



<http://rniito.org>

Principles of frame construction for fracture treatment — equipment and terminology

Leonid Solomin
Professor

«Basic principles of external skeletal fixation. Temporary fixation and treatment of fractures according to Ilizarov»
St.Petersburg, 2022

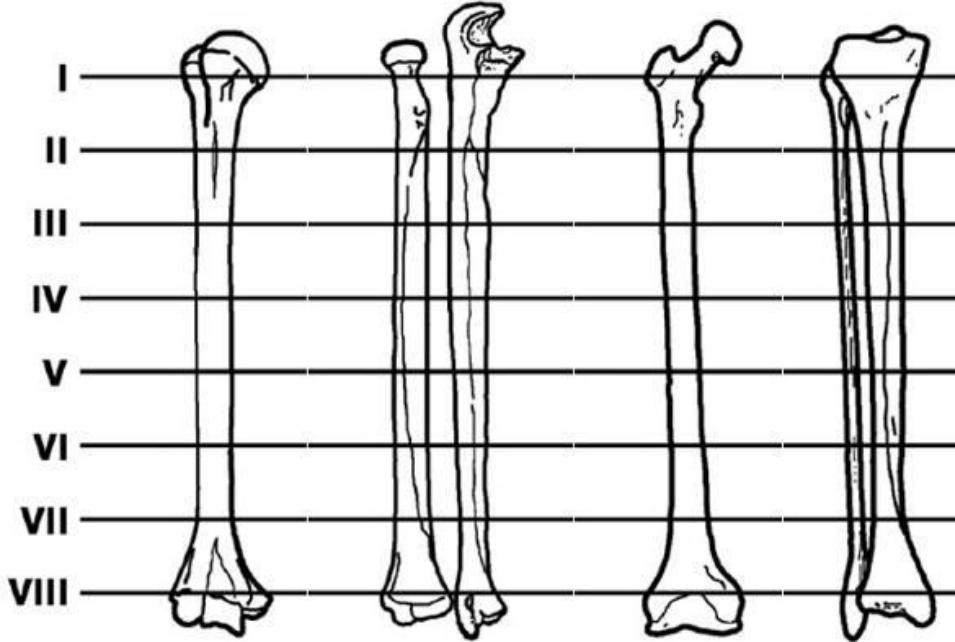
Learning objectives

- Recall the theoretical foundations of external fixation
- Outline standard frame arrangement terminology
- Reproduce planning steps of ring frame for definitive fractures fixation

Theoretical basis

CDEF: Coordinates

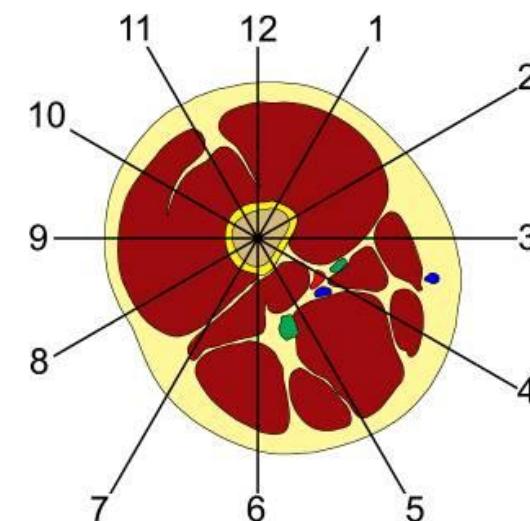
Levels



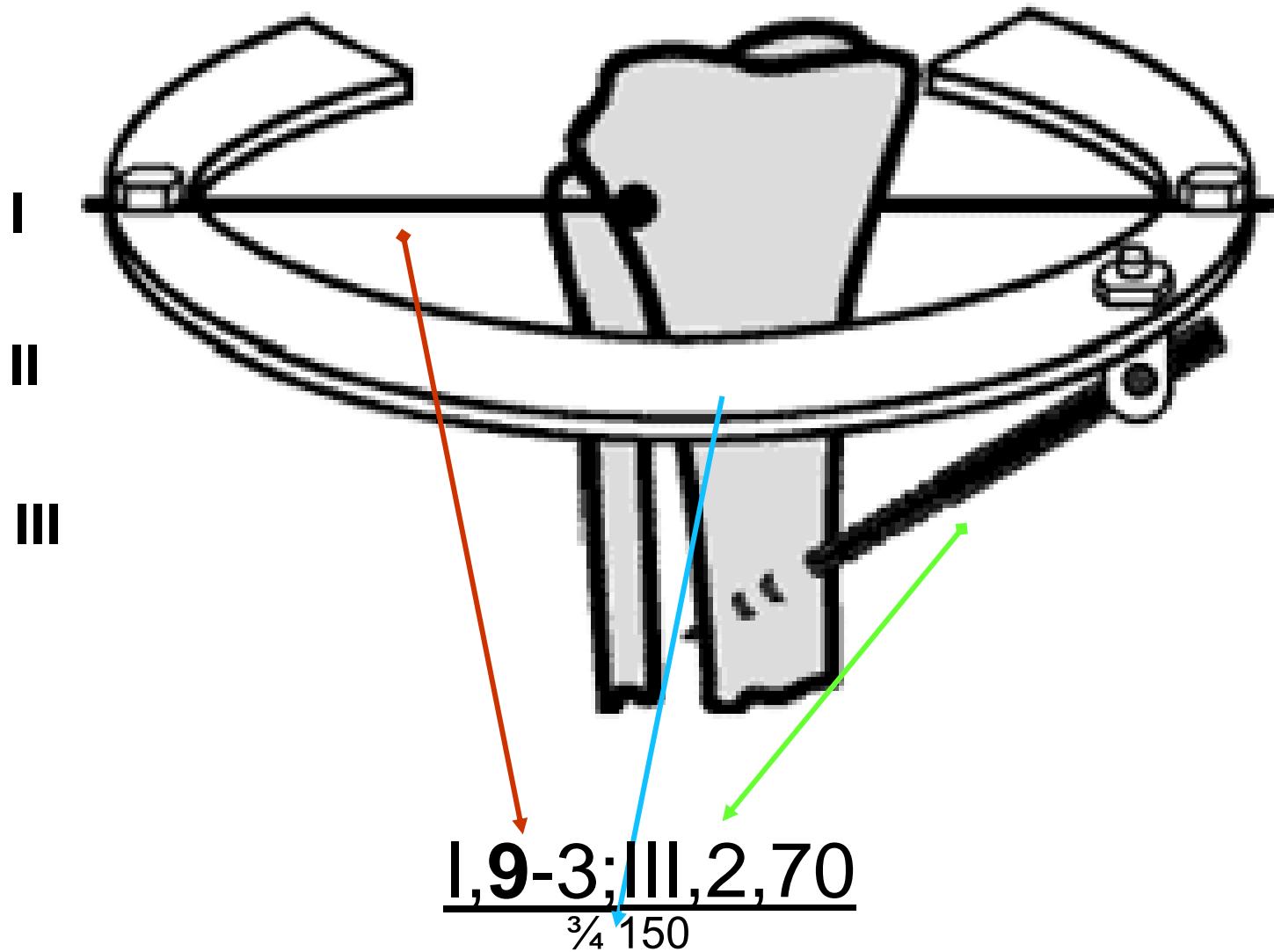
Positions

3 – medially

12 – anteriorly



CDEF: Ring designation



CDEF: Ring designation

I,9-3;III,2,70
 $\frac{3}{4}$ 150

CDEF: Frame designation

- - neutral
- ← - compression
- ←→ - distraction
- - hinge
- ←○→ - distraction hinge
- hex— - hexapod



I,3-9; I,4-10; I,8-2 — III,9-3; III,4-10 →← V,9-3; V,4-10 — VIII,3-9; VIII,4-10; VIII,8-2
160 160 160 160

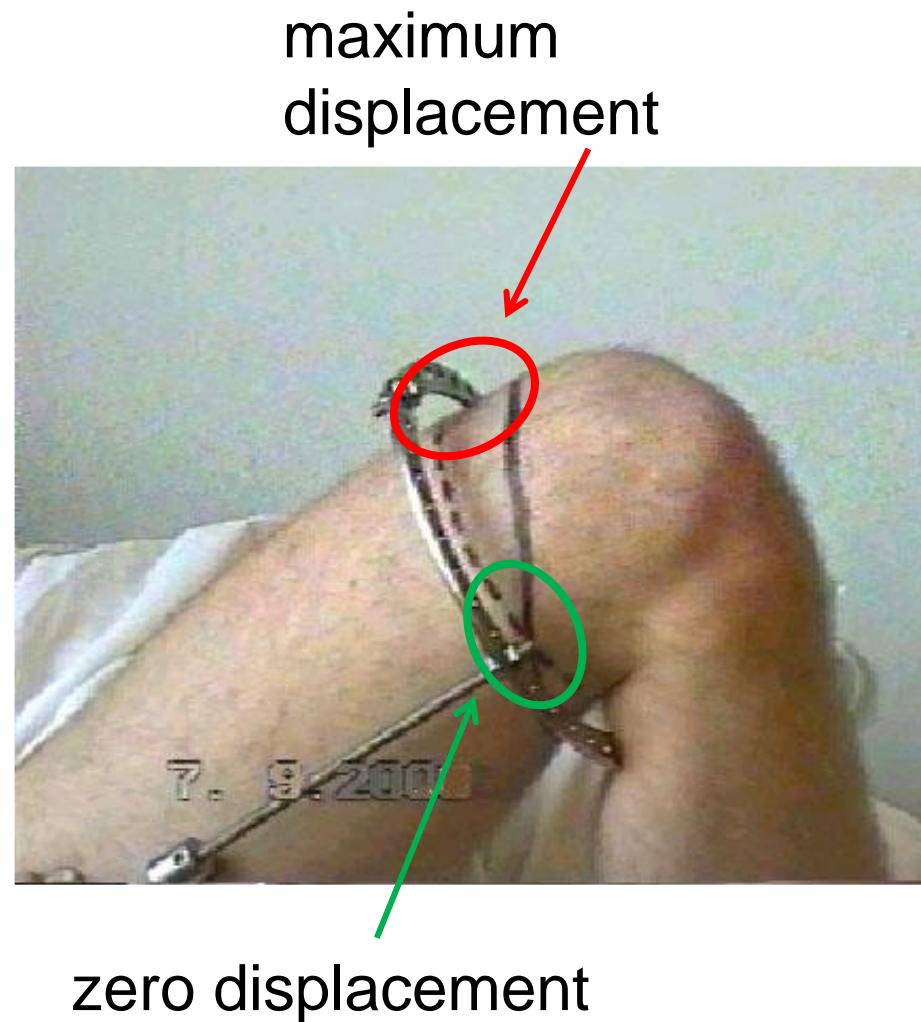
CDEF: Frame designation

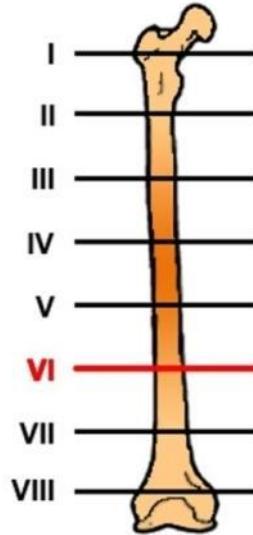
I,3-9; I,4-10; I,8-2 160 — III,9-3; III,4-10 160 →← V,9-3; V,4-10 160 — VIII,3-9; VIII,4-10; VIII,8-2 160

Frame optimization: Optimal Positions (OPs)



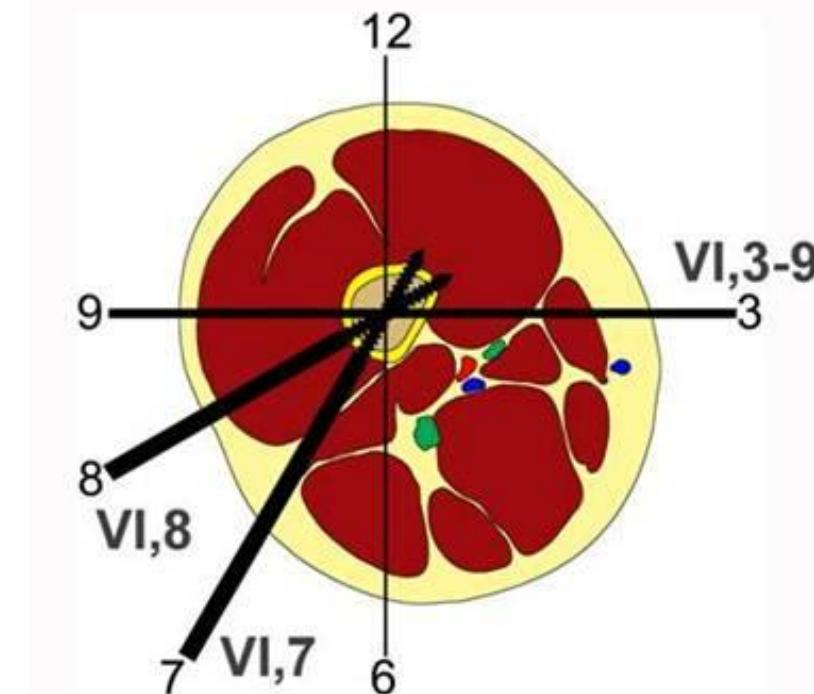
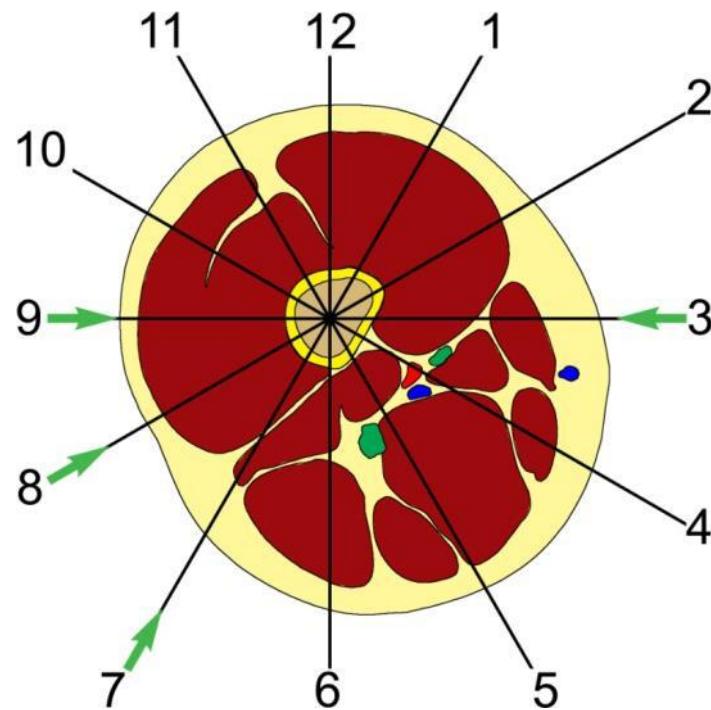
Reference Positions (RP)

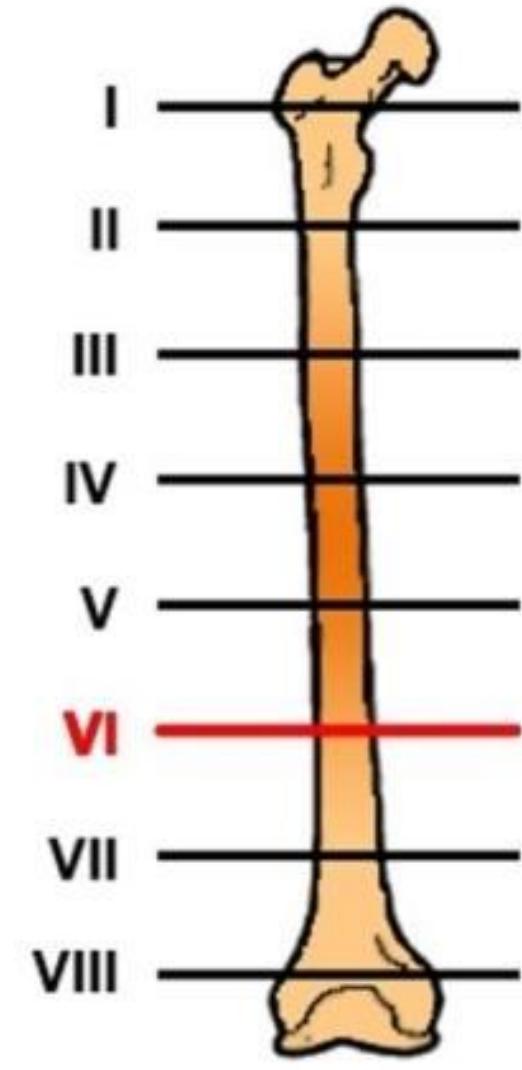




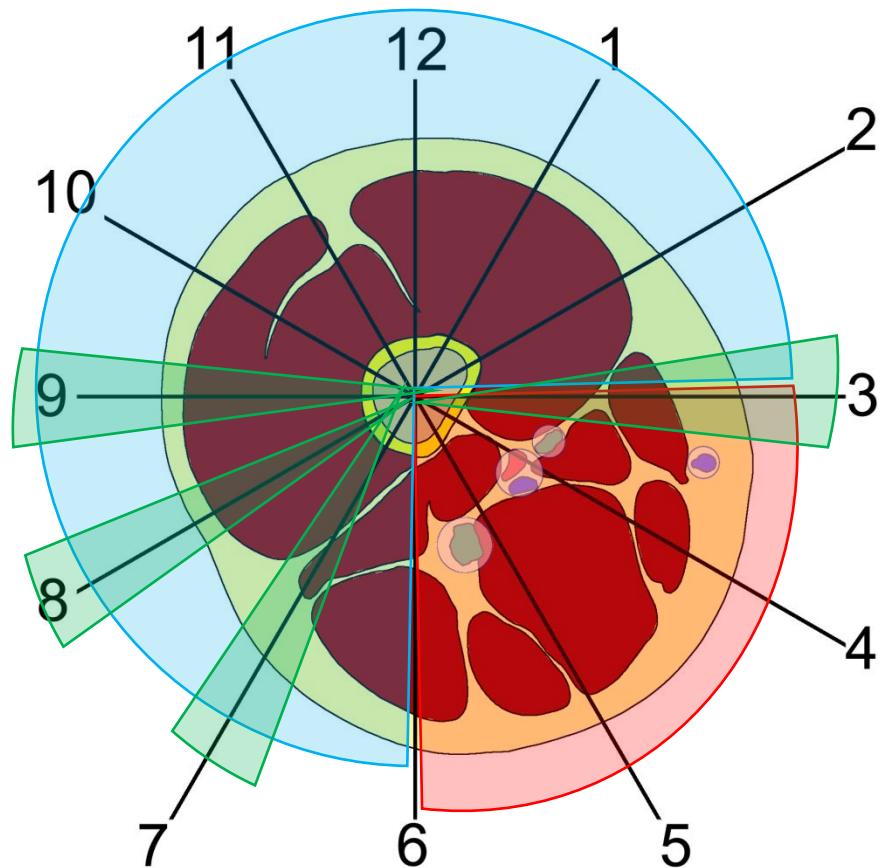
Forbidden Positions: 4,5,6
Safe Positions: 1,2,3,7,8,9,10,11,12
Reference Positions (RP): 3,7,8, 9

Reference transosseous elements:
VI,3-9; VI,3; VI,7; VI,8; VI,9

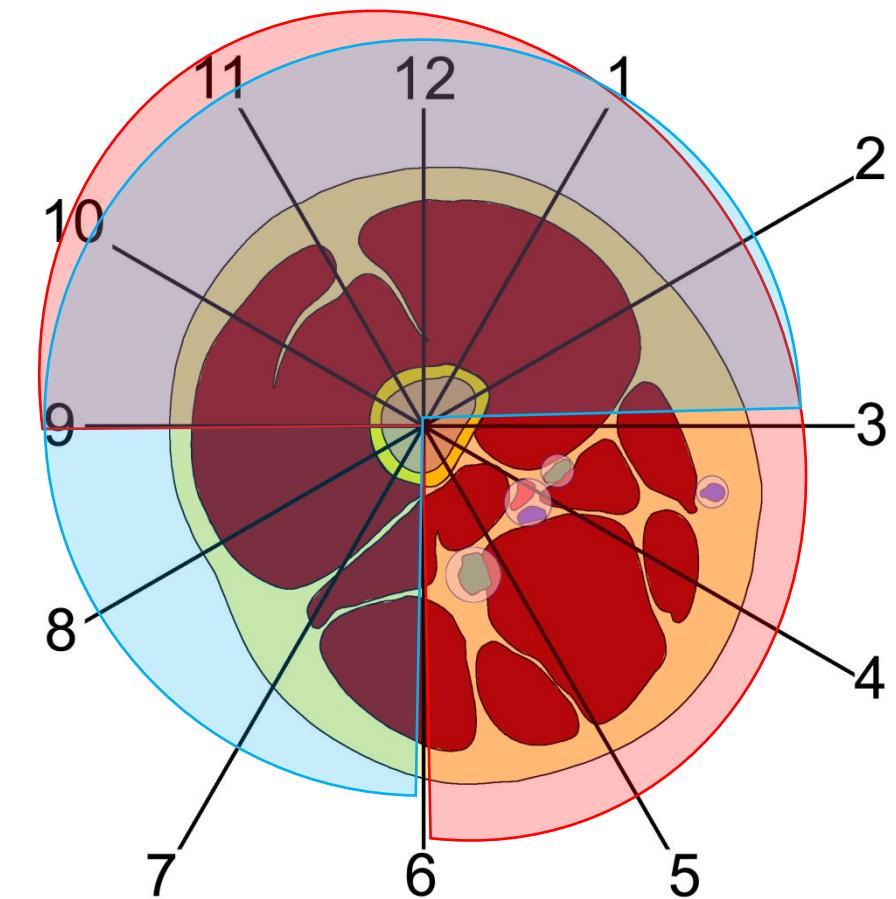




Forbidden Positions: 4,5,6
Safe Positions: 1,2,3,7,8,9,10,11,12
Reference Positions (RP): 3,7,8, 9

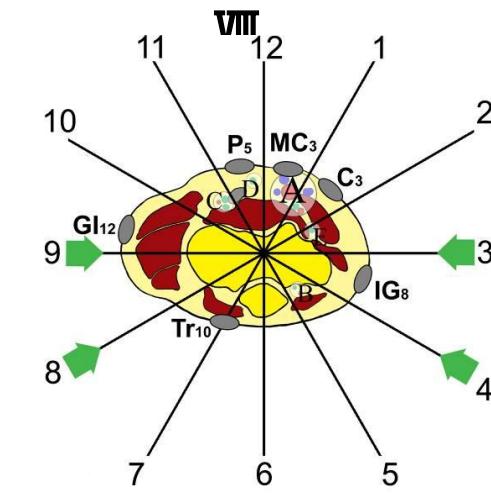
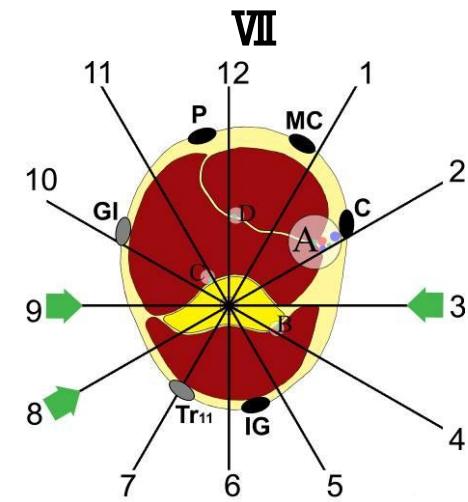
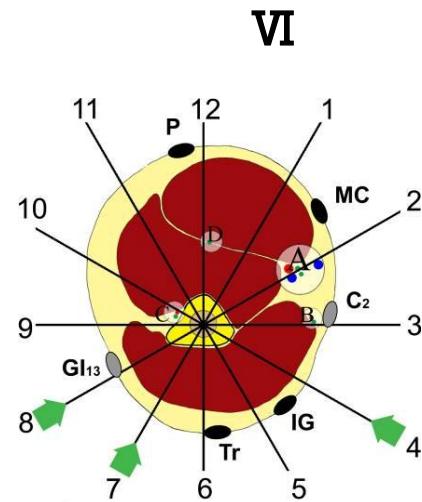
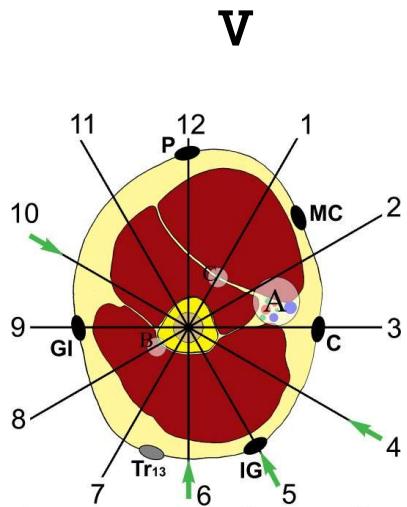
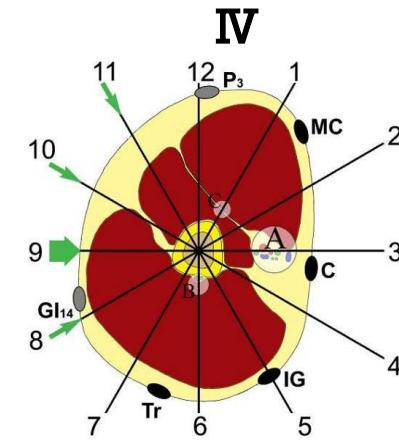
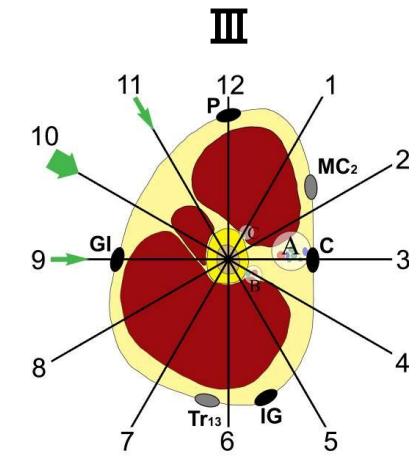
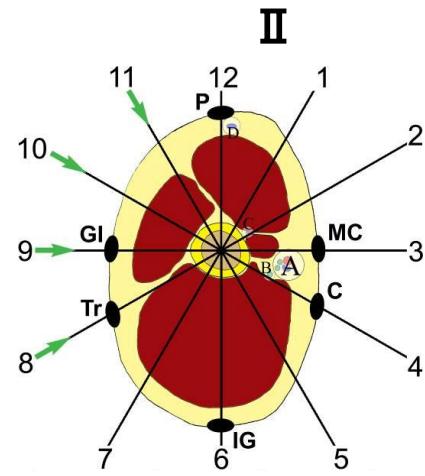
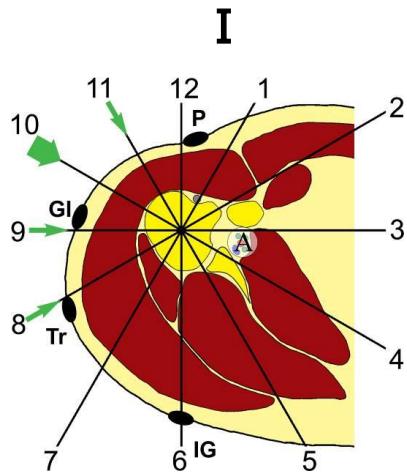


Definitive fixation

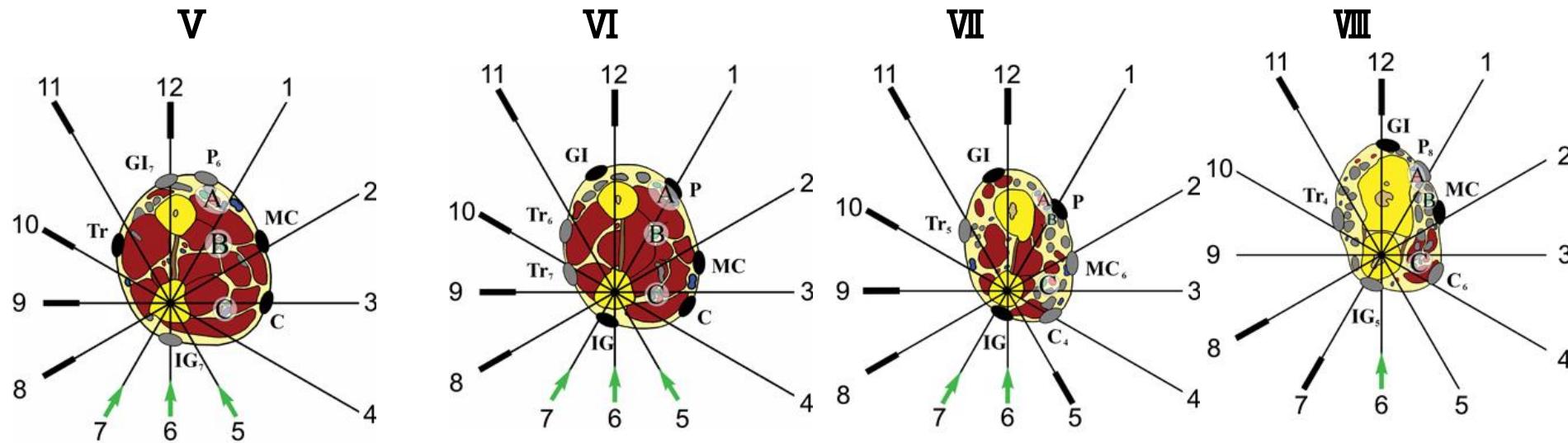
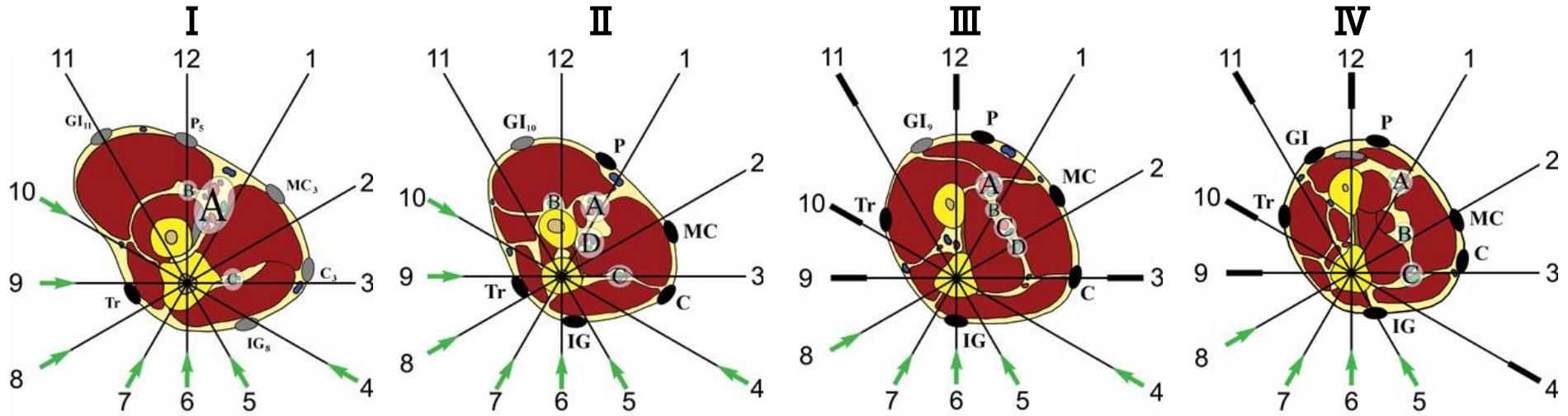


Temporary fixation

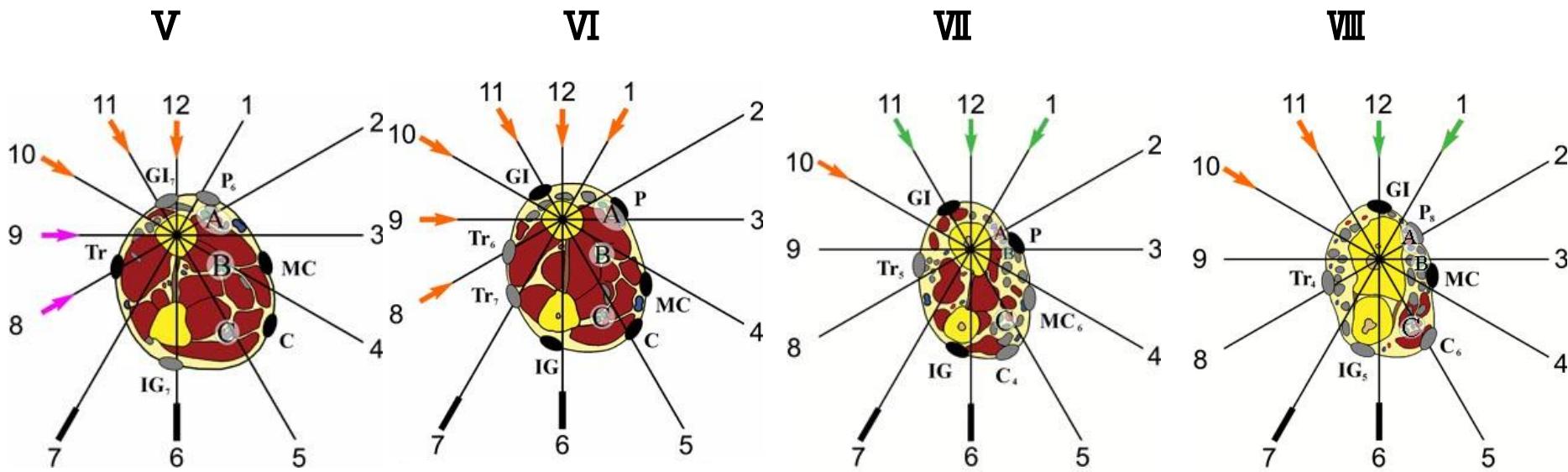
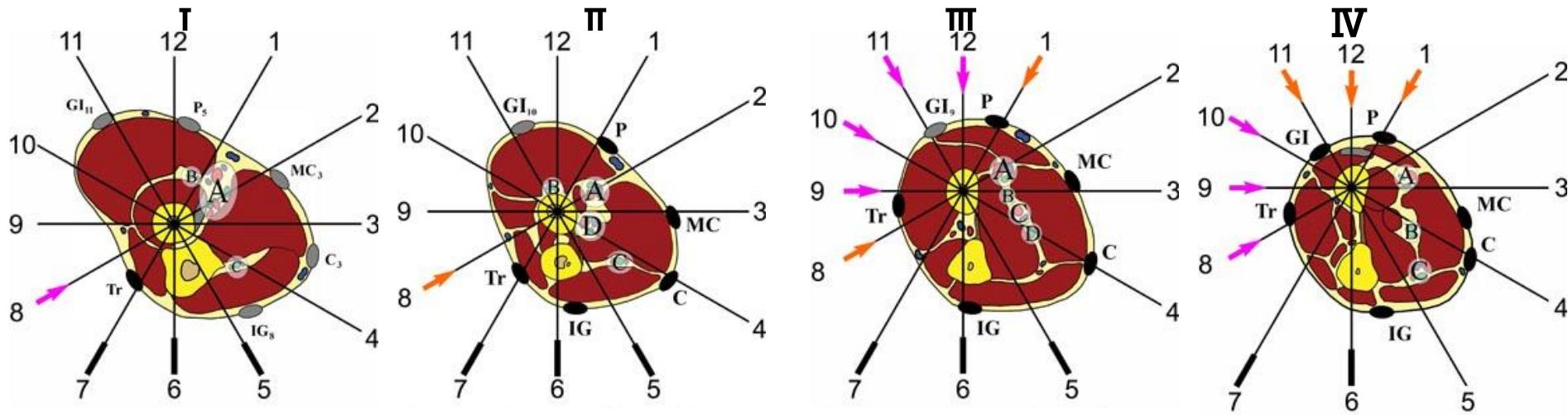
Reference Positions (RP): Upper Arm



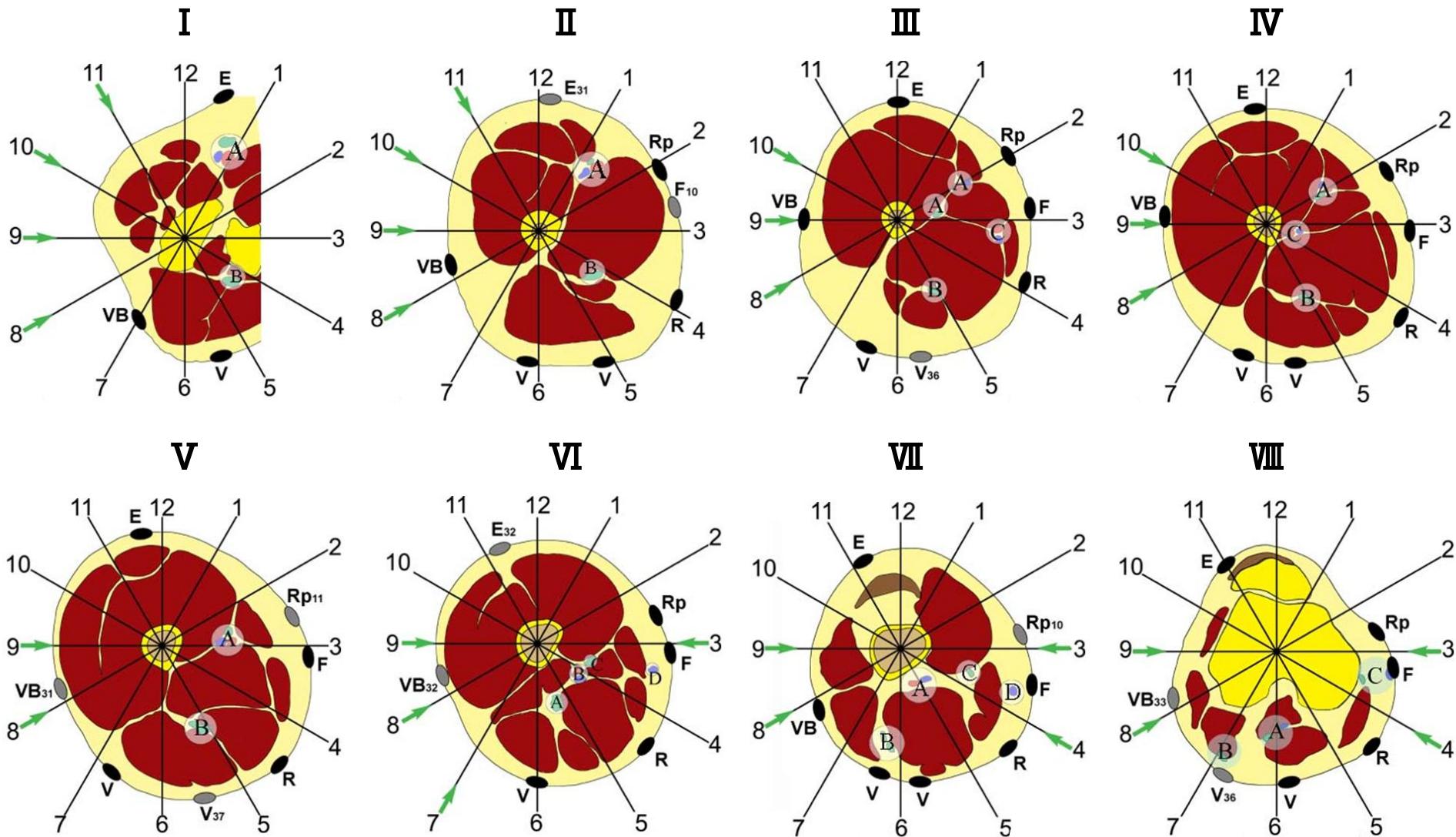
Reference Positions (RP): Forearm (Ulna)



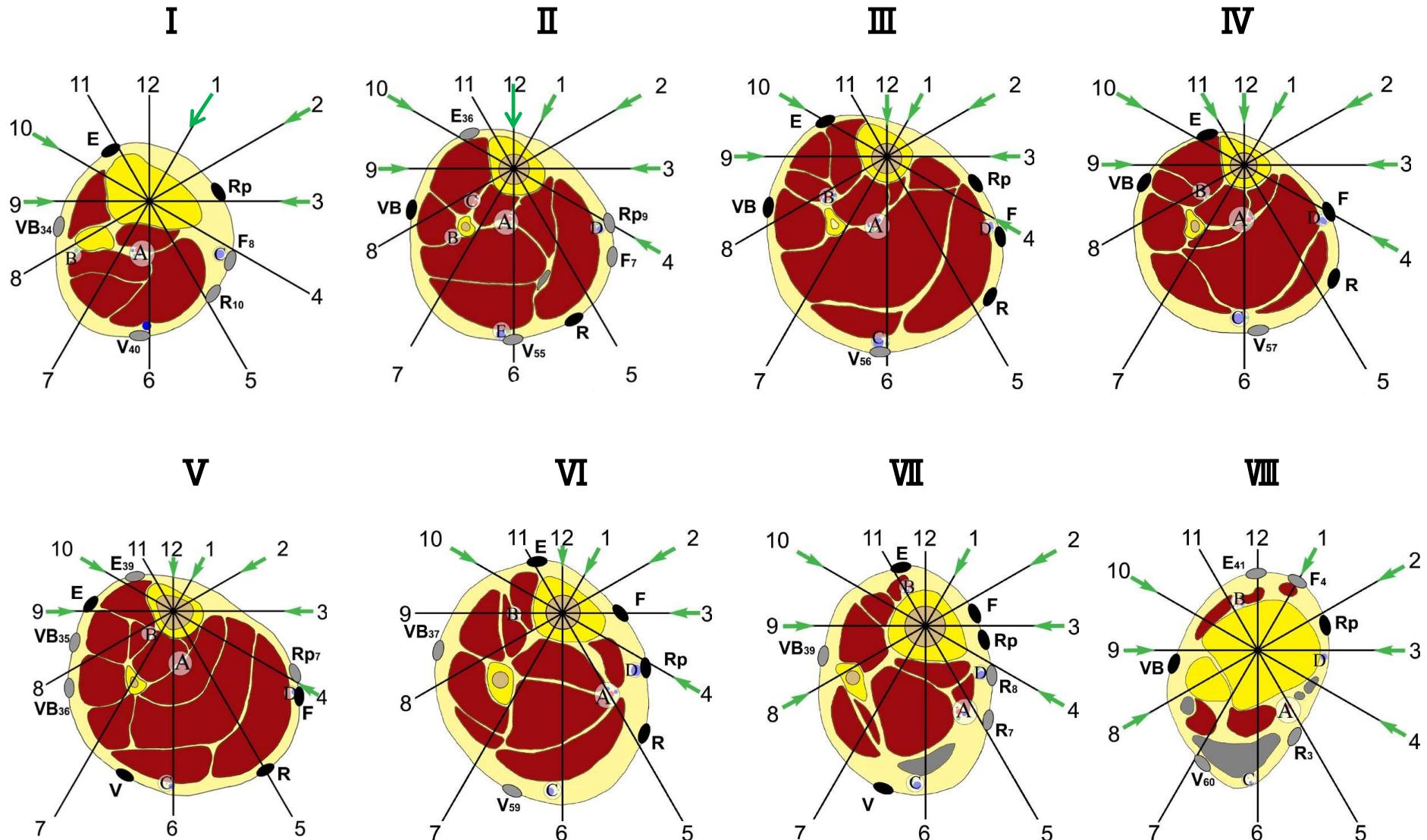
Reference Positions (RP): Forearm (Radius)



Reference Positions (RP): Femur

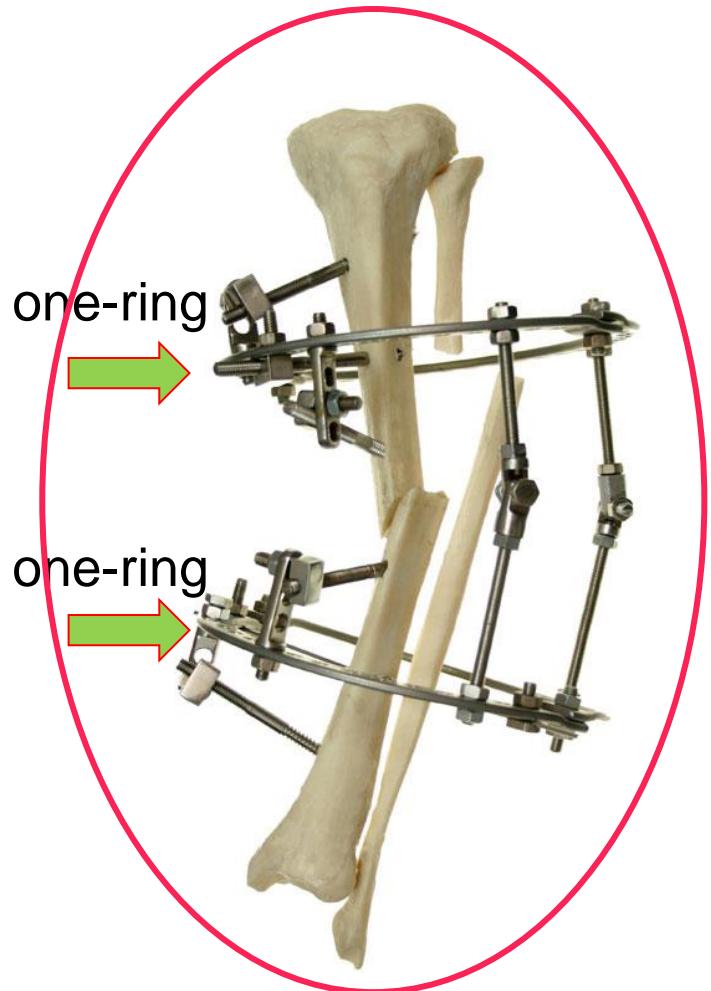


Reference Positions (RP): Lower Leg

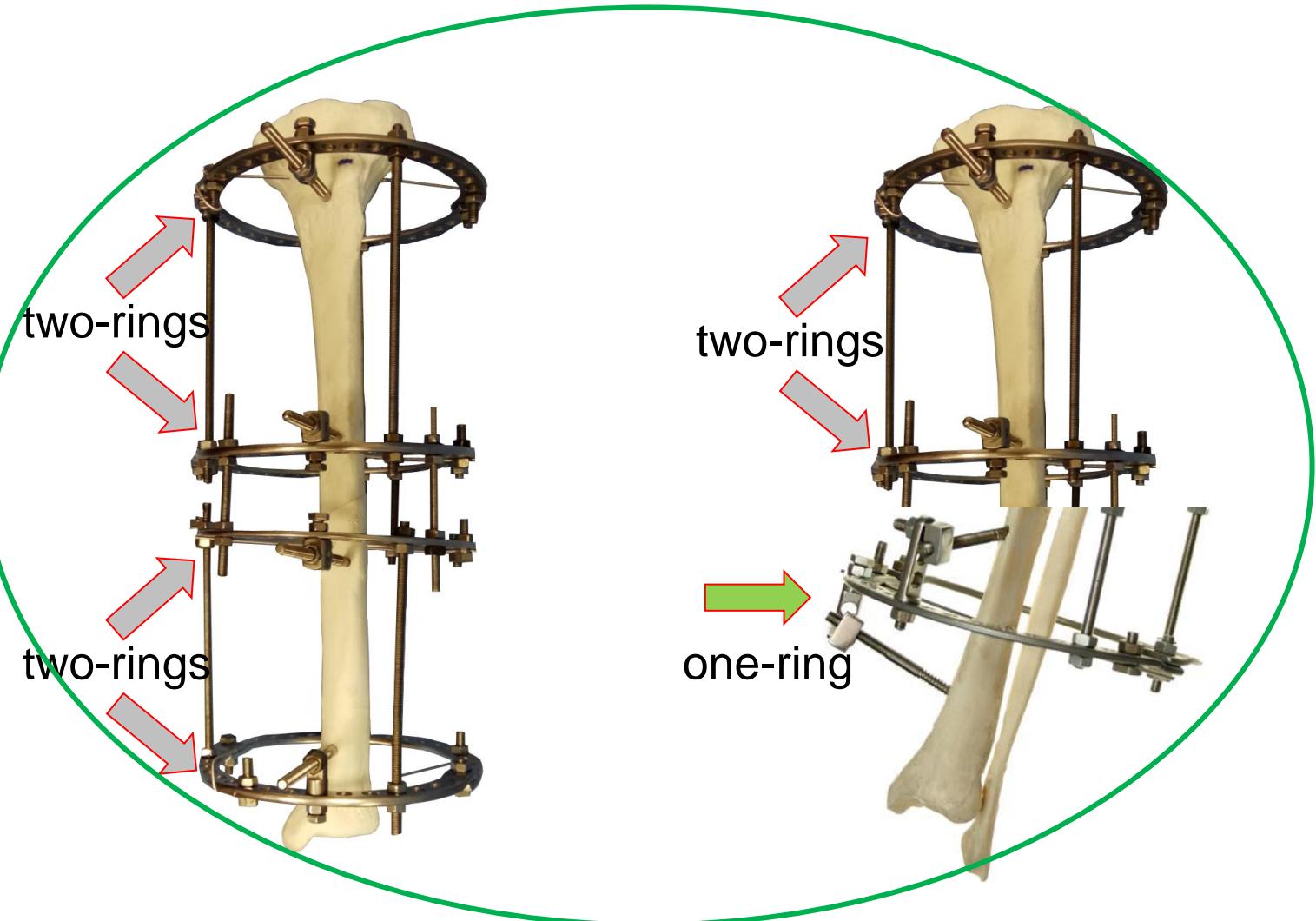


Note! Positions 9 and 10 not desirable for the threaded pins insertion

Module types: in fractures

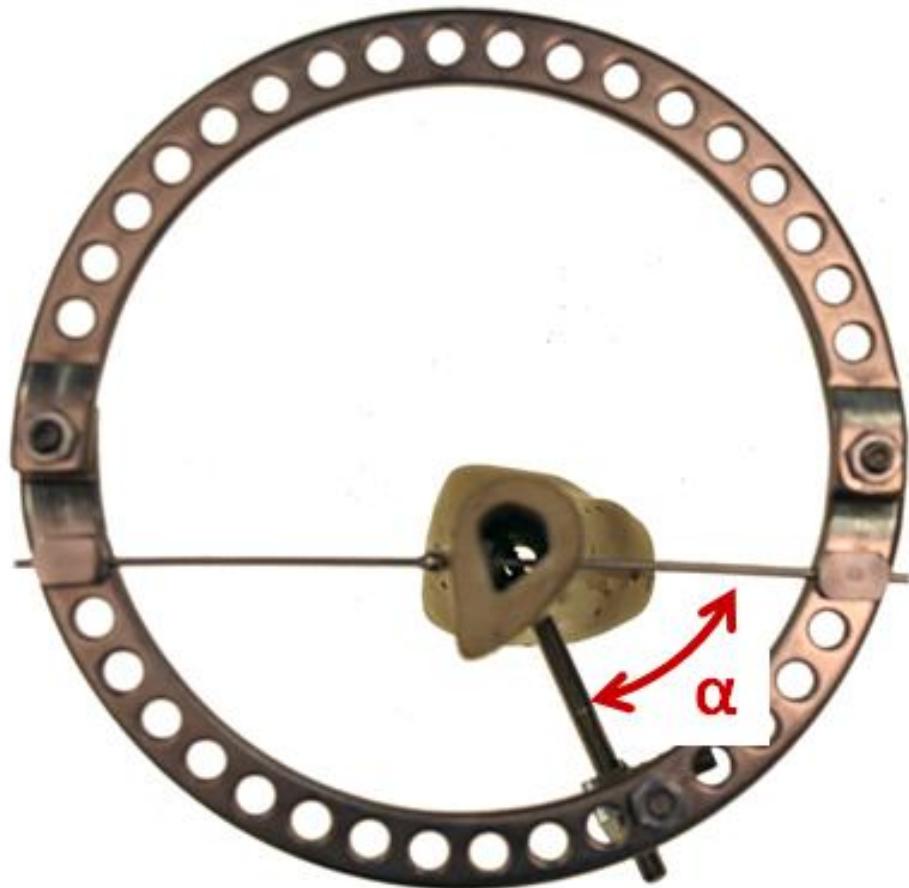


Temporary fixation



Definitive fixation

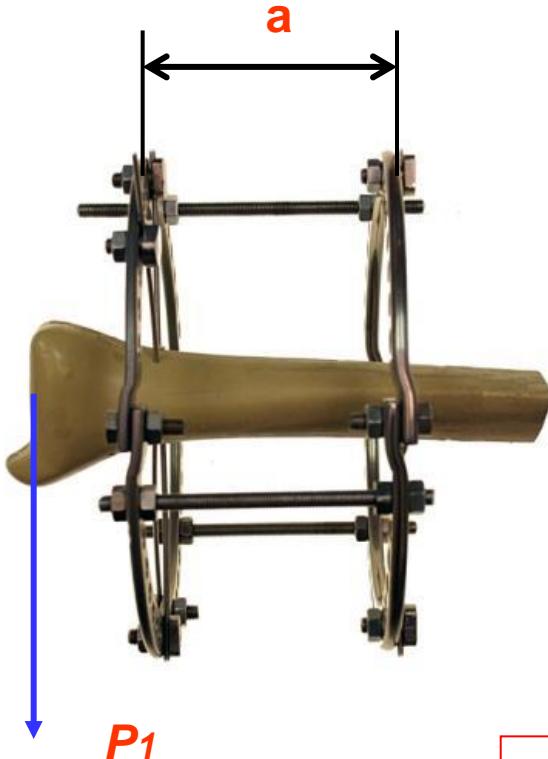
Frame construction base: Angles of bone component insertion



α - crossing angle

$$\alpha = 60^\circ (75^\circ \pm 15^\circ)$$

Two-ring module biomechanics: Distance between rings



$$a < b$$

$$P_1 < P_2$$

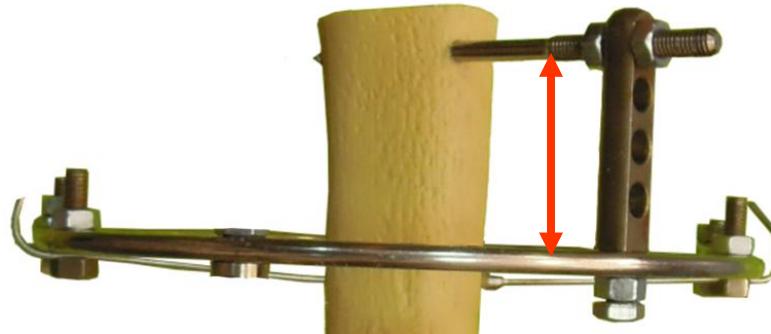
$$\alpha = 60^\circ (75^\circ \pm 15^\circ)$$

$$\beta = 90^\circ$$



wires and pins are fixed to the rings directly

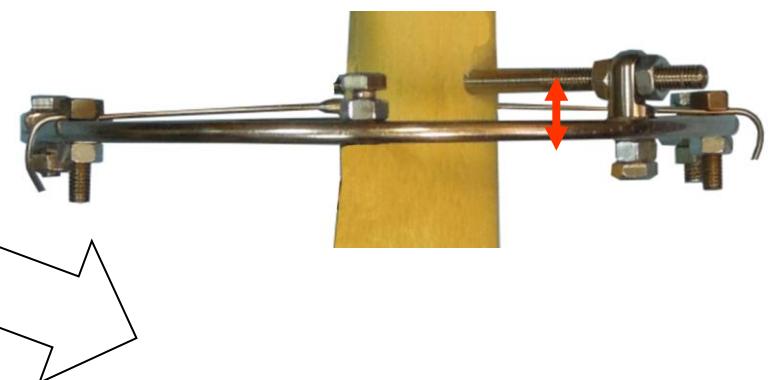
One-ring module biomechanics: Distance between bone components



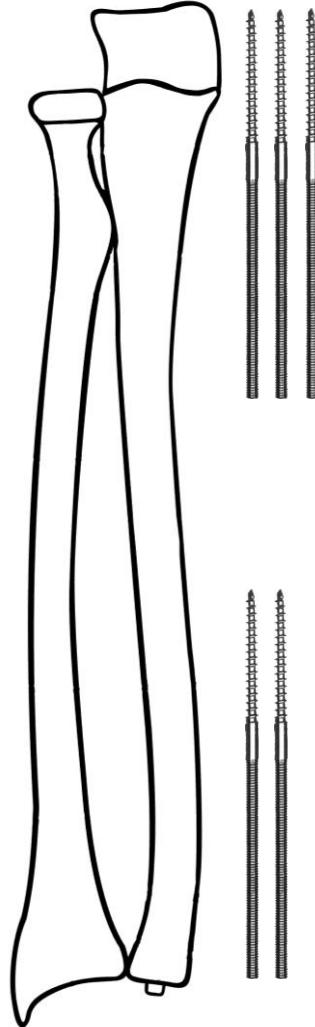
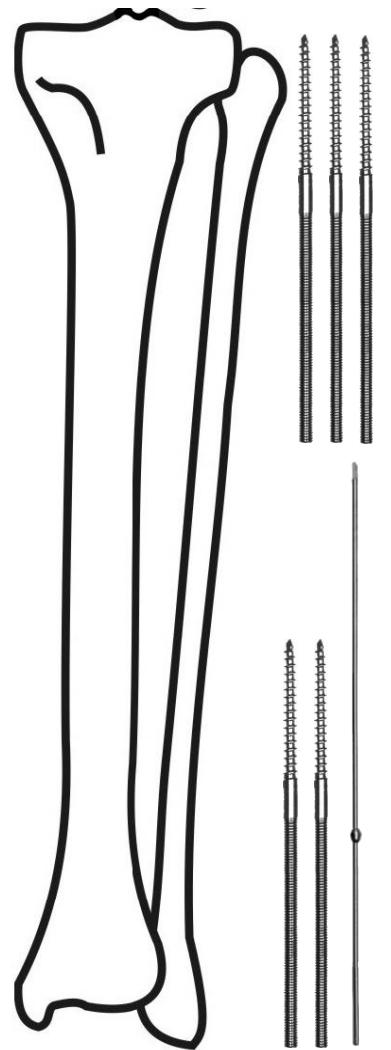
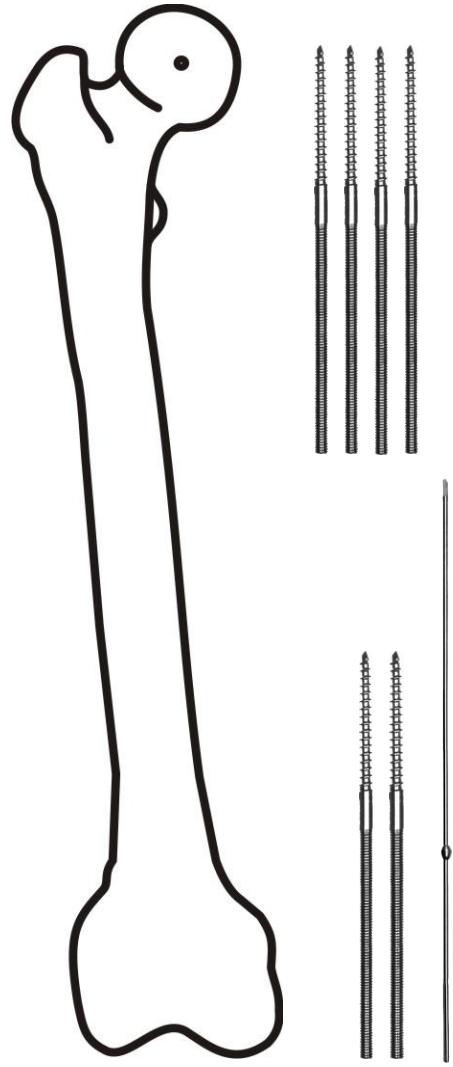
“Four-hole post forever!”



Osteosynthesis Rigidity



Number of bone components

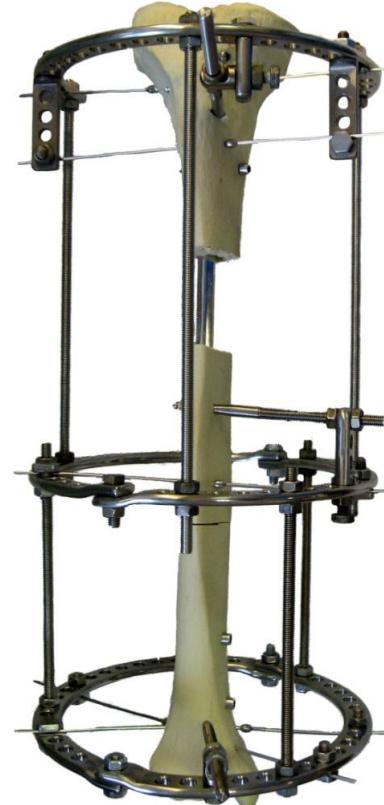


Principal types of frame assembling

for fracture
healing



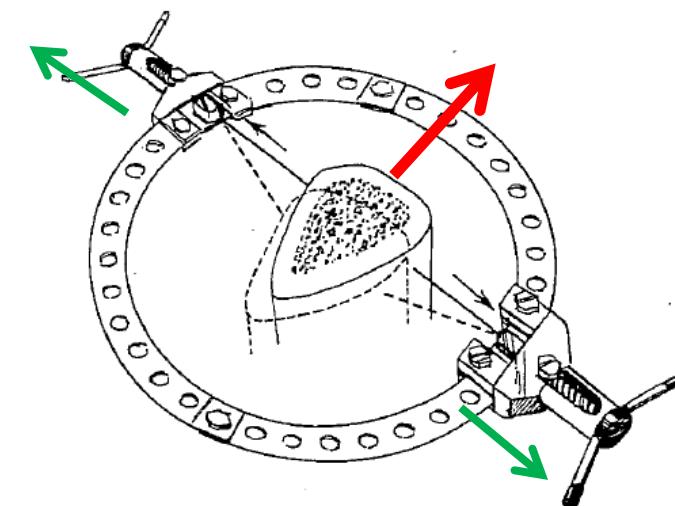
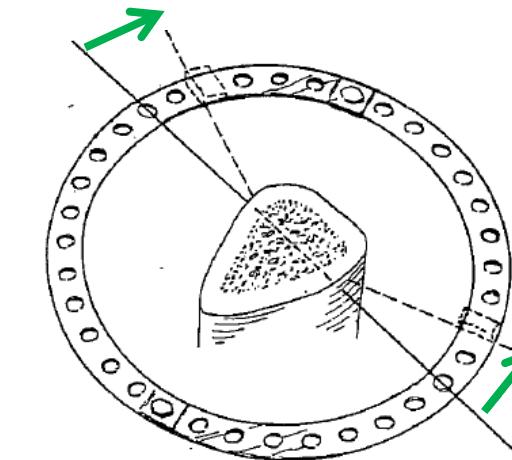
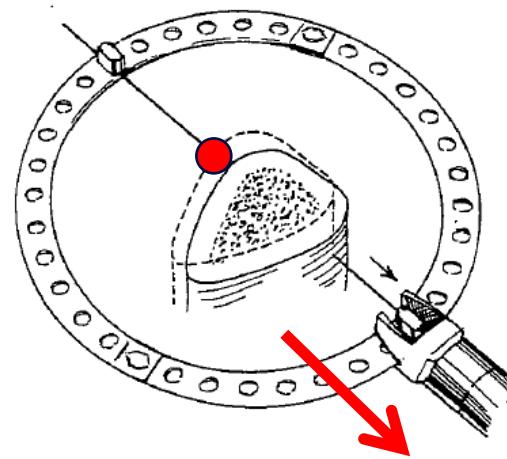
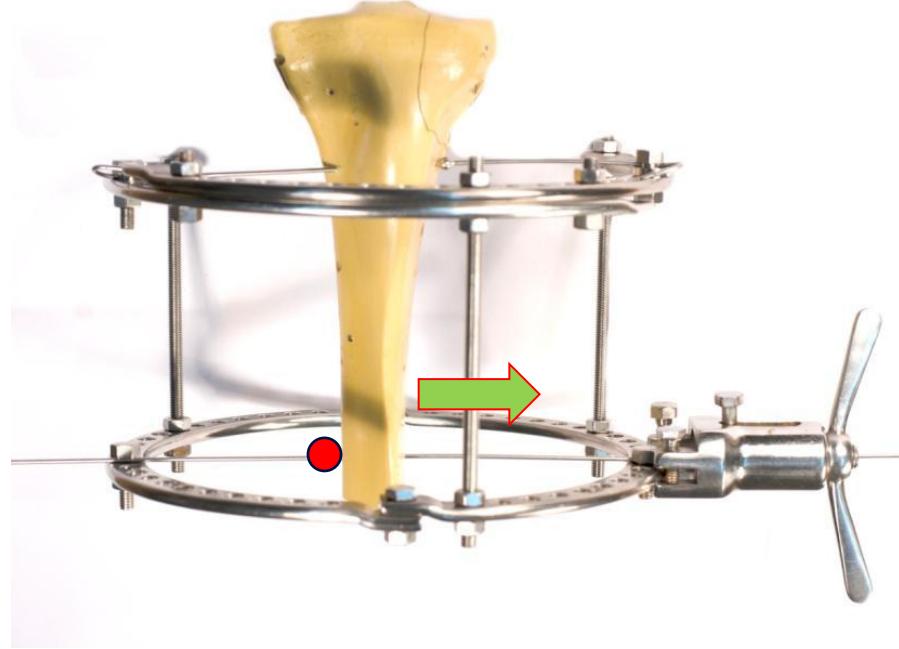
for bone
transport



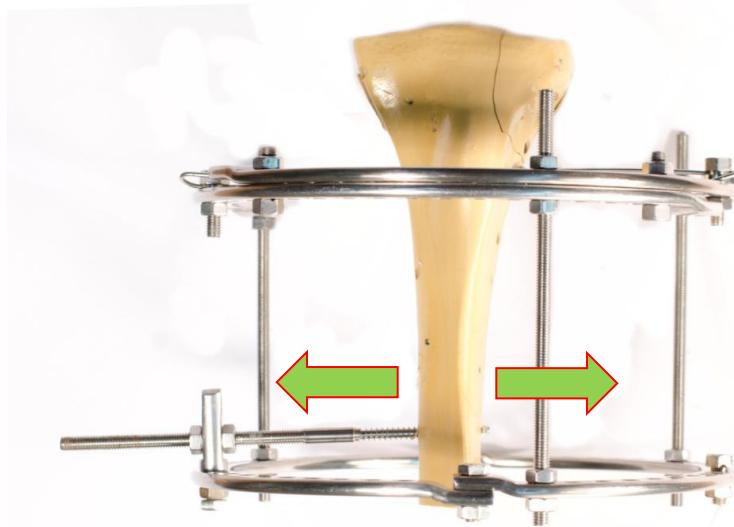
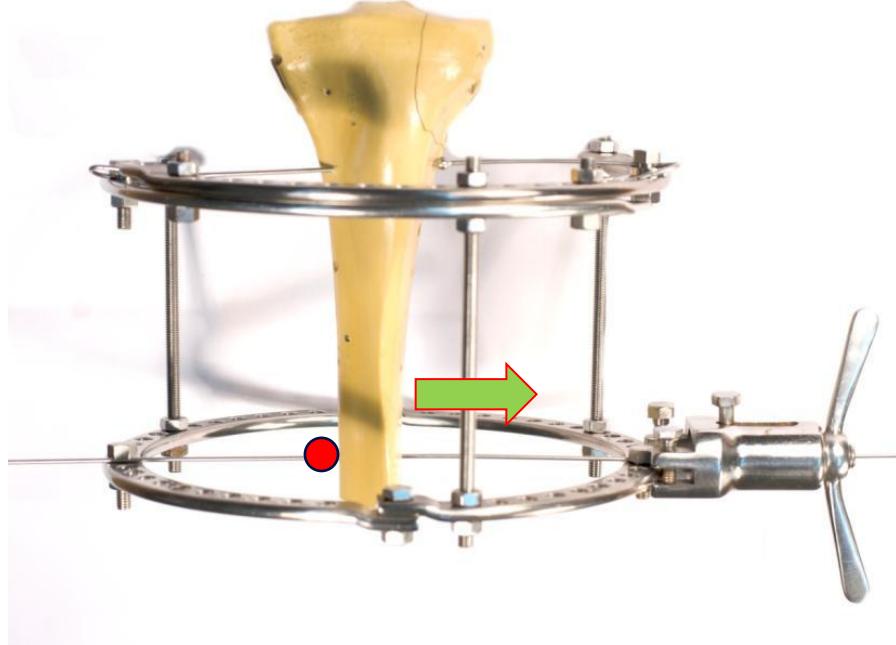
for deformity
correction



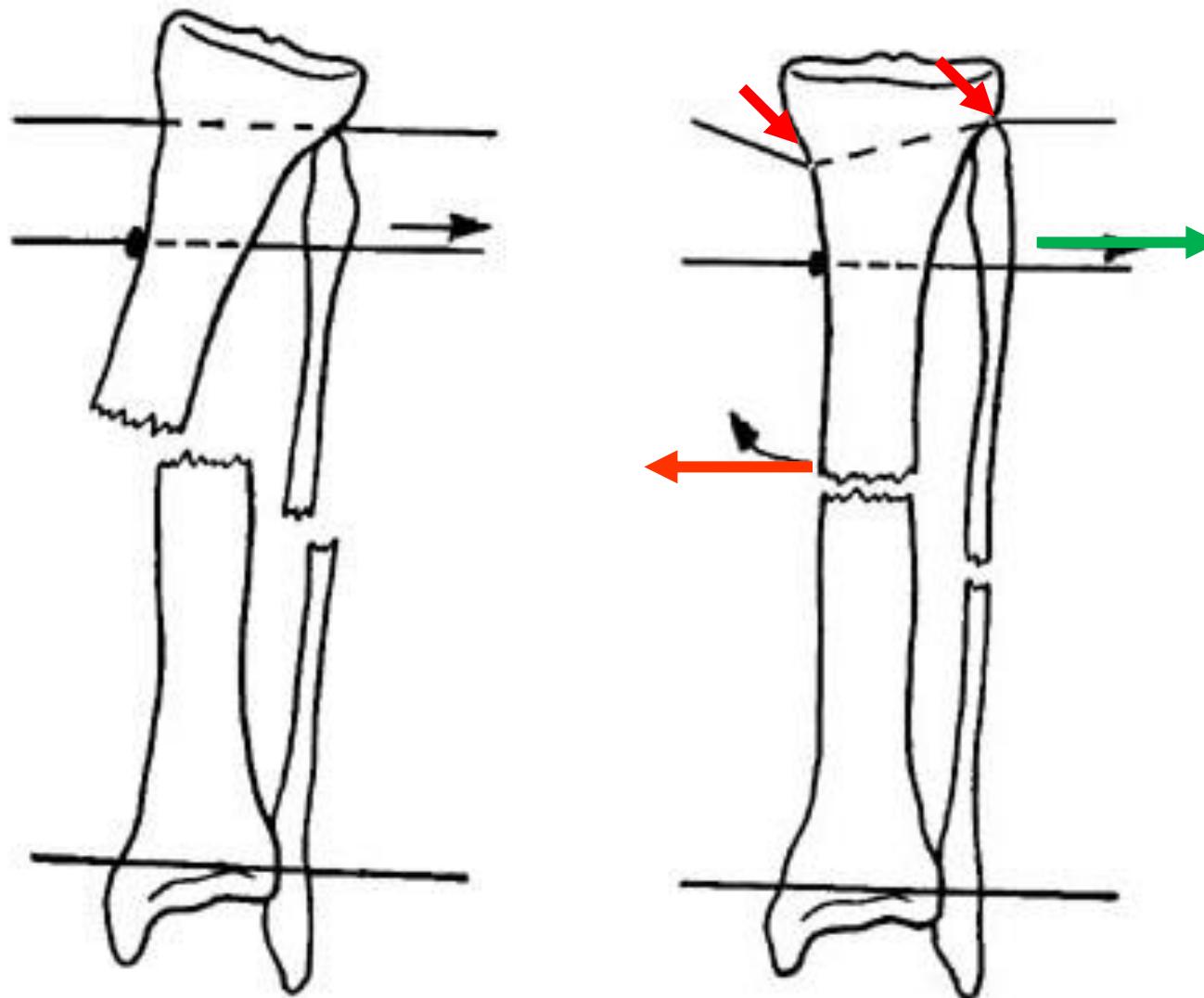
Bone fragment reduction: inside of the frame



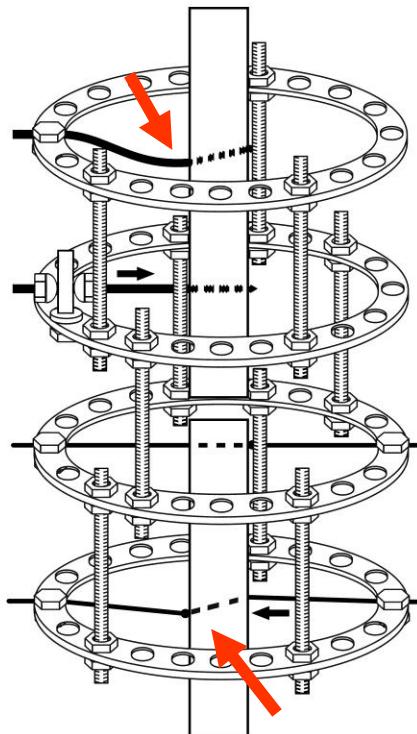
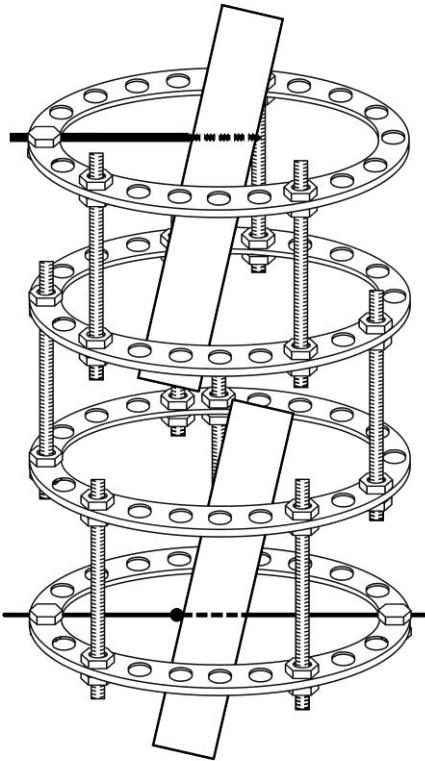
Bone fragment reduction: inside of the frame



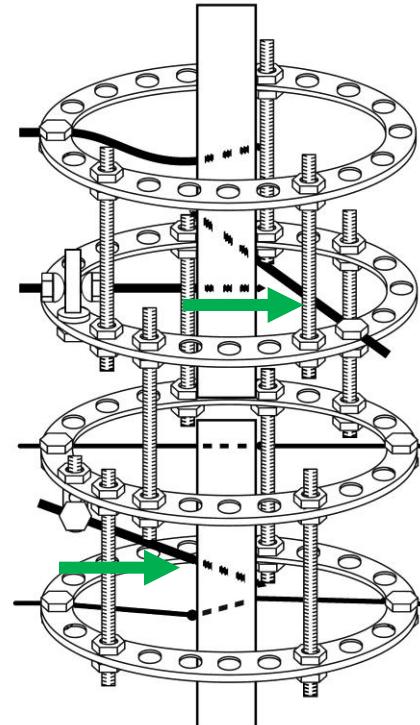
Bone fragment reduction: occurrence of displacing forces



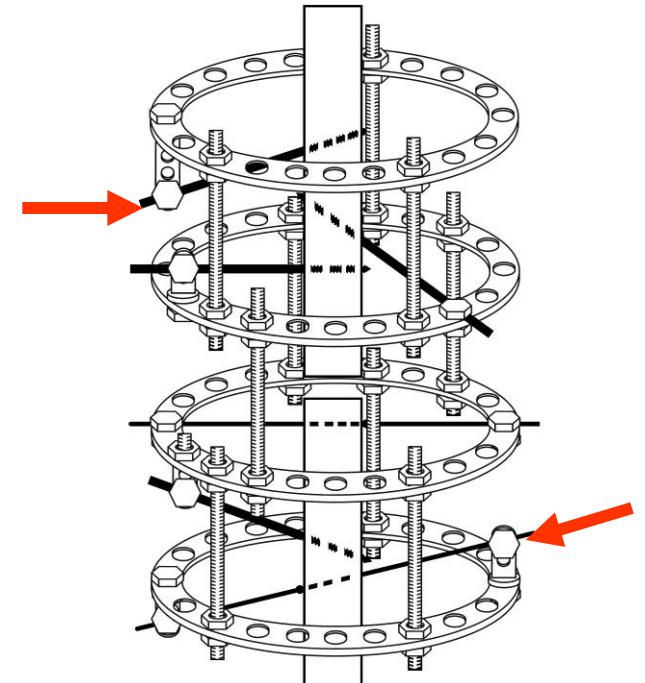
Bone fragment reduction: elimination of displacing forces



base wires and pins
deformity



insertion of
stabilizing pins



re-fixation of base
wires and pins

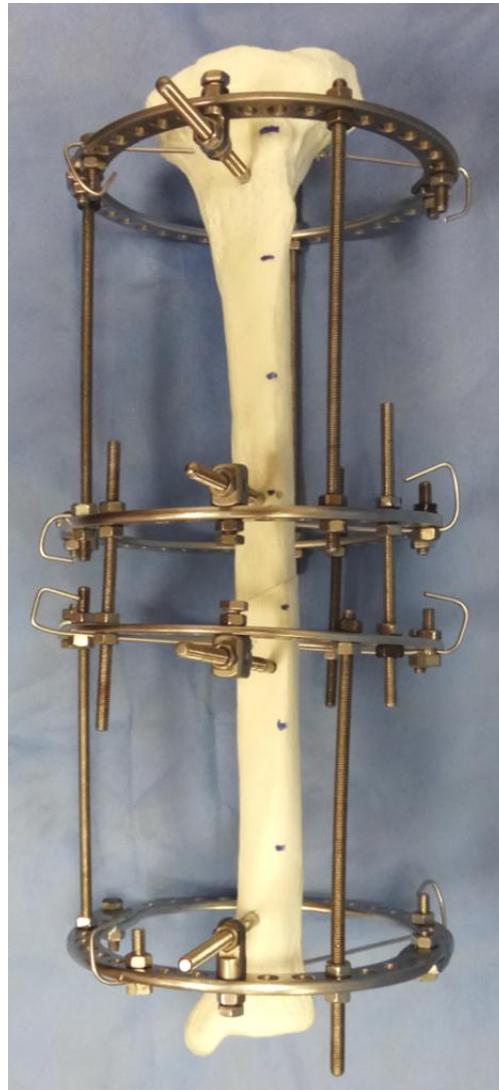
Fracture treatment: standard frame arrangement terminology

stabilizing wire/pin

stabilizing wire/pin

stabilizing wire/pin

stabilizing wire/pin



proximal base ring

proximal base wire/pin

proximal reduction ring

proximal reduction wire/pin

distal reduction ring

distal reduction wire/pin

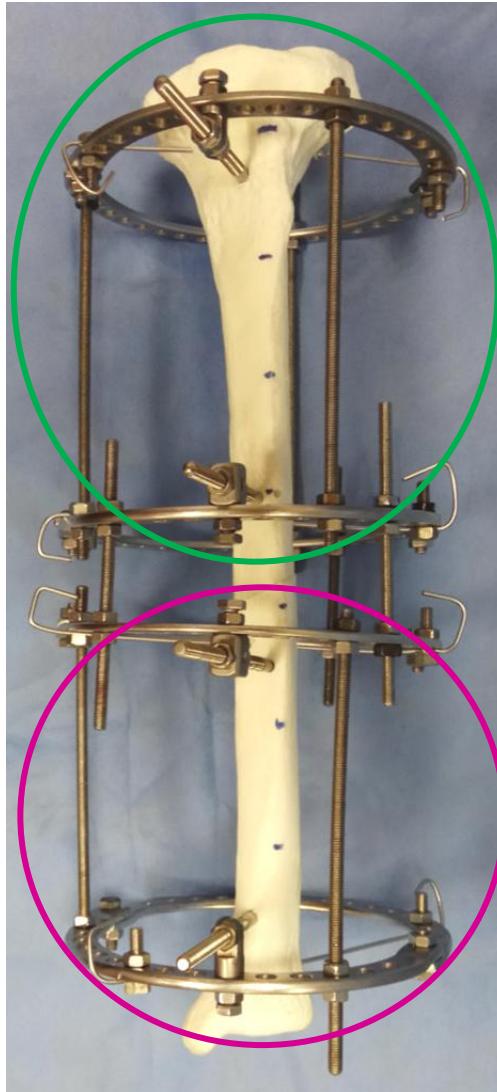
distal base wire/pin

distal base ring

Fracture treatment: standard frame arrangement terminology

proximal module

distal module



proximal base ring

proximal reduction ring

distal reduction ring

distal base ring

Stages of frame construction planning



Step 1. Identification of the *levels* for bone components insertion

- base
- reduction
- stabilizing

Step 2. Identification of the *positions* for bone components insertion

- base
- reduction
- stabilizing

Step 3. Identification optimal number of the rings

Step 4. Identification of the rings type and diameter

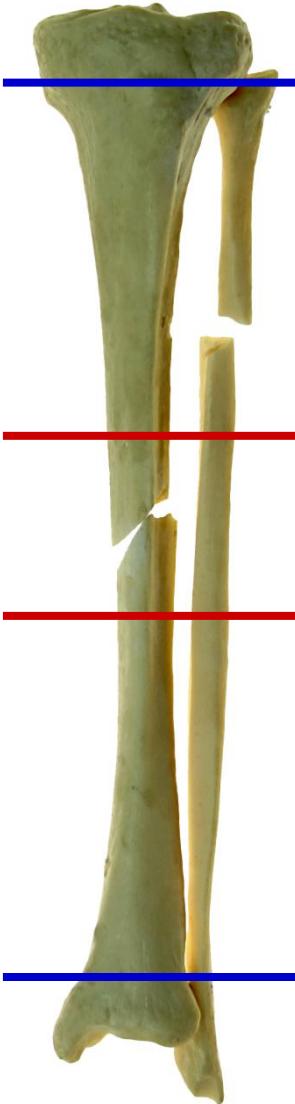
Step 1: Identification of levels for (all) wires and pins insertion



base bone component

base bone component

Step 1: Identification of levels for (all) wires and pins insertion

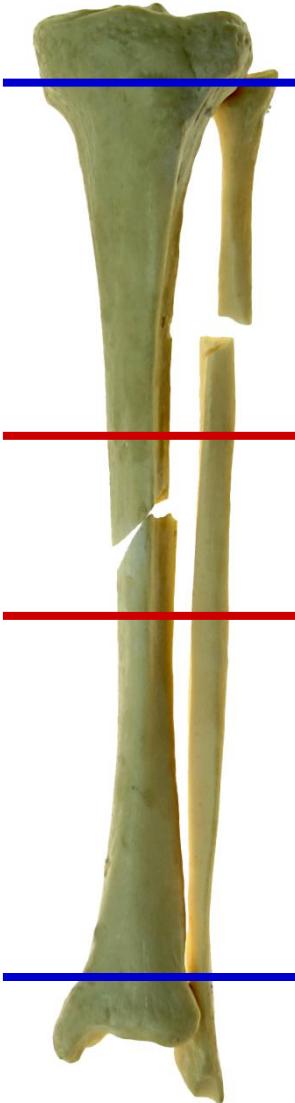


base bone component

Reduction bone components

base bone component

Step 1: Identification of levels for (all) wires and pins insertion



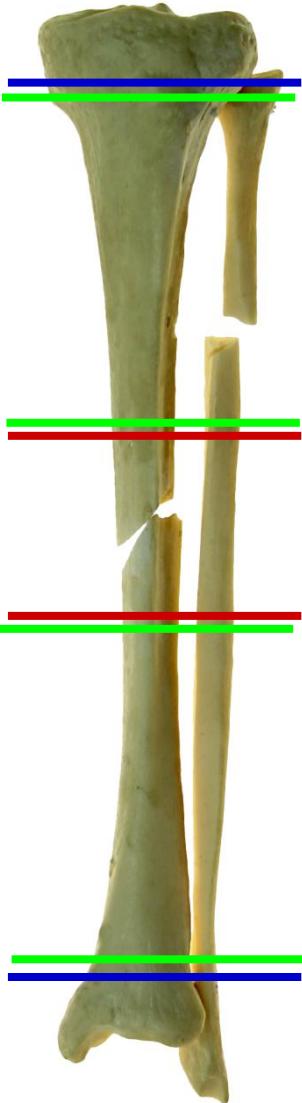
base bone component

stabilizing bone component

Reduction bone components

base bone component

Step 1: Identification of levels for (all) wires and pins insertion



base bone component
stabilizing bone component

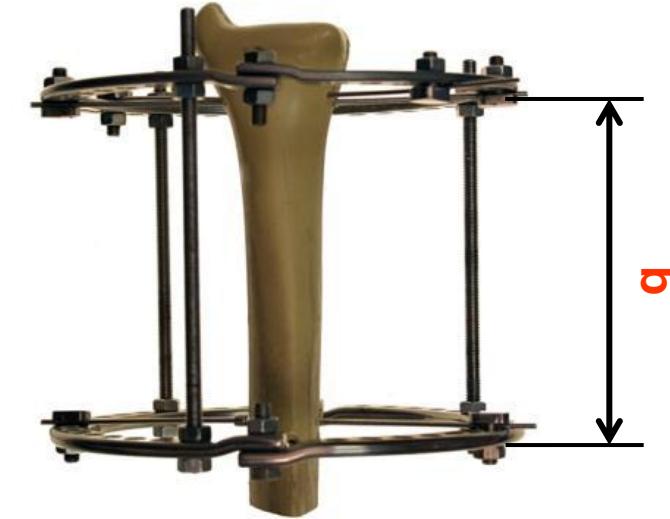
stabilizing bone component

Reduction bone components

stabilizing bone component

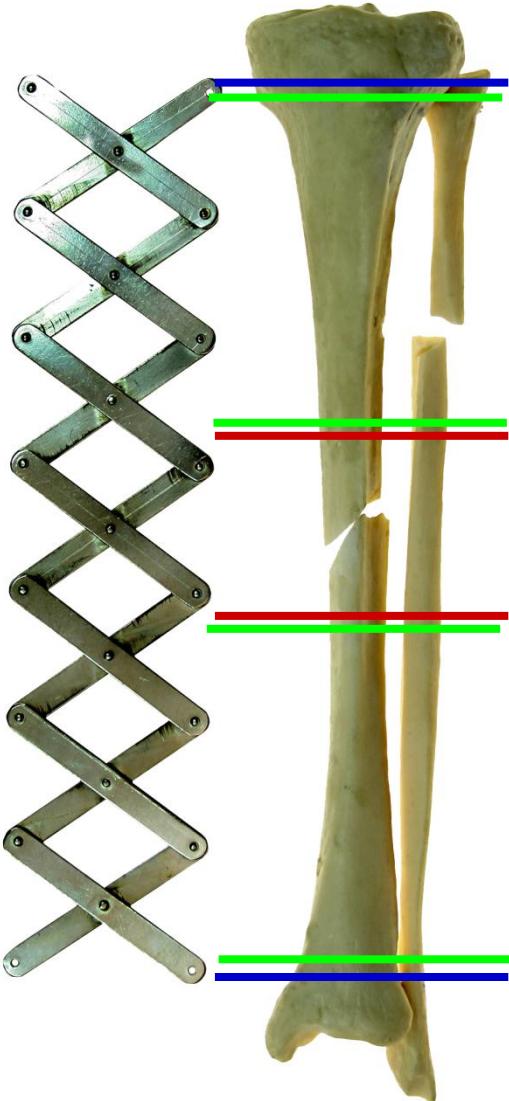
stabilizing bone component

base bone component



direct to the ring wires
and pins fixation
 $\beta = 90^\circ$

Step 1: Identification of levels numbers for (all) wires and pins insertion



base bone component
stabilizing bone component

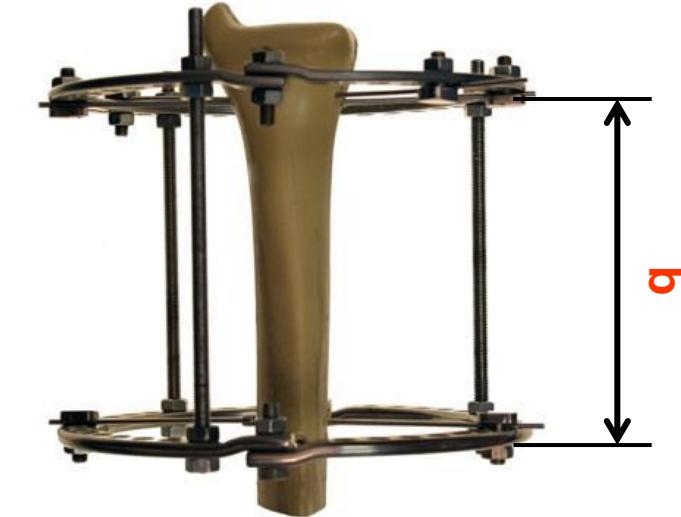
stabilizing bone component

Reduction bone components

stabilizing bone component

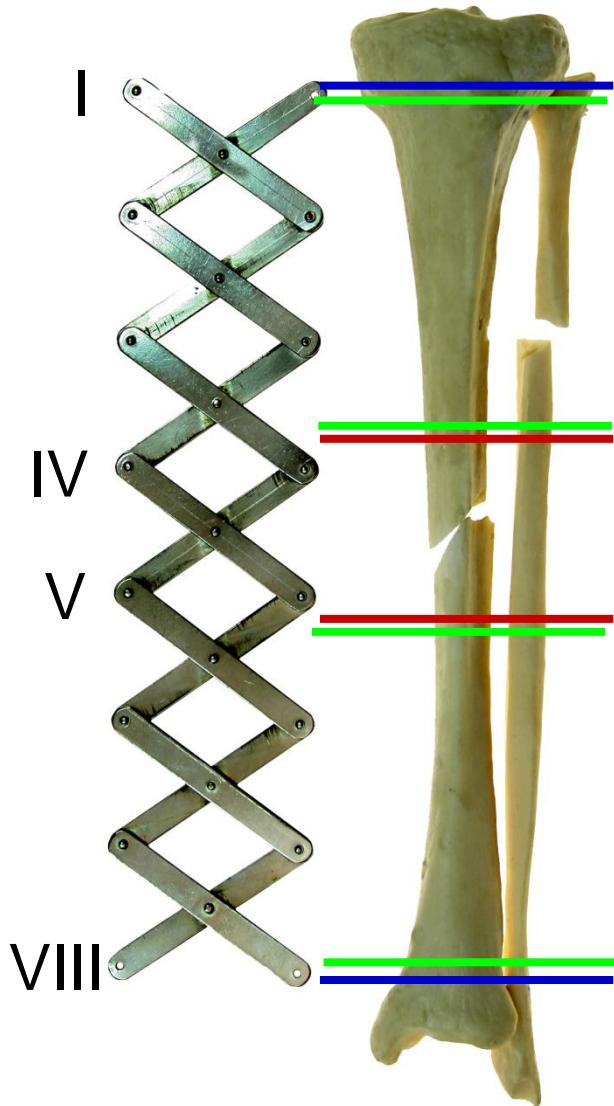
stabilizing bone component

base bone component



direct to the ring wires
and pins fixation
 $\beta = 90^\circ$

Step 1: Identification of levels numbers for (all) wires and pins insertion



base bone component
stabilizing bone component

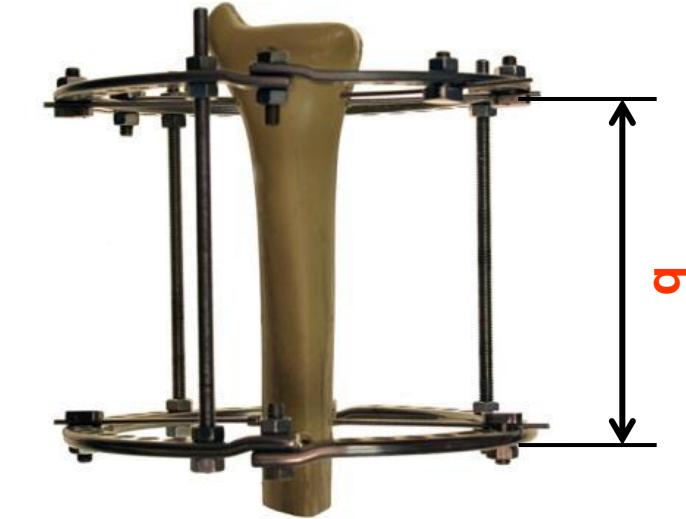
stabilizing bone component

Reduction bone components

stabilizing bone component

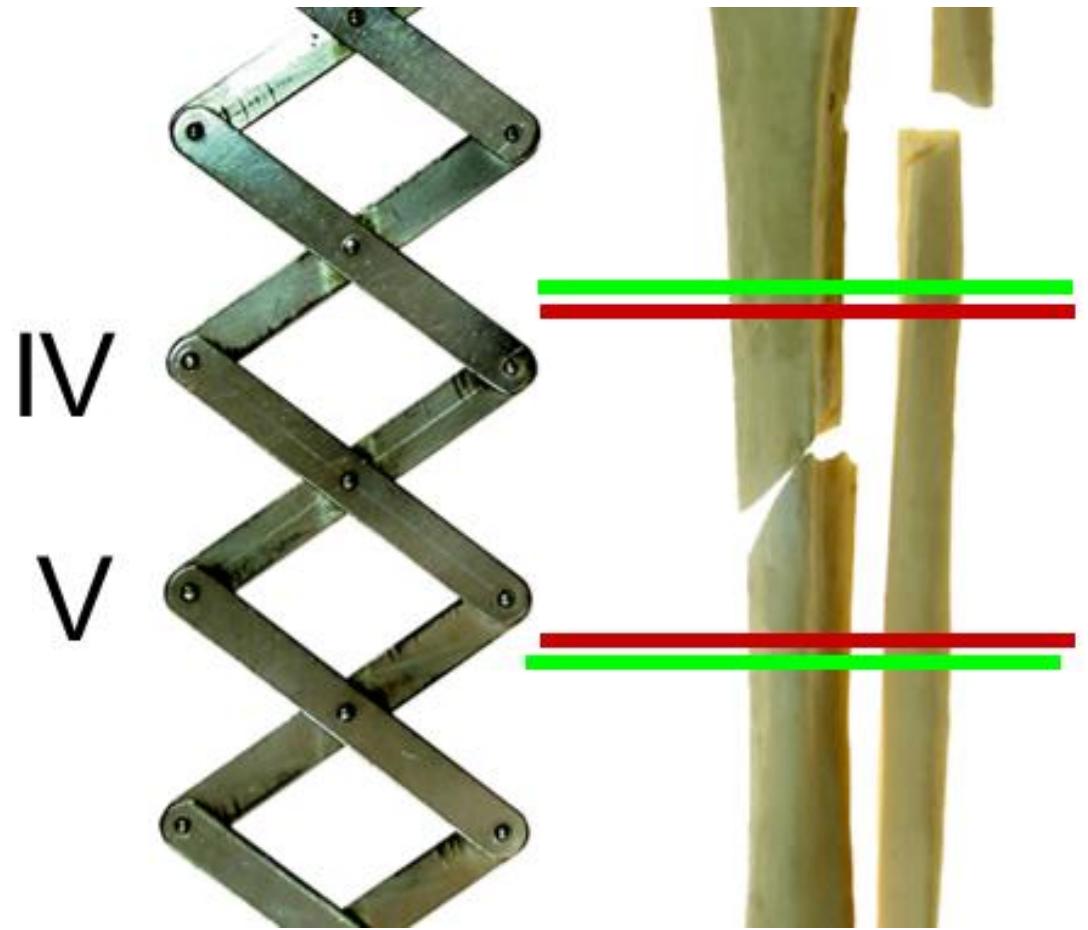
stabilizing bone component

base bone component

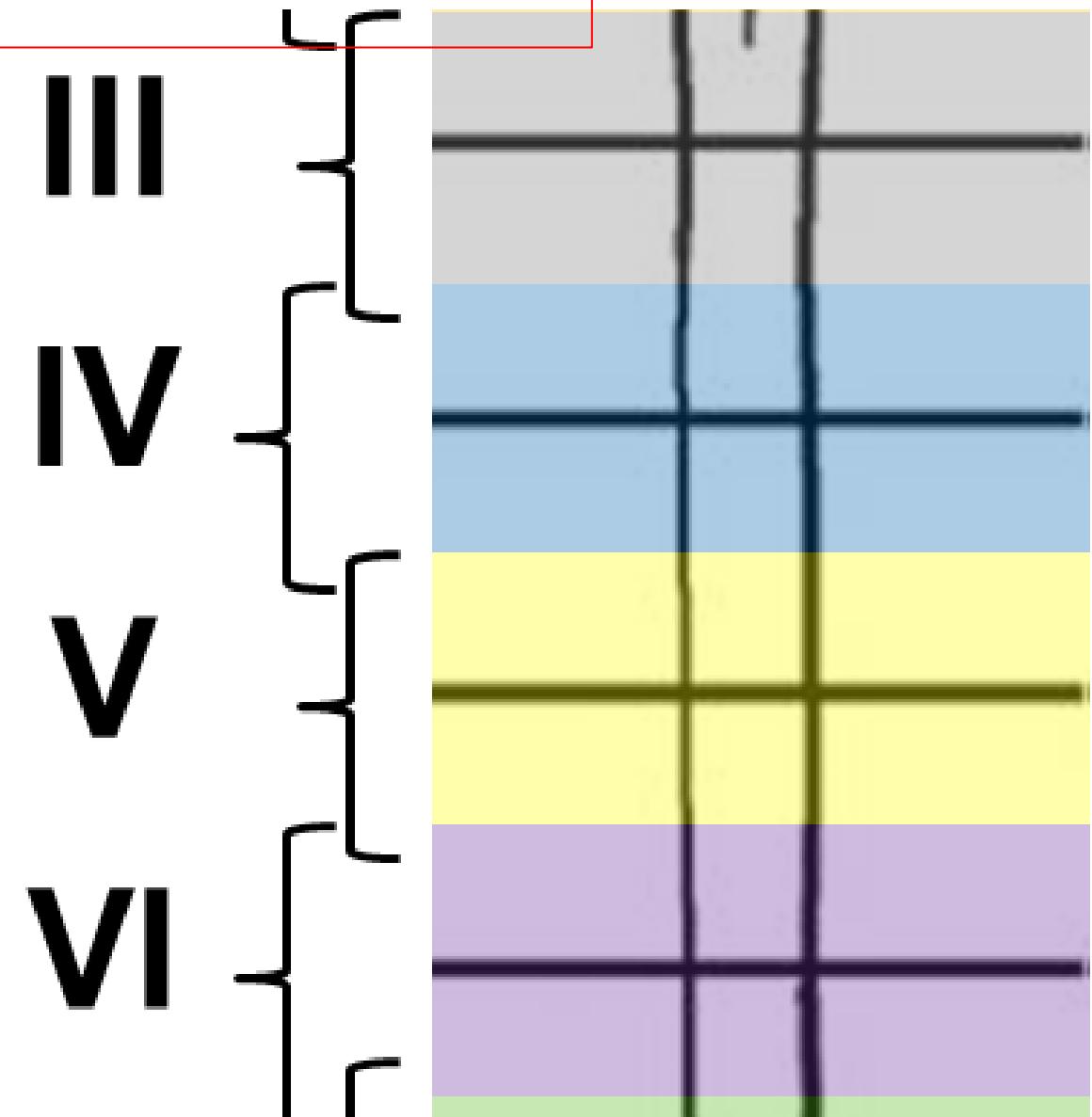
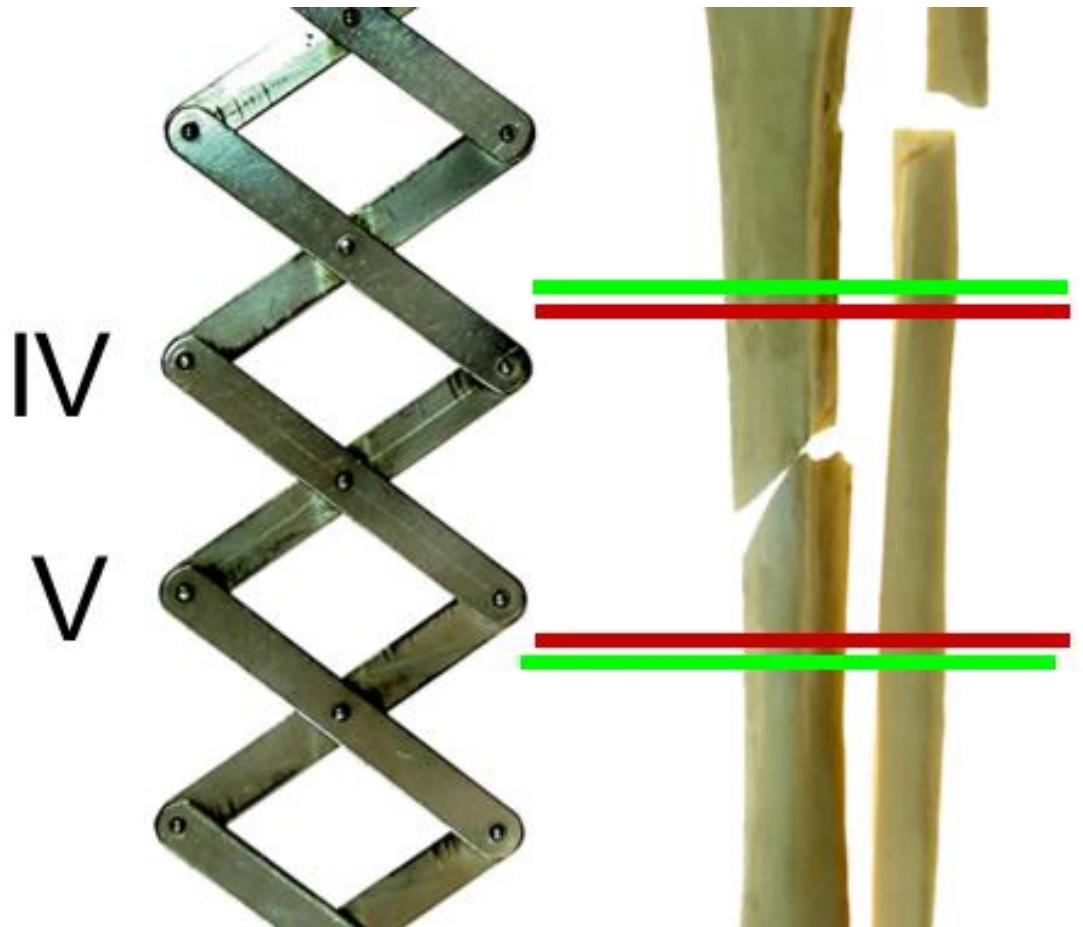


**direct to the ring wires
and pins fixation**
 $\beta = 90^\circ$

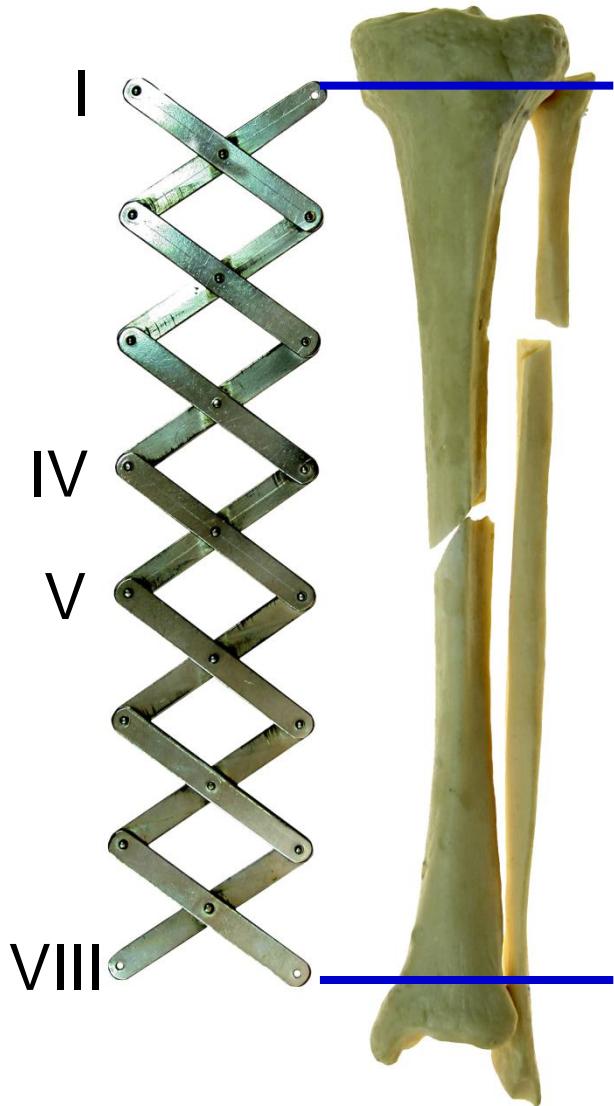
NOTE! Exact match with the levels is not necessary!



NOTE! Exact match with the levels is not necessary!

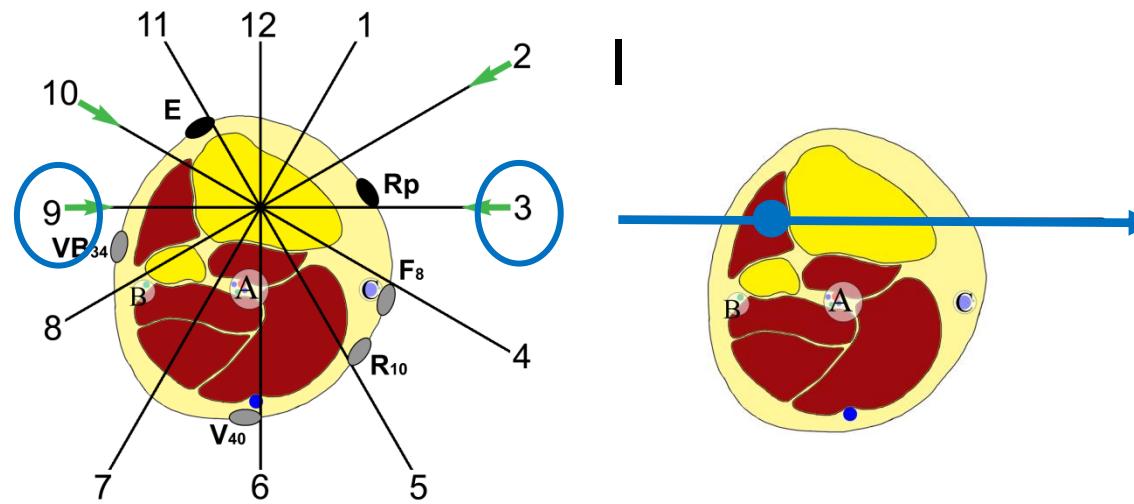
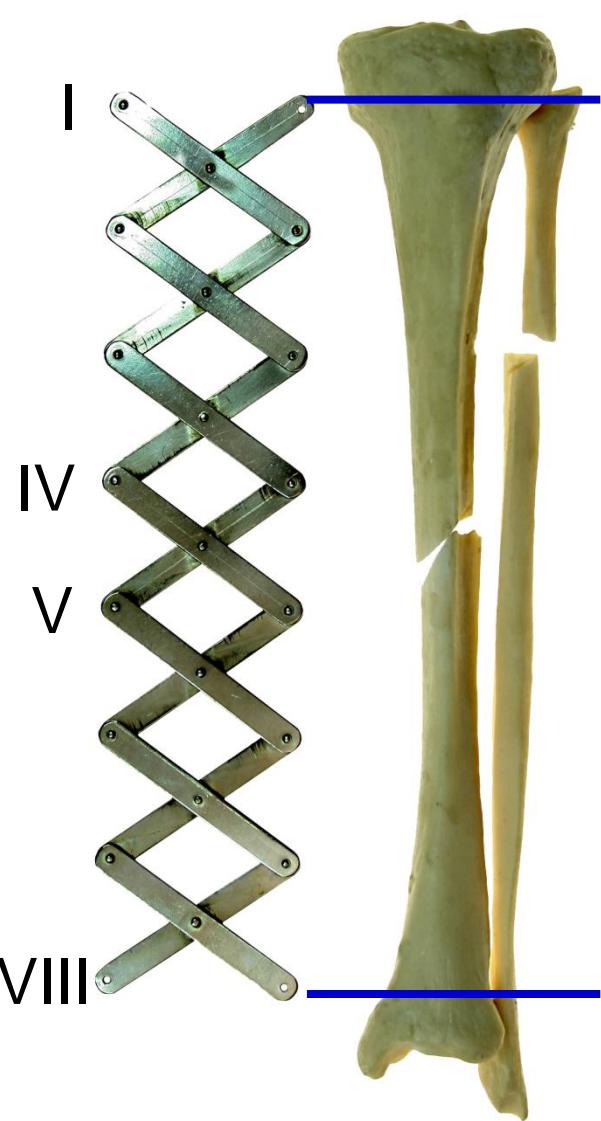


Step 2: Identification of positions for base wires and pins insertion

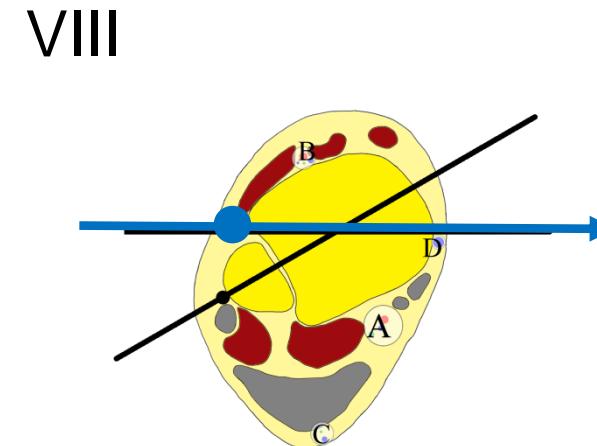
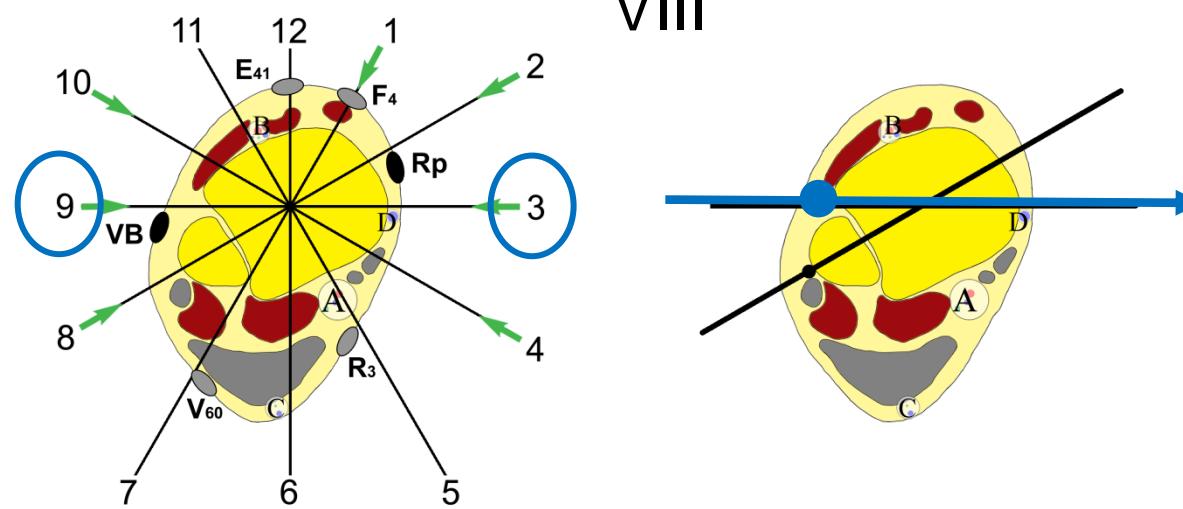
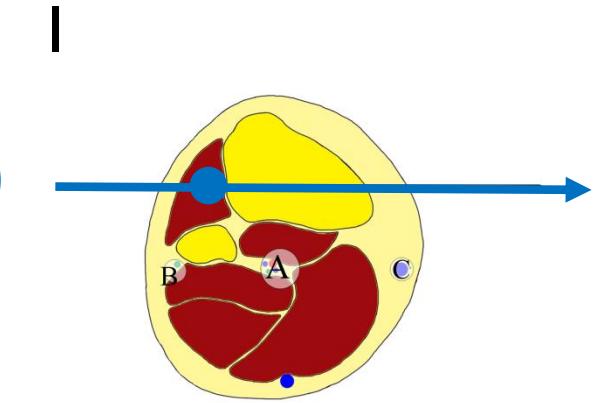
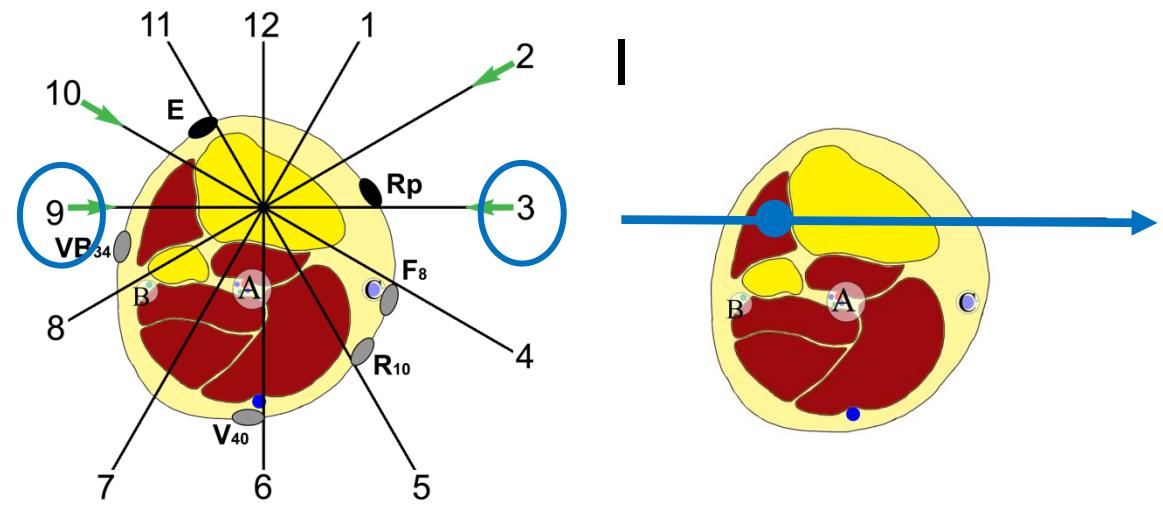
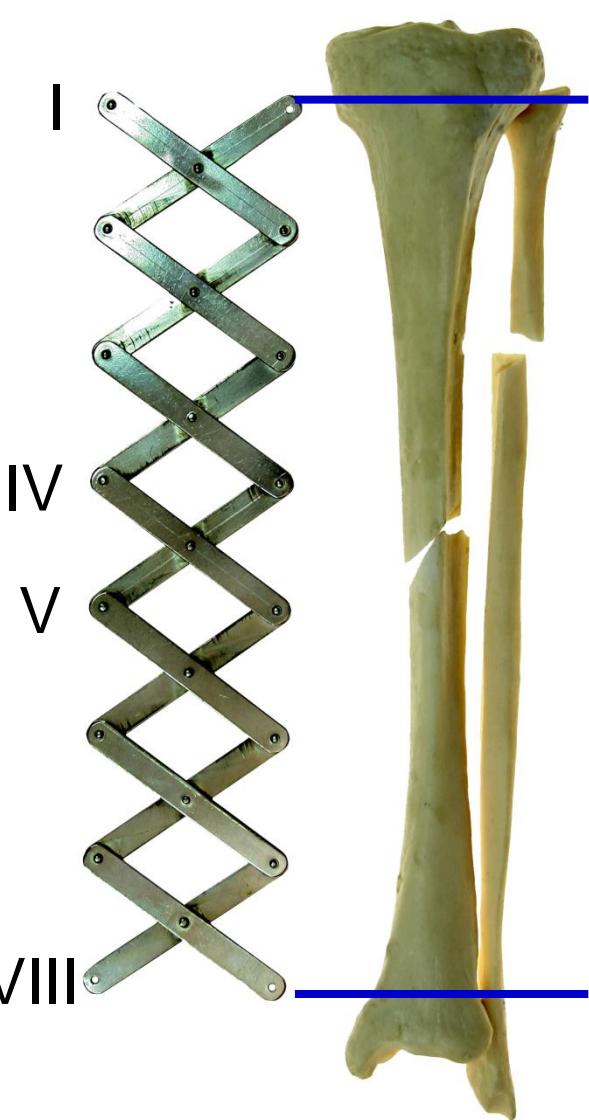


Positions
3 and 9
6 and 12
should be used

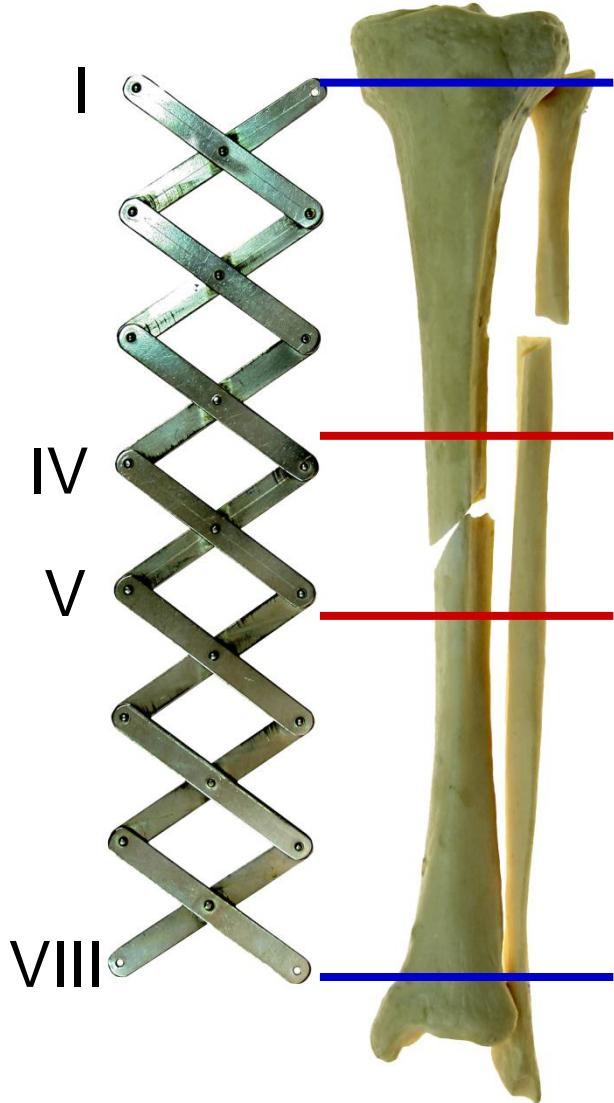
Step 2: Identification of positions for base wires and pins insertion



Step 2: Identification of positions for base wires and pins insertion

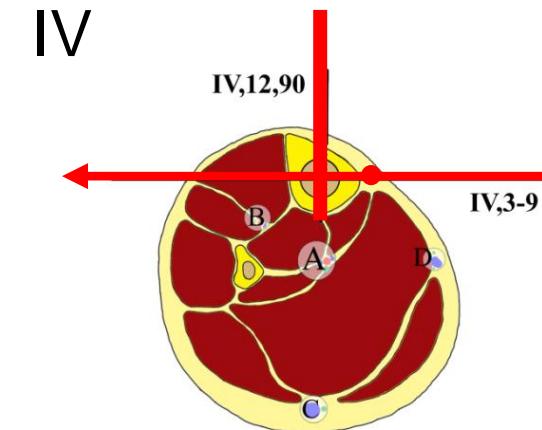
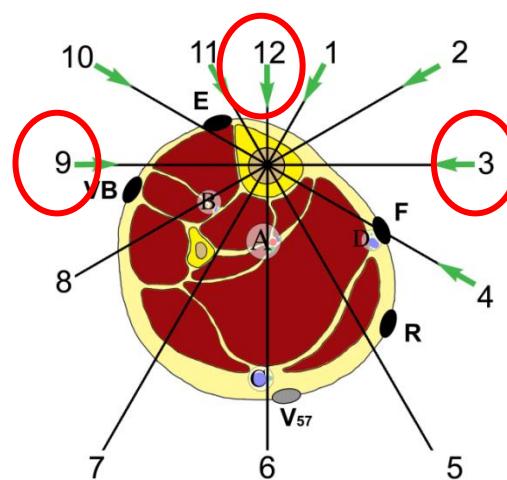
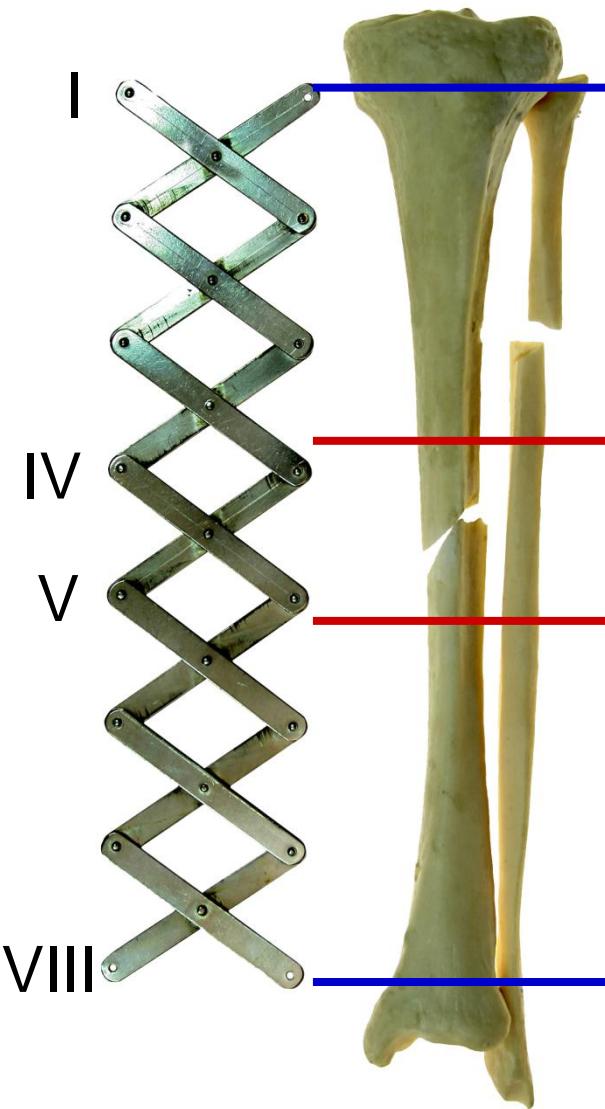


Step 2: Identification of positions for reduction bone components insertion

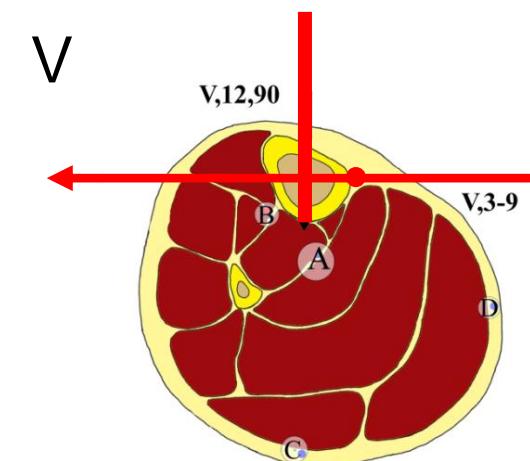
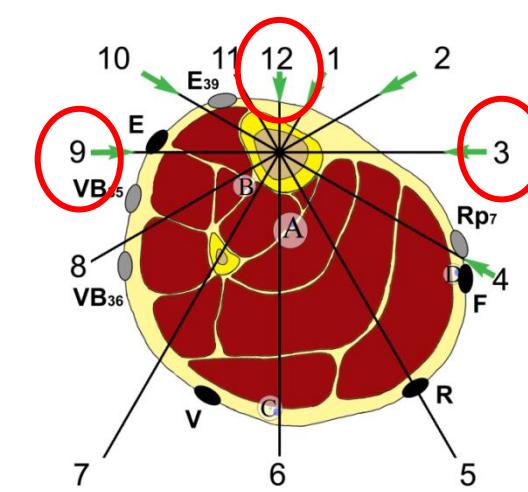
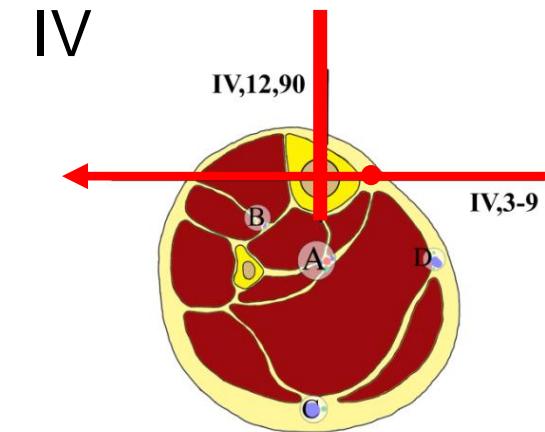
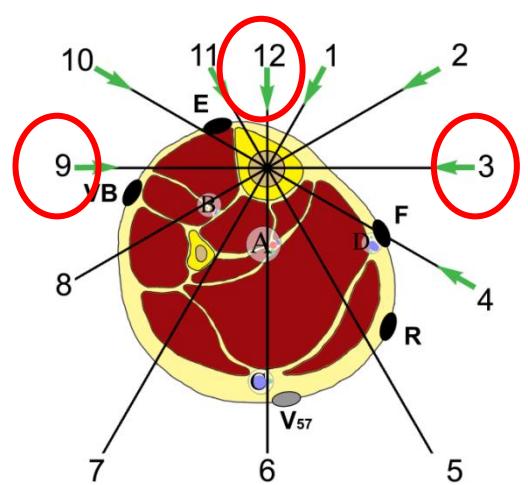
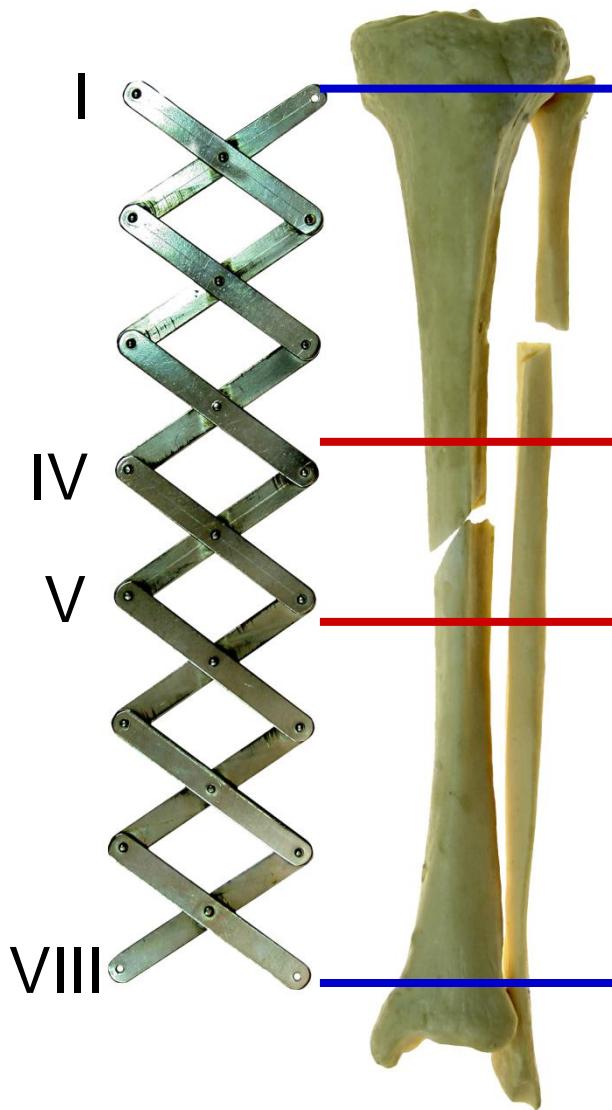


Positions
3 and 9
6 and 12
should be used

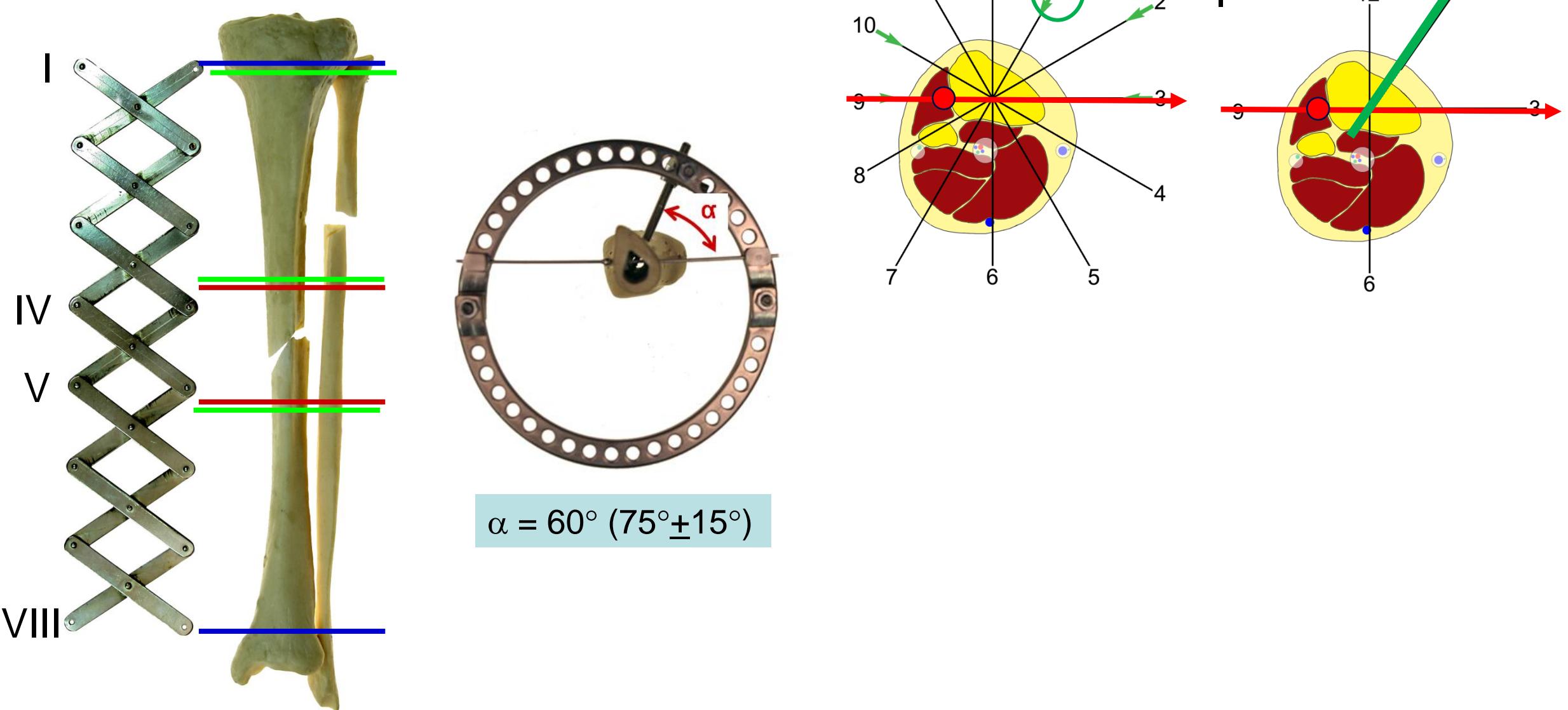
Step 2: Identification of positions for reduction bone components insertion



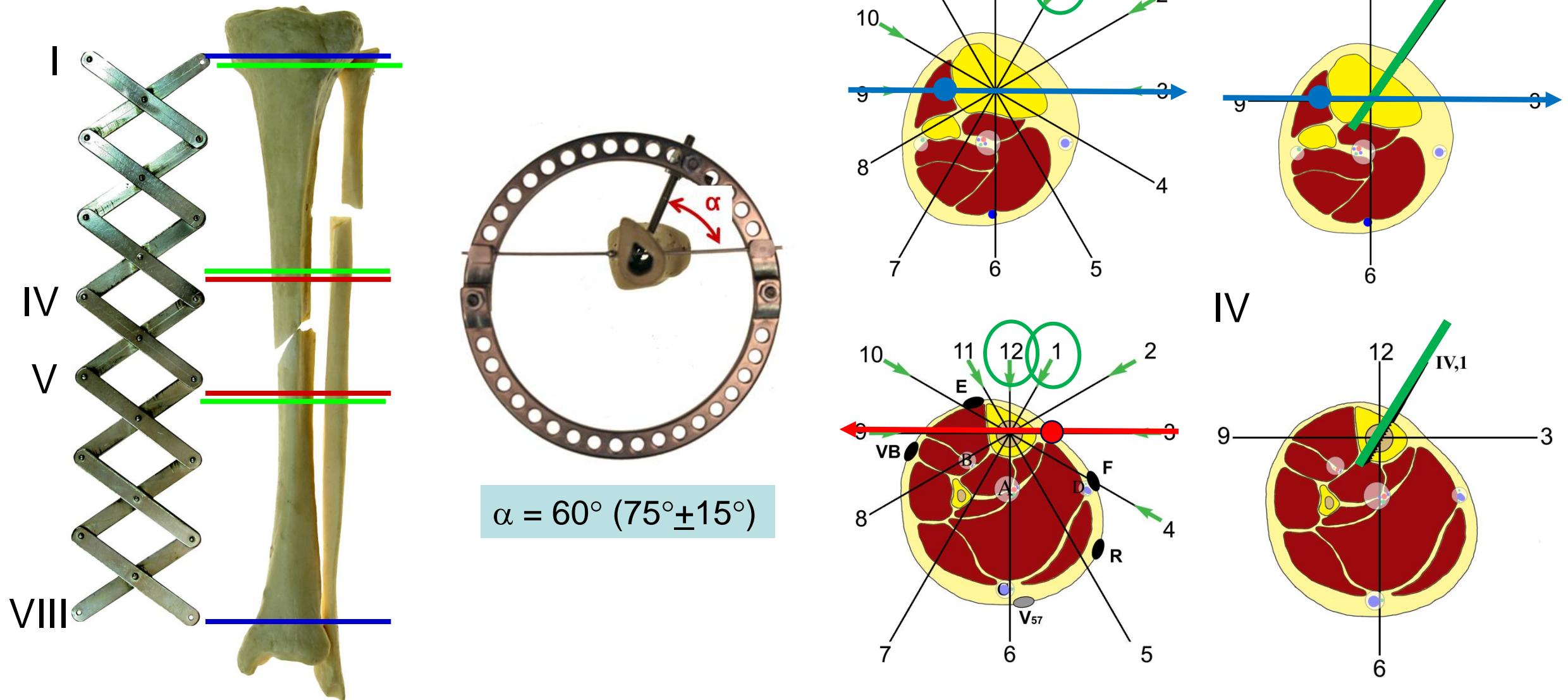
Step 2: Identification of positions for reduction bone components insertion



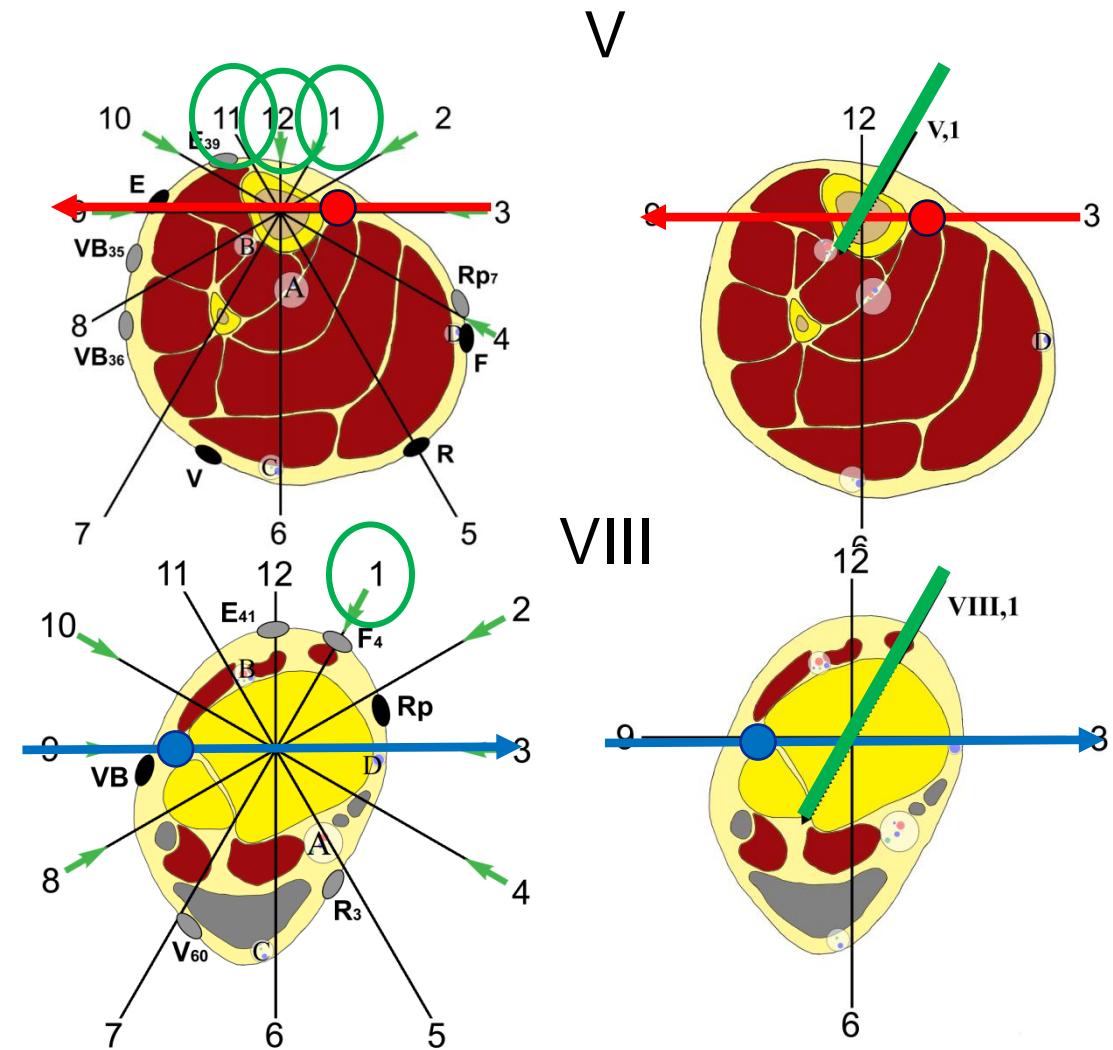
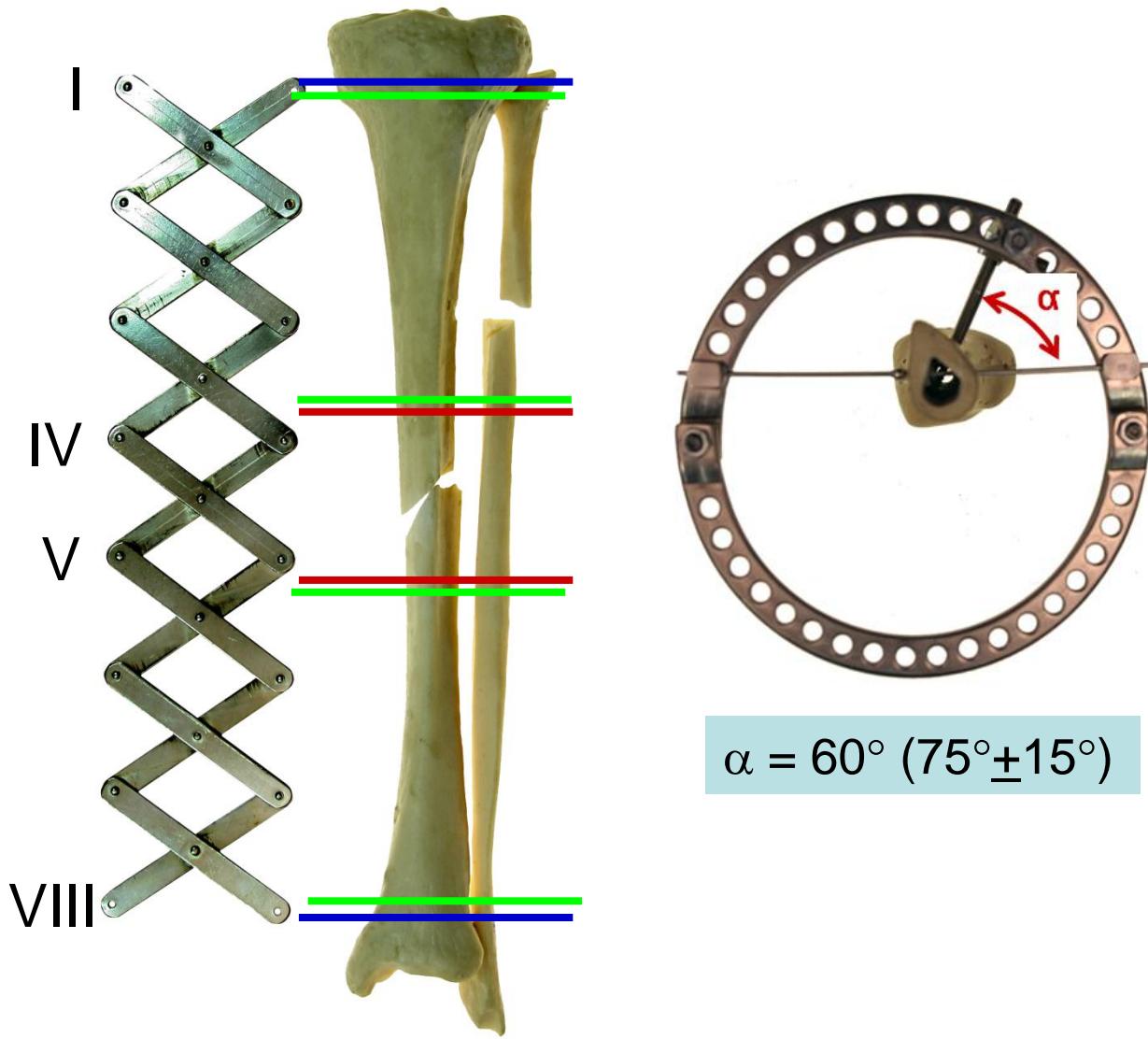
Step 2: Identification of positions for stabilizing bone components insertion



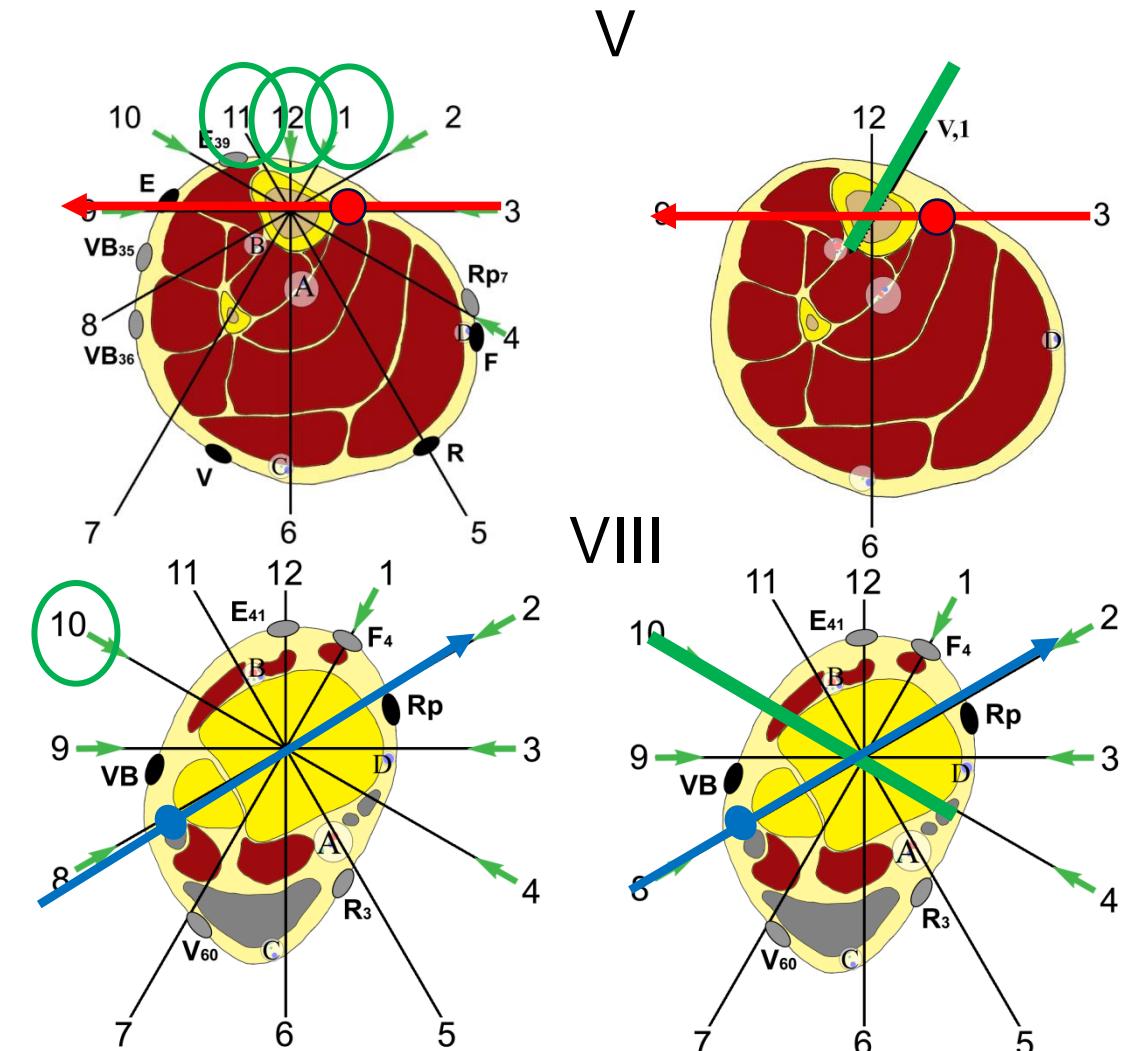
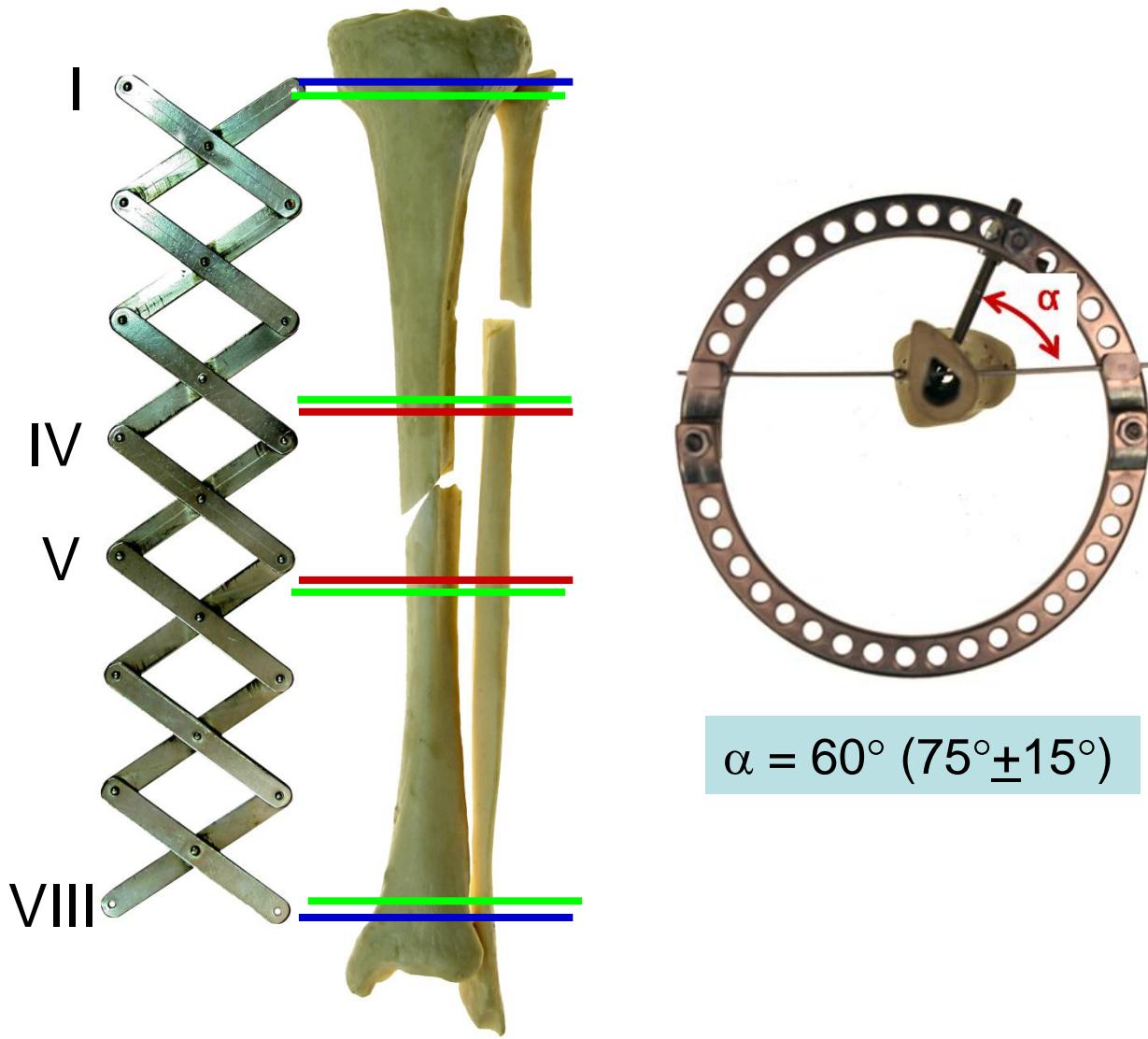
Step 2: Identification of positions for stabilizing bone components insertion



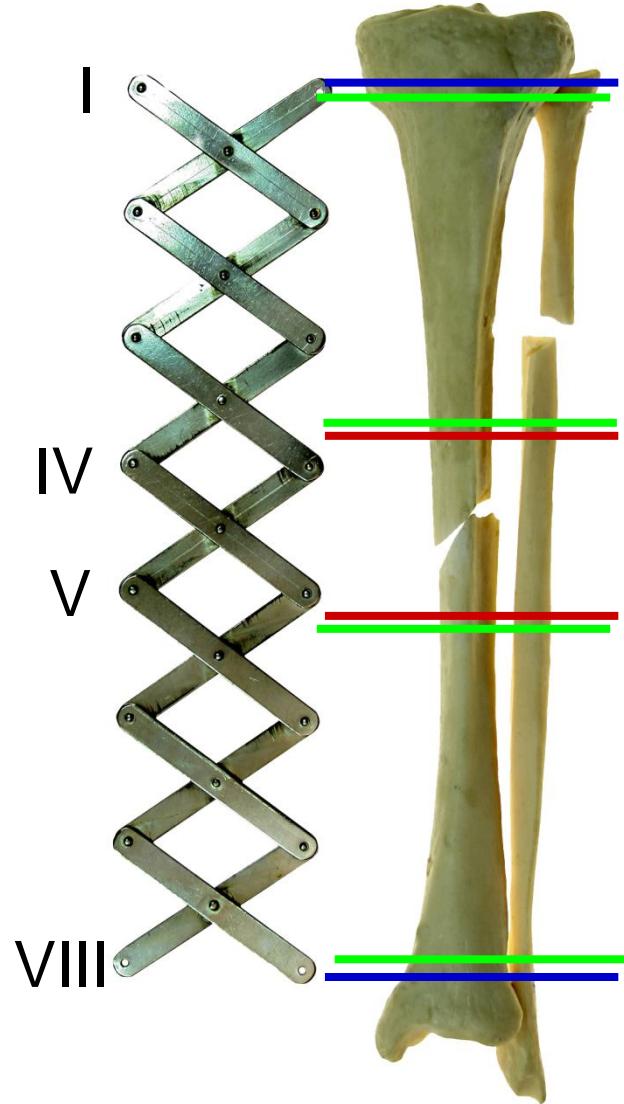
Step 2: Identification of positions for stabilizing bone components insertion



Step 2: Identification of positions for stabilizing bone components insertion

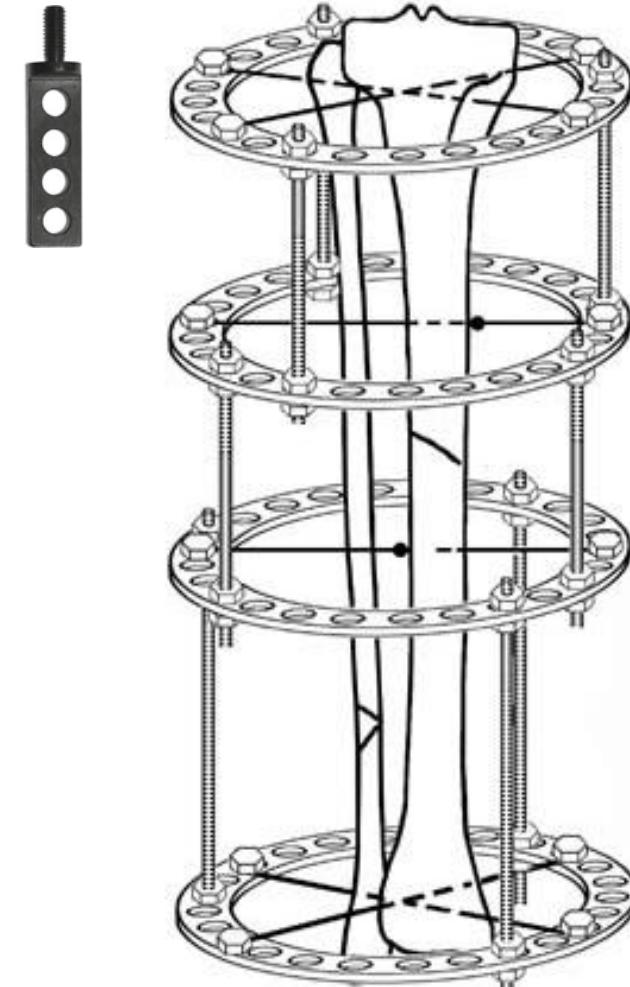
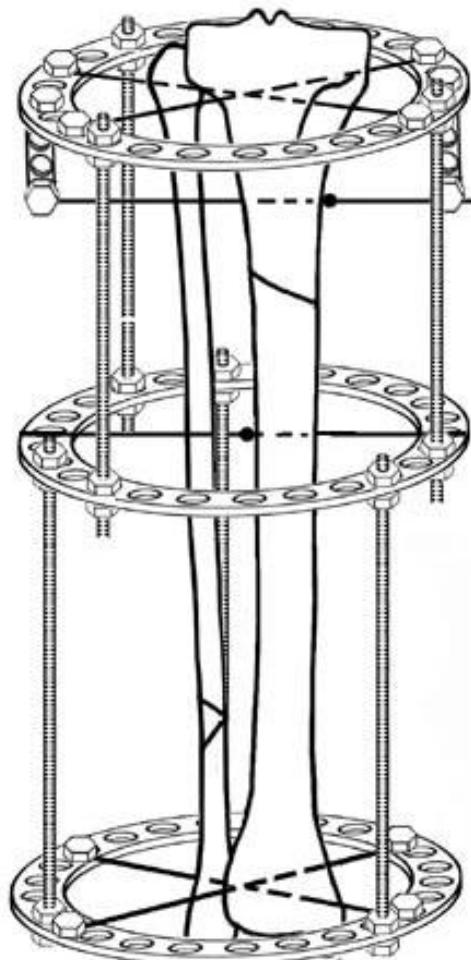
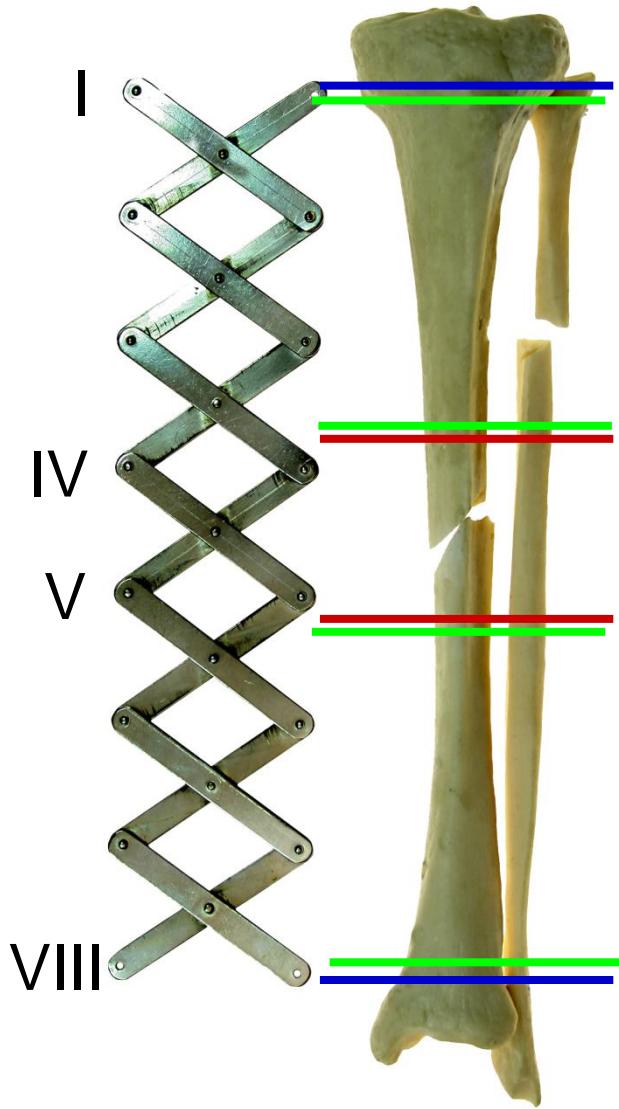


Step 3: Identification of the rings number

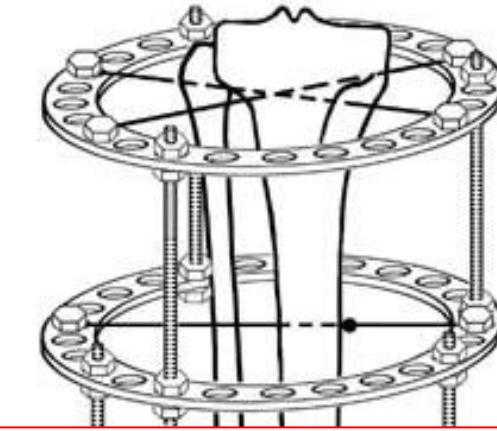
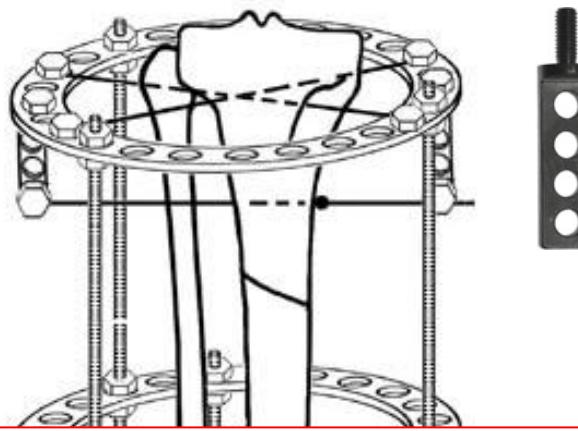
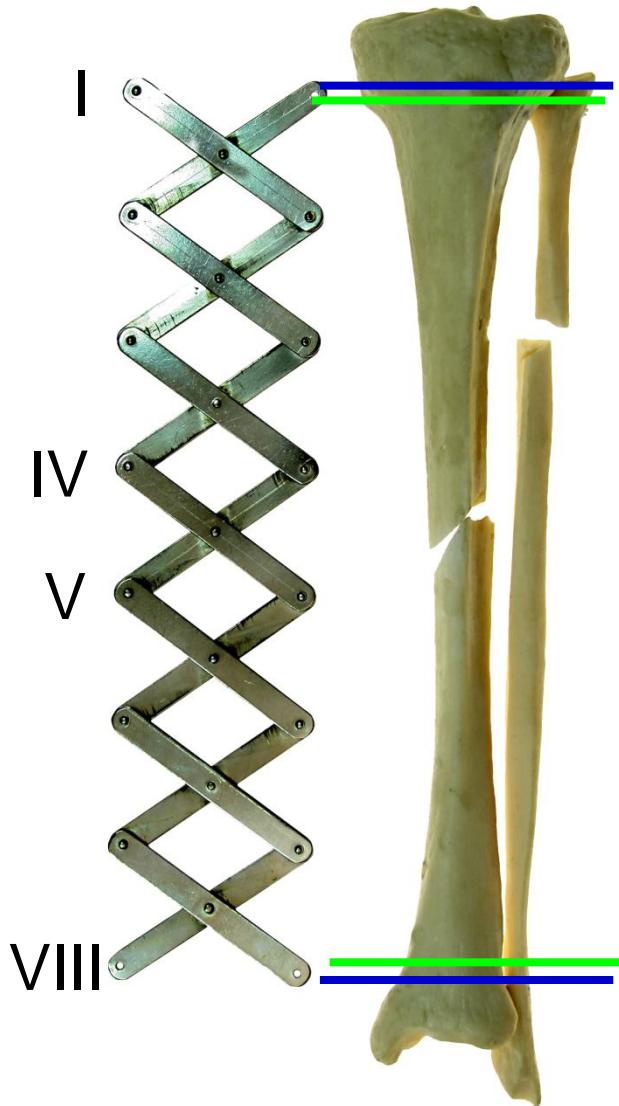


“Four-hole post forever!”

Step 3: Identification of the rings number



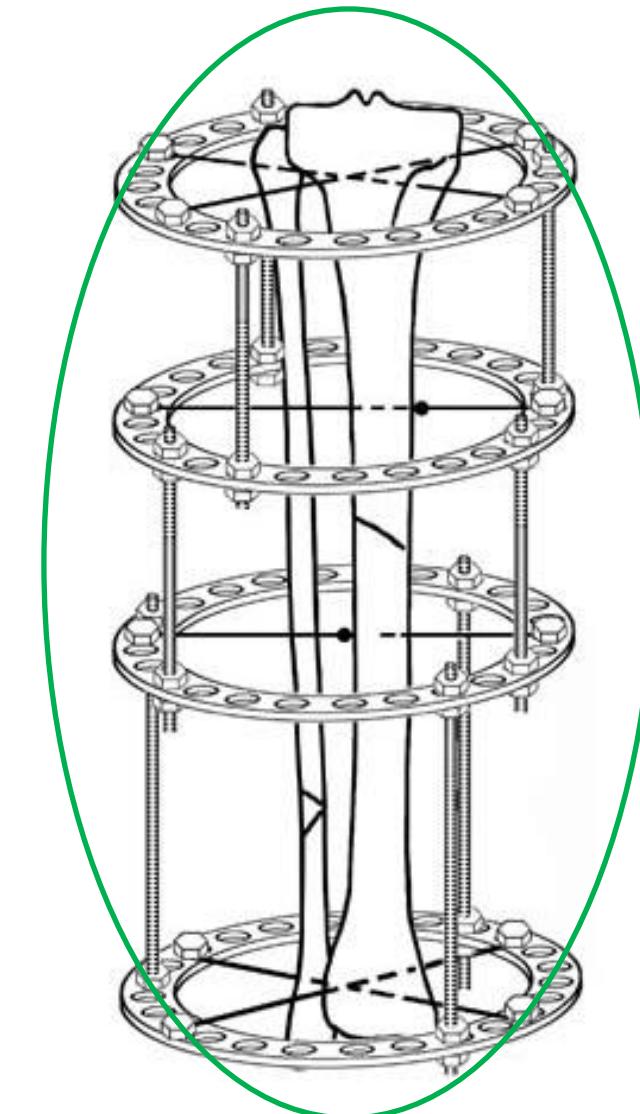
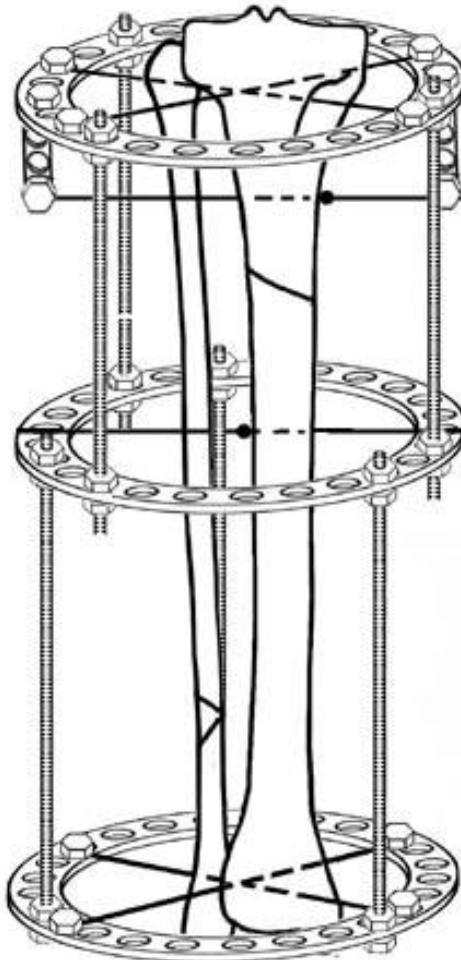
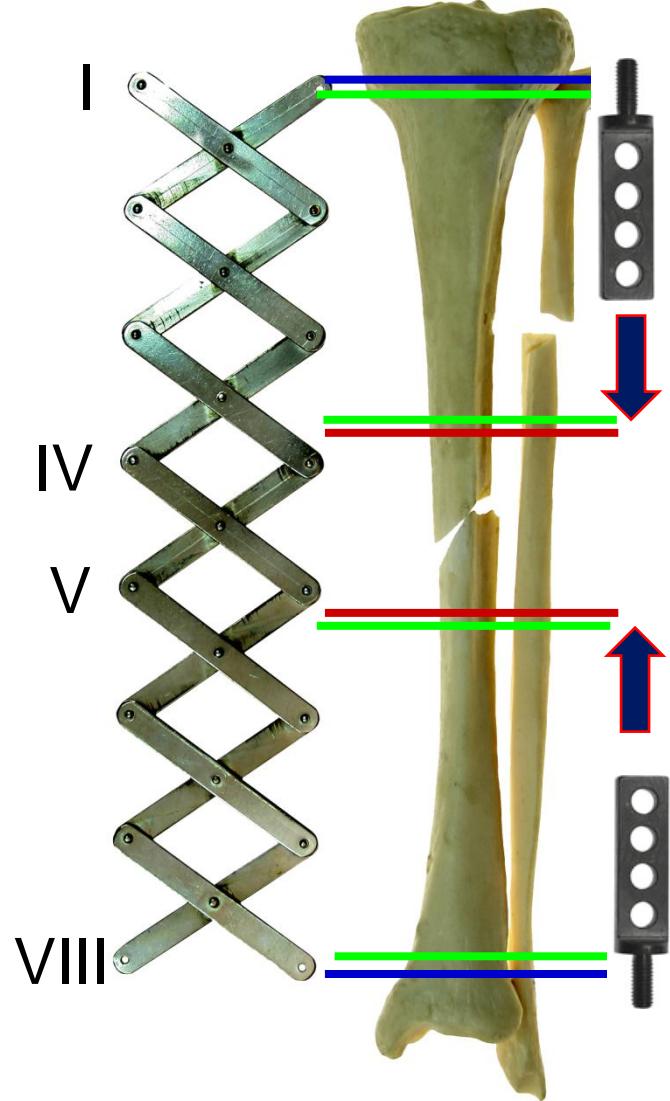
Step 3: Identification of the rings number



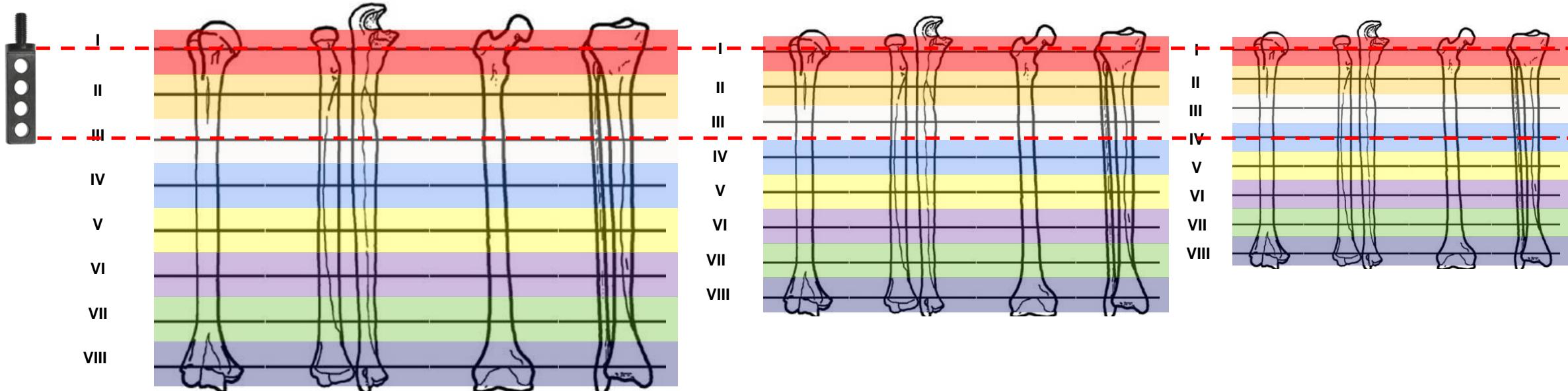
If there are some doubts:

“should we use one- or two-ring module?”,
two-ring module must be used!

Step 3: Identification of the rings number



NOTE! Indications for the reduction ring depend
on the distance between the levels



Step 4: Identification of the rings type and diameter



- levels I and II of femur



- levels III, IV, VIII of the upper arm
- level I of forearm
- levels III, IV, VIII of femur
- level I of lower leg

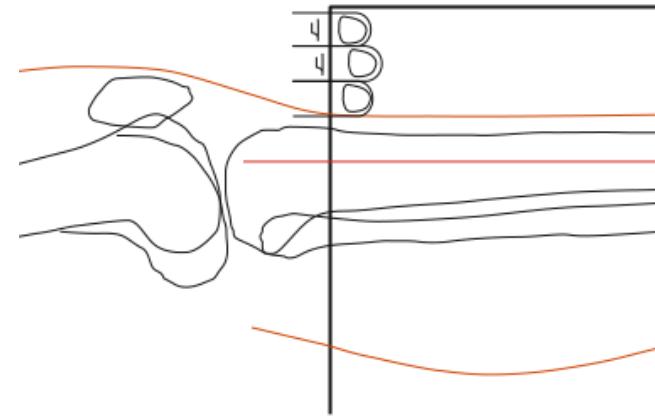
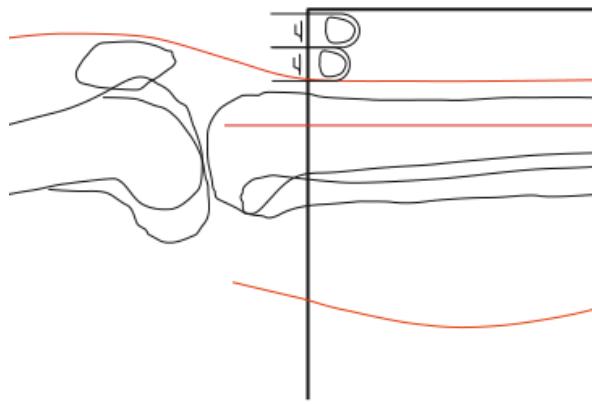


- levels I and II of upper arm



- rings - in all other cases

Step 4: Identification of the rings type and diameter



Step 4: Identification of the rings type and diameter

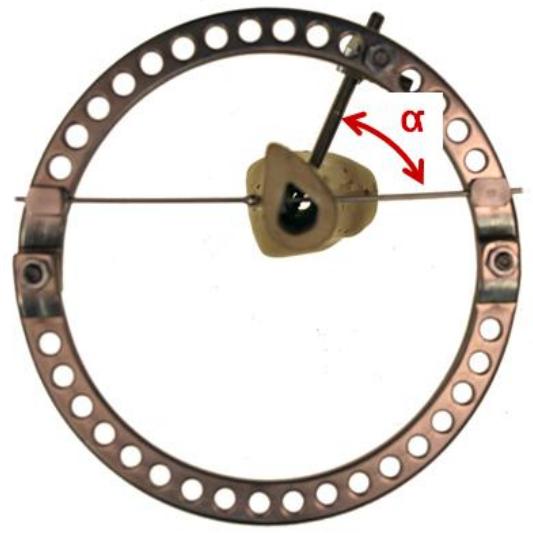
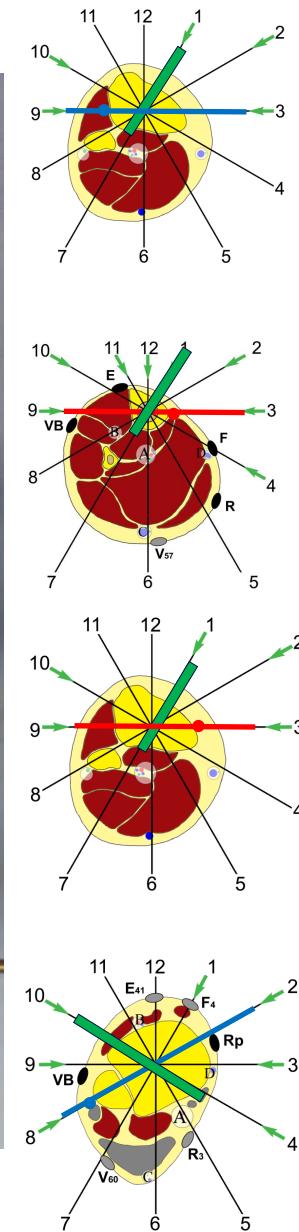
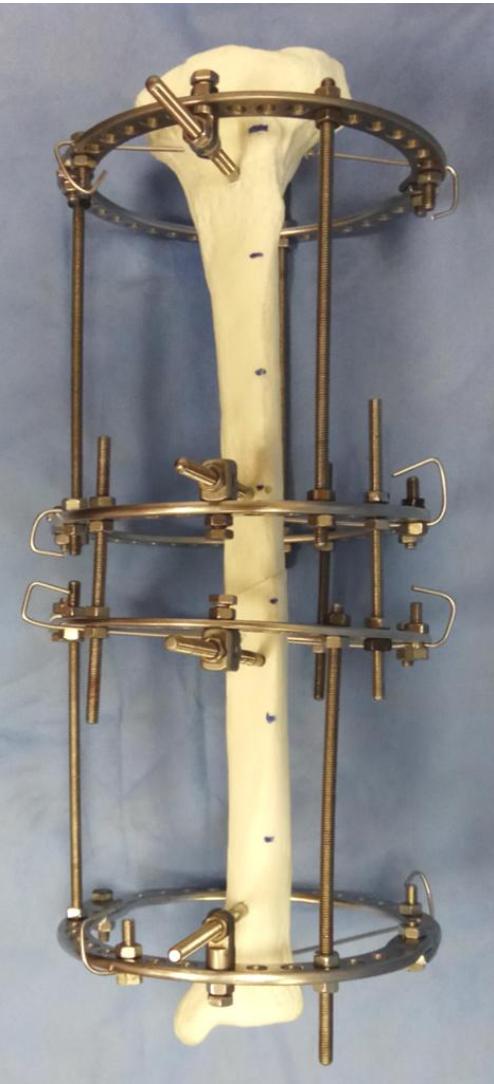
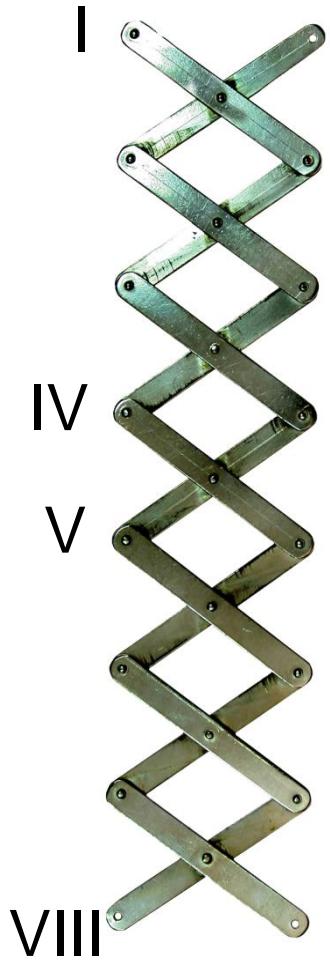
If there are some doubts:

“Should we use a 140 mm ring or 150 mm ring?”

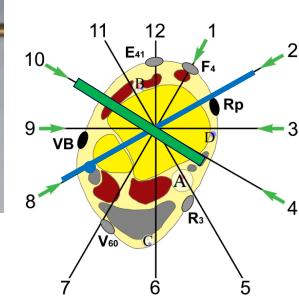
→ **160 mm ring must be used!**



Frame assembly project is ready!



$$\alpha = 60^\circ \quad (75^\circ \pm 15^\circ)$$



Take-home message: Principal types of frame assembling

for fracture
healing



for bone
transport



for deformity
correction



Take-home message: Stages of frame construction planning



Step 1. Identification of **the levels** for bone components insertion

Step 2. Identification of **the positions** for bone components insertion

Step 3. Identification optimal **number of the rings**

Step 4. Identification of **type and size** of the rings

Take-home message: Stages of frame construction planning

