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Principles of Artificial Deformity Creation (ADCr) method in treatment of fractures with large soft tissue defect

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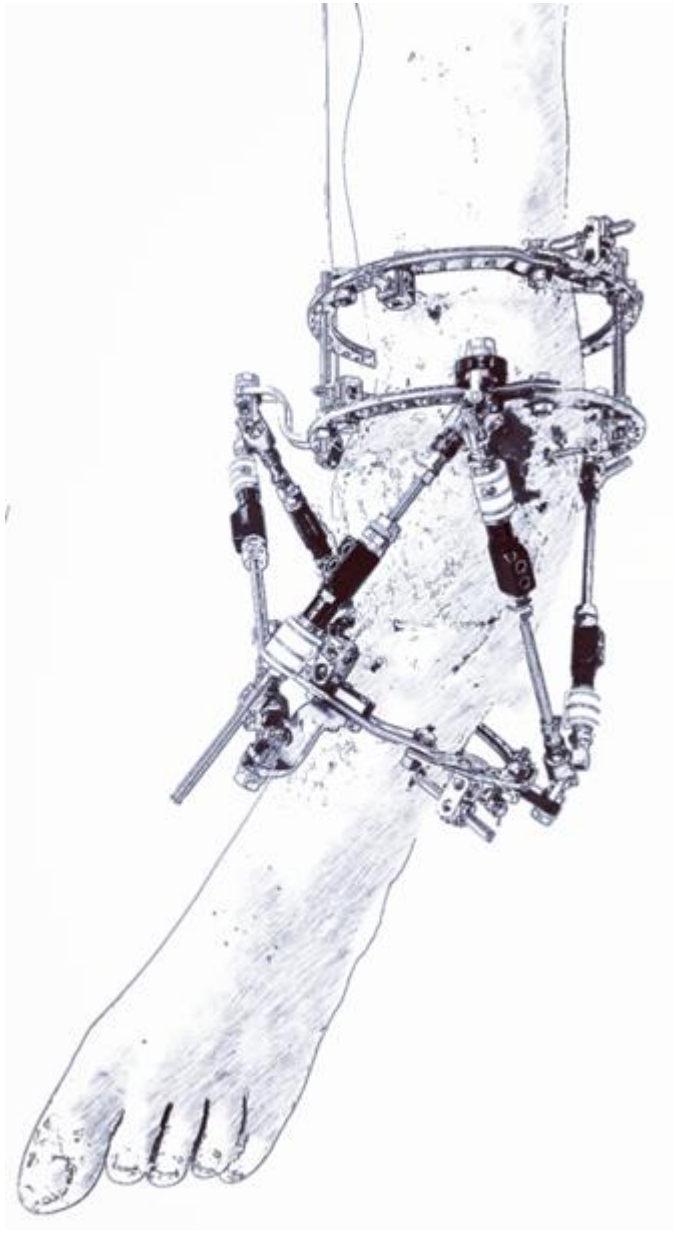
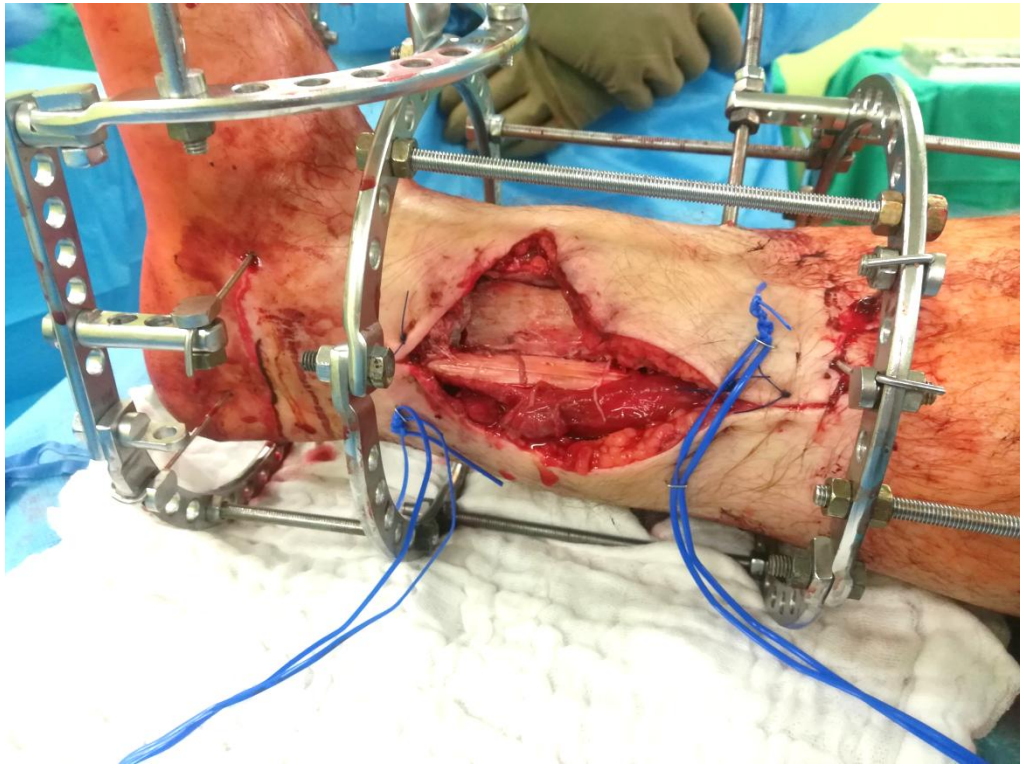
Learning objectives

1. Identify the artificial deformity creation method (ADCr)
2. List indications and contraindications for ADCr
3. Describe equipment for ADCr realization
4. Reproduce different options for ADCr



Introduction

Soft-tissue defect treatment by open fractures or as a result of the infection is always a serious and challenging problem that needs high qualified medical personal, a lot of time, resourses and patient's compliance. In some situations it is not possible to make a defect coverage with a flap[1,2,3].



FLAP ???

1. Duman H, et al: Lower extremity salvage using a free flap associated with the Ilizarov method in patients with massive combat injuries. Ann Plast Surg 2001; 46(2): 108-12.

2. Agarwal S, et al: Management of soft-tissue problems in leg trauma in conjunction with application of the Ilizarov fixator assembly. Plast Reconstr Surg 2001; 107(7): 1732-8

3. Naique SB, Pearse M, Nanchahal J: Management of severe open tibial fractures: the need for combined orthopaedic and plastic surgical treatment in specialist centres. J Bone Joint Surg Br 2006; 88(3): 351-7.

Indications of ADCr method

1. Lack of human and technical resources to carry out complex microsurgical procedure.
2. Severe general condition of polytraumatic patient.
3. Open high-energy fractures, combined with soft tissue loss and main vessels and nerve damage (Gustilo-Anderson type 3C). Primary end-to-end suture possibility.
4. The presence of a single main vessel in the damaged limb.
5. Massive deep and extensive damage to the soft tissues of the limb with an unclear demarcation zone.
6. Necrosis of the previous flaps and the absence of suitable required volume soft tissues for further reconstructions.
7. Specific conditions of the patient that significantly increase the risk of complications when using soft-tissue flaps: diabetes mellitus, immunodeficiency, exhaustion, high degree of obesity, etc.
8. Mass casualty situations where the surgical care in full volume is excluded.
9. Open fractures with extensive soft tissue defects as result of mine-explosive combat trauma in the presence of multiple remote shrapnel injuries limiting donor site choice.

Contraindications of ADCr method

1. Severe hemodynamically unstable patient’s condition;
2. Basic contraindications for trans-osseous osteosynthesis, such as pyoderma or severe angiopathy

Equipment for ADCr method implementation

1. Equipment for intraoperative duplex sonography and pulse oximetry
2. Set for tubular external fixation
3. Set of ring fixator: Ilizarov device or its equivalent
4. Orthopedic hexapod frame
5. Device for skin grafting

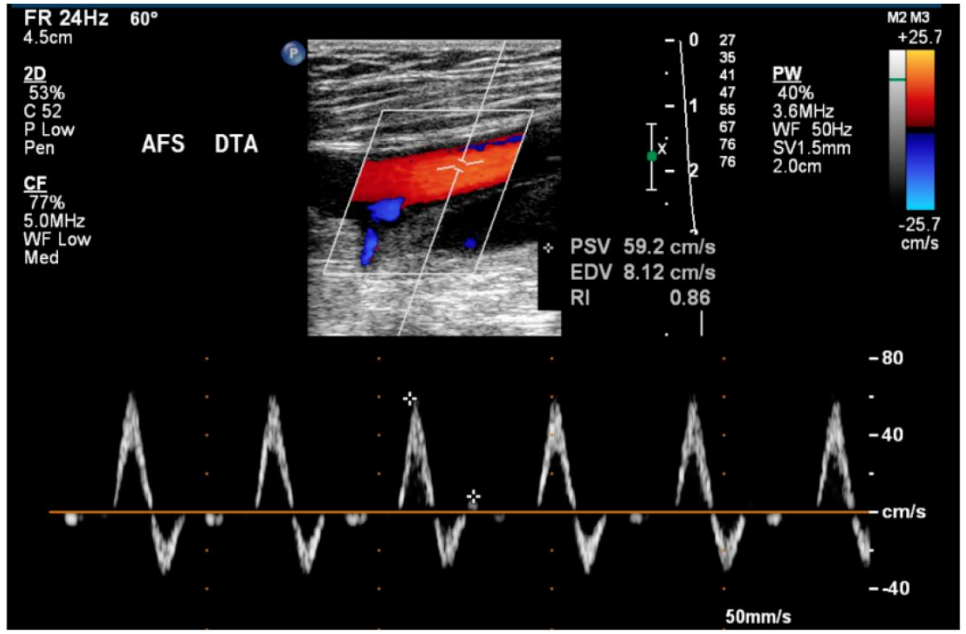
General principles of ADCr method

1. Adequate primary debridement +/- “second look” after 48-72h
2. Permanent vascular status monitoring of the injured limb both clinically (peripheral pulses, skin and nail bed coloration and capillary filling) and instrumentally (Doppler and pulse oximetry)
3. DSA or CT-angio postoperative for complex cases
4. Both tubular and circular external fixation frames can be used for primary fracture stabilization
5. Deformity correction only after complete soft tissue healing (3-4 weeks)
6. Use orthopedic hexapod for complex limb deformity correction

Vascular status monitoring during surgery

The main and basic rule during creating of the artificial deformity is permanent vascular status monitoring of the injured limb.

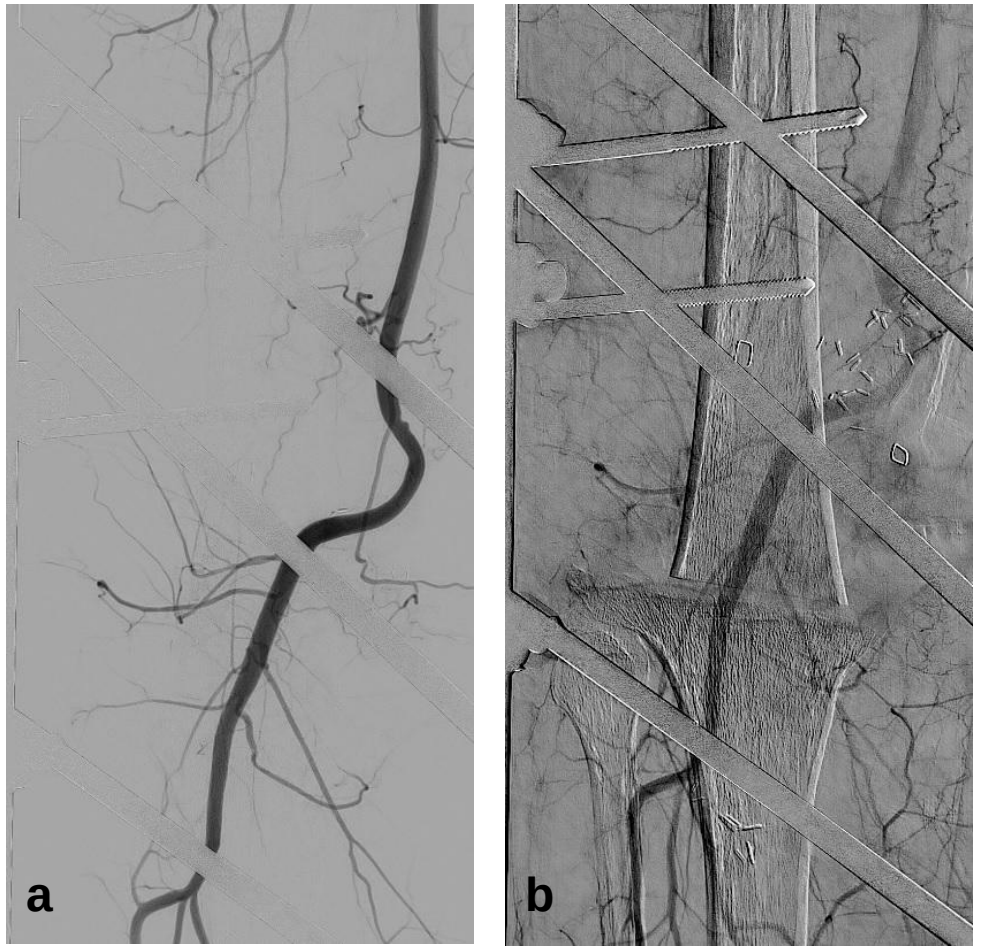
The criterion to stop or even revers creation of artificial limb deformity is skin color change or the first alterations in Doppler examination or Hallux pulse oximetry.



Postoperative vascular status monitoring

Regular further postoperative monitoring of the mal-alignmented limb is also of crucial importance.

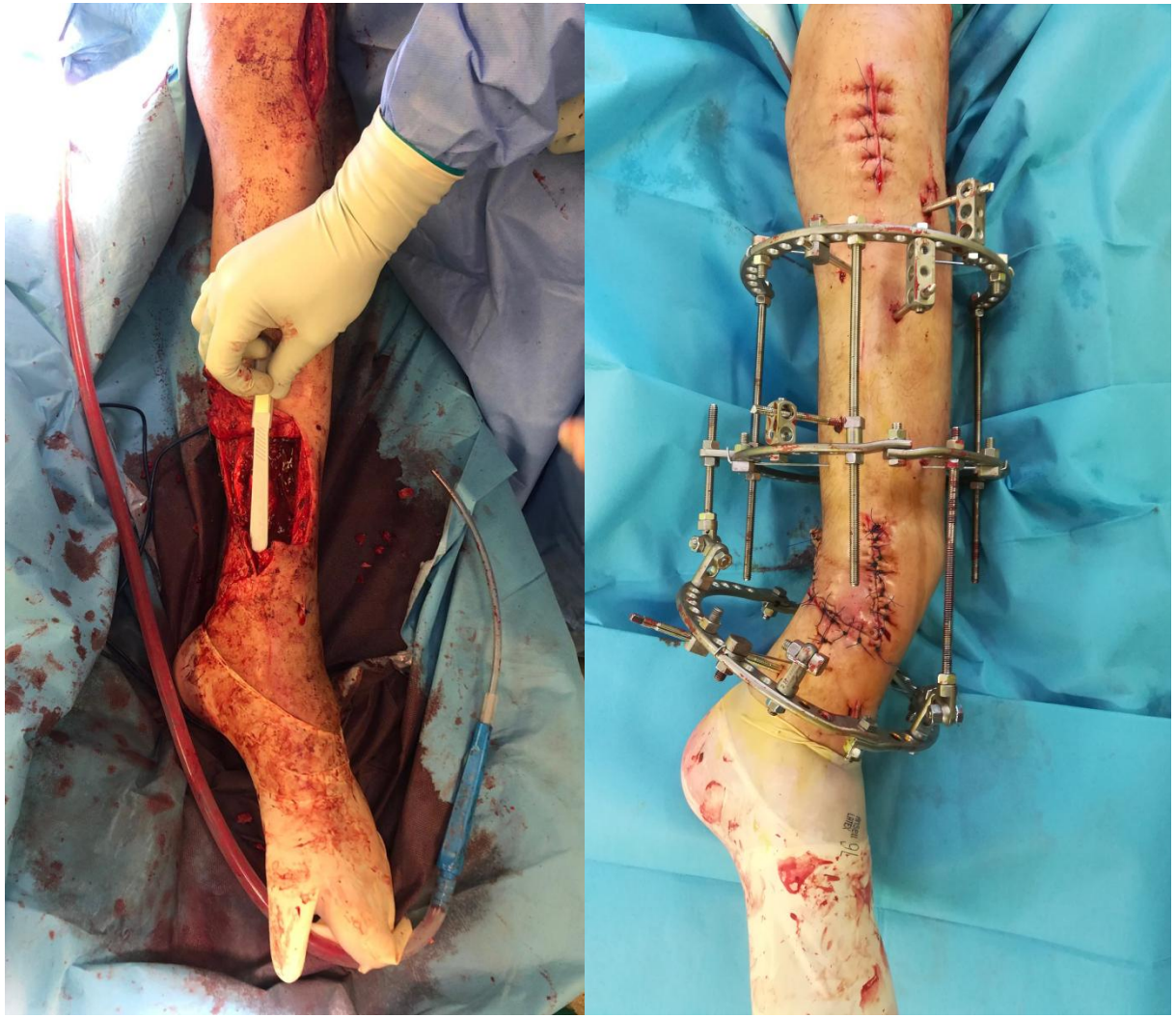
Digital subtraction angiography and CT angiography can be used for blood flow control in postoperative period.



Digital subtraction angiography performed after knee joint resection with simultaneous acute limb **shortening by 10 cm**: (a) filling and configuration of a. poplitea, (b) appearance of a. poplitea on the background of resected femur and tibia

Primary fracture stabilization after ADCr

Both tubular and ring frames can be used for primary fracture stabilization and soft tissue defect closure



Tubular frame: in ADCr

positive:

- Requires less time for its installation, which is especially important in the management of a severe polytrauma patients (damage control)
- Greatly facilitates access to the wound for the dressing
- Easy access for second look surgical procedures

negative:

- Needs conversion to circular frame for deformity correction

Ring frame: in ADCr

positive:

- Ready for deformity correction
- More stable fixation

negative:

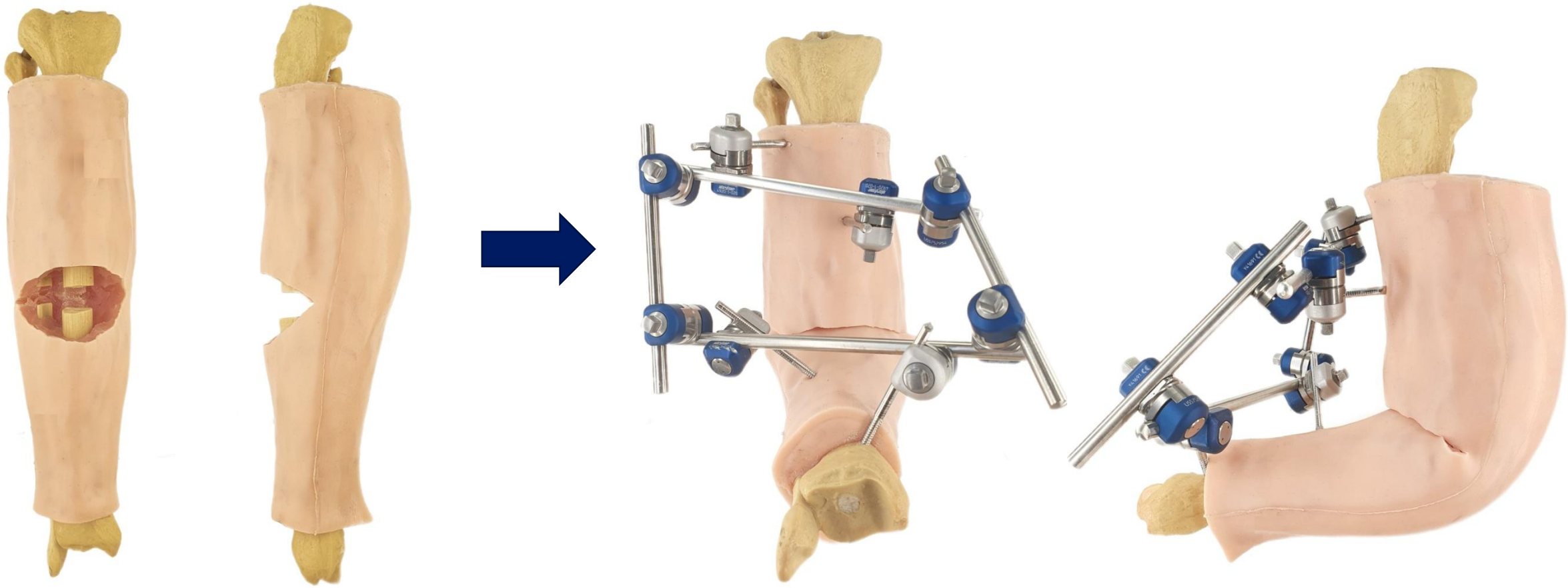
- More time consuming when mounting
- Some difficulties in access for wound care and second look procedures

Acute angulation

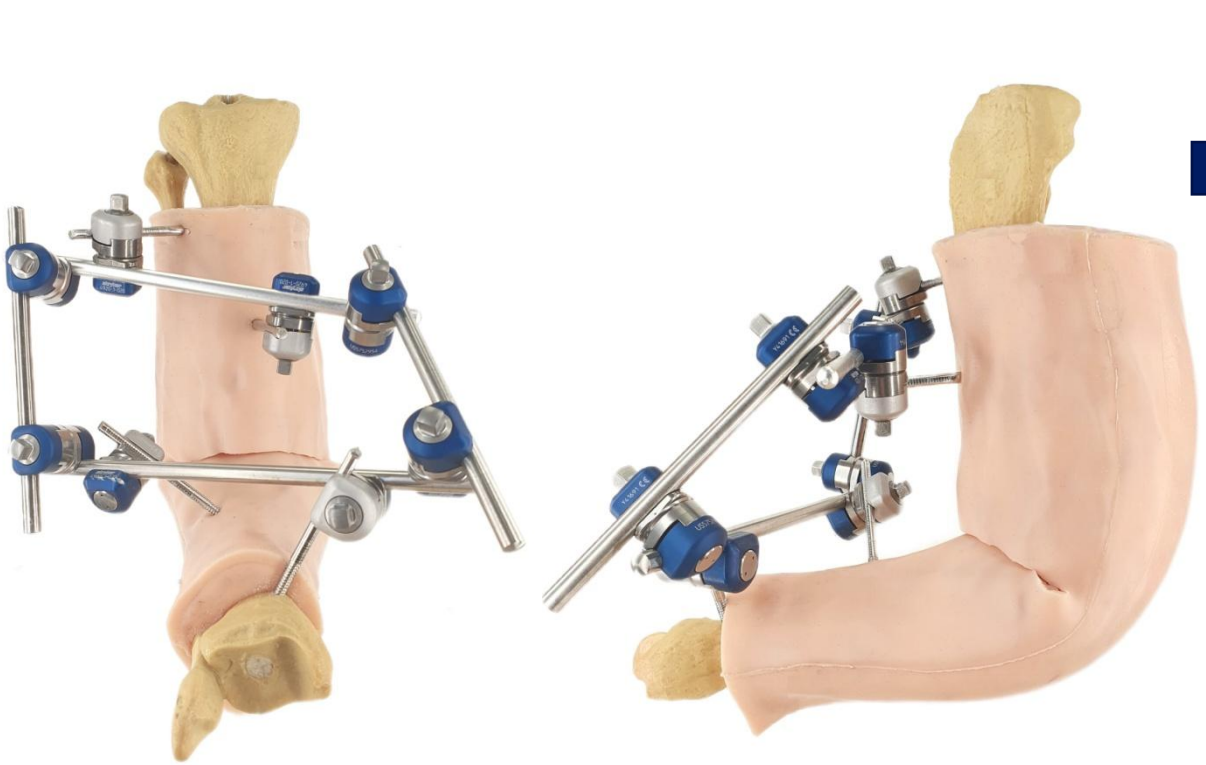
1. Simplest version of ADCr
2. Good for unilateral transverse soft tissue defects
3. No need for additional resection and shortening for the healthy bone
4. Avoids the corrugation of soft tissues on the opposite side of the limb
5. Deformity correction with Ilizarov hinges or by orthopedic hexapod

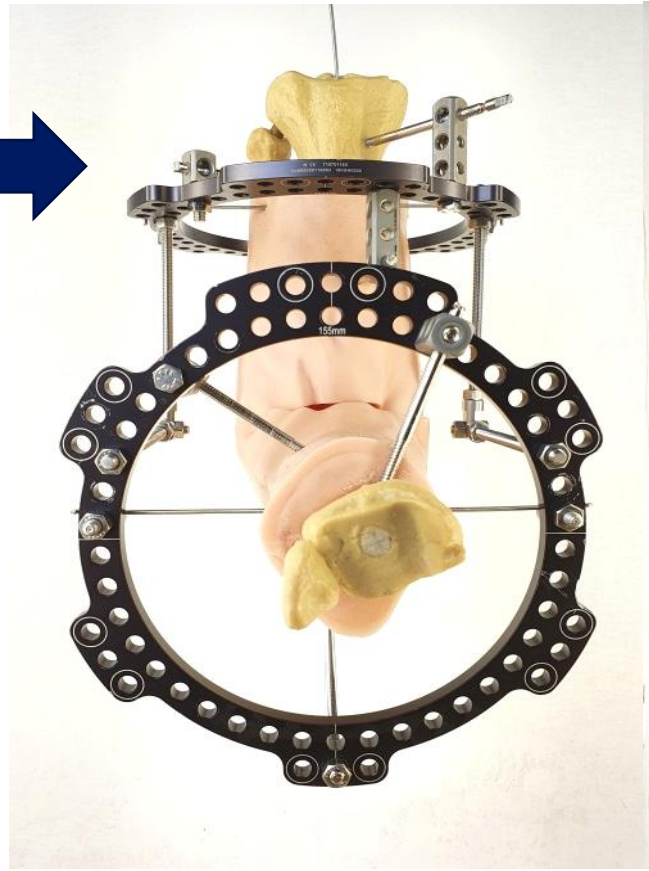
Acute angulation

ExFix application and artificial deformity creation

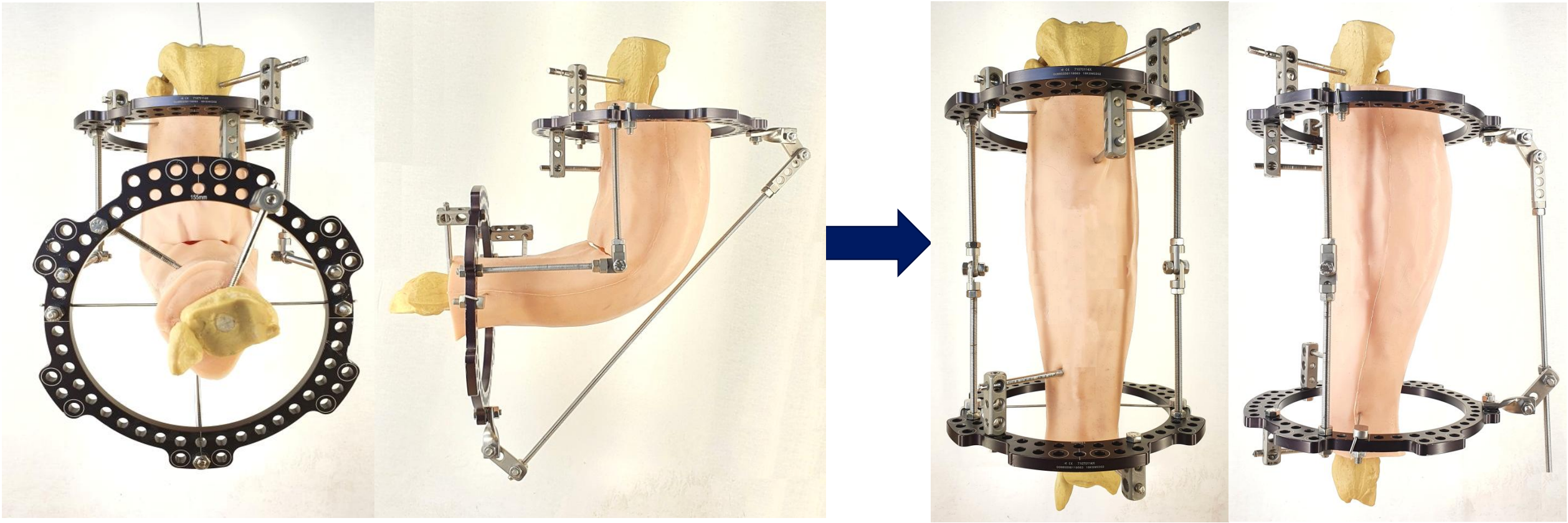


Tubular ExFix conversion to circular frame with Ilizarov hinges

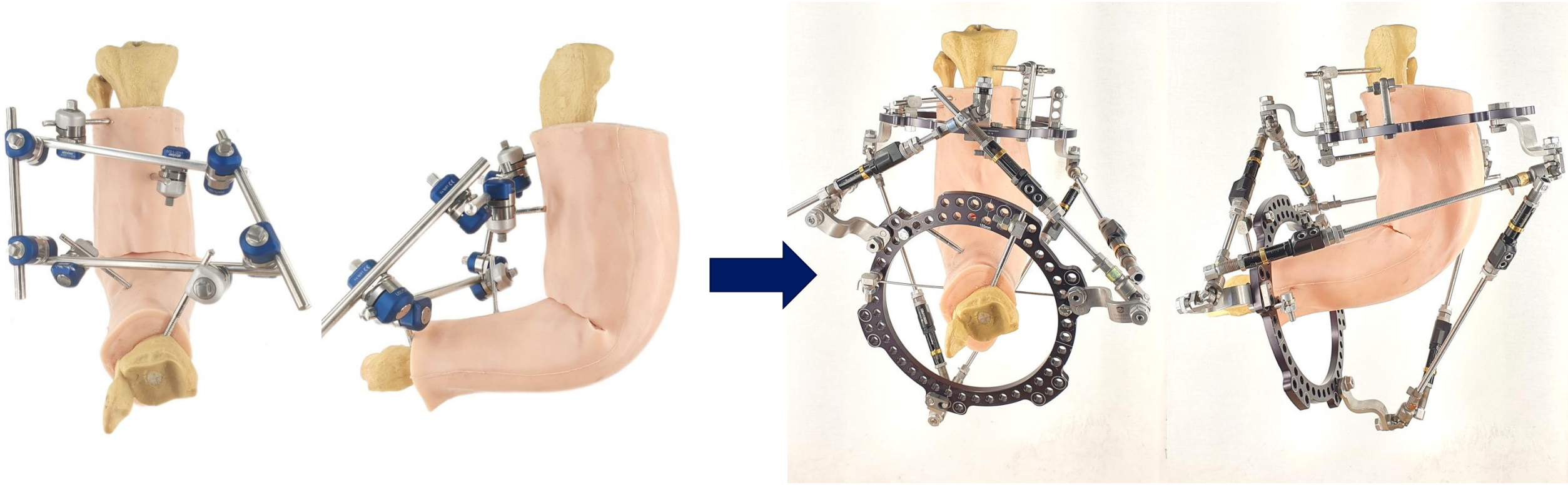




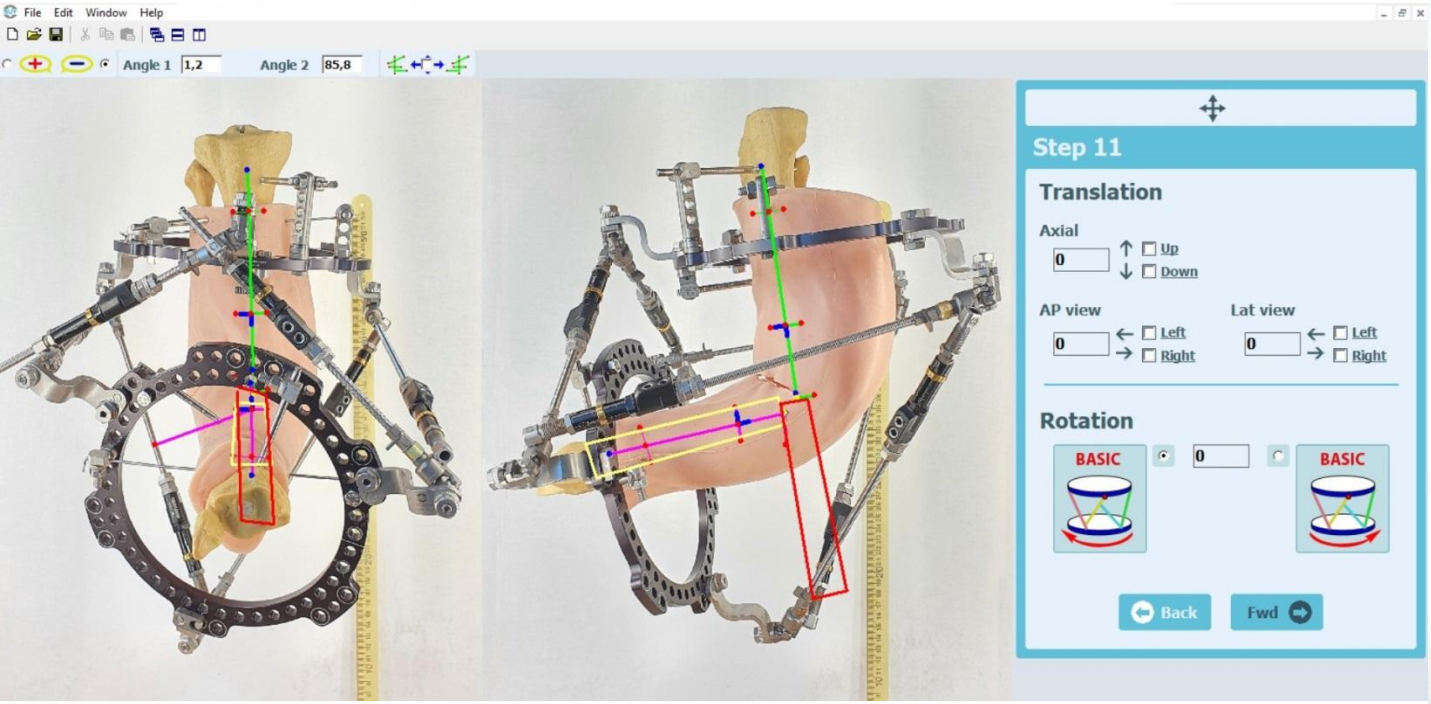
Deformity correction using Ilizarov principles

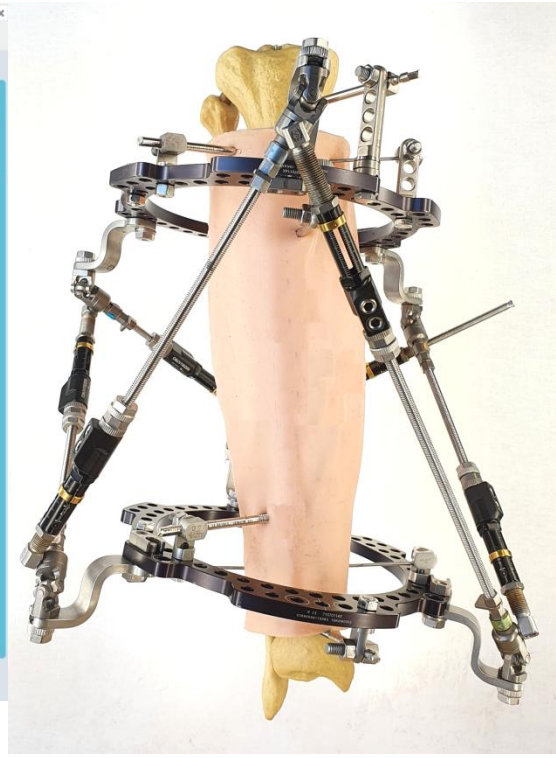


Tubular ExFix conversion to orthopedic hexapod



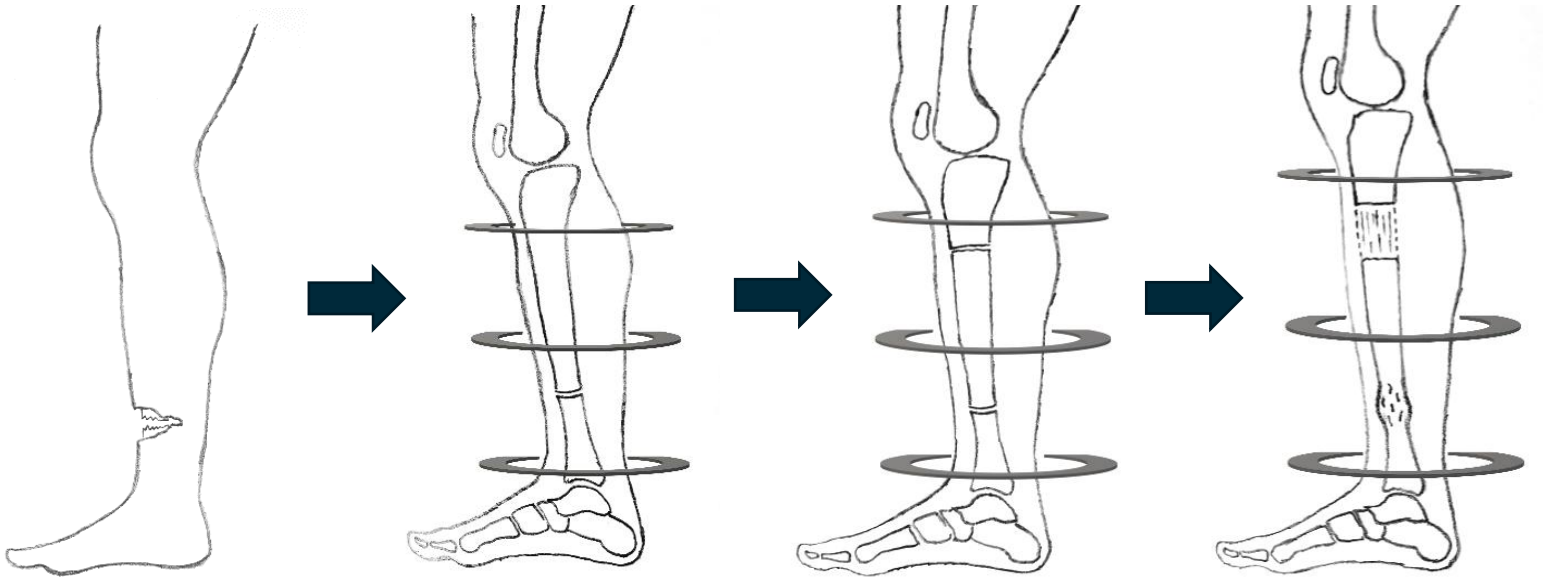
Deformity correction with orthopedic hexapod Ortho-SUV Frame





Acute shortening

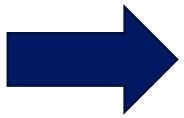
1. Good for transversely oriented and circular extensive soft tissue defects
2. Bayonet method - temporary superposition (duplication) of proximal and distal bone fragments to avoid additional resection of a healthy bone



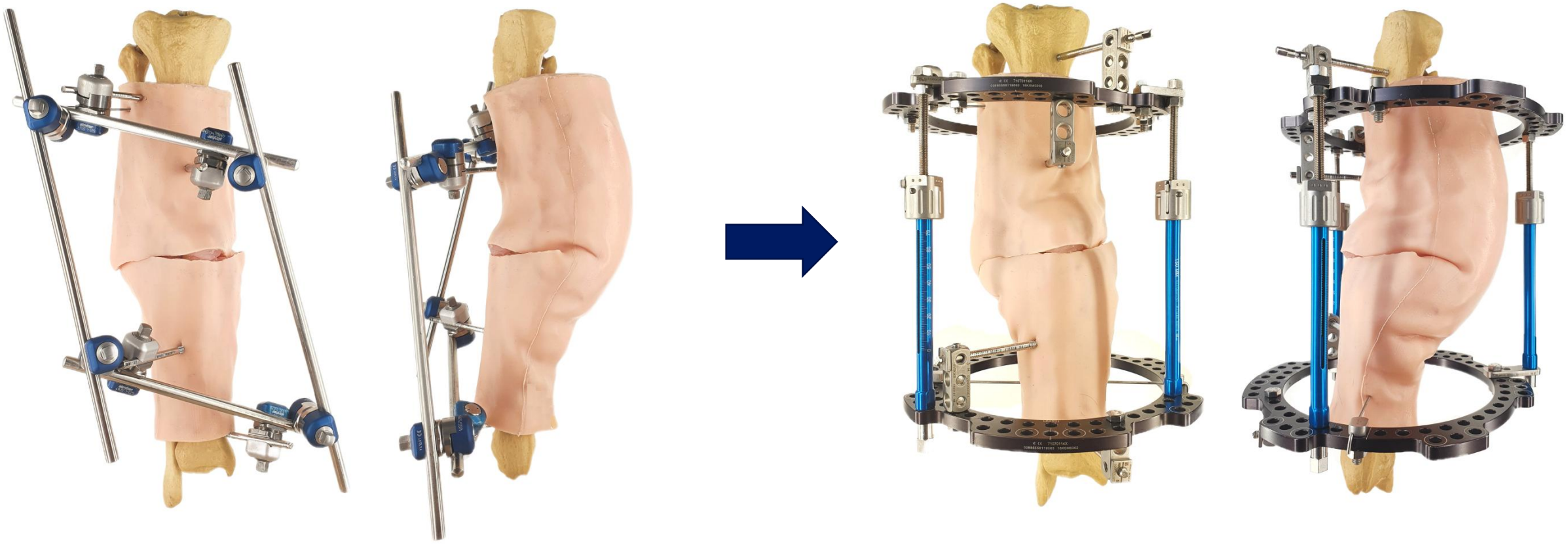
Bayonet method

Acute shortening

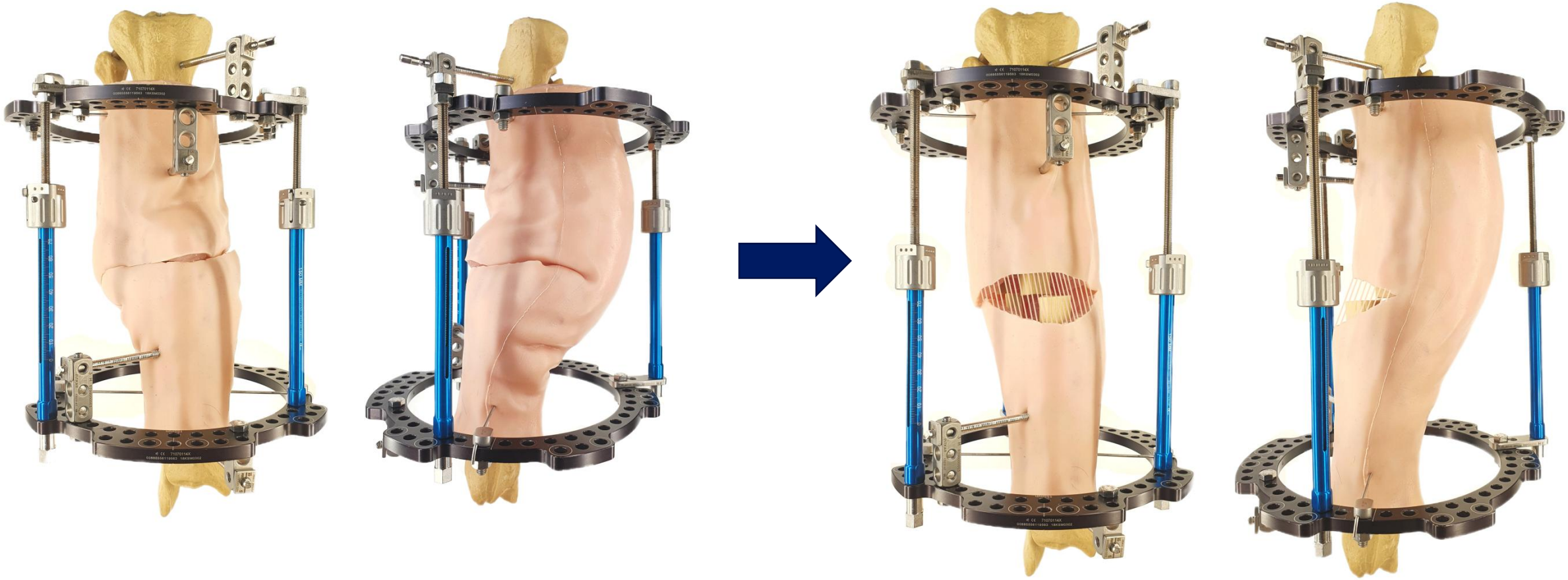
ExFix application and artificial deformity creation (Bayonet method)



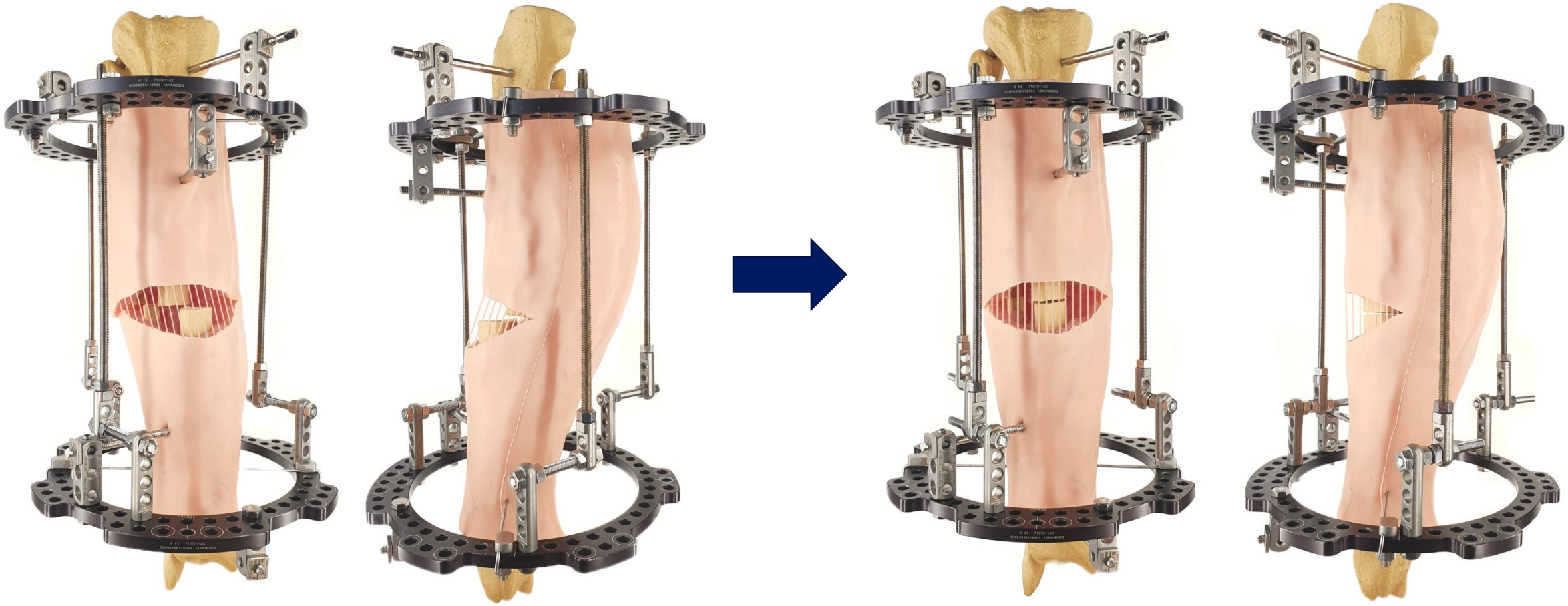
Tubular ExFix conversion to circular frame



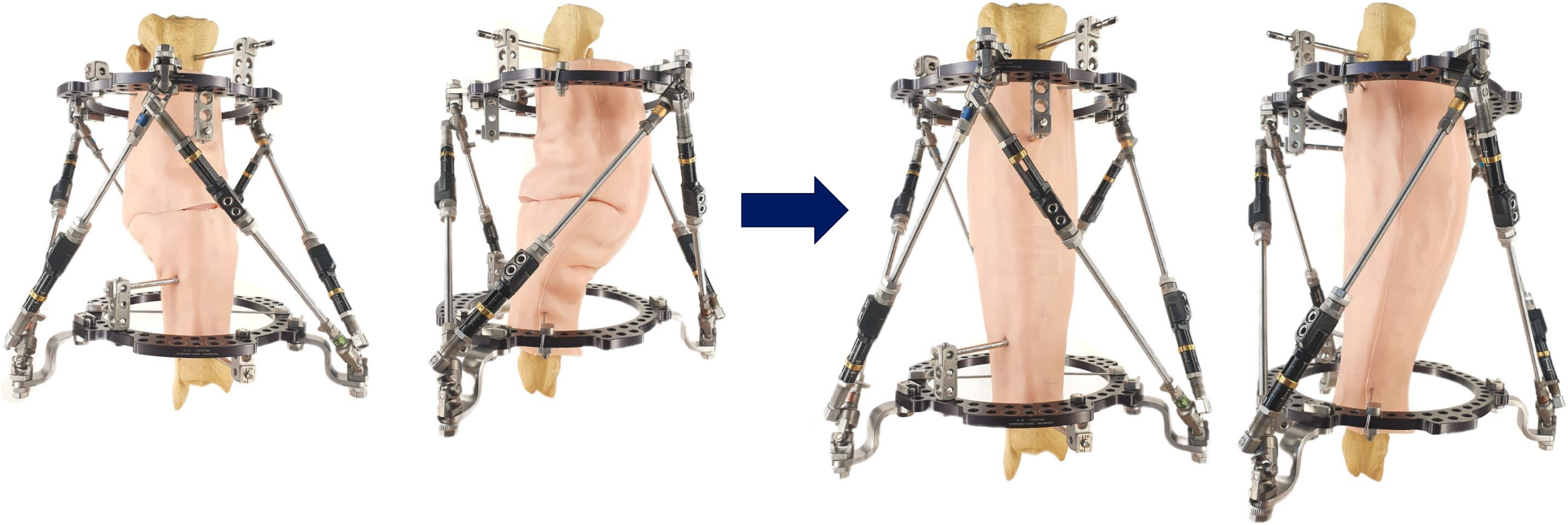
Deformity correction using Ilizarov principles (lengthening)



Deformity correction using Ilizarov principles (translation)



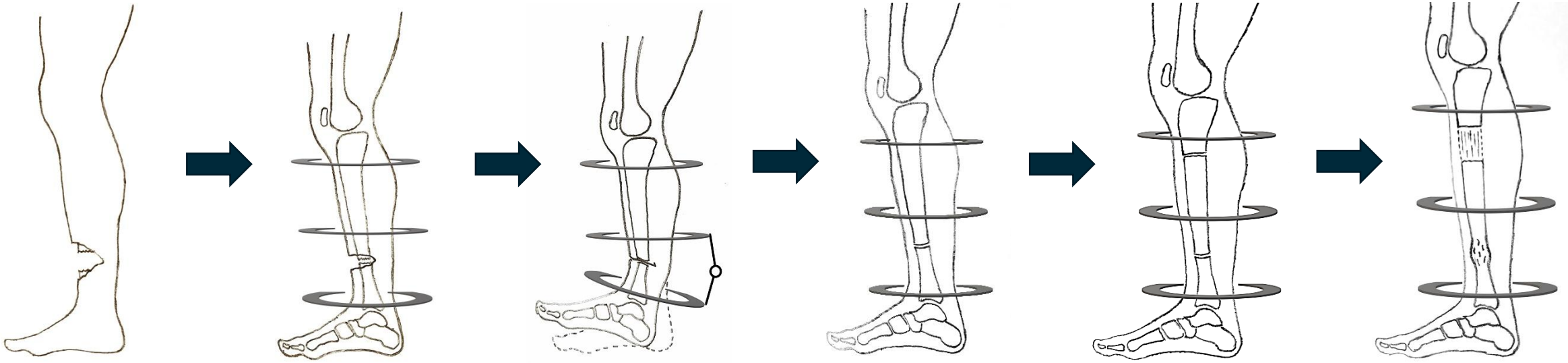
Deformity correction with orthopedic hexapod Ortho-SUV Frame



Acute shortening and angulation

1. For situations when acute shortening procedure alone can’t brought close together the edges of the wound without performing additional significant resection of the healthy bone ends, and also when isolated limb angulation does not allows the defect to be completely closed

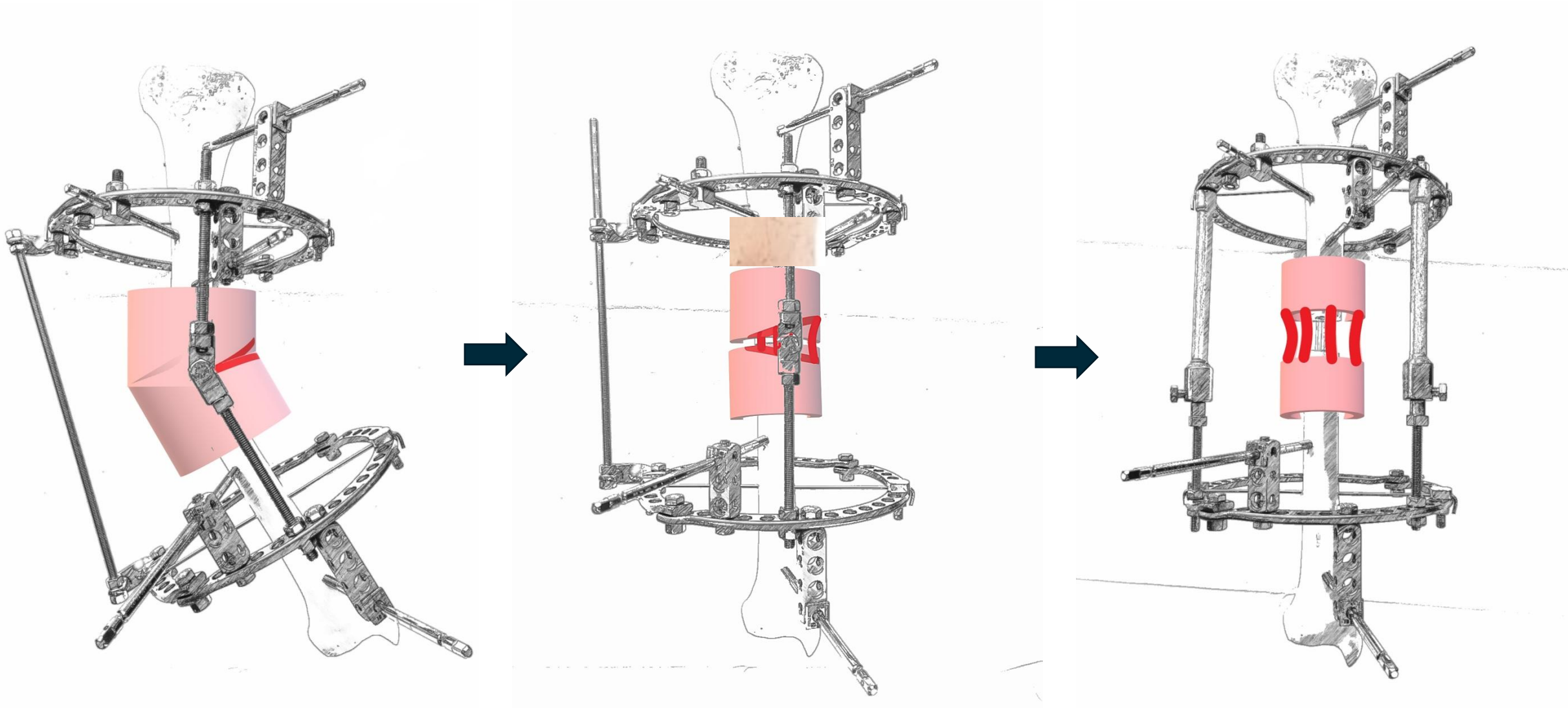
2. Both the Ilizarov apparatus and the orthopedic hexapod frame can be used to correct artificially created limb deformity



Acute shortening and angulation

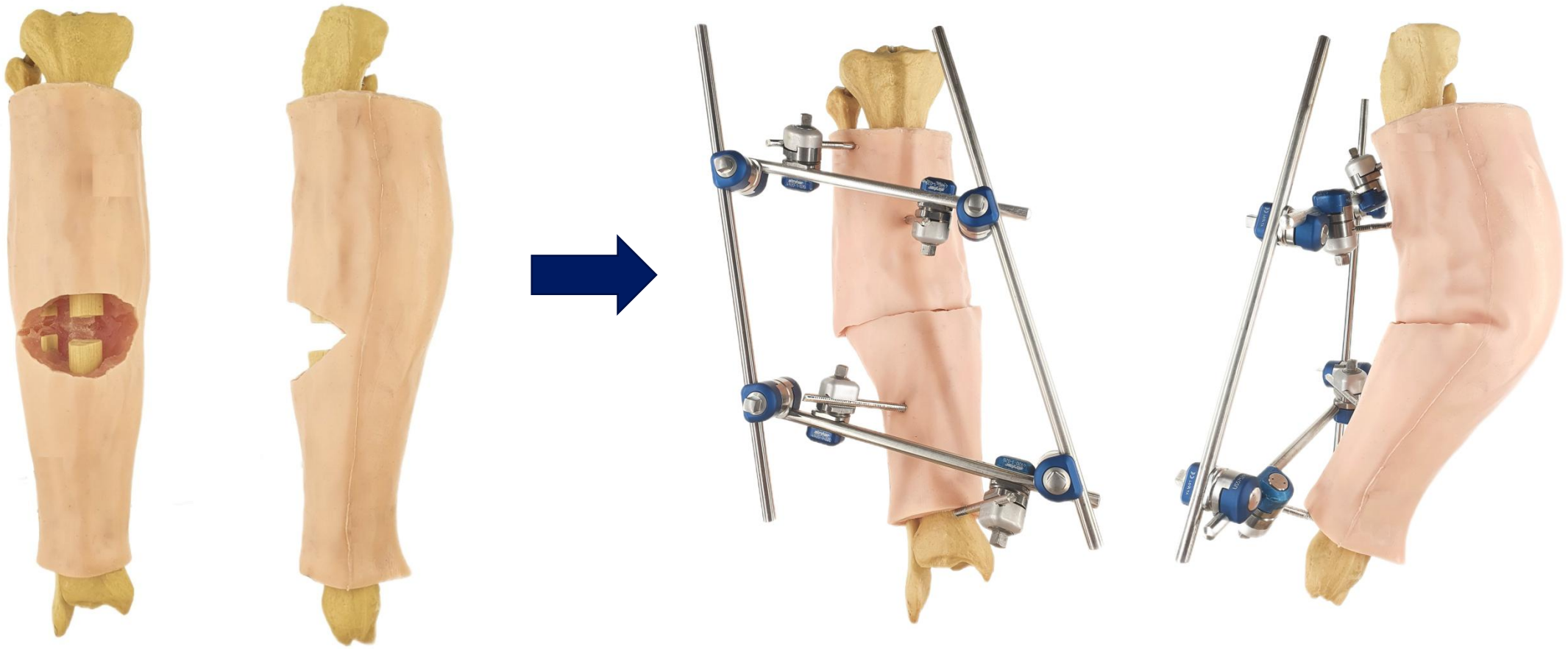
Principles of frame construction and conversion using Ilizarov technique for deformity correction

Ilizarov hinges + lenghtening

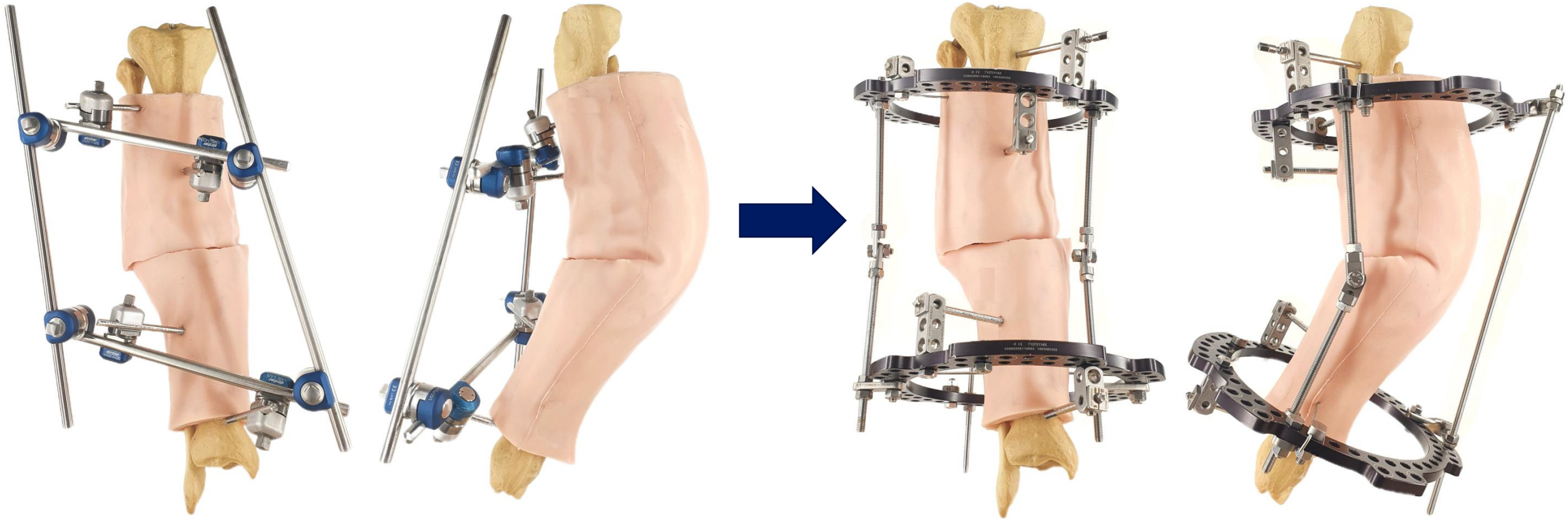


Acute shortening and angulation

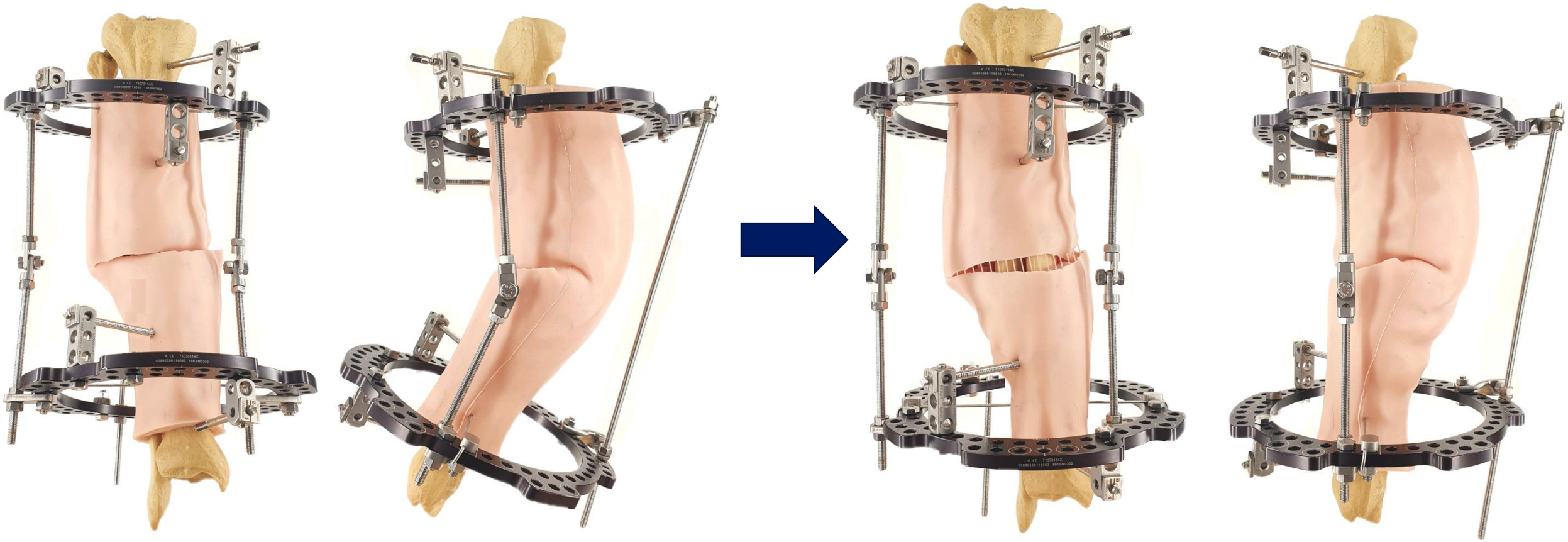
ExFix application and artificial deformity creation (Bayonet method + angulation)



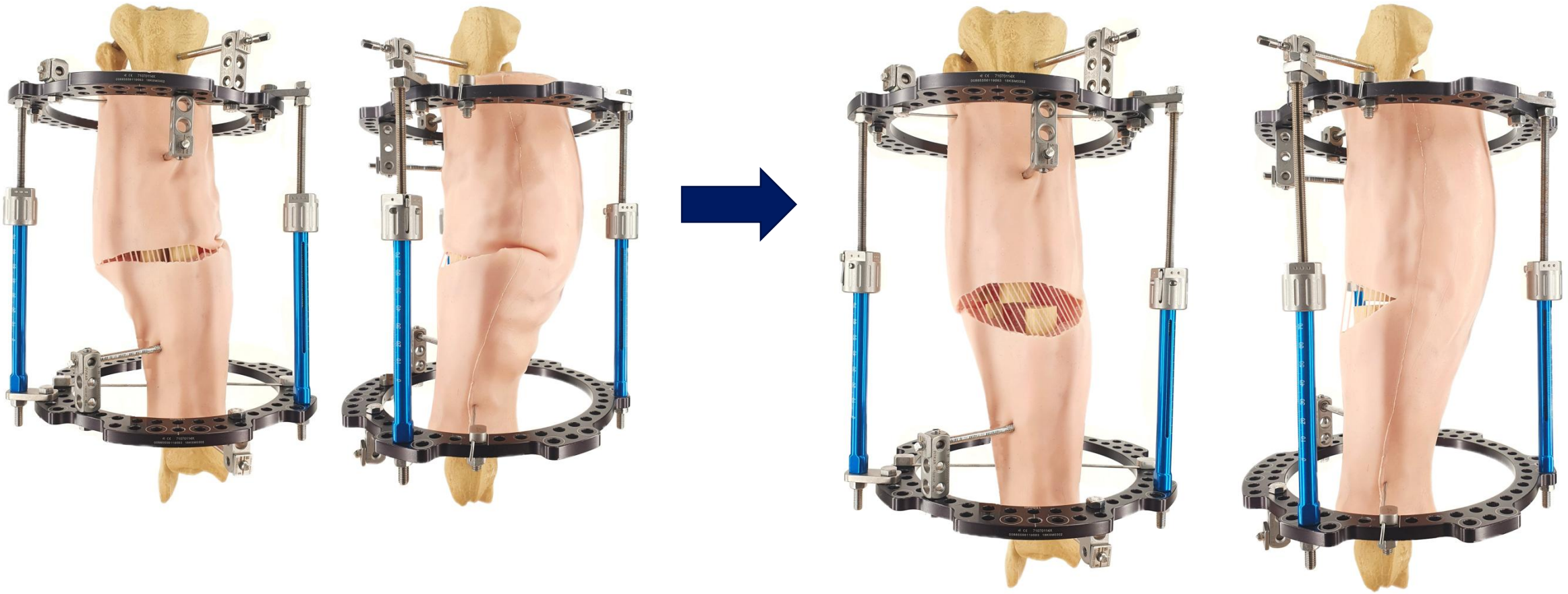
Tubular ExFix conversion to circular frame with Ilizarov hinges



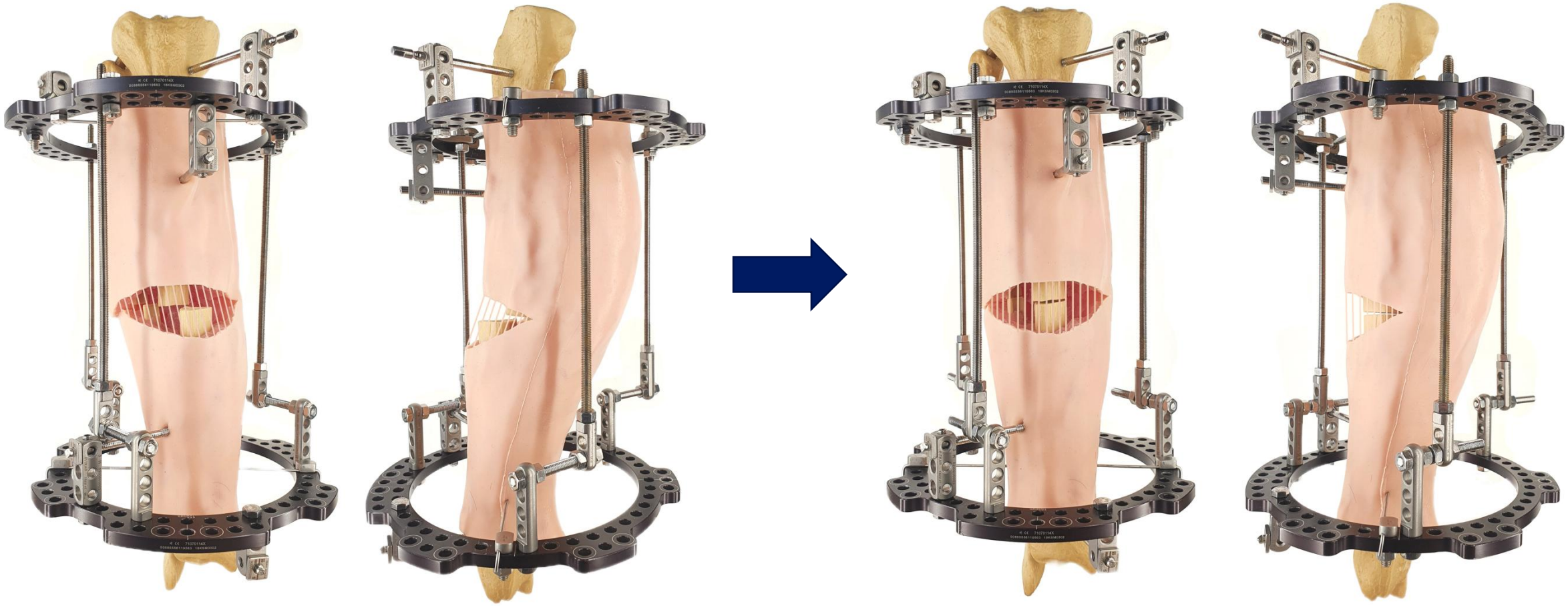
Deformity correction using Ilizarov principles (angulation)



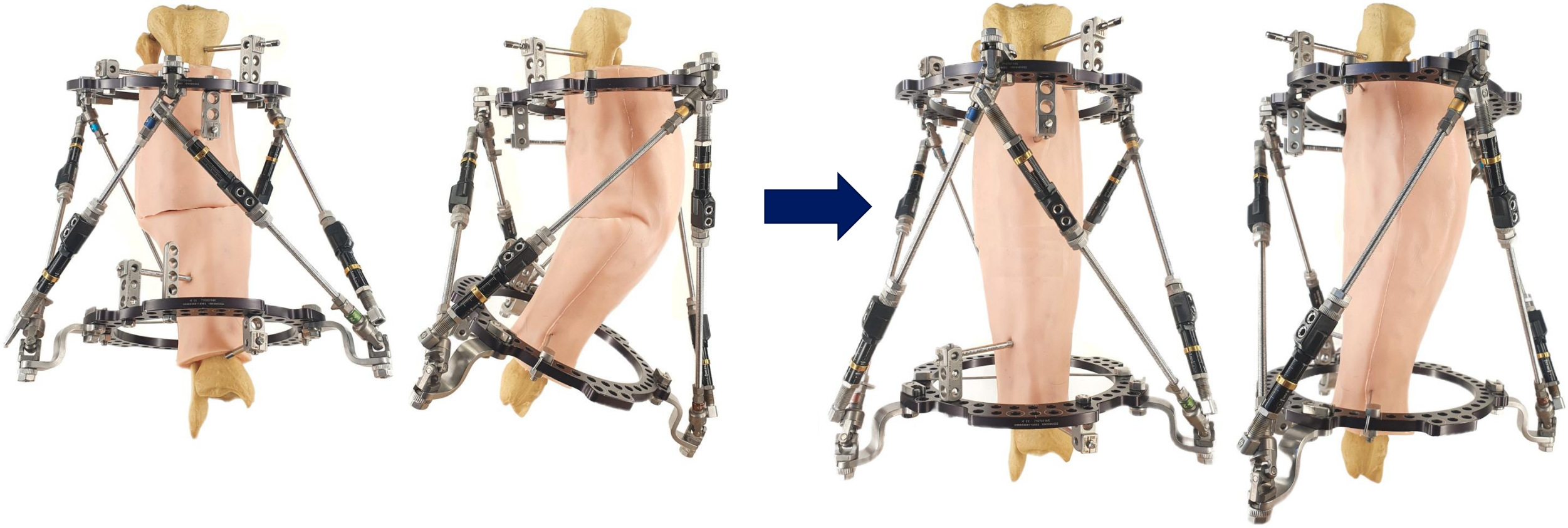
Deformity correction using Ilizarov principles (lengthening)



Deformity correction using Ilizarov principles (translation)



Deformity correction with orthopedic hexapod Ortho-SUV Frame

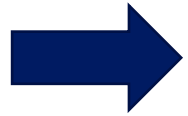


Acute shortening, angulation and rotation

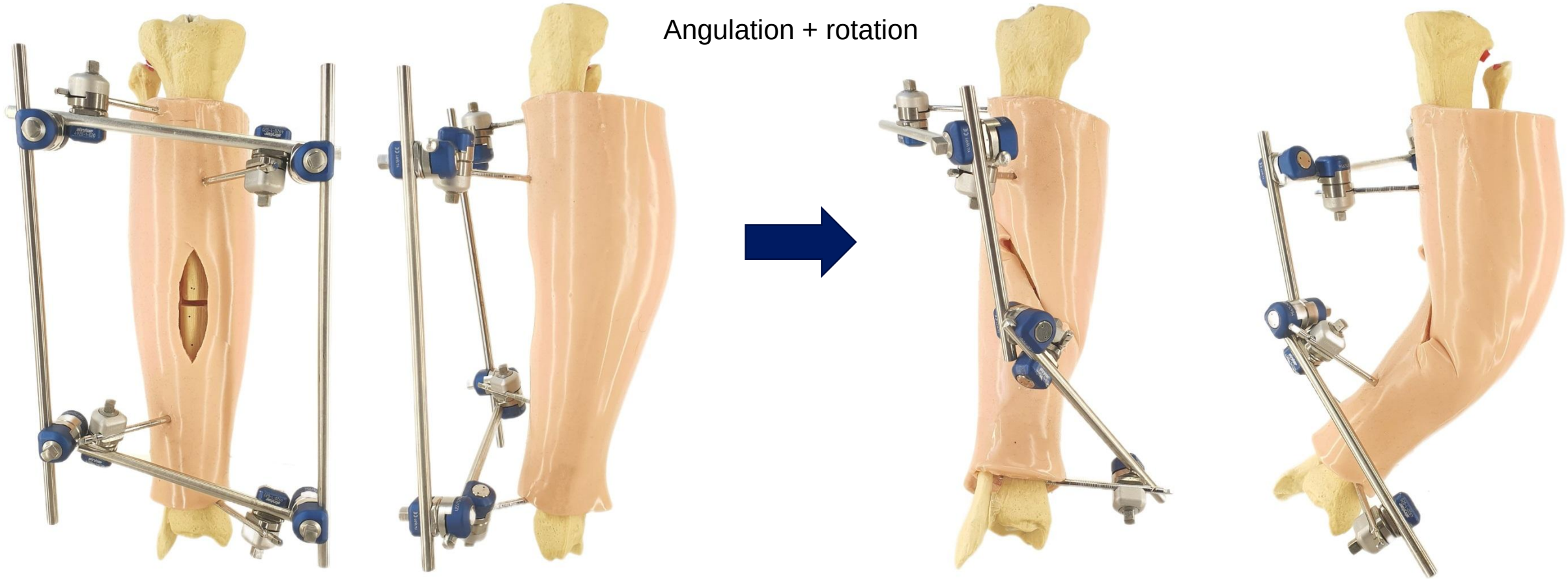
1. Used in surgical challenged cases of severe high-energy trauma with a combined extensive bone and soft tissue defect when bone fragments remain open even after acute shortening and angulation.
2. Good for longitudinal and oblique soft tissue defects
3. Use orthopedic hexapod for deformity correction
4. The well-thought-out layout of the orthopedic hexapod avoids the conflict "struts - bone component" and "struts - soft tissues", as well as the need in rewiring of the hexapod itself and additional software calculations.

Acute shortening, angulation and rotation

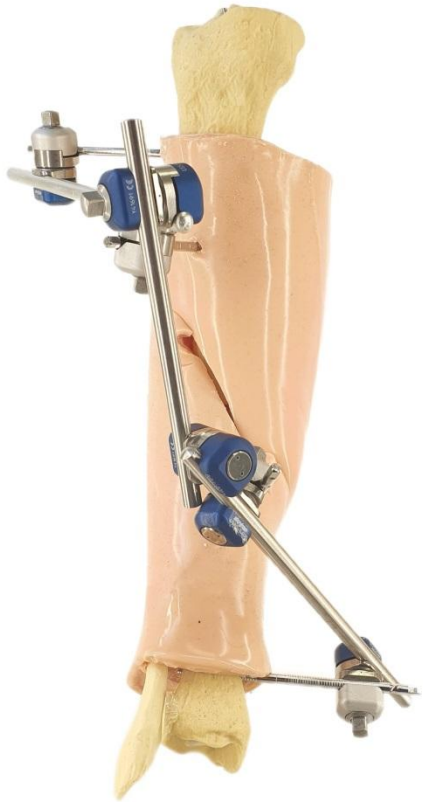
ExFix application

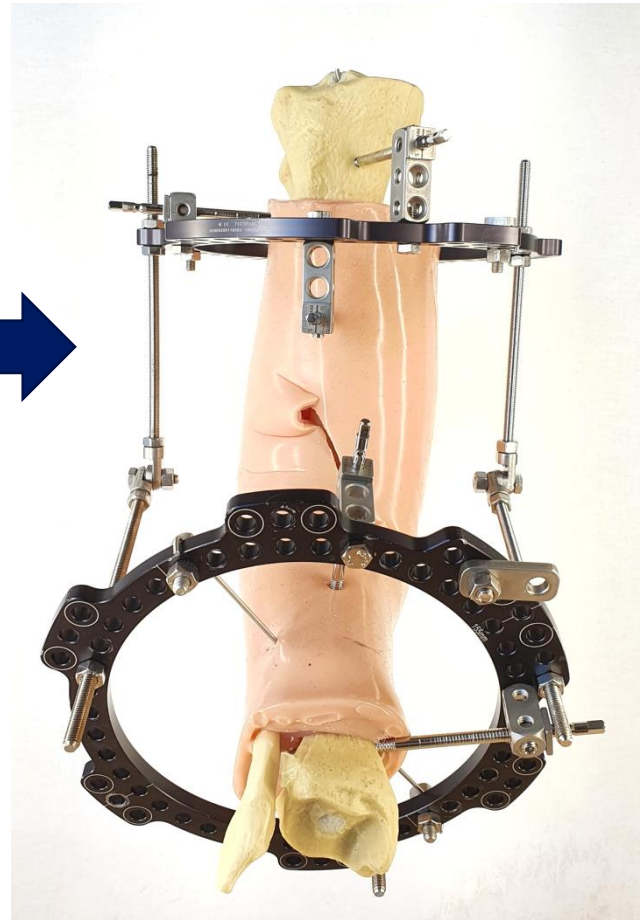


Acute shortening, angulation and rotation



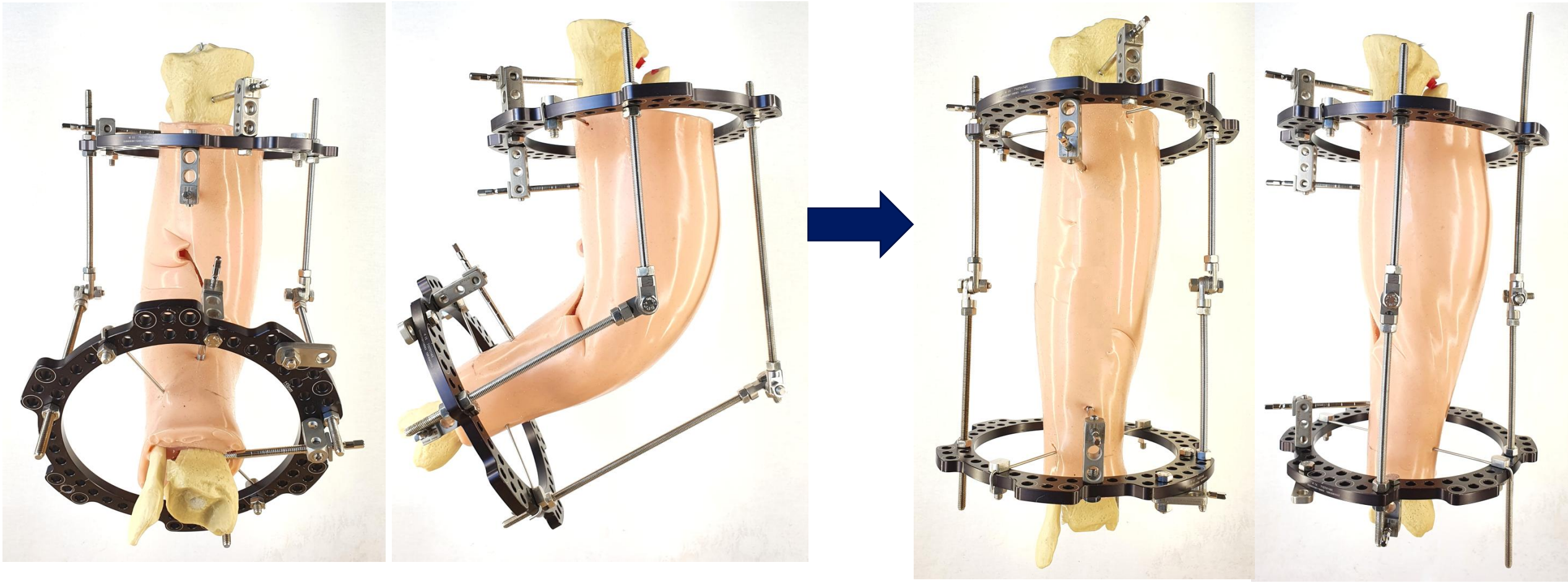
Tubular ExFix conversion to circular frame with Ilizarov hinges





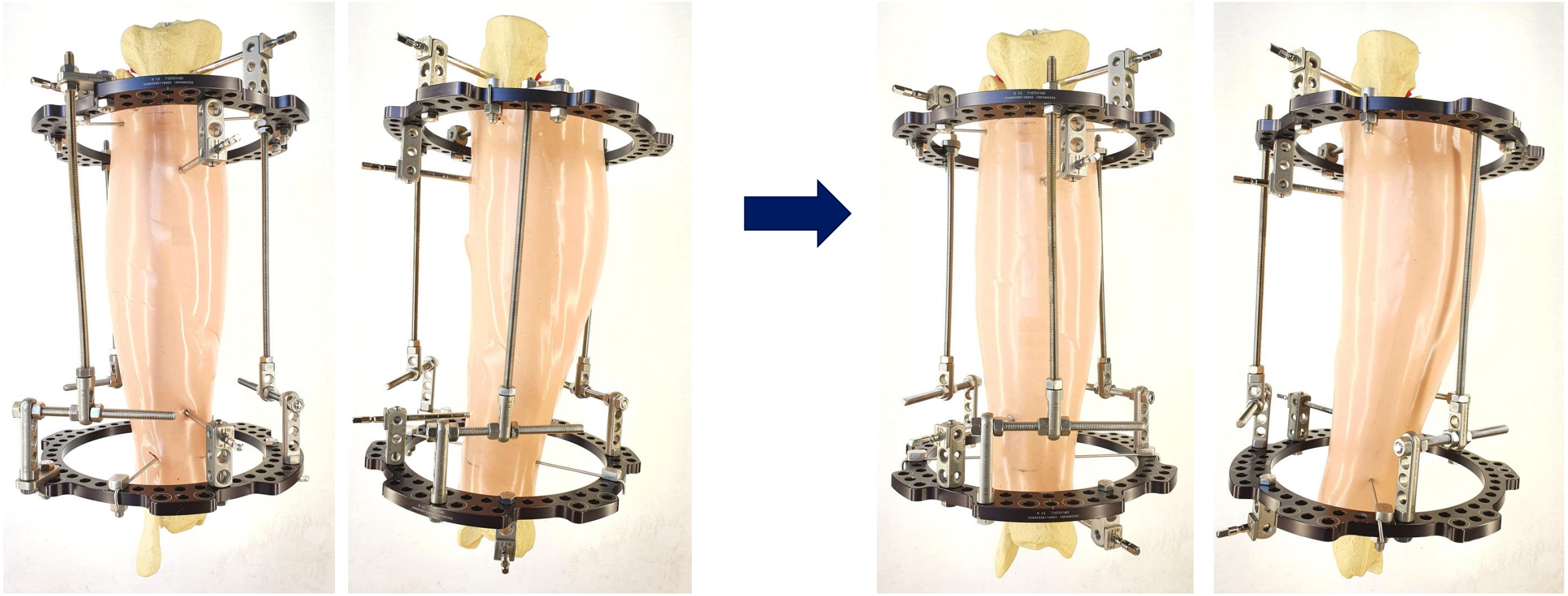
Deformity correction using Ilizarov principles

Angular deformity correction

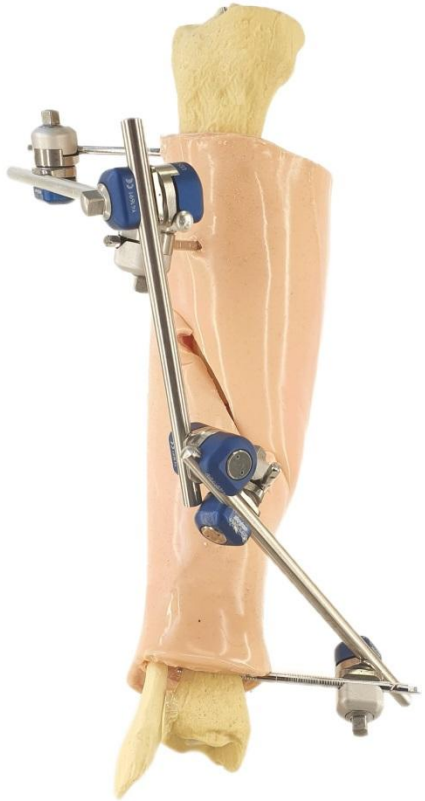


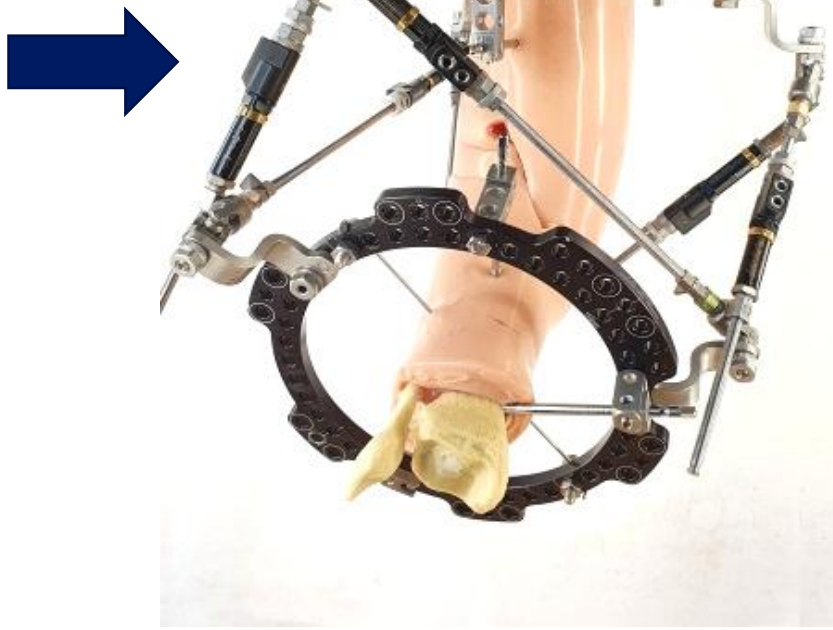
Deformity correction using Ilizarov principles

Rotation deformity correction

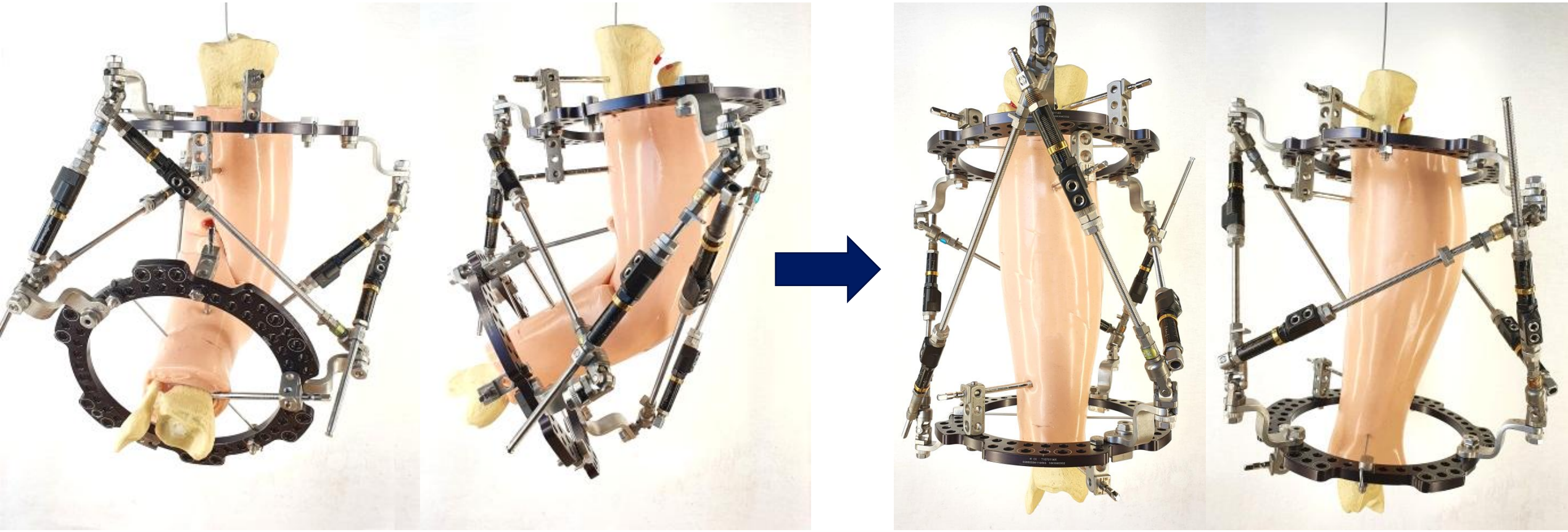


Tubular ExFix conversion to orthopedic hexapod



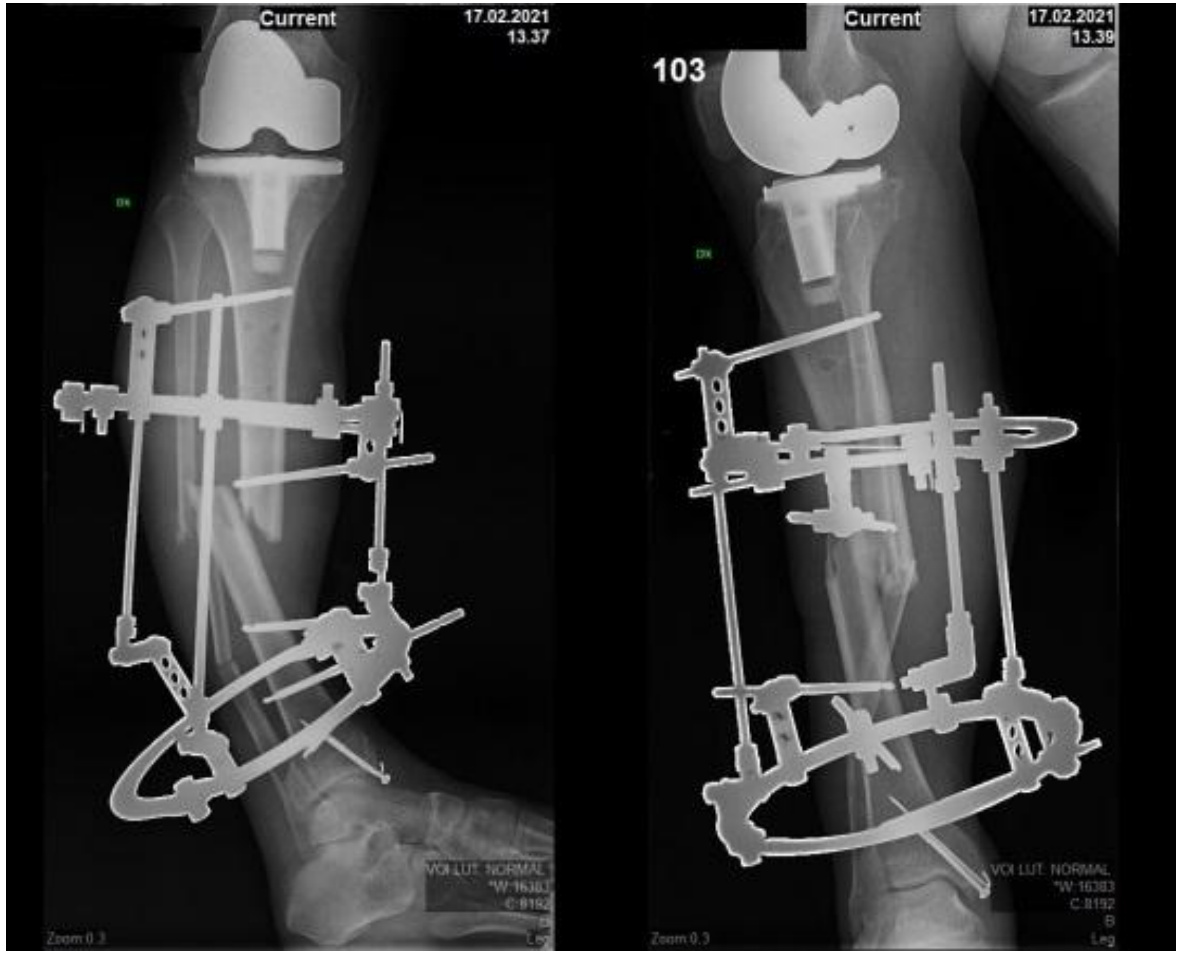


Deformity correction with orthopedic hexapod Ortho-SUV Frame



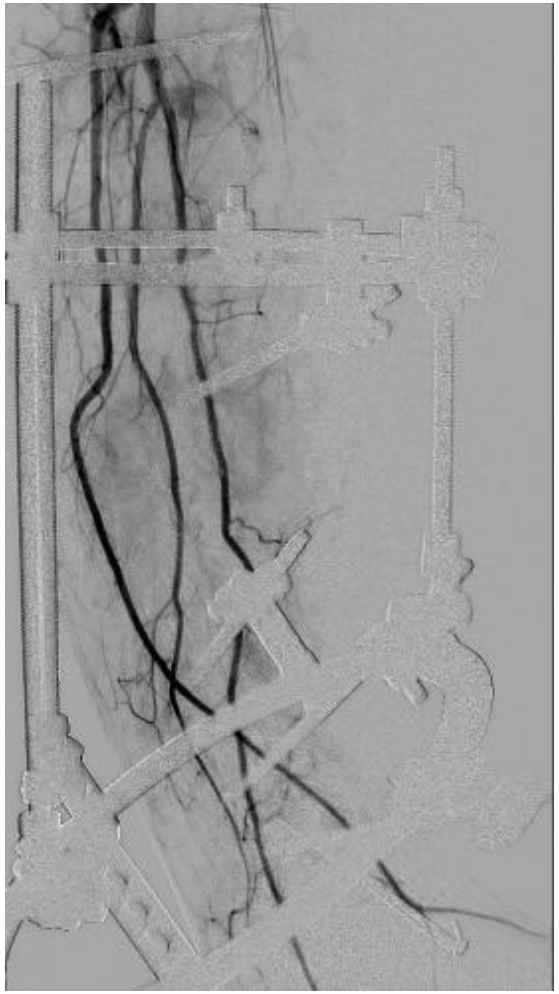
Acute shortening, angulation and rotation (case example 1)

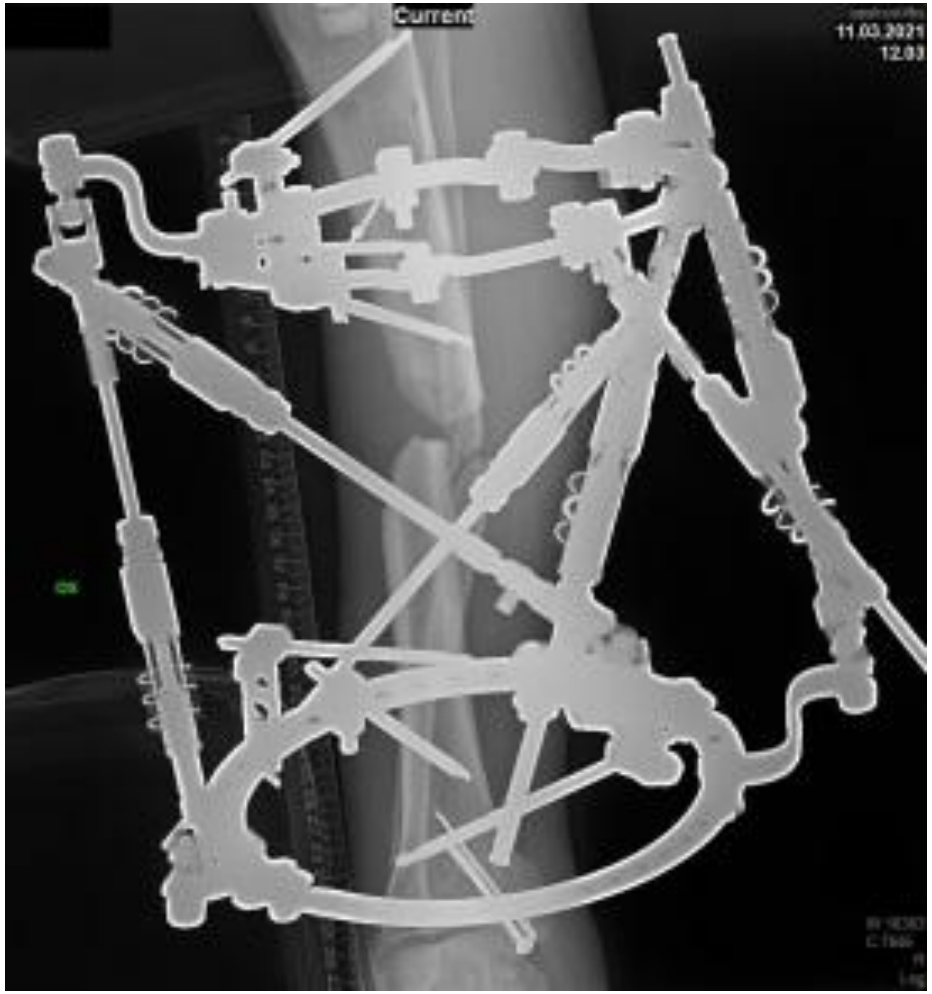
In the treatment of a patient with an open (Gustillo IIIB) fracture of the middle third of the tibia and an extensive soft tissue defect on the anterior side, acute shortening in superposition (tibial bayonet method), angulation 20° and rotation 85° was performed.

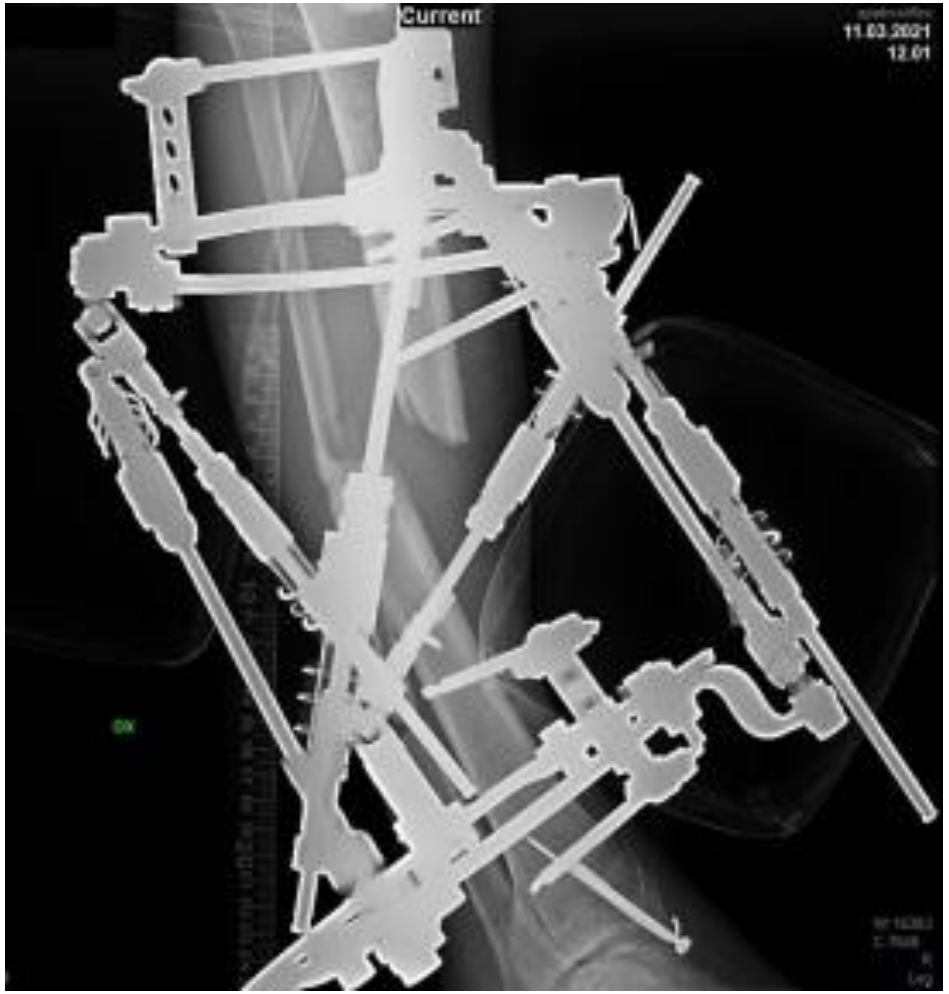


Acute shortening, angulation and rotation (case example 1)

Postoperative blood flow control with DSA and orthopedic hexapod application for deformity correction.





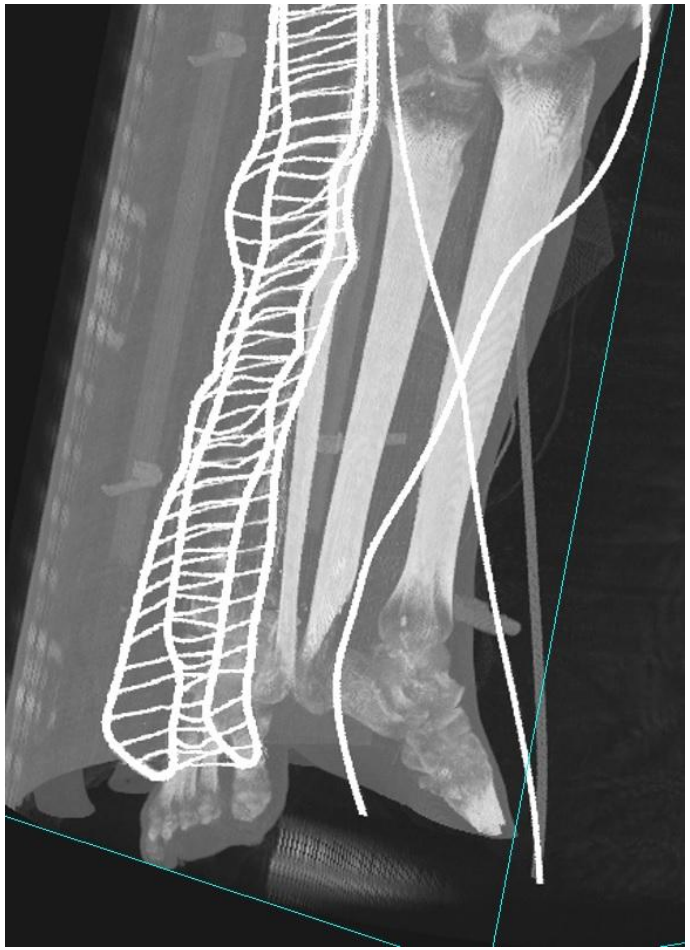


Acute shortening, angulation and rotation (case example 1)

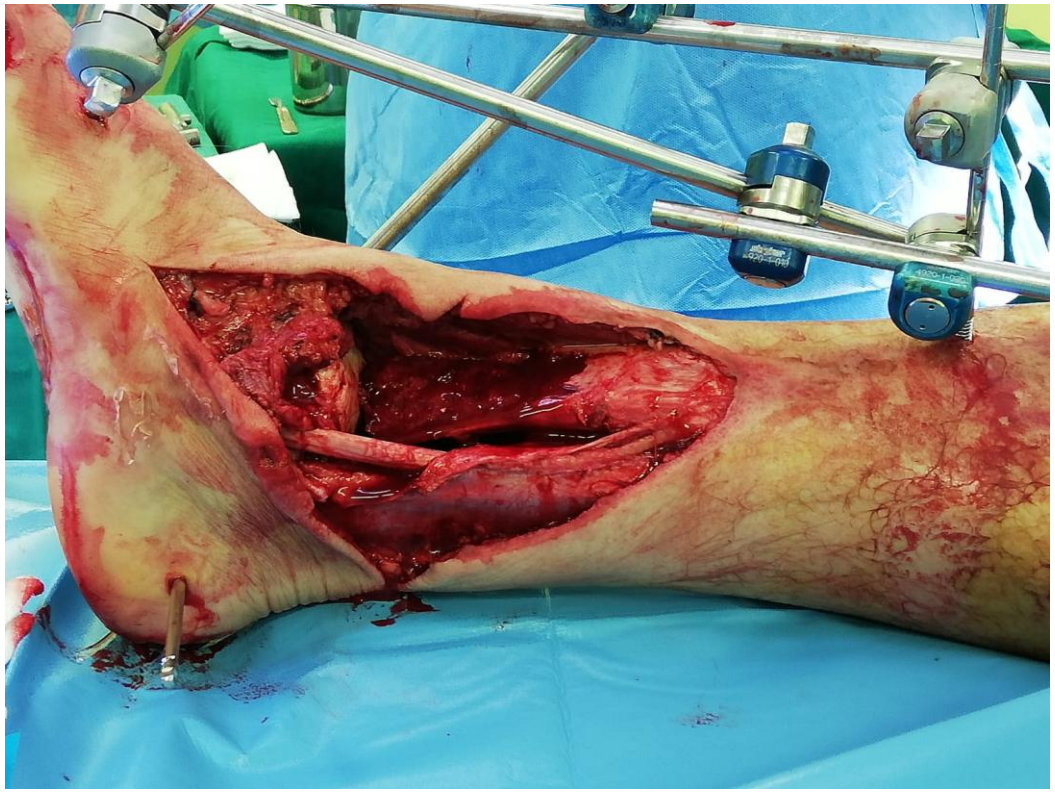
Final result

Acute shortening, angulation and rotation (case example 2)

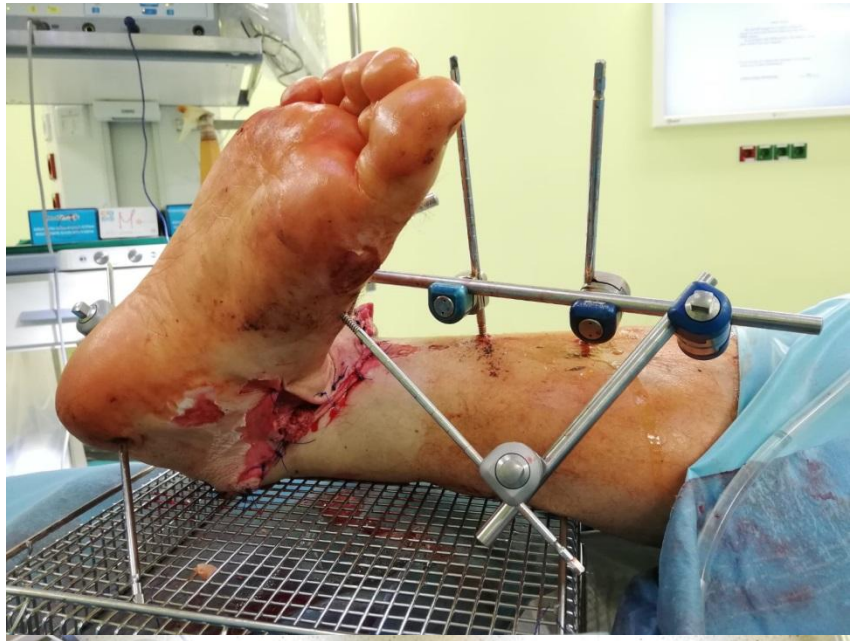
Motorcycle accident: distal tibia open fracture (Gustillo IIIB) with complete tibial cartilage and 10 cm bone loss.

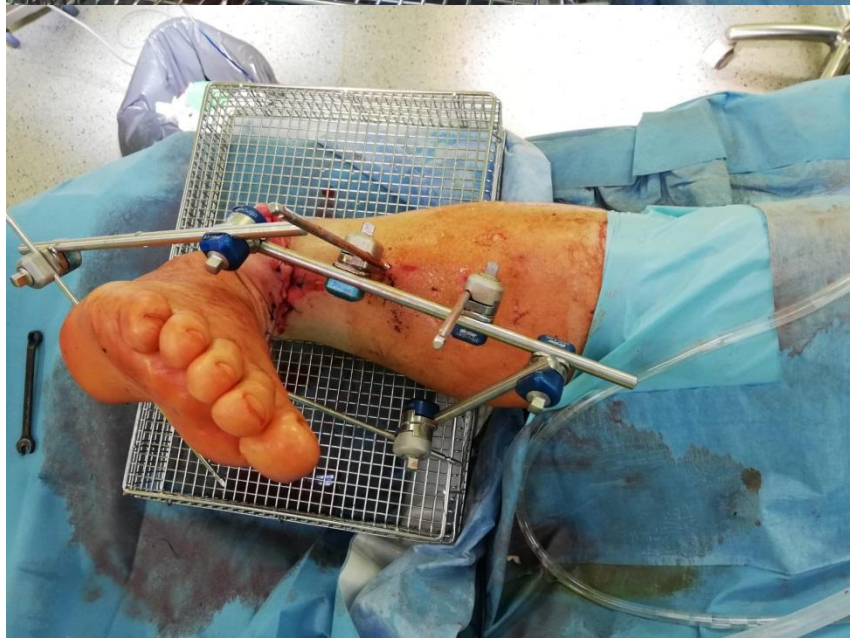


Soft tissue and bone defect after 1st debridement



Acute shortening, angulation and rotation (case example 2)

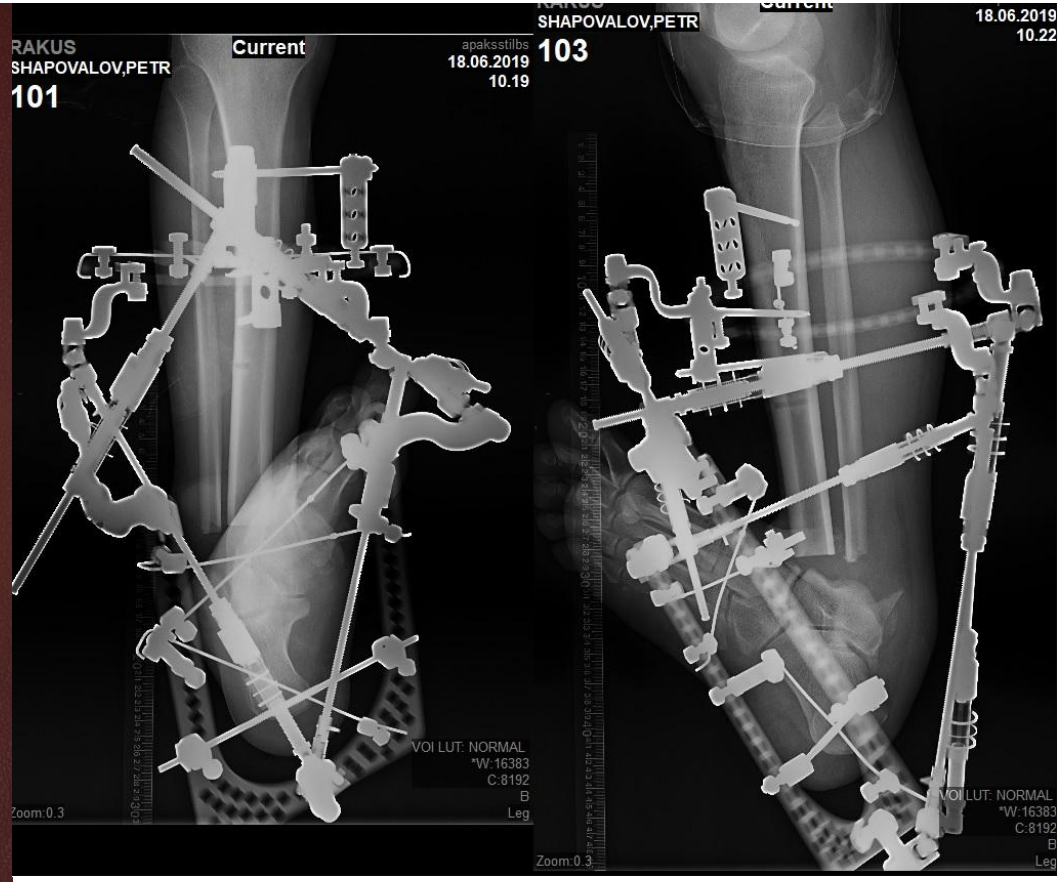




Shortening – 9 cm
Angulation – 32º varus, 45º apex posterior
Rotation (inner) – 15º
Translation – 3 cm posterior, 1 cm medial

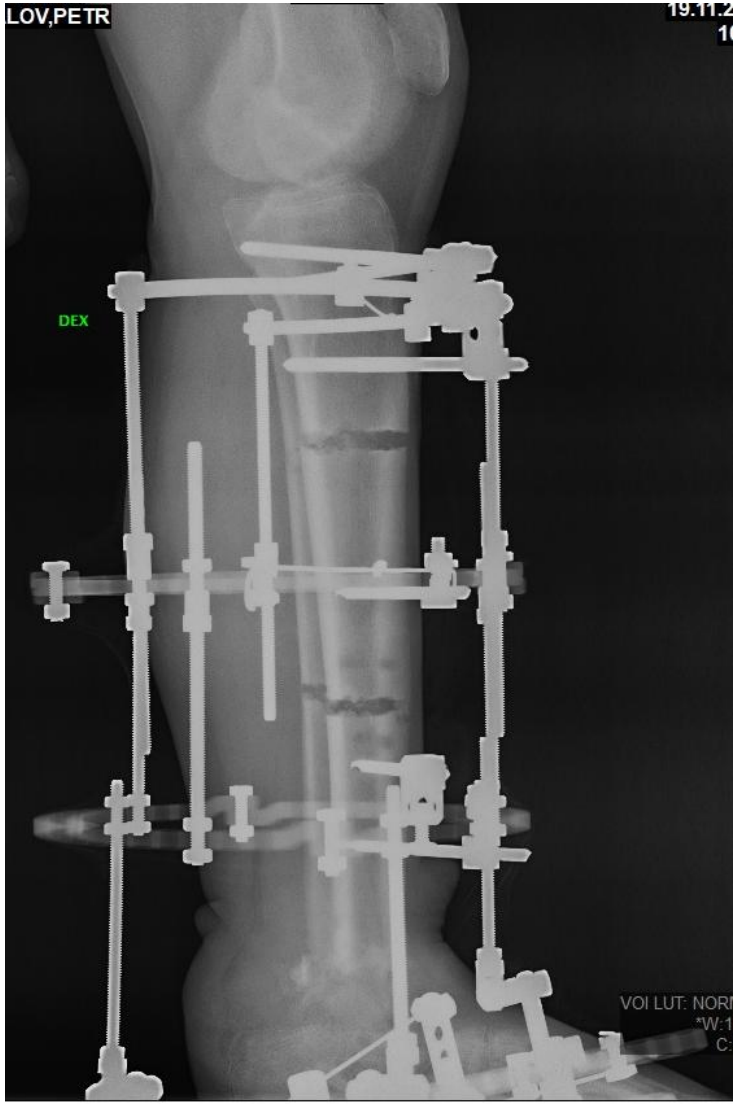
Acute shortening, angulation and rotation (case example 2)

Tubular Ex-Fix conversion to Ilizarov with orthopedic hexapod application.



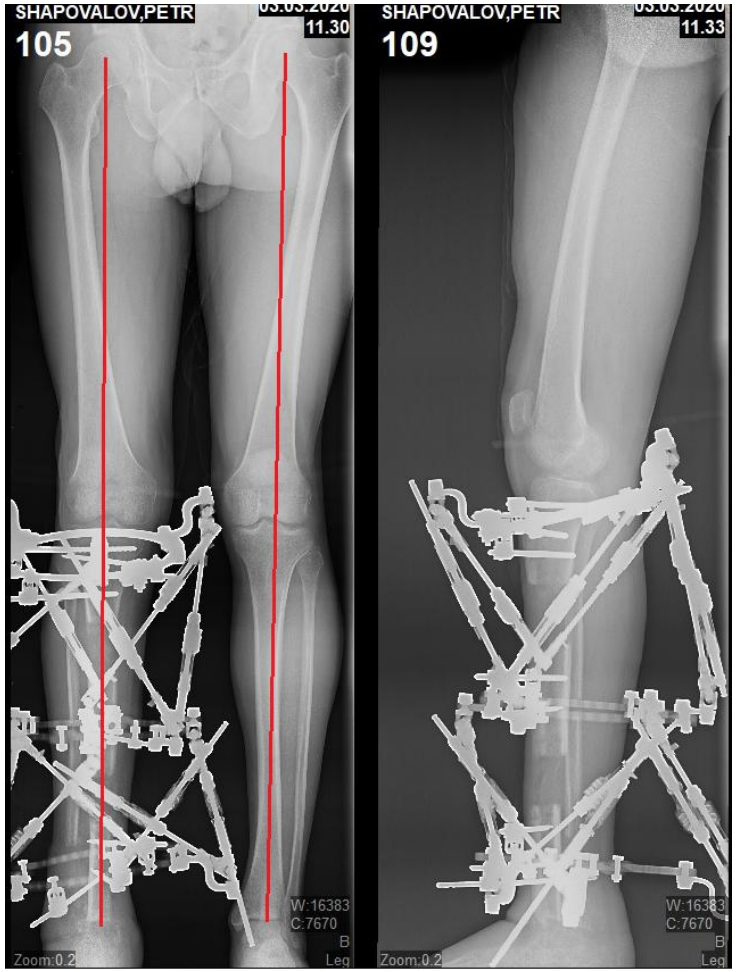
Acute shortening, angulation and rotation (case example 2)

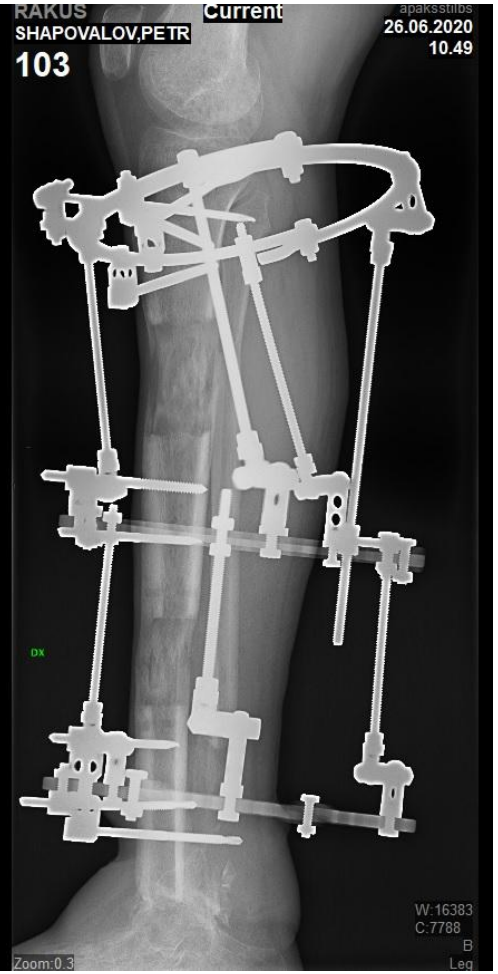
Talocrural arthrodesis with double-level tibial osteotomy for length restoration



Acute shortening, angulation and rotation (case example 2)

Final result





Conclusion

1. (ADCr) is a reasonable alternative to complex microsurgical technique in situations where the closure of a soft tissue defect with a free or rotated soft tissue flap is not possible.

2. Method of ADCr allows performing early coverage of the bone fragments and fracture site by viable blood-supplied soft tissue without need for complex prolonged surgical procedures, avoiding the risk of traumatic tissue transplantation.

3. Limb axis correction and tissue induction or reconstruction are achieved by gradual realignment and distraction through one or more corticotomies using callotasis bone induction technique and controlled by classic Ilizarov or hexapod constructs.

4. Orthopedic hexapod frame allows correction of complex multicomponent deformations without the need for additional remounting. This allows to reduce time of the correction itself, and, accordingly, the general time limb fixation in the external frame. Using computer navigation to calculate hexapod deformation correction increases the accuracy of the final result.

Thanks for attention!!!