# Physical bases of orthodontics

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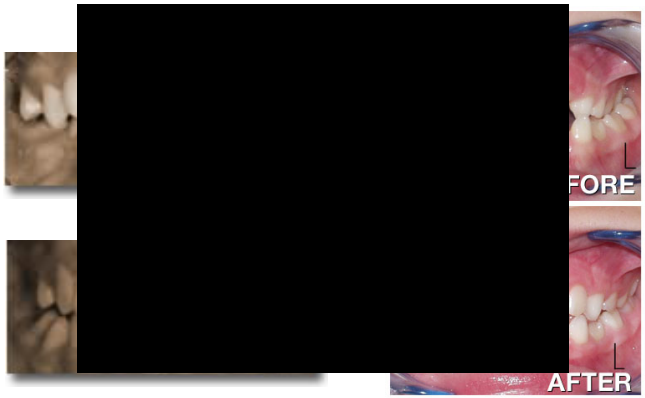


2

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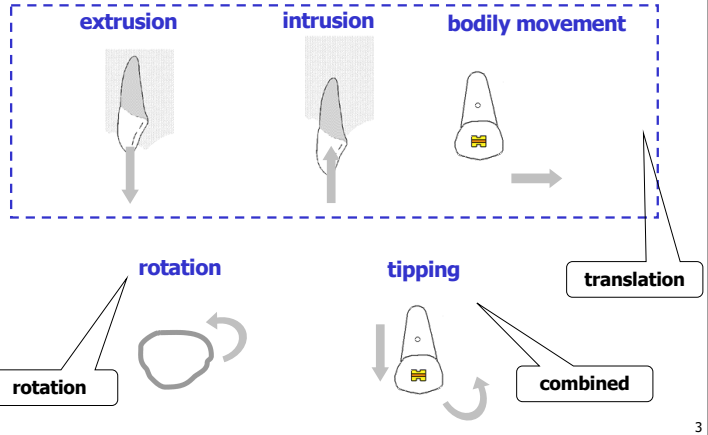
## Tooth movement in orthodontics




3

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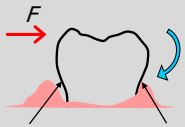
## Moving tooth by forces

Resting forces:
$F$ = 1–10 cN
„constant"
⇓
no consequence

Forces used in orthodontics:
$F$ = 50 cN — 400 cN
„constant"




tensile stress ⇓ bone growth (calcification)

compressive stress ⇓ bone decay (decalcifitation)

⇓

**bone remodelling** ⇒ tooth movement

Mastication:
$F$ = 100–800 N
$t \leq 1$ s
If it would be constant,
⇓
$t$ = 3–5 s: pain
≈ hours: damage
7–14 days: loosening

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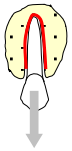
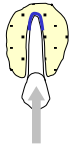
## Mechanisms of tooth movements

**translation**

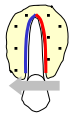
extrusion



intrusion



bodily movement

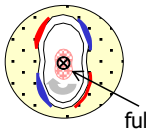


bone formation

bone decay

**rotation**

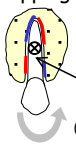
rotation



fulcrum

**translation + rotation**

tipping



fulcrum

(center of resistance = CR)

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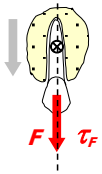
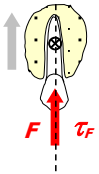
## Forces required for tooth movements

**extrusion:**



$F$ $\tau_F = 0$

**intrusion:**

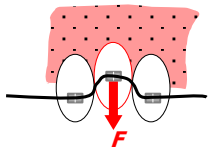


$F$ $\tau_F = 0$

⇒ single force without torque

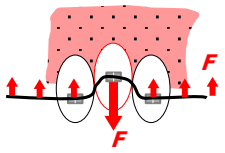
⇒ translation without rotation

Example:



$F$

force distribution (!):



$F$

$F$

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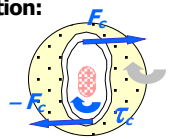
## Rotation:



$F_c$

$-F_c$

$\tau_c$

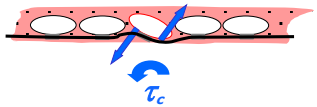
Couple results in tourqe only without net force

⇒ rotation without translation

$\Sigma F = 0$

couple = c

example:



$\tau_c$

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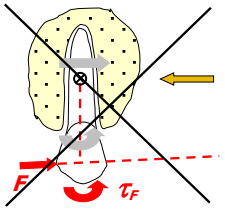
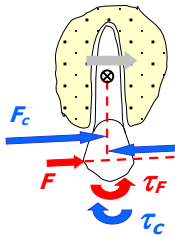
**Bodily movement:**



$F$

$\tau_F$

By using only one force torque woud be generated too.



$F_c$

$-F_c$

$F$

$\tau_F$

$\tau_c$

force + couple

⇒ translation without rotation

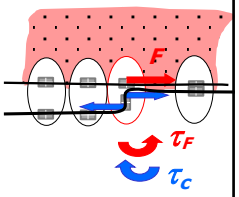
$\sum F = F$

$\sum M = 0$

translation only

$\tau_c = \tau_F$ ($\tau_c / \tau_F = 1$)

Example:



$F$

$\tau_F$

$\tau_c$

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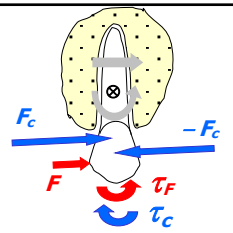
**Tipping:**




| force | couple | $\sum F$ | $\sum \tau$ | |
|---|---|---|---|---|
| – | ✓ | **0** | $\tau_c$ | ⇒ rotation |
| ✓ | – | $F$ | $\tau_F$ | ⇒ **tipping: :** translation + rotation |
| ✓ | ✓ | $F$ | $\tau_F - \tau_c$ | ⇒ **controlled tipping:** translation + rotation |

$0 < \tau_F - \tau_c \quad (\tau_F - \tau_c < 1)$

$\tau_F - \tau_c < 0 \quad (1 < \tau_F - \tau_c)$

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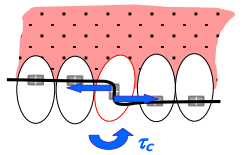
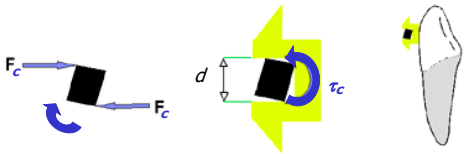
Example:

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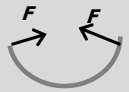
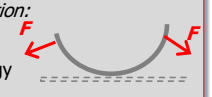
## Dental brace

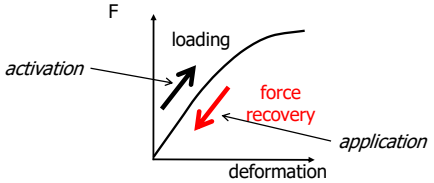
Dental braces are elastic bodies, that will recover the elastic energy after deformation by exerting forces on the teeth (**„mechanical battery"**).

*activation:*
deformation
(energy input)




*dental application:*
**recovery**
(stored energy utilizued)

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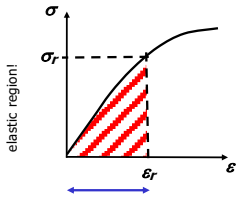
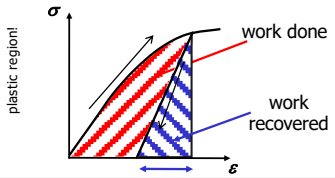
## Mechanical properties of braclets

- properties: stiffness, elastic strain recovery, resilience




work done = work recovered,
assuming no friction!!




Example:
- polymers
- steel
- Co-Cr alloys
- Ti alloys

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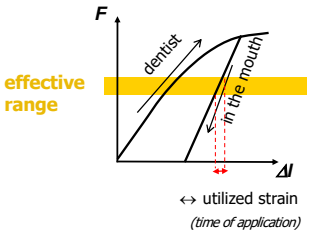
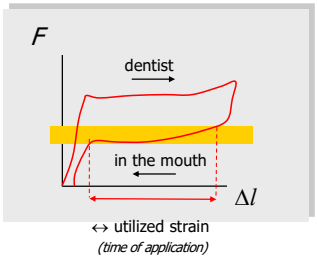
## Restoring force

- magnitude?
- time course?

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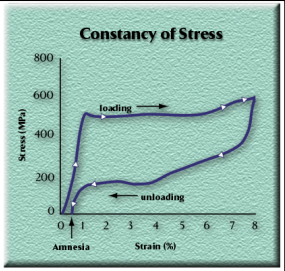
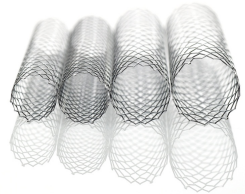
## Superelastic materilas

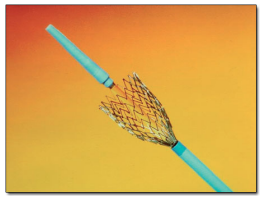
Ni+Ti  Cu+Al+Zn  Cu+Al+Ni

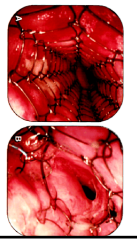
**Nitinol** (**Ni**ckel-**Ti**tanium **N**aval **O**rdnance **L**aboratory)

- Superelastic (pseudoplastic)
- shape memory
- biomechanical compatibility
- biocompatible







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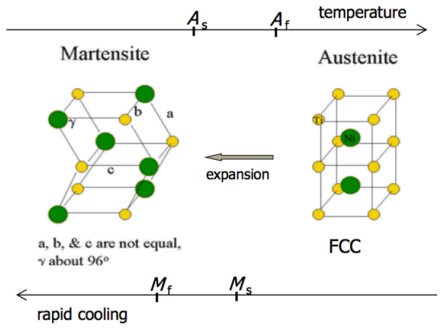
elastic (reversible) response to an applied stress, caused by a phase transformation between the austenitic and martensitic phases of a crystal.

$M_s$-martensite start temperature
$M_f$-martensite finish temperature
(totally martensite)

$A_s$- austenite start temperature
$A_f$- austenite finish temperature
(totally austenite)

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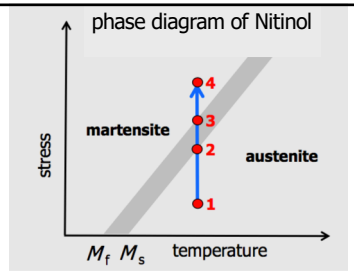


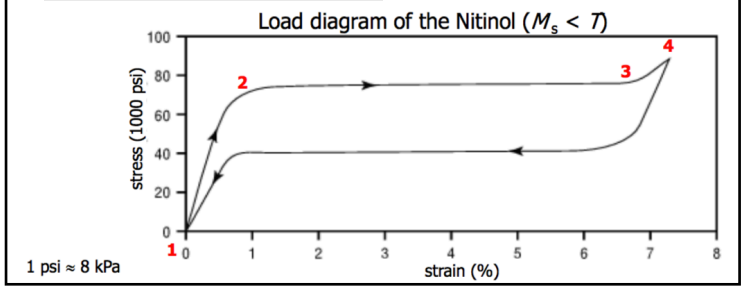


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