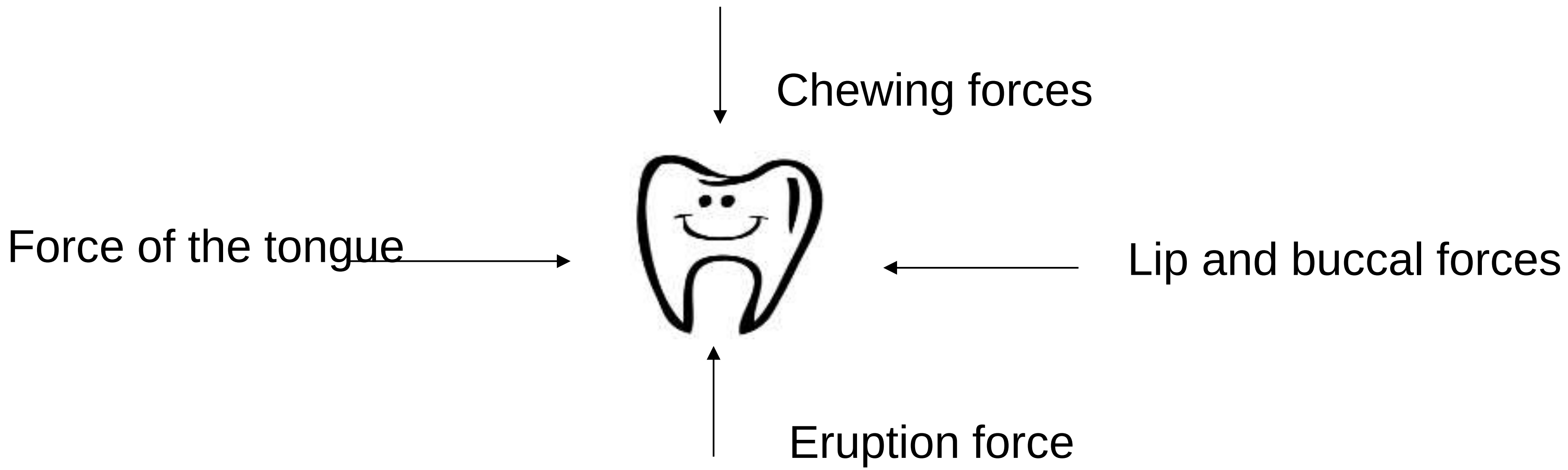
Biophysics of tooth movement

Dr. Bálint Nemes
Semmelweis University
Department of Pedodontics and Orthodontics

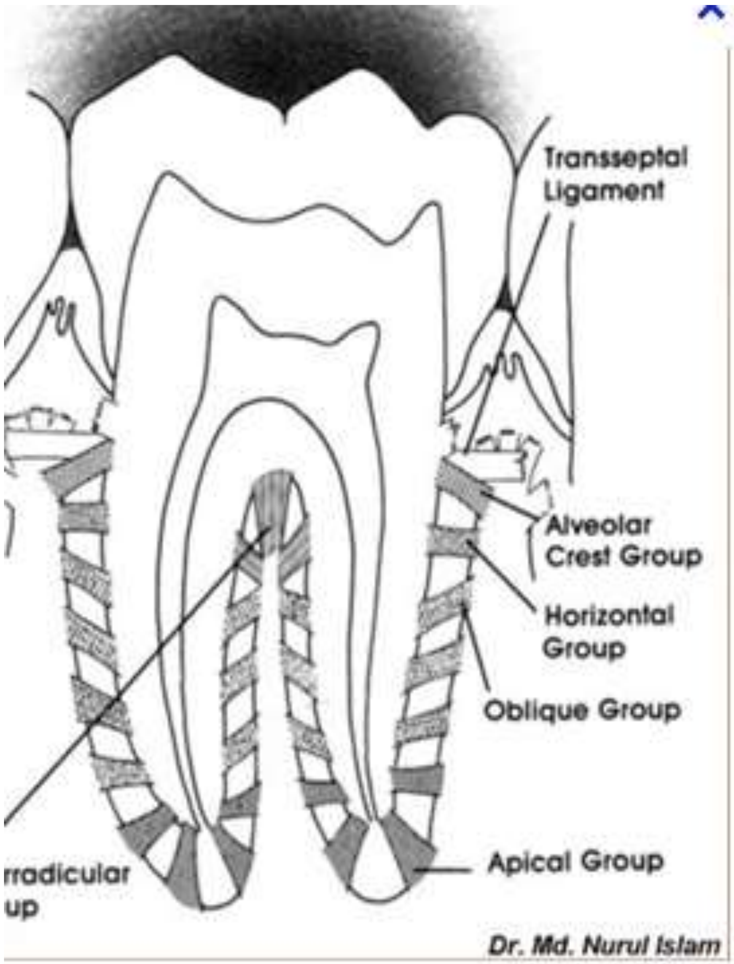
Tooth movement

<u>Eqilibrium Theory</u>:

The tooth does not move if the sum of forces acting to it, are zero. Is the balance changing, the tooth will start to move.



Light forces - Why?



The capillaries of the periodontal room are compressed if too big forces are acting. This results in decrease of the bone-metabolism. Hyalinic change of the bone will appear, wich to eliminate macrophages are needed. This takes more time and may damage the root surfaces.

Active tooth movement: Basic rules – I.

- On the tension side of the root, bone formation, on the pressure side bone resorbtion appears.

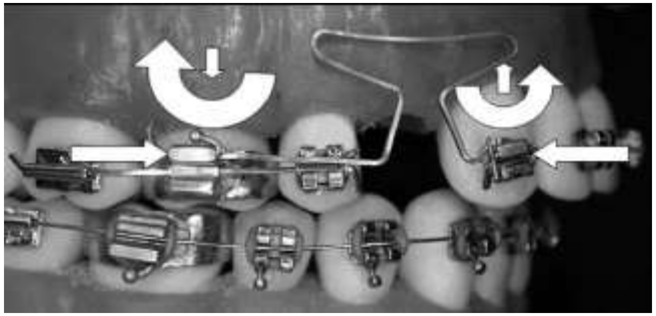
- Is the periodontal room overloaded, the capillaries are compressed. This will result in hyalinisation of the bone, and decreases the effectiveness of the tooth movement.

- Effective tooth movement is NOT right becouse of theese facts proportional to the magnitude of the force.The force magnitude has to reach a limit, but must not be too high.

Active tooth movement: Basic rules – II.

The force loaded to the tooth must be in proportion with the root surface. (Note: periodontally affected teeth – smaller root surface)

III. Law of Newton: Action = Reaction. Also the anchor-teeth move if they are loaded. (Skeletal anchorage is sometimes needed)



We can’t load the teeth in their resistence-center, so we always have to count with moments acting, wich result in tipping and rotation of the teeth.

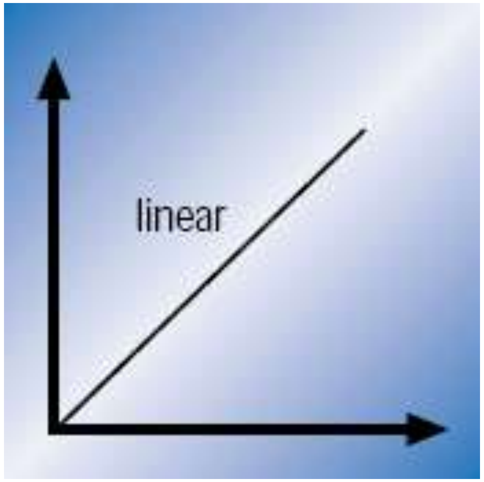
Force magnitudes in orthodontics

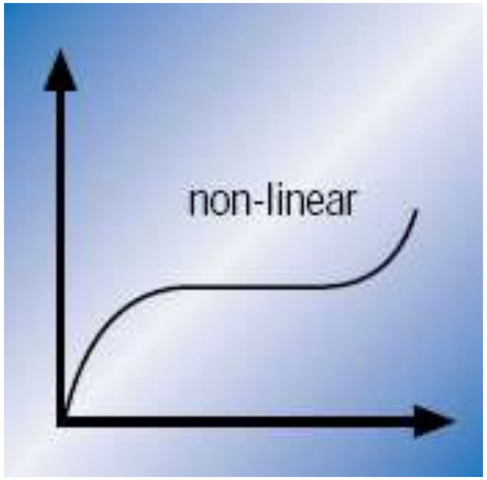
Numerical Force Values for Optimal Tooth Movements

TEETH	SHORT ROOTS	MED. LENGTH ROOTS	LONG ROOTS
Mandibular Incisors	50-55 gm.	55-65 gm.	65-70gm.
Mandibular Canines	85-95 gm.	95-110 gm.	110-130 gm.
Mandibular Premolars	70-80 gm.	80-90 gm.	90-100 gm.
Maxillary First Molars	280-300 gm.	300-320 gm.	320-360 gm.
Maxillary Incisors	65-75 gm.	75-85 gm.	85-95 gm.
Maxillary Lateral Incisors	60-65 gm.	75-85 gm.	85-95 gm.
Maxillary Canines	105-115 gm.	115-130- gm.	130-170 gm.
Premolars, Single Roots	85-100 gm.	100-115 gm.	115-135 gm.
Premolars, Multiroots	100-110 gm.	120-130 gm.	130-140 gm.
Mandibular First Molars	230-250 gm.	250-270 gm.	270-320 gm.

Elasticity and material characters

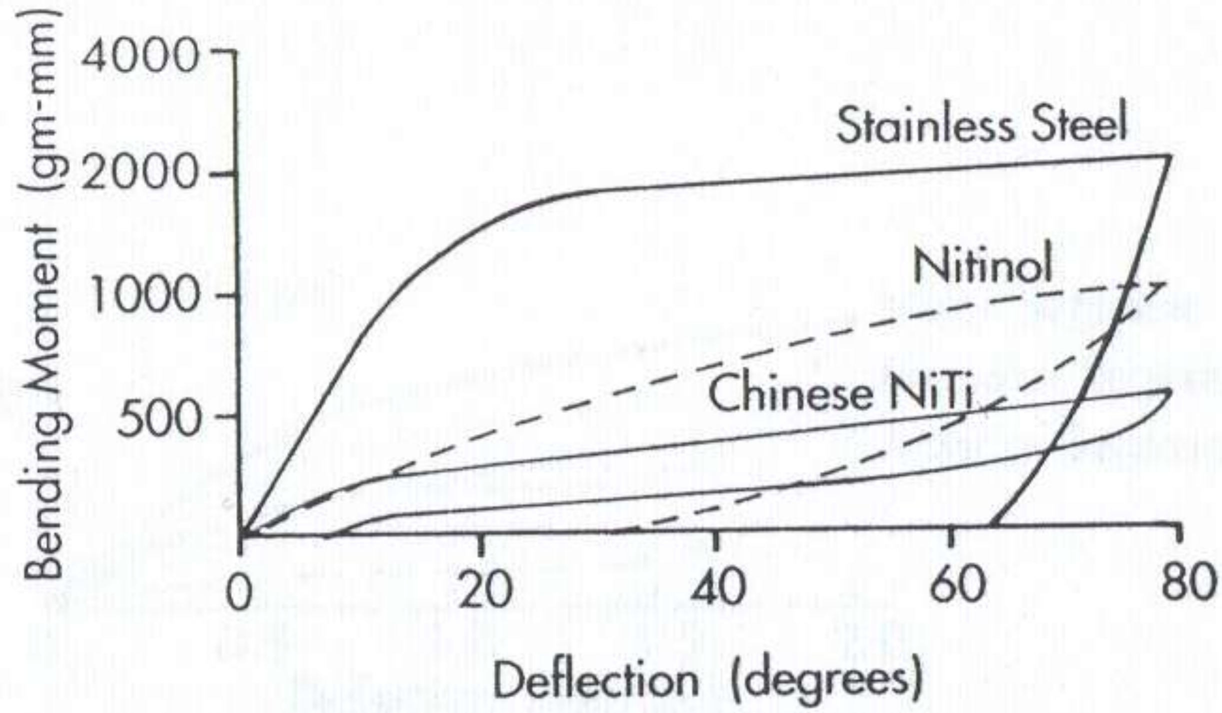
- Gold-alloys
- Steel-alloys
- Titanium-alloys





Steel-alloys

- Cr-Ni-Fe
- Co-Cr-Ni-Fe



Co-Cr-Ni-Fe
Elgiloy

- Ingrediants:

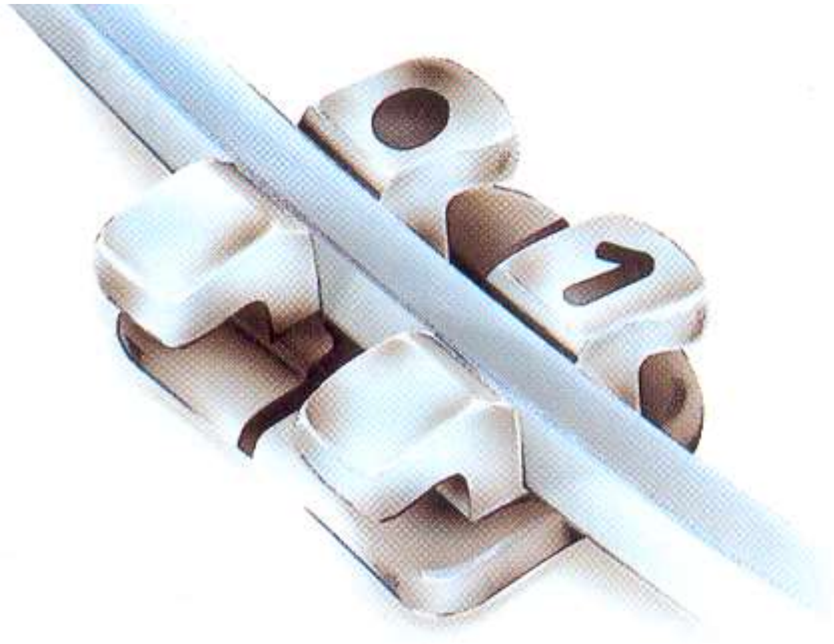
  Cobalt(40%)

  Crom(20%)

  Nikkel(0,15%),
  Molibden(7%),
  Mangan(2%),
  Berillium(0,04%)
  Carbon(15%

  Steel (15,81%)

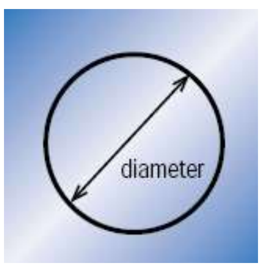
- Heat-treatment

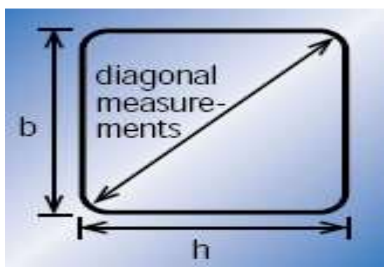


Physics of the spring

$$\text{Force of the spring} \approx \frac{1}{\text{Lenght of the spring}}$$

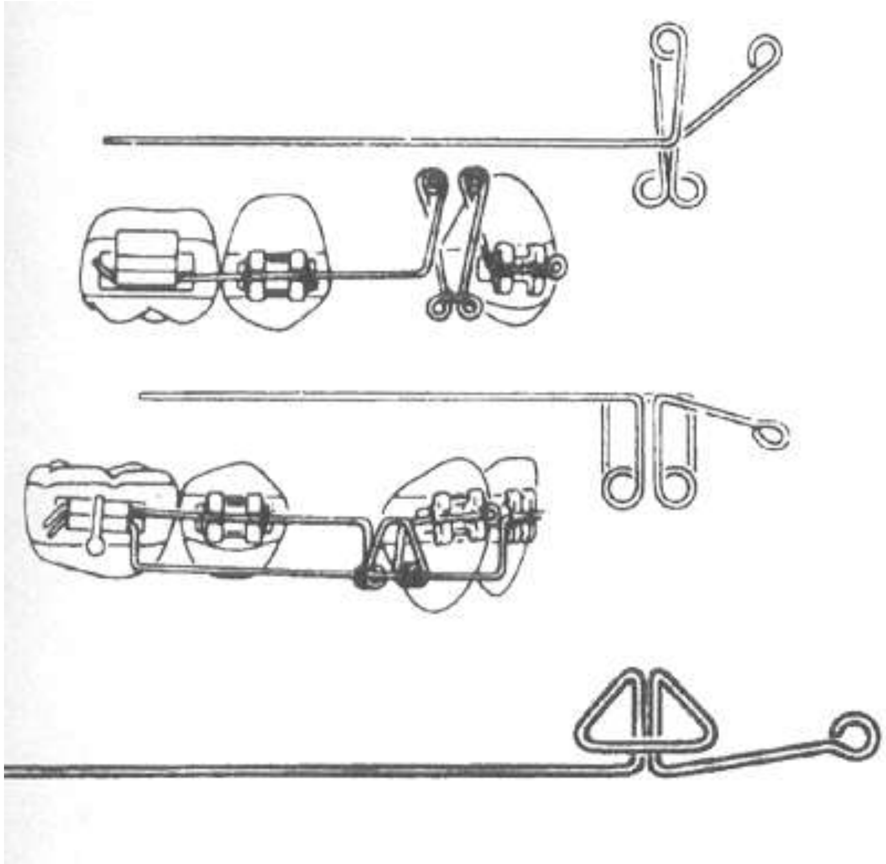
Crossection of the spring

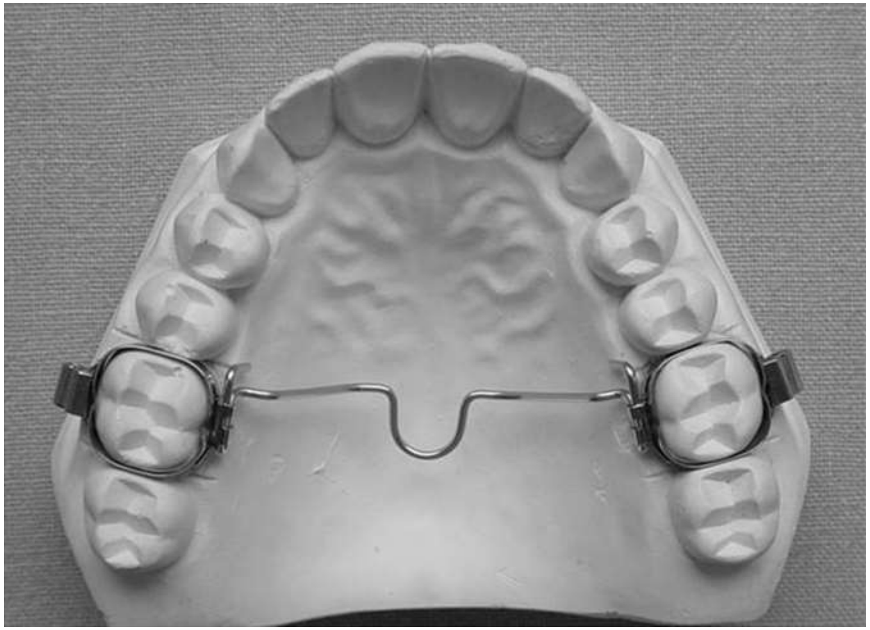




Loop Systems

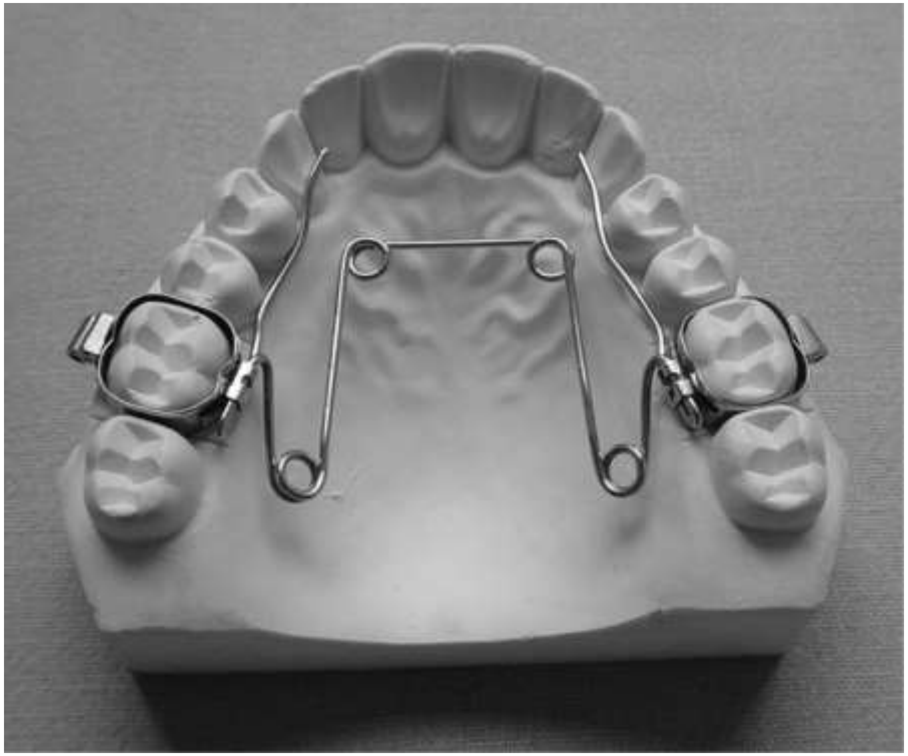
- UJ-Retraktor (Triplehelix)
- LJ- Retraktor (Doublelhelix)
- Doubledelta-Loop





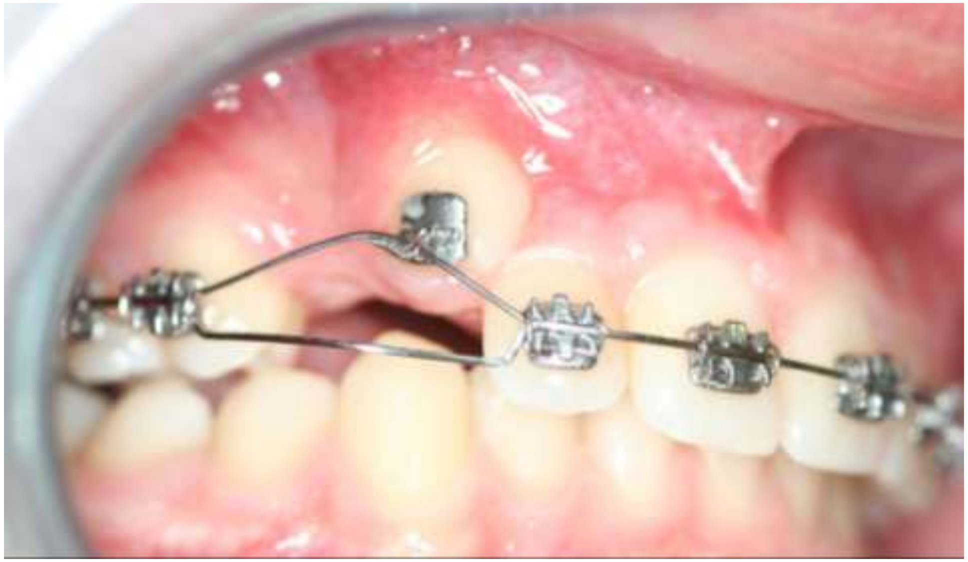
Quadhelix

Transpalatal-arch (TPA)



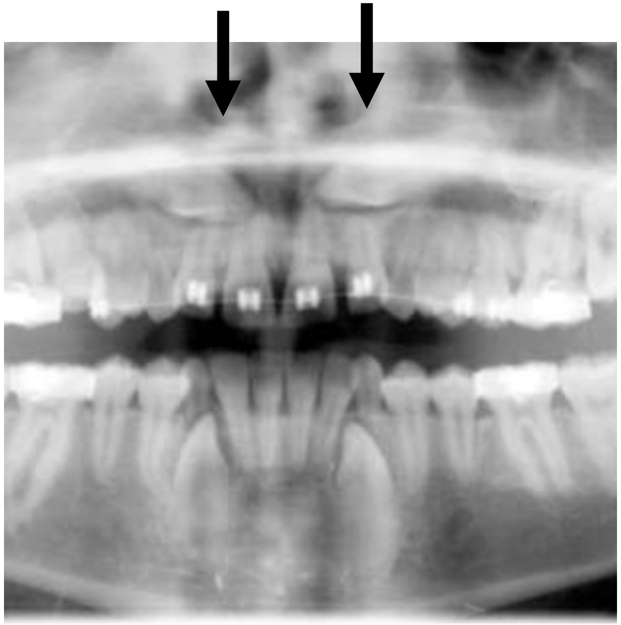
Leading the eruption of an impacted canine

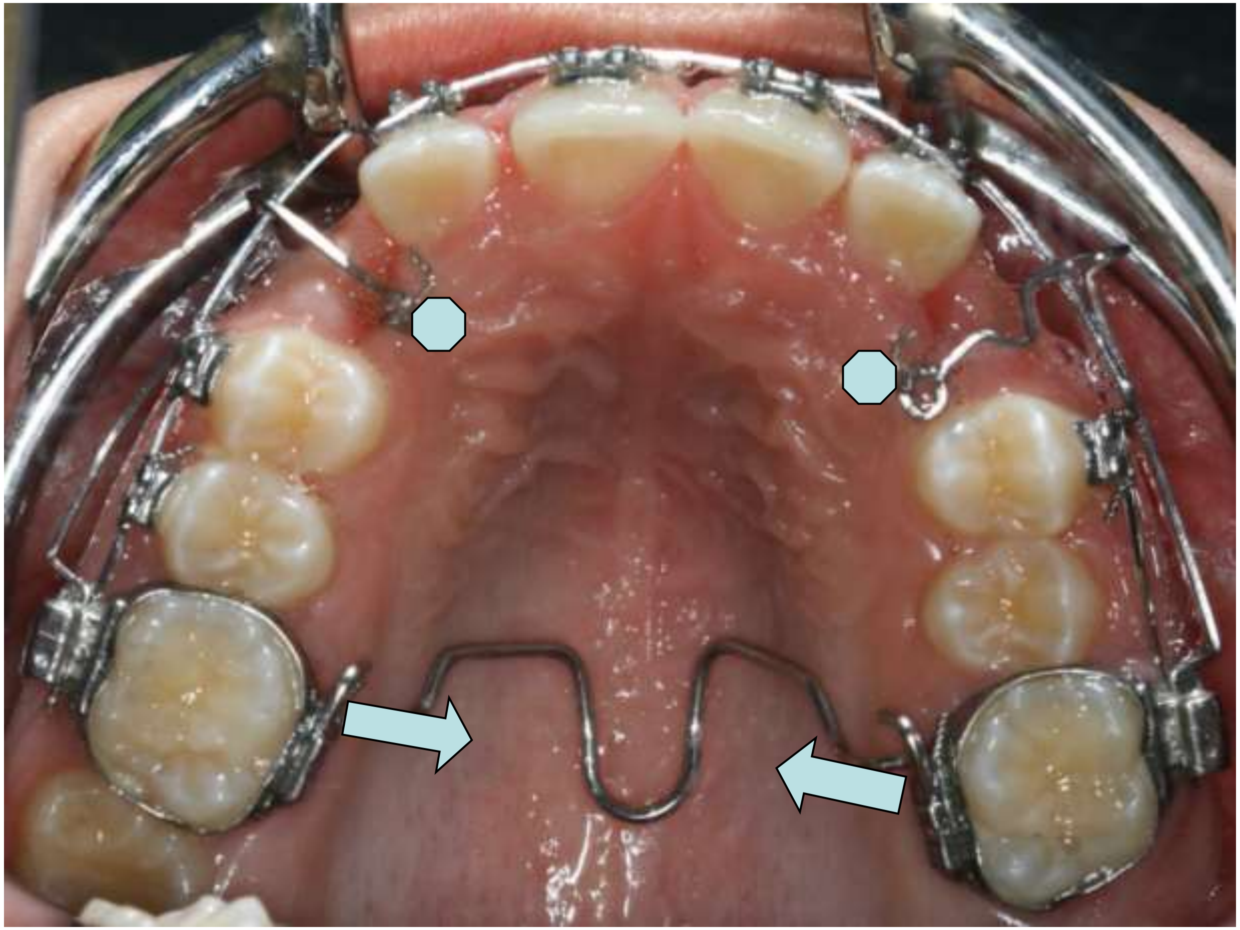
With the help of Lever arm spring



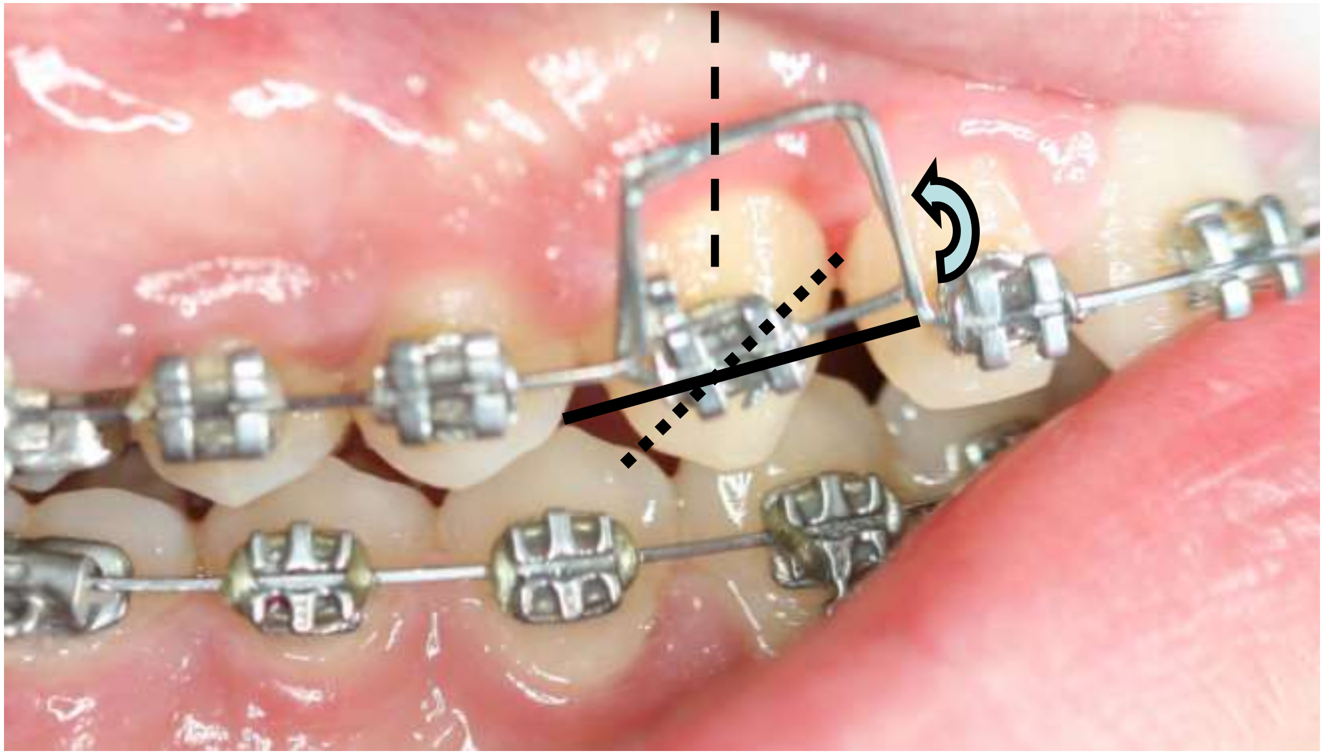
With the help of an elastic wire

Impacted canines





Box-loop



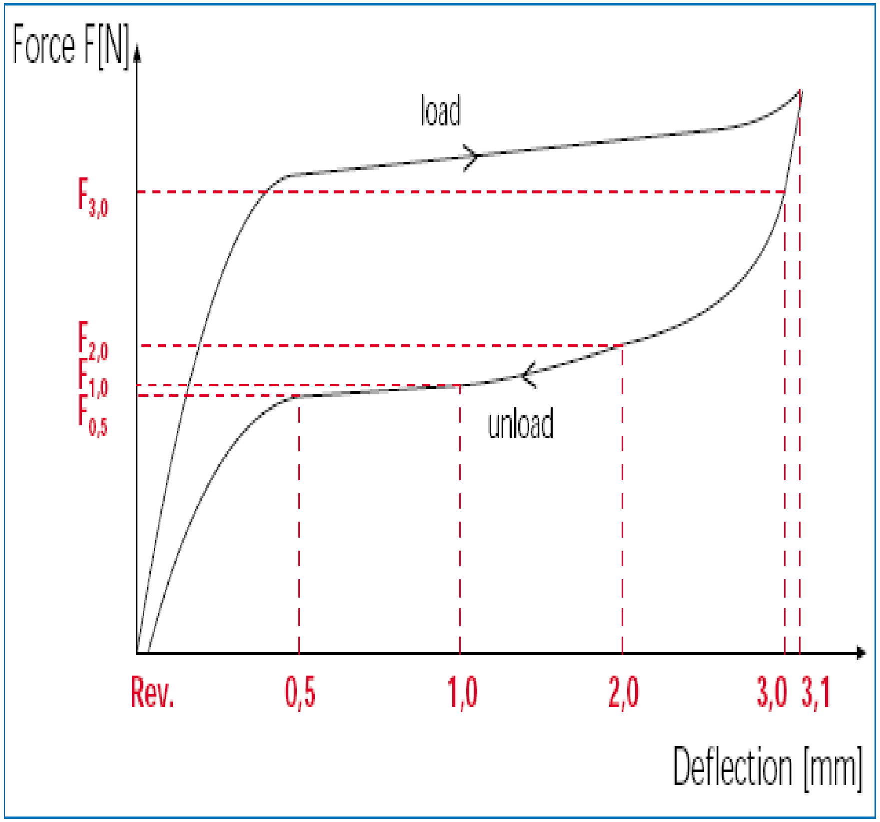
Angulation of a canine with a box-loop. The force loaded to the tooth is in upsidedown relation with the lenght of the wire/spring.

Tooth movement with skeletal anchorage: cervical headgear

Distalisation of the molars with a cervical-pull headgear

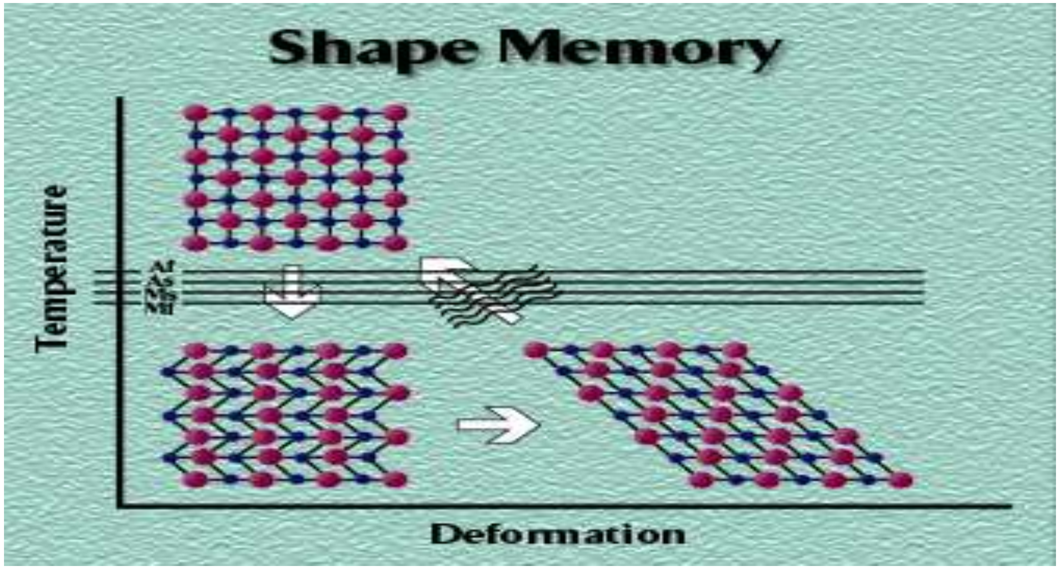
Titanium alloys

- Alloys stabilized in Martensit-Phase
- Alloy stabilized in Austenit Phase: TMA or β-titanium
- Super-elastisc NiTi arches
- Cu-NiTi (Heat-activated)

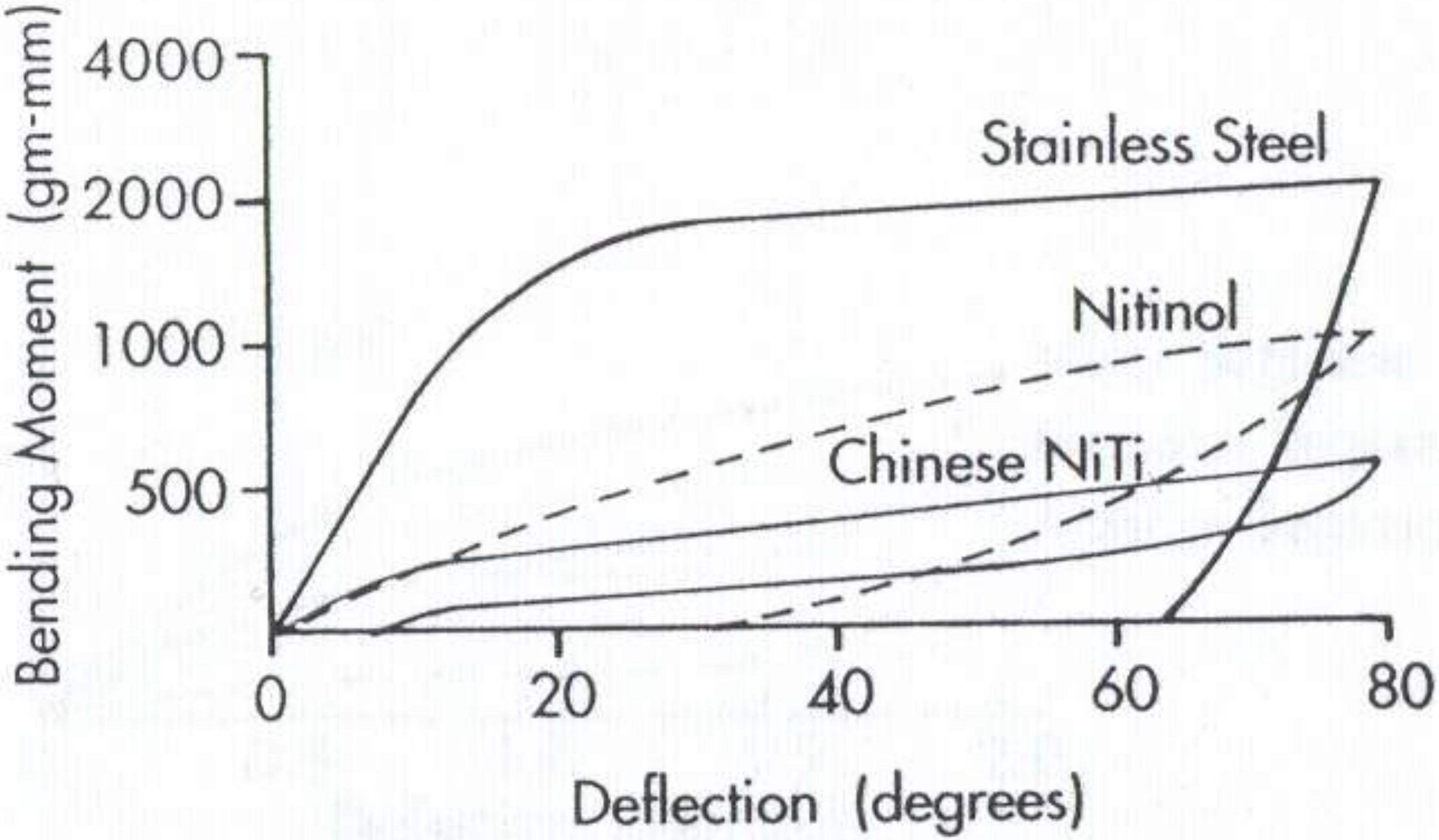


How NiTi arches work

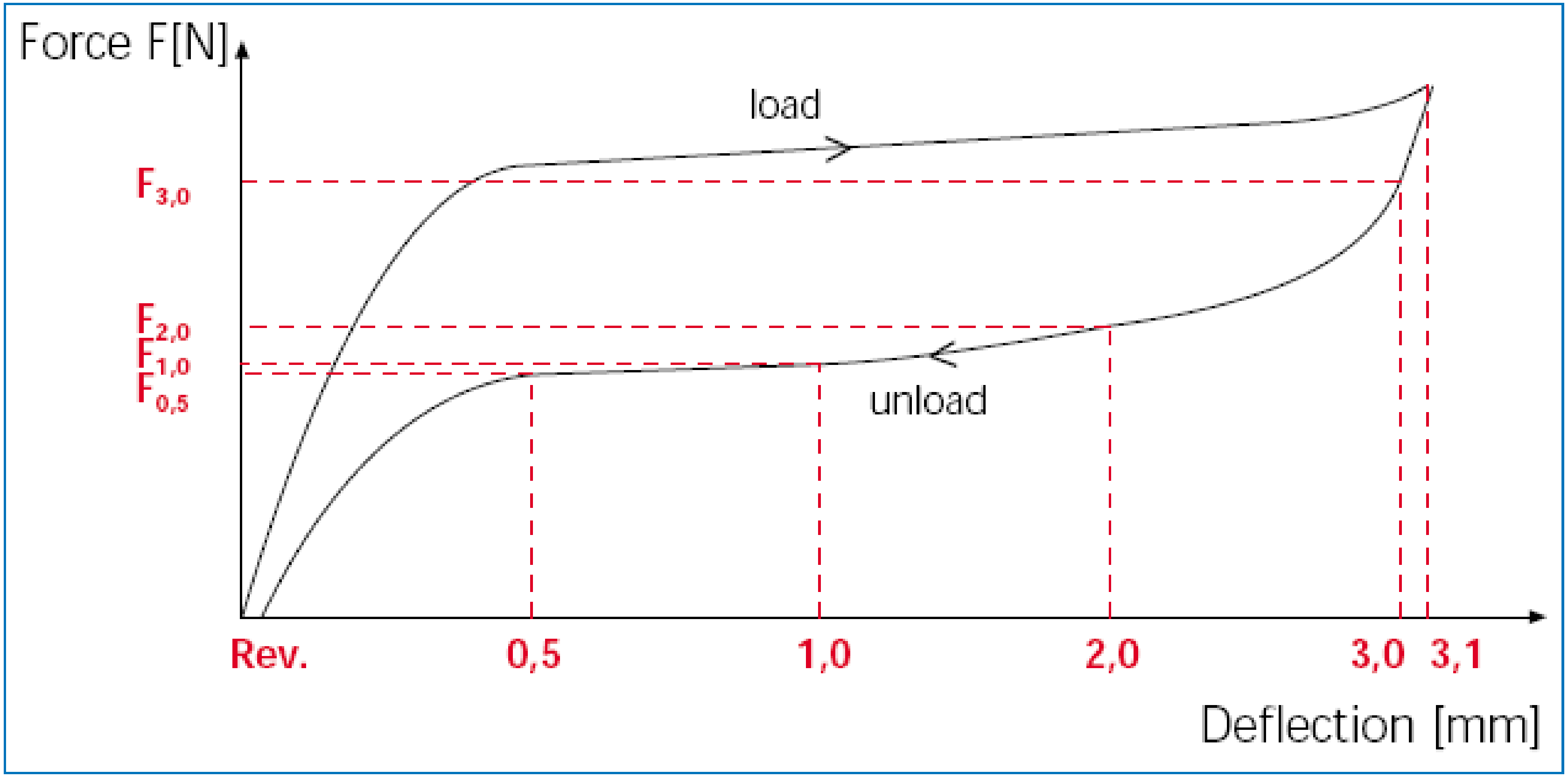
- By deforming martensit-phase NiTi arch the crystal-stucture of the metal changes, so the Energie in stored in the Metals crystal-structure



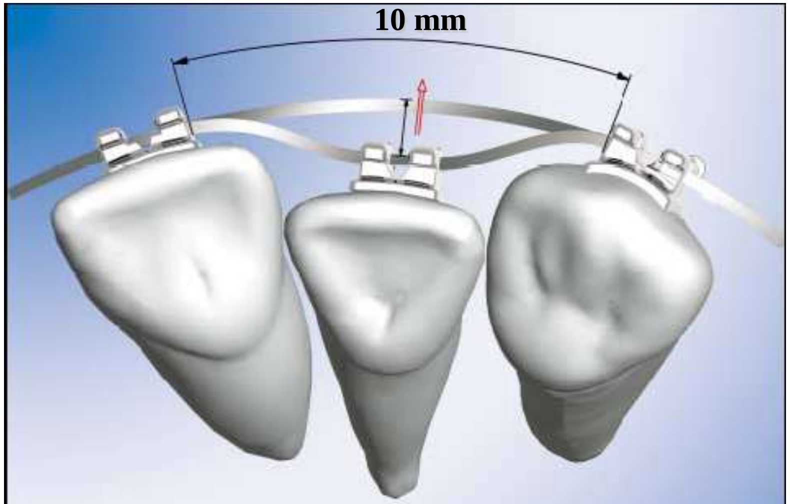
Alloys stabilized in Martenzit-Phase : Nitinol



Force-Deflection diagram of superelastic arches

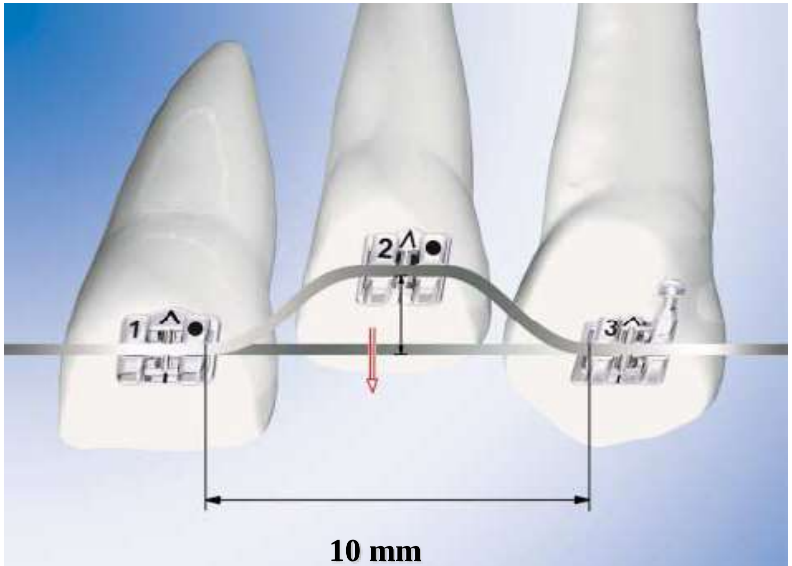


Leveling with superelastic NiTi arch



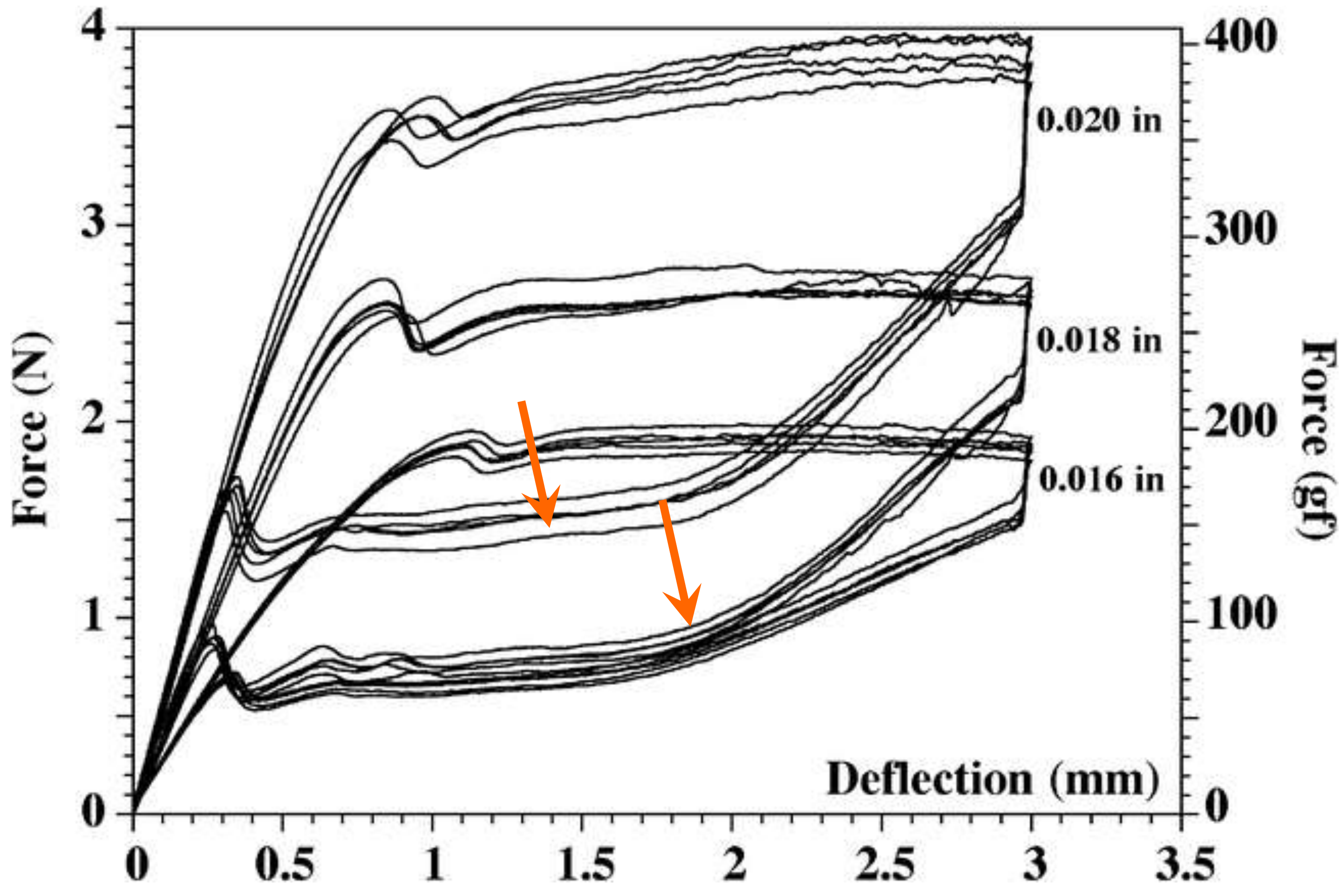
16x22 Stainless Steel: 1360cN

16x22 superelastic NiTi 118cN



16x22 Stainless Steel: 730cN
16x22 superelastic NiTi: 63cN

Force-Deflection diagram of superelastic arches



Distalising molars with two palatal miniscrews and opened coil springs

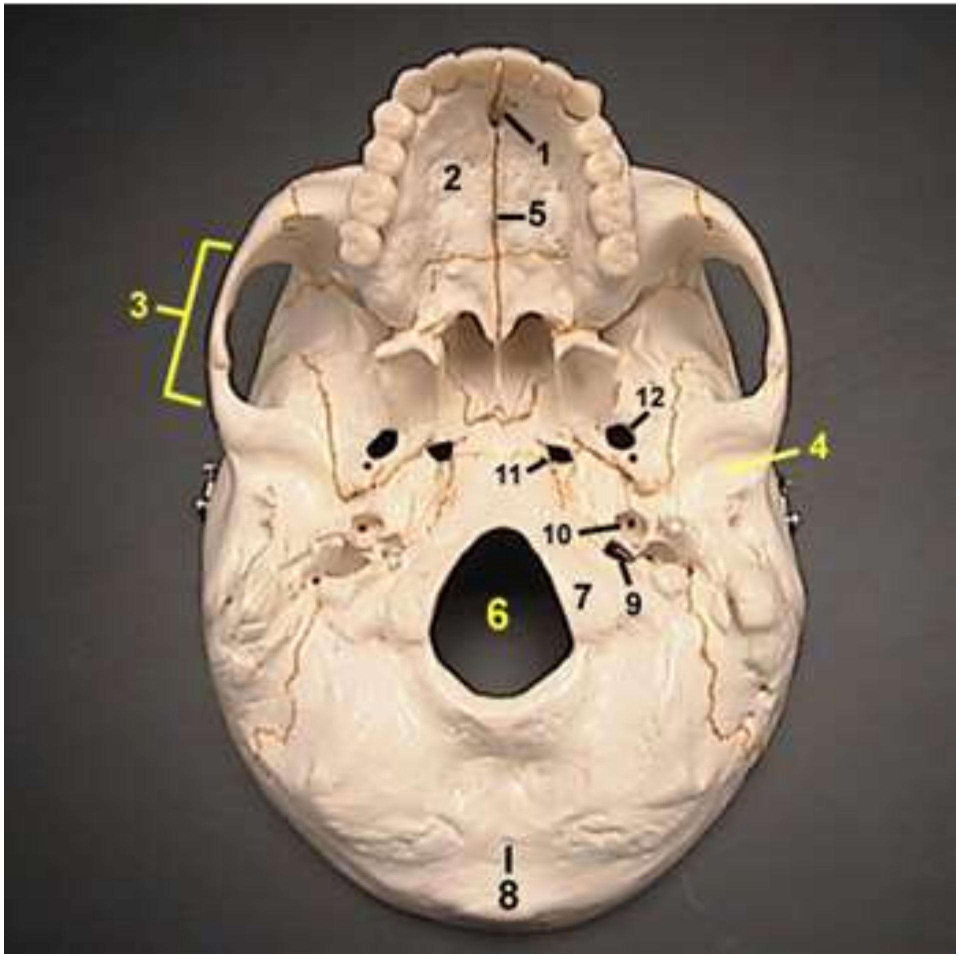
Mesialising of molars and premolars with palatal miniscrews and closed coil springs due to missing lateral incisors

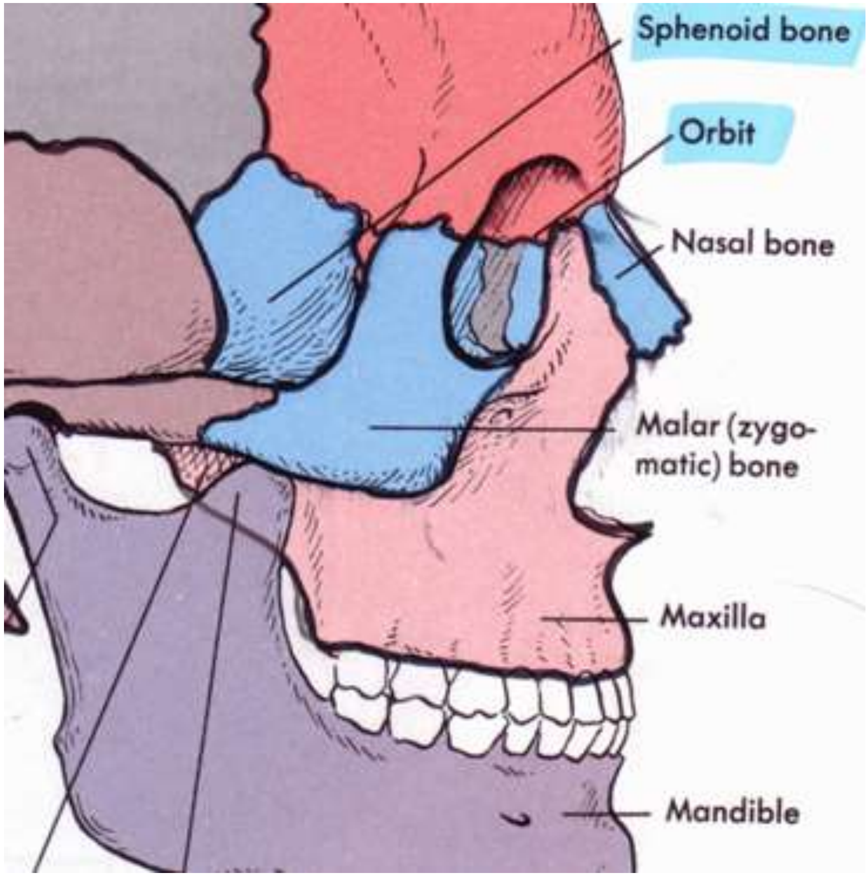
TABLE 11-4 Material Stiffness Numbers (Ms) of Orthodontic Alloys and Braided Steel Wires*

Material	M_s
Alloys	
Stainless steel (ss)	1.00
TMA	0.42
Nitinol	0.26
Elgiloy blue	1.19
Elgiloy blue (heat treated)	1.22
Braids	
Twist-flex	0.18 to 0.20
Force-9	0.14 to 0.16
D-rect	0.04 to 0.08
Respond	0.07 to 0.08

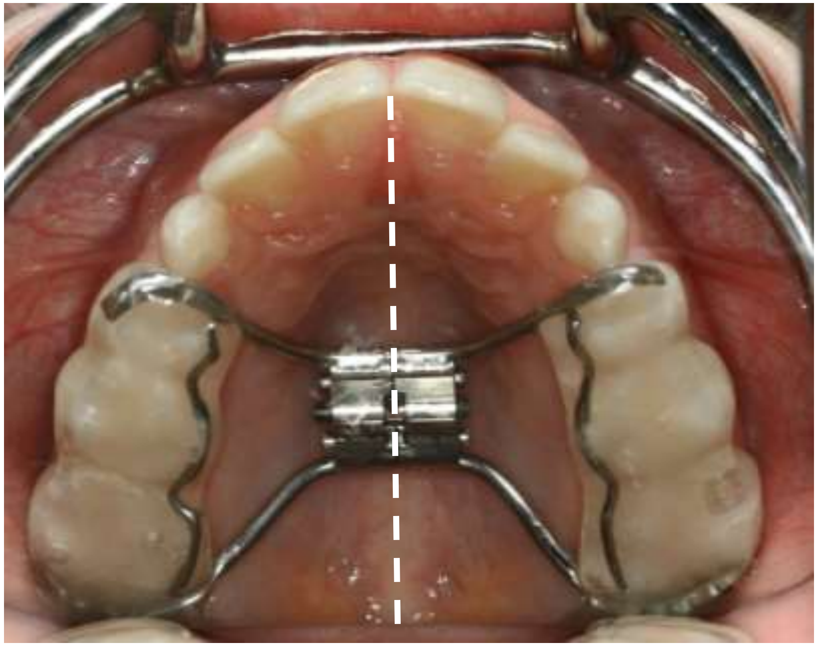
From Burstone CJ: *Am J Orthod* 80:1, 1981. With permission from the American Association of Orthodontists. *Based on E = 25 × 106 psi.

Big forces - Why?

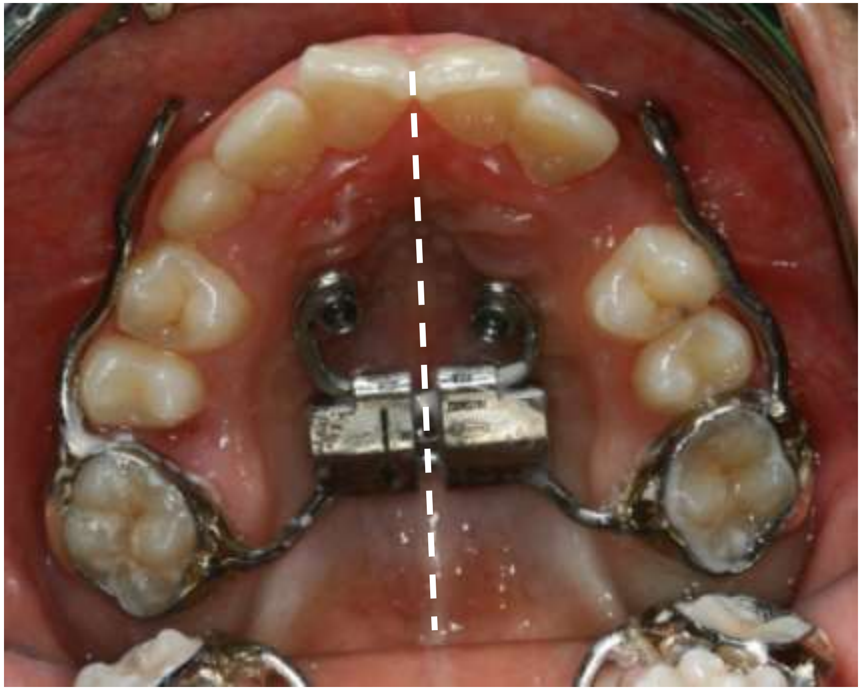


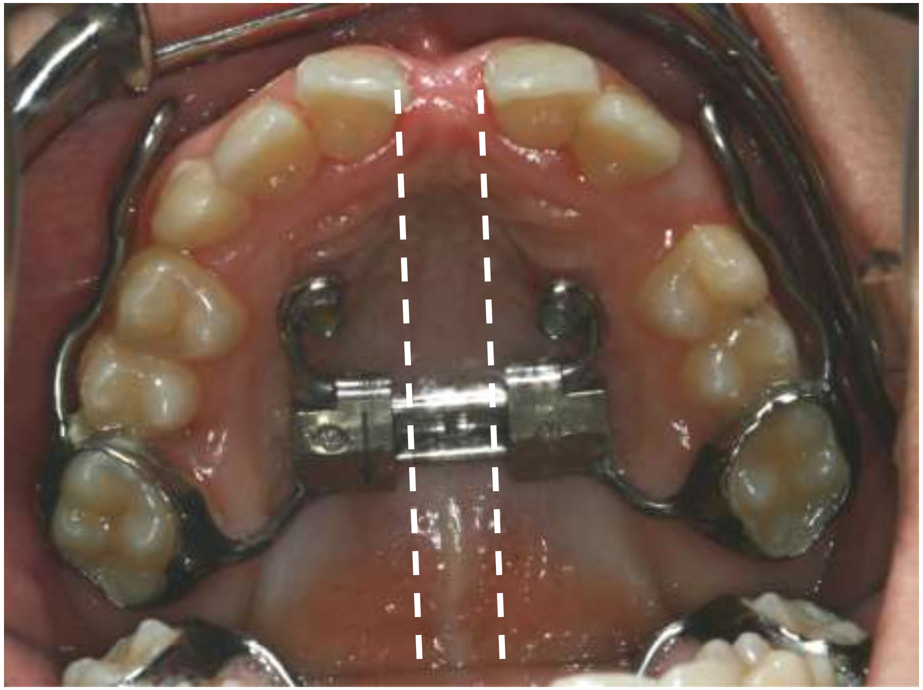


Rapid Maxillary Expansion
RME



Rapid Maxillary Expansion with miniscrew anchorage



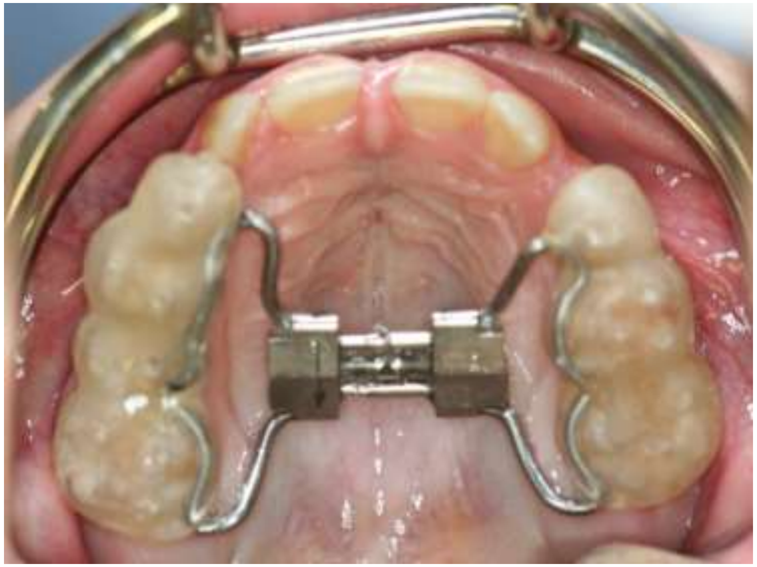


Transpalatal Distractor (TPD) a bone-born device

Frontal and unilateral crossbite due to hypoplastic upper jaw

Hyrax + Delaire-Mask

RME



Maxillary

Protraction

Orthopedic traction of the upper jaw

Thank you for your kind attention!