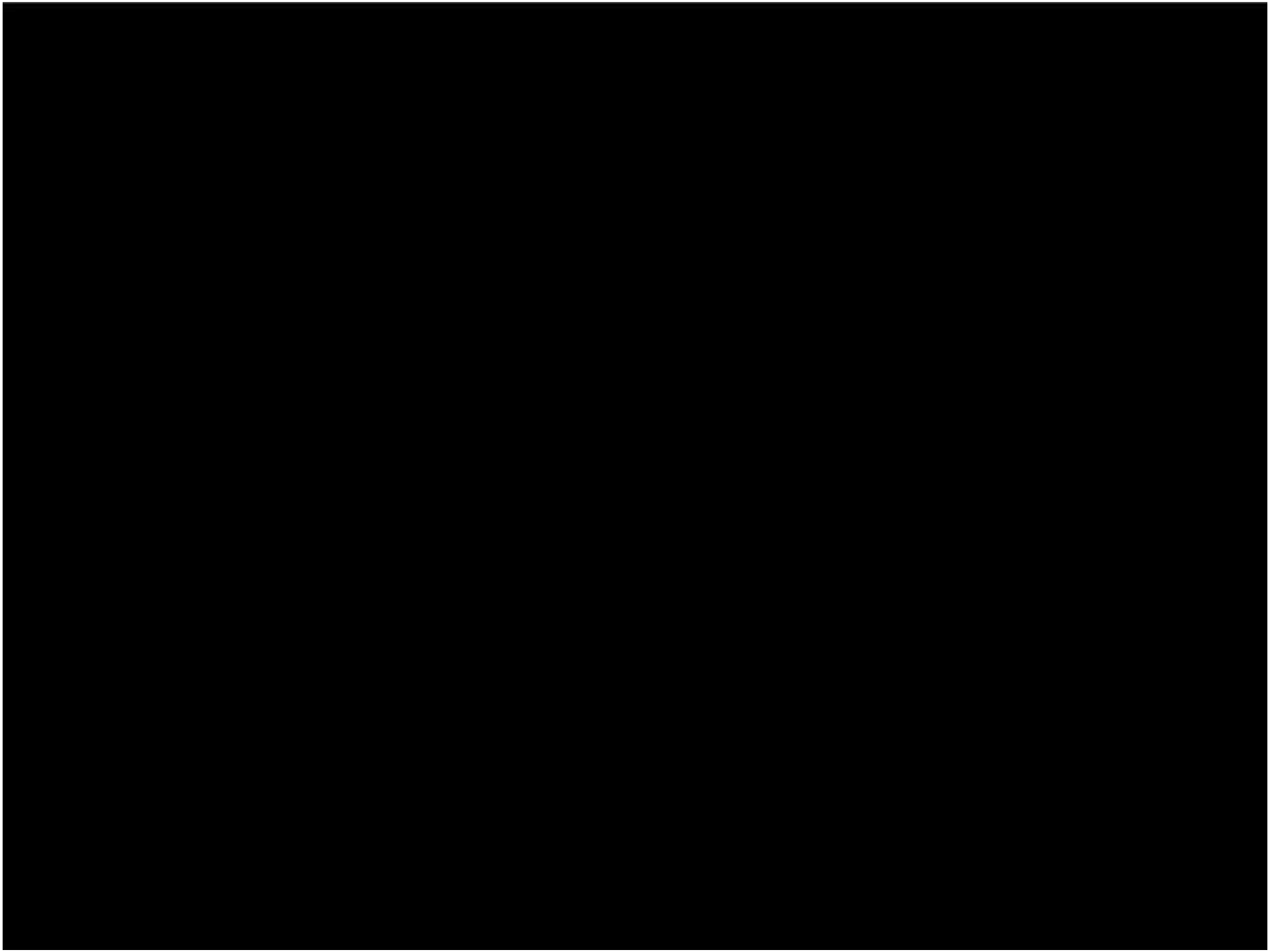
This Centre of rotation can be

a. at the Centre of Resistance,
b. apical to the Centre of resistance,
c. at the root apex or
d. it can be at infinity.

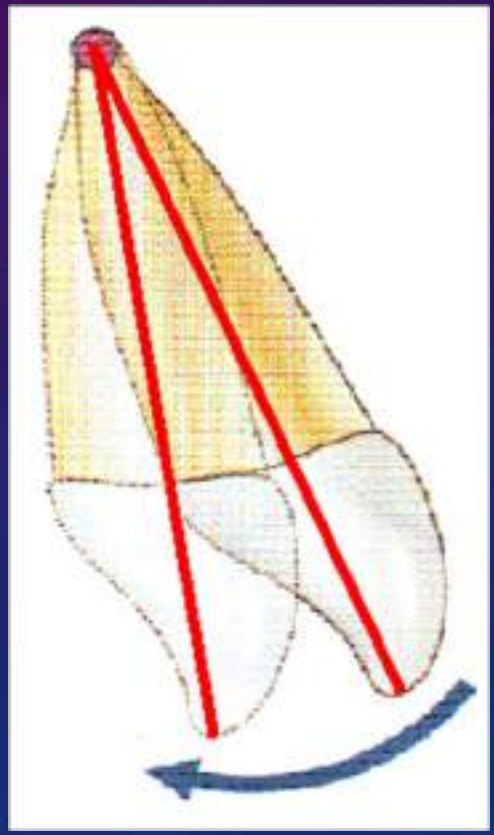
Depending on the Centre of rotation we can have uncontrolled tipping, controlled tipping, and translation or bodily movement.

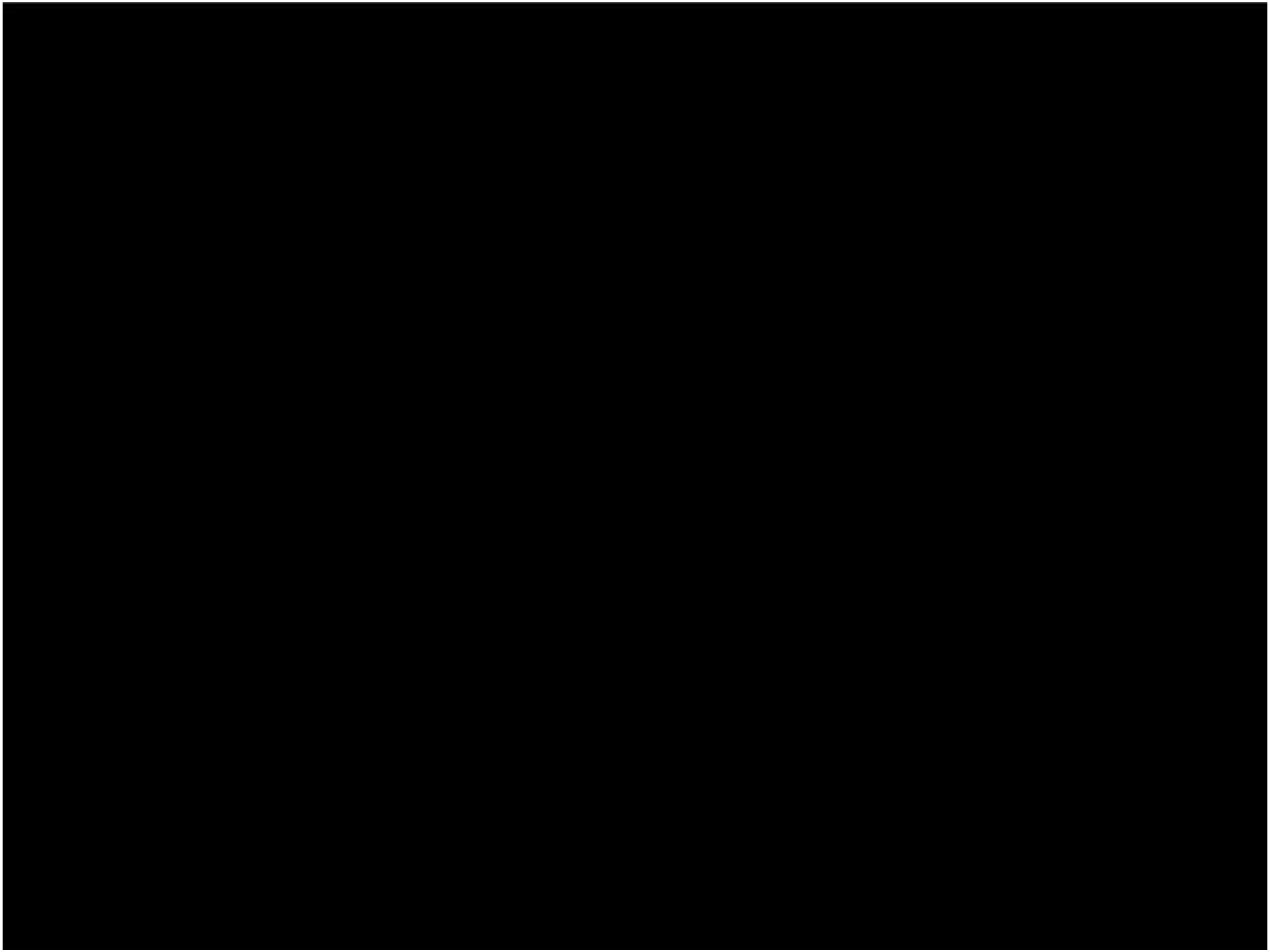
In the first situation as you can see here, when the force is applied, the crown moves in one direction and the root moves in the opposite direction. Here the Centre of rotation lies somewhere near the Centre of resistance of the tooth. This is referred to as **Uncontrolled tipping.**

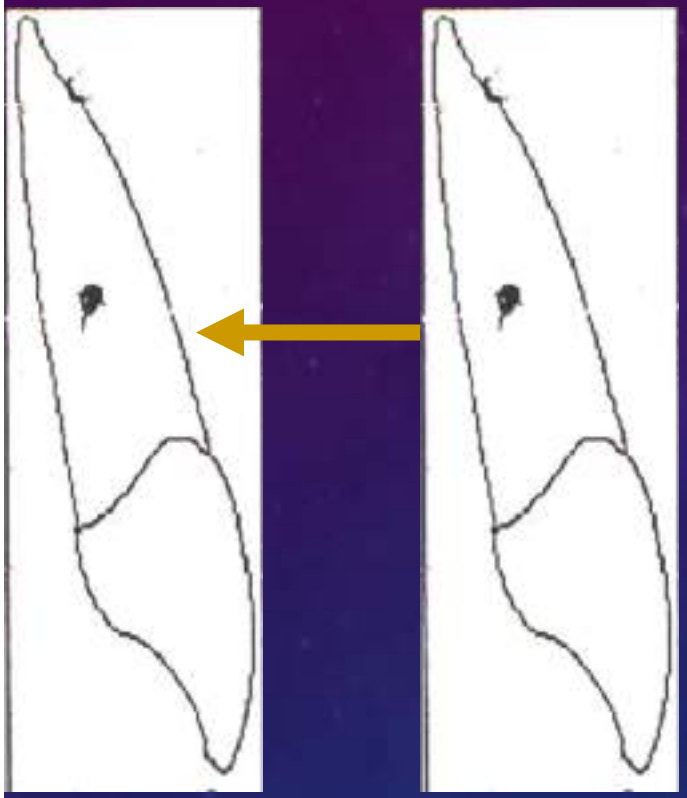




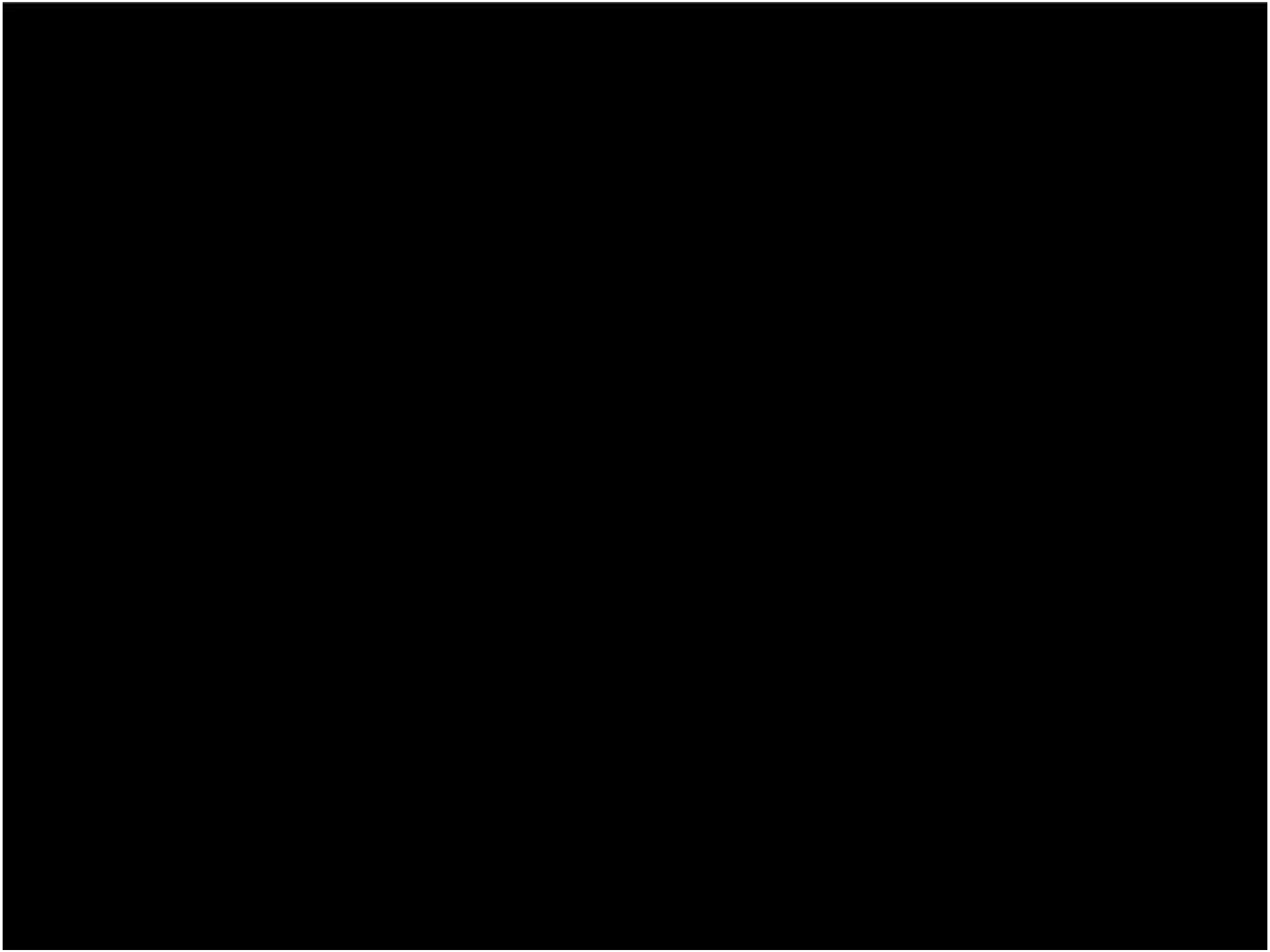
In the second case, the Centre of rotation lies near or close to the apex. Here the crown moves in one direction but the root position remains the same or gets minimally displaced. This is what is referred to as **Controlled tipping.**



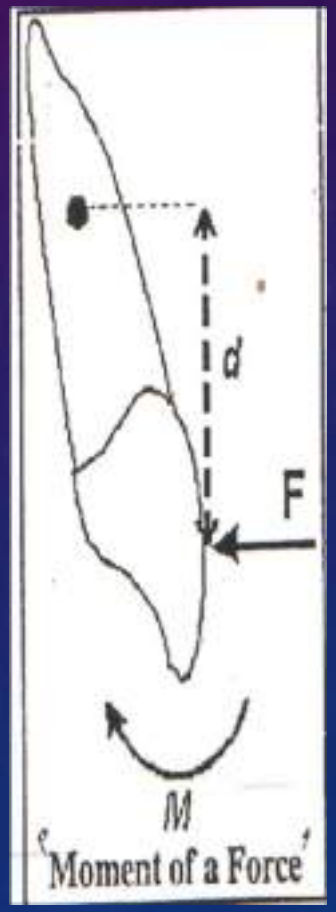




In the third situation where the long axis of the tooth in its initial and final position do not meet, the Centre of rotation lies at infinity. This is referred to as **Translation or Bodily Movement.** Generally speaking, the Centre of resistance of a tooth does not change, only the Centre of rotation changes.



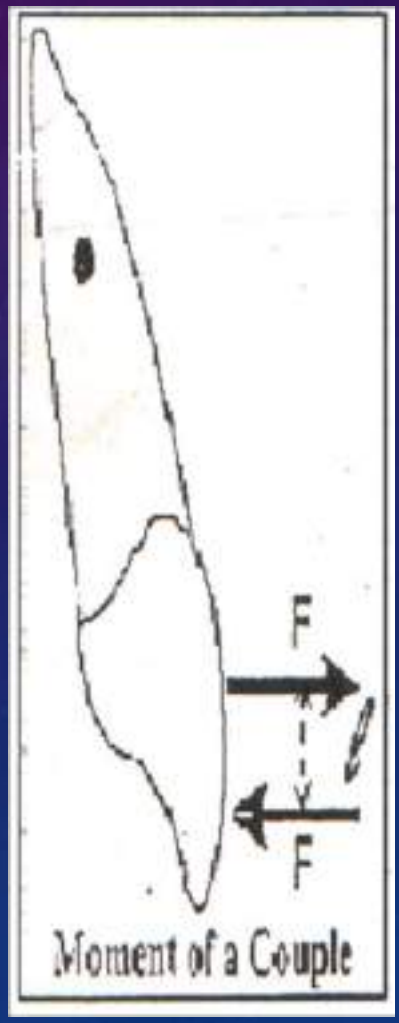
Since the tooth is embedded in the alveolar bone, the force we apply always acts at a distance from the Centre of resistance. The effect of this is termed as the **moment.** Moment is the product of force times the perpendicular distance from the point of force application to the Centre of resistance and is measured in units of **gm.-mm.**

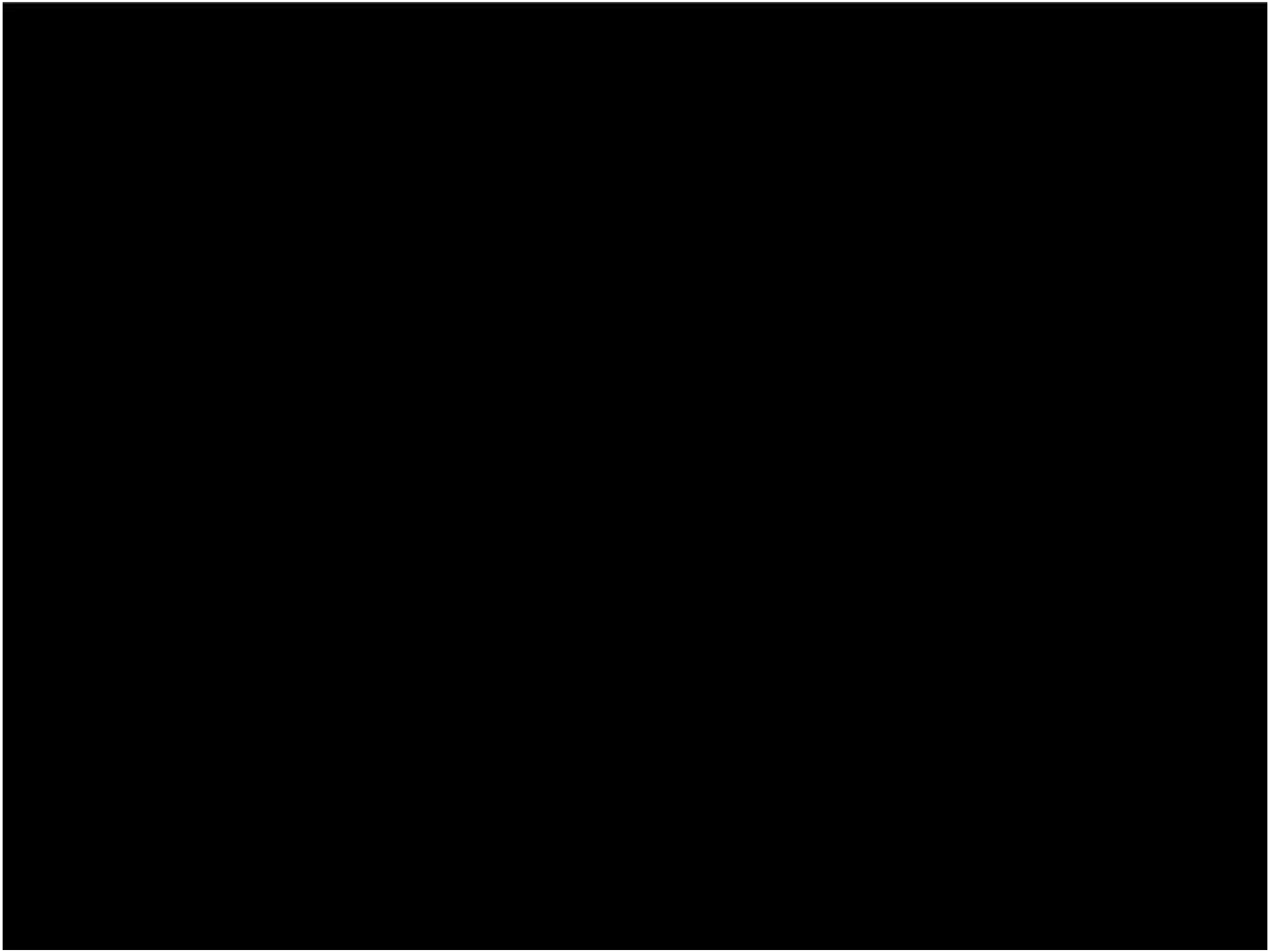


For example, if we apply 100gms of force at a distance of 10mm from the Centre of resistance of the tooth, a moment of 1000 gm-mm is produced. Depending upon the force applied or the distance at which it is acting, the moment can be varied. The effect of this force is to translate the tooth as well as to rotate the tooth around the Centre of resistance. **This moment is also termed as, moment of a force.**

Instead of a single force, if we apply two forces equal in magnitude and opposite in direction the moment created is called the **moment of a couple.**

The moment of a couple is the product of one of the forces times the distance between the two forces. This distance is called, the **moment arm of the couple.** When the tooth is embedded within the alveolar bone we cannot apply a couple with one force on the crown and the other force on the root. We can apply a couple only on the exposed part of the tooth.





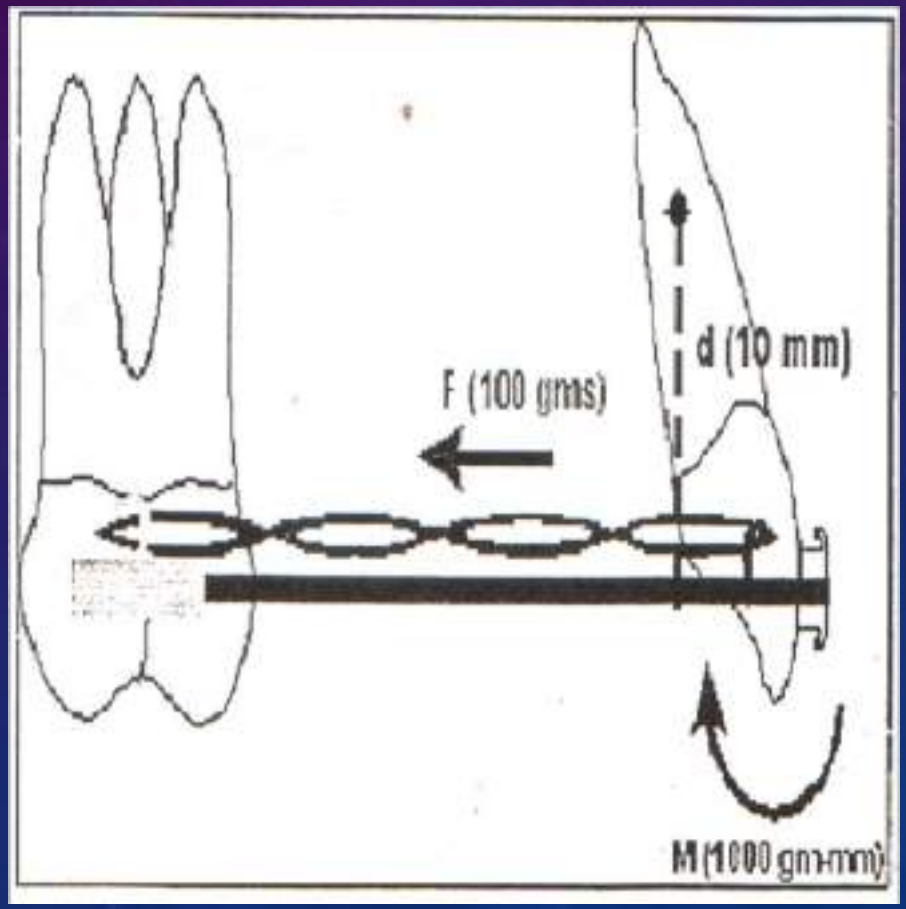
Now that we have understood the basic terms, lets see how they work in our **clinical situations.**

In order to retract an incisor tooth we apply a force on the crown of the tooth. This force creates a moment, as it is away from the Centre of resistance and will cause **tipping.** This is not the way we want the tooth to move. What we need is to keep the tipping of the tooth to a minimum, so we have to create another moment on this tooth, in a direction opposite to that created by the force. This can be done easily by applying a **couple having an anti-clockwise moment.**

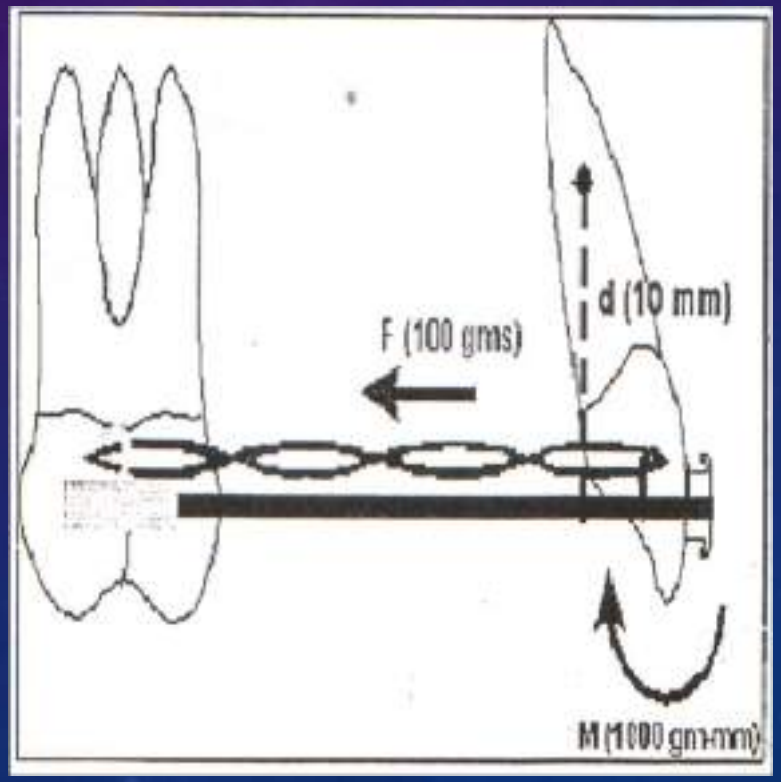
The ratio of moment produced to the net force that is applied will determine the type of tooth movement that will occur. This ratio is called the **moment to force ratio.**

Bodily movement of a tooth requires a moment to force ratio of **8:1 or 10:1** depending on the **length of the root.**

Let us consider a clinical situation of a tooth with an **edgewise bracket** where we want to retract the tooth in a **bodily fashion.**



Let us say we apply a force of 100gm, but because this force is acting at a distance from the Centre of resistance of the tooth, say 10mm, a clockwise or –ve moment of 1000gm-mm is produced which will cause the tooth to tip.



Since tipping is undesirable we must generate a counter balancing moment of 1000gm-mm so that a bodily movement is obtained. This can be achieved by **twisting the anterior segment of the rectangular wire** and fitting it into a rectangular slot. The wire is twisted as it is put into the bracket slot. The two points of contact are at the edges of the wire, which contacts the bracket.

Once this wire is engaged in the bracket slot it generates a moment of a couple called the **Inherent moment of a couple,** which is nothing but the couple produced within the wire itself. But in a rectangular wire the moment arm is the depths of the wire which is very small.

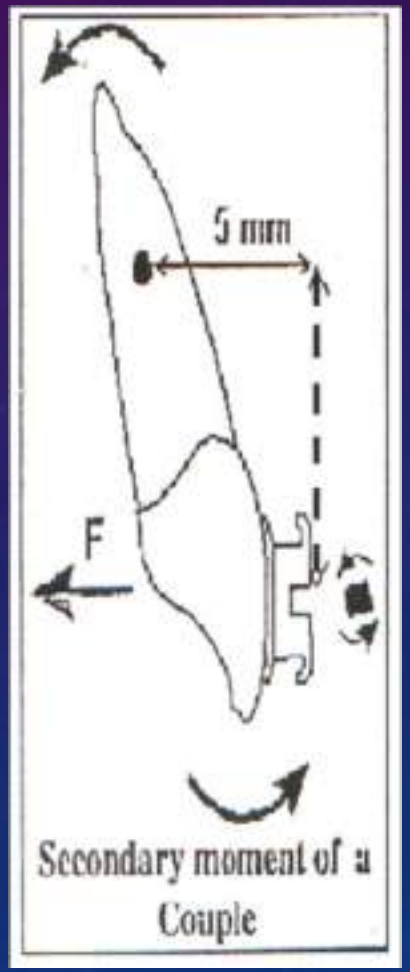
Since moment is force times the distance

Moment = Force x Distance,

therefore, force is equal to moment divided by the distance.

$$\text{Force} = \frac{\text{Moment}}{\text{Distance}}$$

From our clinical experience we know that such heavy forces are not required to achieve bodily movement. The reason for that being the moment of a couple generated by torquing the rectangular wire acts at a certain distance (say 5mm) from the Centre of resistance of the tooth. This again produces a moment of a couple called the **secondary moment of a couple.** This secondary moment of a couple adds to the inherent moment of a couple generated by the rectangular wire.



Therefore the actual force is 1000gm divided by 5mms which is around 200gms. This is clinically feasible.

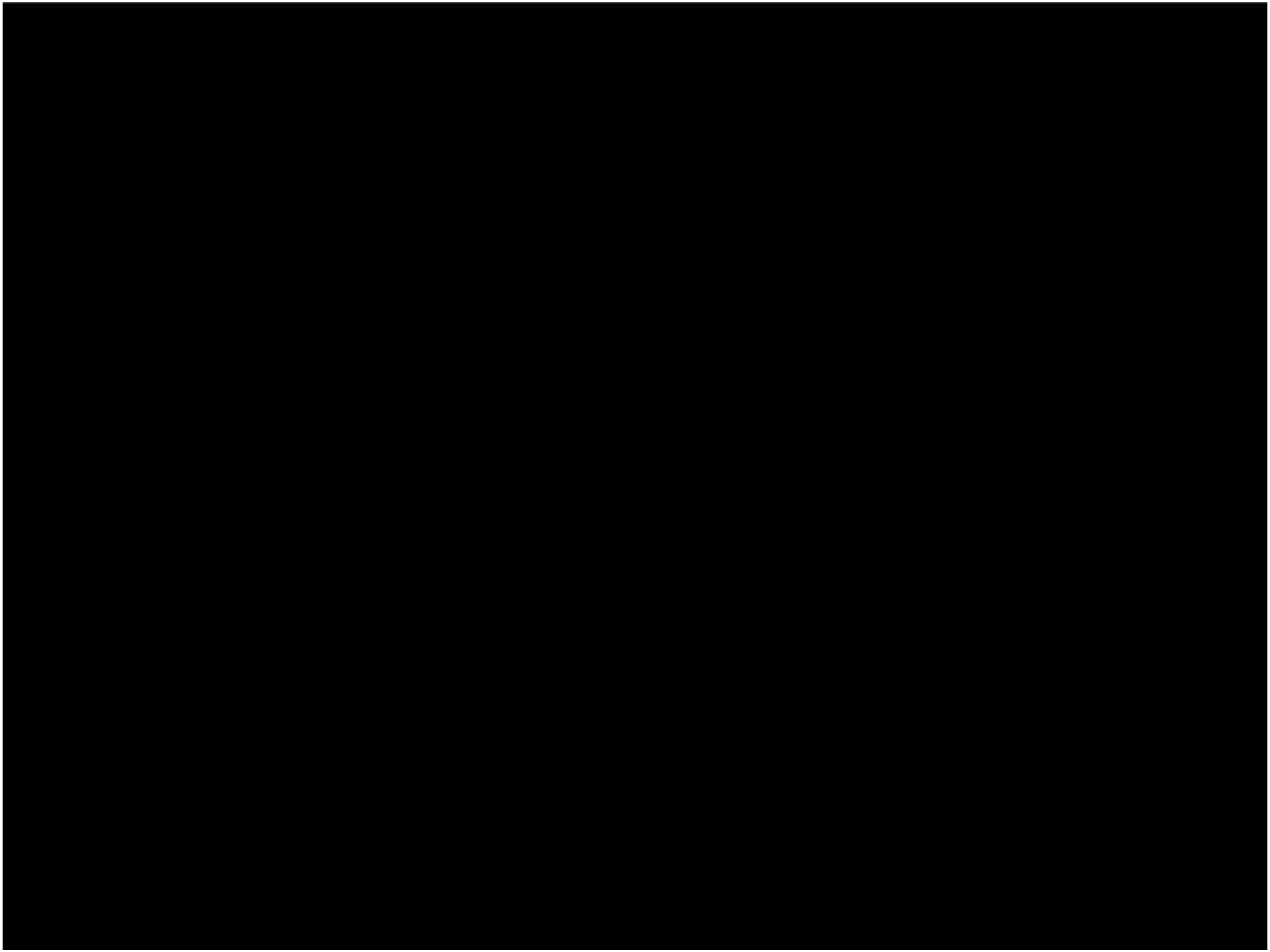
$$\text{Force} = \frac{1000}{5} = 200 \text{ gm.}$$

To summarize what we have discussed so far, the **M:F ratio,** that is, the ratio between the force applied to move a tooth and the counter balancing moment used to control root position determines the **type of tooth movement.**

With no counterbalancing moment, the tooth tips around the Centre of resistance which is called **pure tipping.**

As the **moment to force ratio increases,** the Centre of rotation is displaced further and further apically from the Centre of resistance producing what is called as **controlled tipping.**

With the moment to force ratio of **8:1 or 10:1** depending on the length of the root, the Centre of rotation is displaced to infinity and **bodily movement or translation** takes place.



THANK YOU