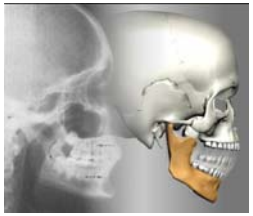
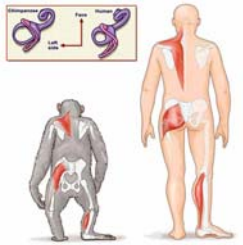


# Biomechanics



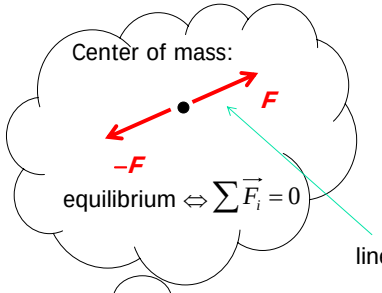


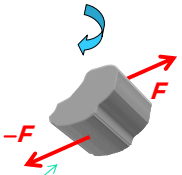


## Statics of the rigid body

Point-like mass body: ⟺ Extended rigid body:

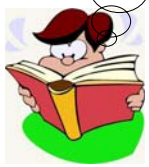
Center of mass:




$\sum \vec{F}_i = 0$

lines of action

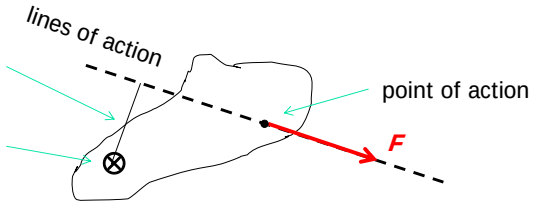


Rotation is possible!

(if the forces have no common line of action)



## Statics of the rigid body – torque




**torque (*M*):**

(moment or moment of force

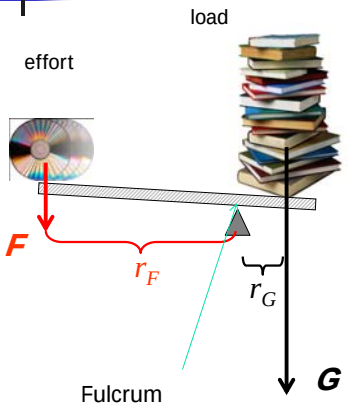
- tendency of a force or forces to rotate an object )

$M = r \cdot F$ Unit: Nm

equilibrium ⇔ $\sum \vec{F}_i = 0$ and $\sum M_i = 0$



## Lever: a simple machine




Equilibrium:

$\sum M_i = 0$

$r_G \cdot G = M_G = M_F = r_F \cdot F$

$\frac{G}{F} = \frac{r_F}{r_G}$

Mechanical advantage: increased force

$\frac{G}{F}$

## Examples












## Types

Force on load

effort

**Class 1**

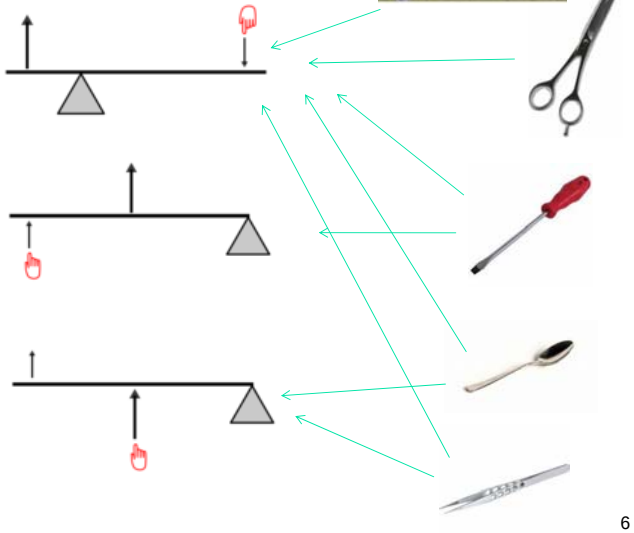
Fulcrum between the effort and load.

**Class 2**

The effort and load on the same side.

**Class 3**

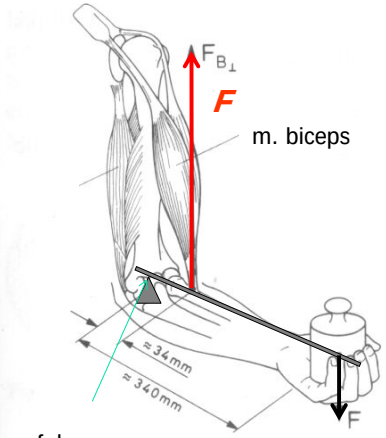
mechanical disadvantage, distance moved by the load is greater.



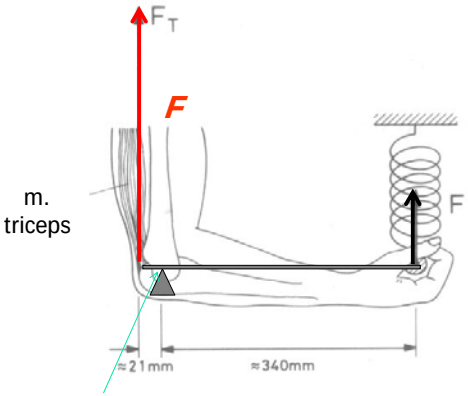


## In the human body

Arm:



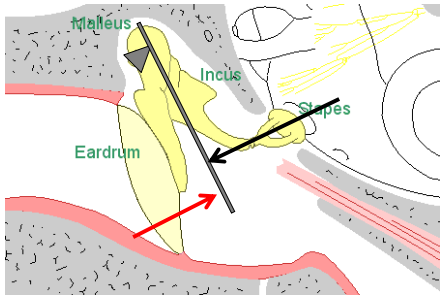

Class 3




Class 1



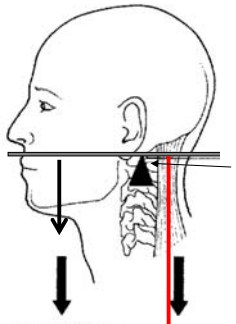
Ear bones:



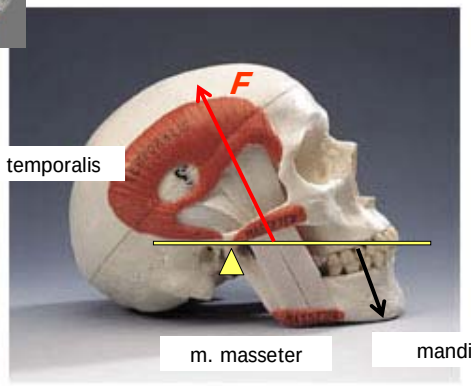

Class 2

Holding the head:

Class 1



Class 3



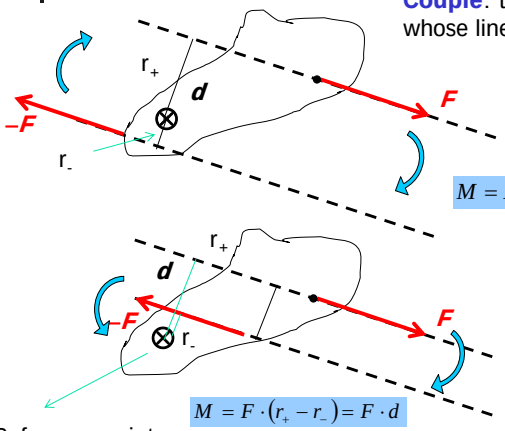



## In dentistry

Class 1



## Couple, replacement of system of forces




**Couple**: two equal and opposite forces whose lines of action do not coincide.

Resultant force: 0

Resultant torque (*M*)

$$M = F \cdot (r_- + r_+) = F \cdot d$$

$$M = d \cdot F$$

(independent of reference point)

$$M = F \cdot (r_+ - r_-) = F \cdot d$$

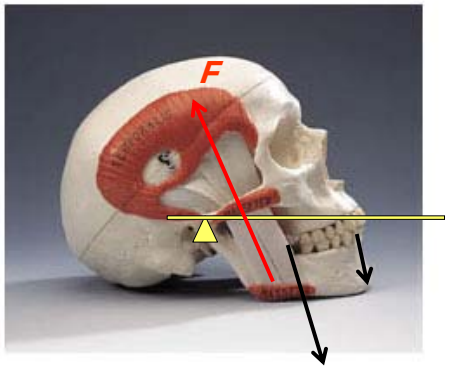
Reference point

Any system of forces may be replaced by a force and a couple.



## Masticatory force

Jaw elevators and depressors

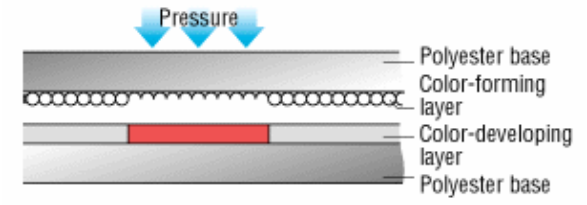

Force system

about 10 000 N

(Guinness: human - 4000 N)

## Measurement of the masticatory force

**Pressure indicating film:**




micro-encapsulated color forming and developing material

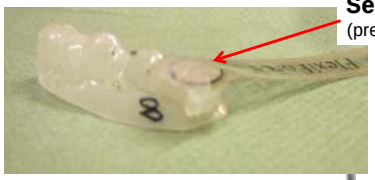
**Piezoelectric sensor:**

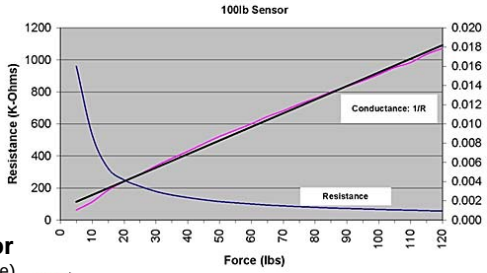
(look at piezoelectric effect!)

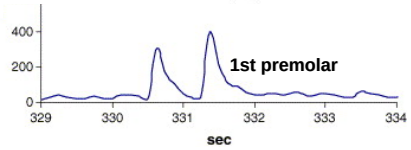



**Flexible printed circuit**

**Sensor** (pressure)





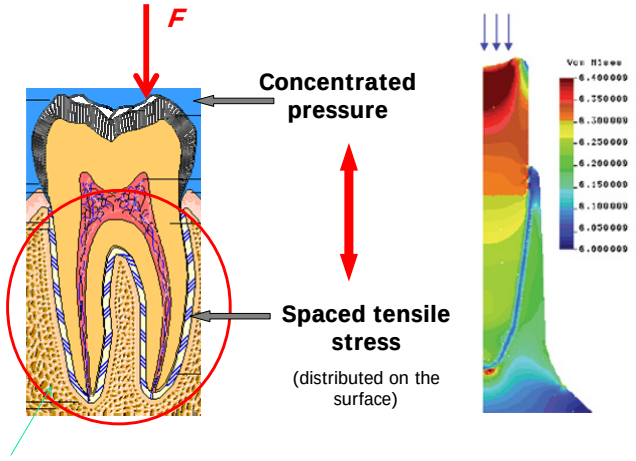


**Other (subjective) methods:**



## Transmission of forces to the bones

Typical load type (input):




Typical load type (output):



**Constructive effect on the bone!**

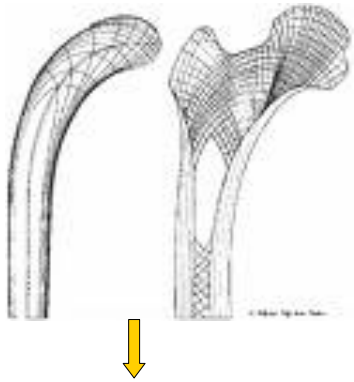


## Bone remodeling

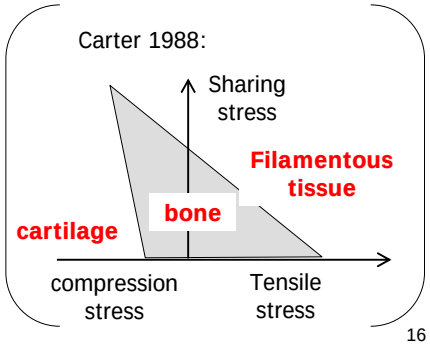
Wolff's law 1870: the bone in a healthy person will adapt to the loads.

Compression stress ⇒ bone resorption

Tensile stress ⇒ ossification



The role of the load



## Mechanism of bone remodeling

mechanical load

↓

electric signal
(piezoelectric/flow potential)

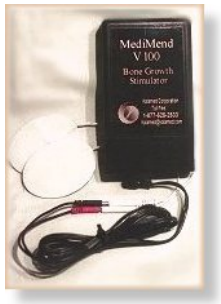
↓

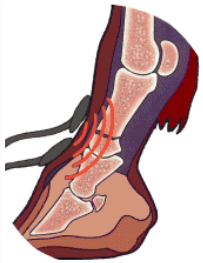
Regulation of the ossification
(osteogenesys)

↓

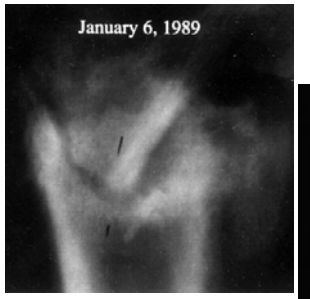
mechanical adaptation

Application of electric fields in the stimulation of bone healing:

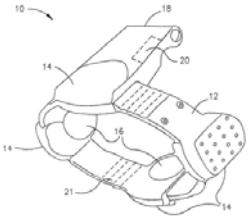


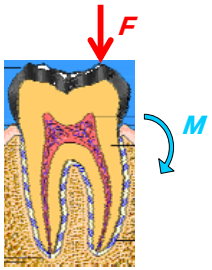


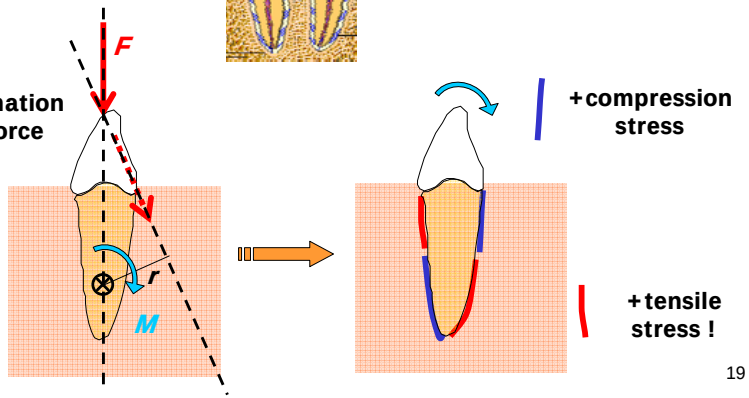




## Torque of the masticatory forces




$$M = r \cdot F$$

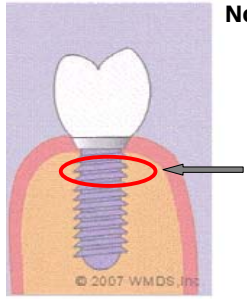


## Force transmission of dental implant

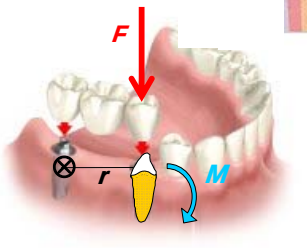
**osseointegration →** **Compression stress!**

**No force distribution!**


typical: titanium screw

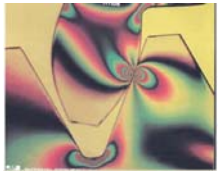



**stress concentration**



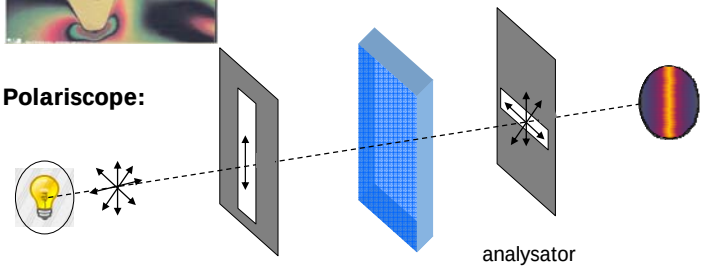

**→ large torque**

## Physical testing methods in implantology



- Stress-optic method

**Polariscope:**






## Computer based method

- **finite element method**

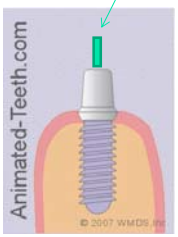
Calculation on a model.



## Stability test

- **Resonance Frequency Analysis** (**RFA**) is a method used to determine stability in dental implants.

small magnet




magnetic pulses are applied to a small magnet and the resonance is analysed.

- **Periotest**


Electrically driven head percusses the implant and the response is monitored.