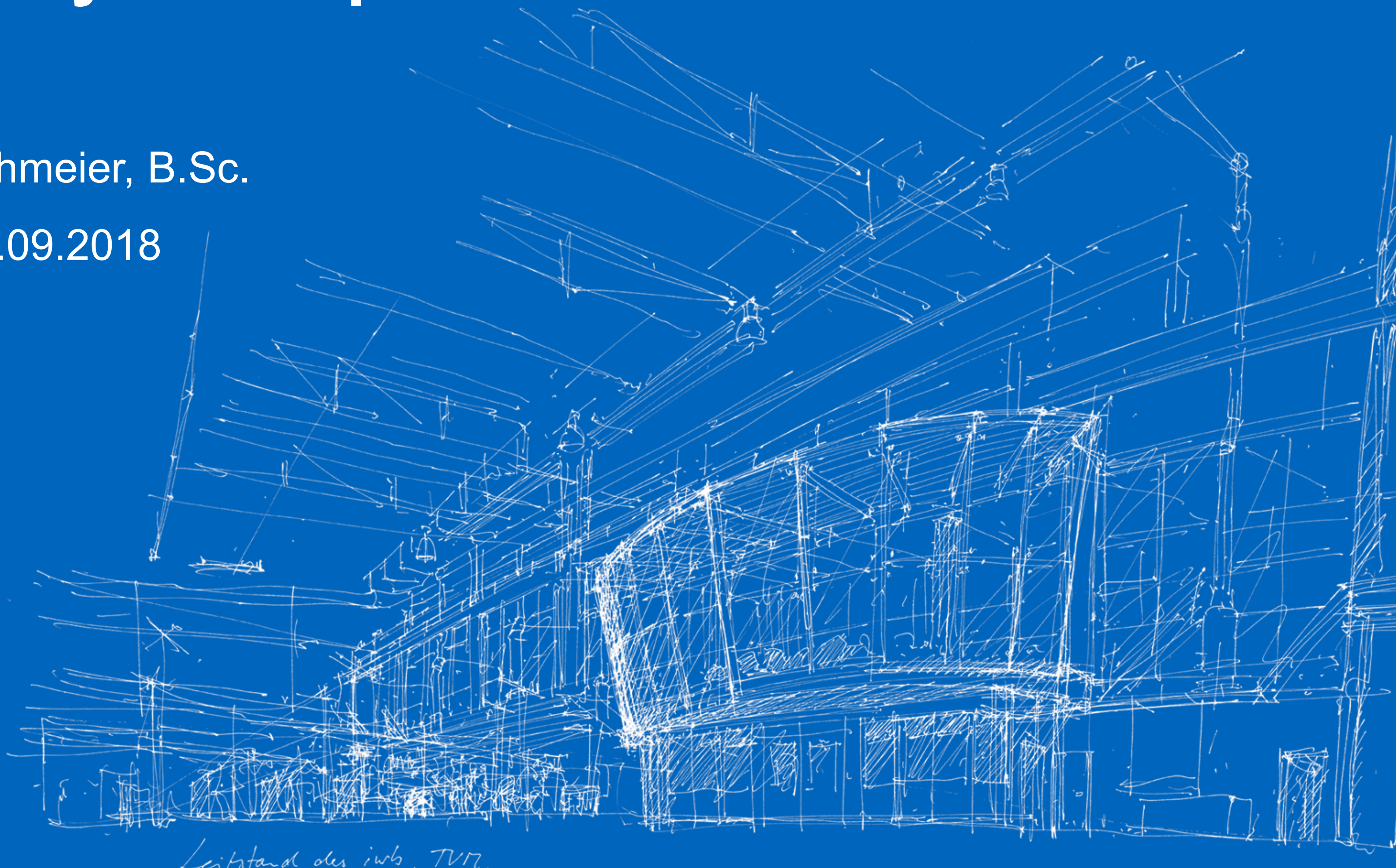
Institut für Werkzeugmaschinen und Betriebswissenschaften
Fakultät für Maschinenwesen
Technische Universität München

Development of a patient-specific surgery technique for the minimally invasive osteotomy of the proximal femur in children

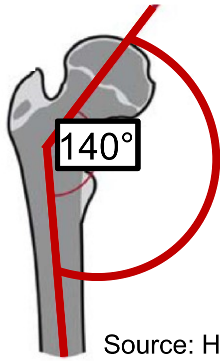
Andreas Bachmeier, B.Sc.

Garching, 10.09.2018



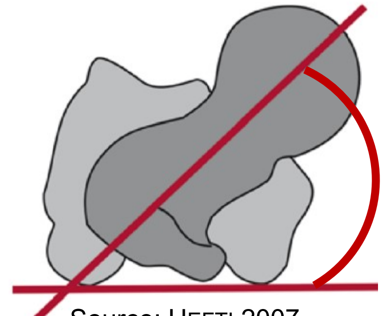
Introduction

Relevant angles and exemplary osteotomy of a child



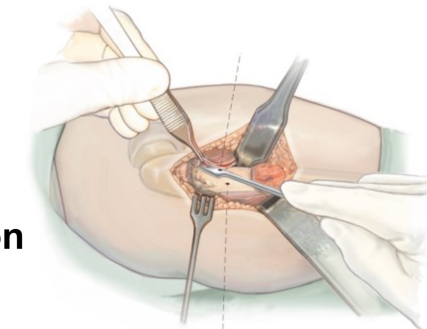
CCD angle

Source: HEFTI 2007

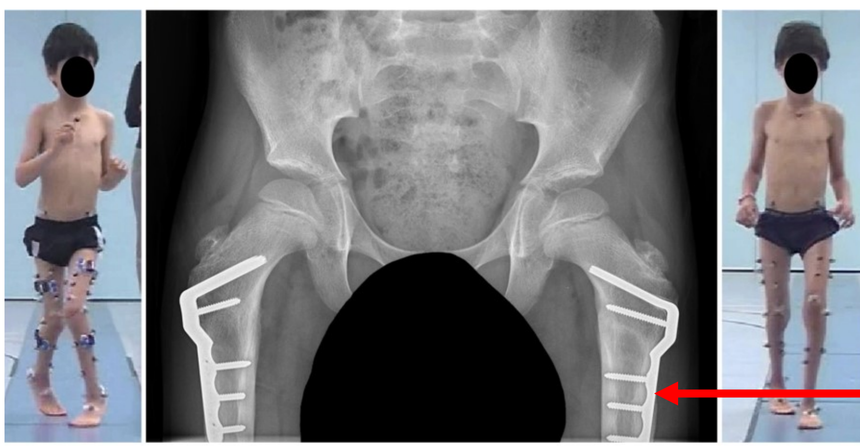


Femoral anteversion

Source: HEFTI 2007



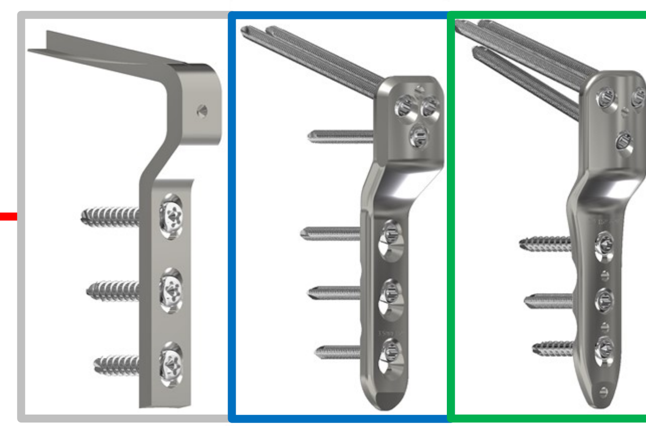
Source: JOERIS ET AL. 2012



Source: ZHOU ET AL. 2017

Intertrochanteric Osteotomy

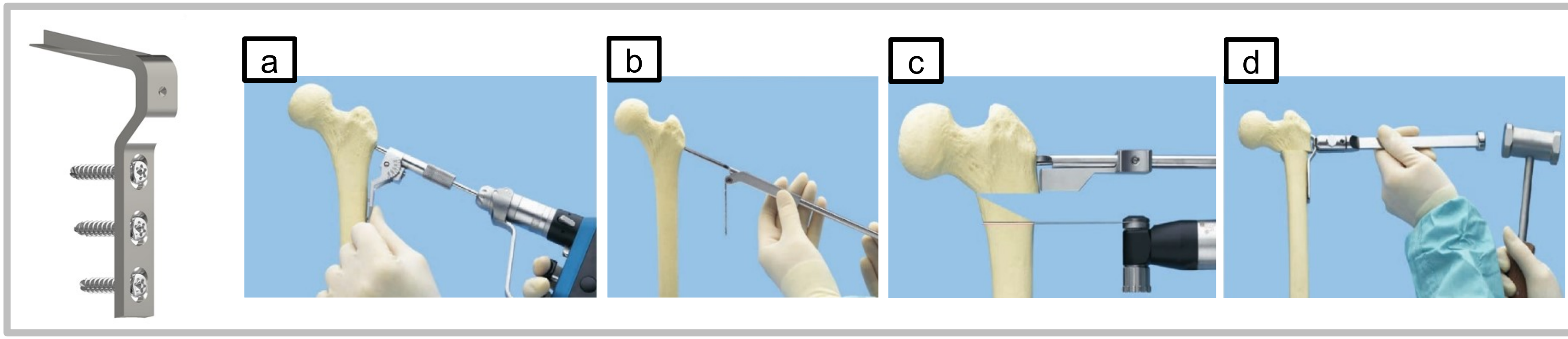
Synthes Blade, Synthes and OrthoPediatrics locking plates



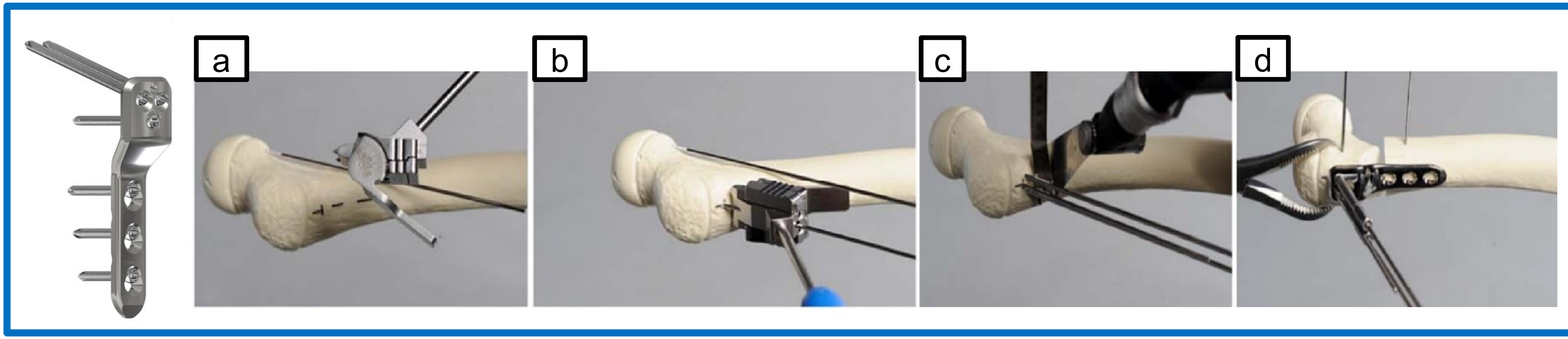
State of the Art

Current surgery Techniques using blade and locking plates

Surgery technique using a Synthes blade plate (DePuy-Synthes 2016)



Surgery technique using a Synthes locking plate (Ziebarth & Slongo 2015)



Motivation

BMBF research project “FOMIPU” and structuring of the thesis

FOMIPU: Novel surgery technique for the osteotomy of the femur in children

- Minimal invasiveness
- Complexity and error reduction
- Patient-specific surgery technique
- Reduced radiation exposure
- Polyaxial and angular stable implants
- Surgery guided by targeting devices

Polyaxial Implant Design

- System Design
- Implant Evaluation

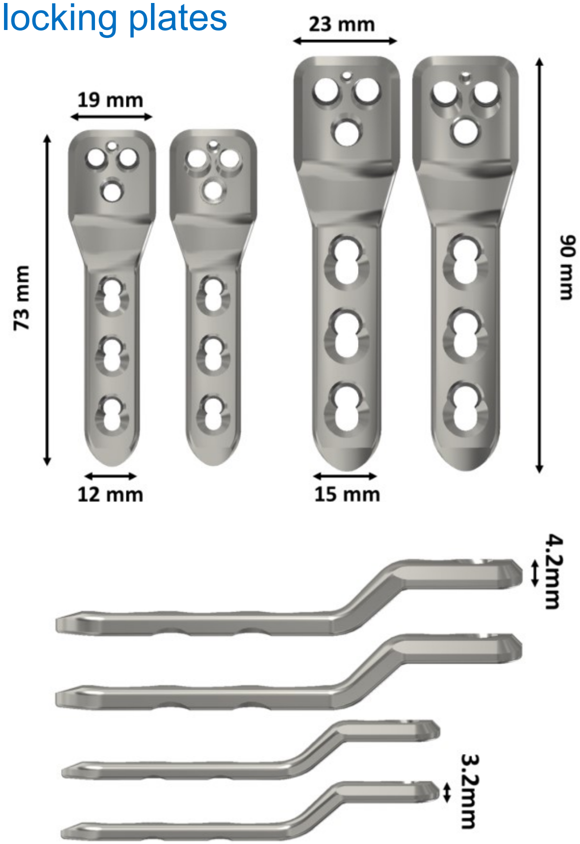
Guided patient-specific and minimally invasive surgery

- Concept Development
- Concept Evaluation

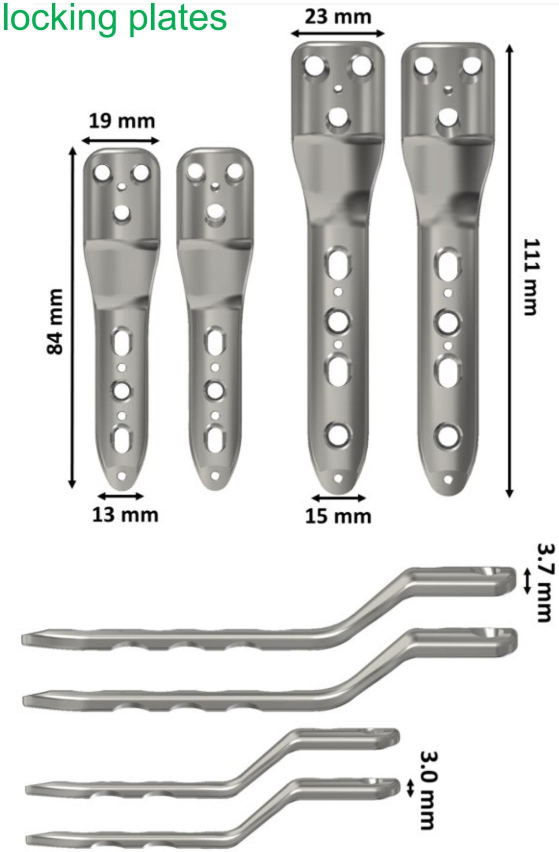
System Design:
State-of-the-art systems

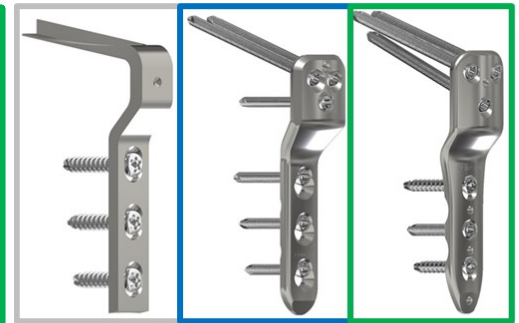
Blade and angular stable locking plates

Synthes 3.5 and 5.0 mm locking plates



OrthoPediatrics 3.5 and 4.5 mm locking plates



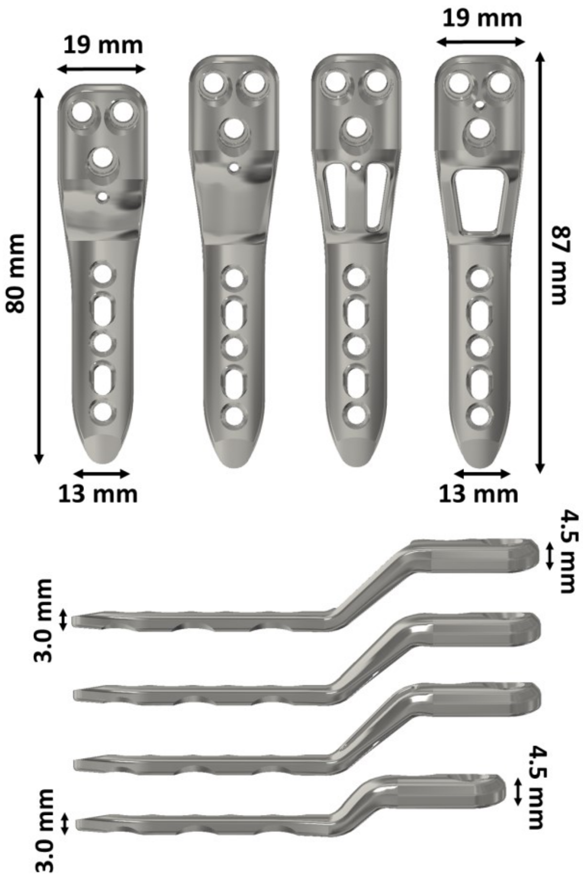


Locking and cortex screws

System Design: Polyaxial system

Parts of the polyaxial system and locking mechanism

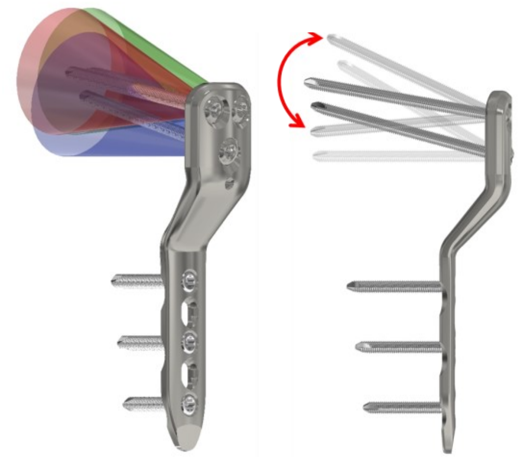
3.5 mm polyaxial locking plates



Locking cap

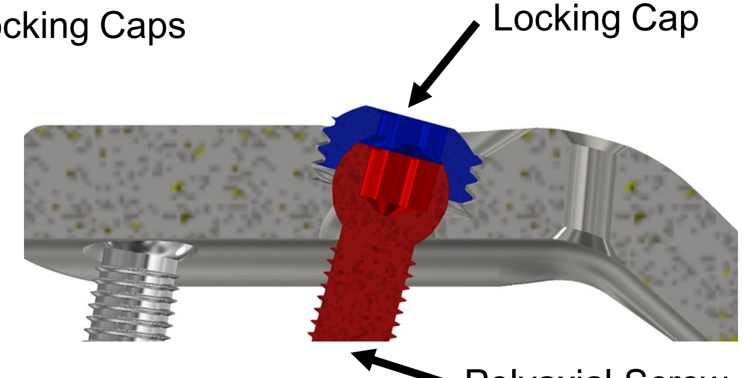
Polyaxial locking screw

Visualization of polyaxiality



Polyaxial locking mechanism: Locking Caps

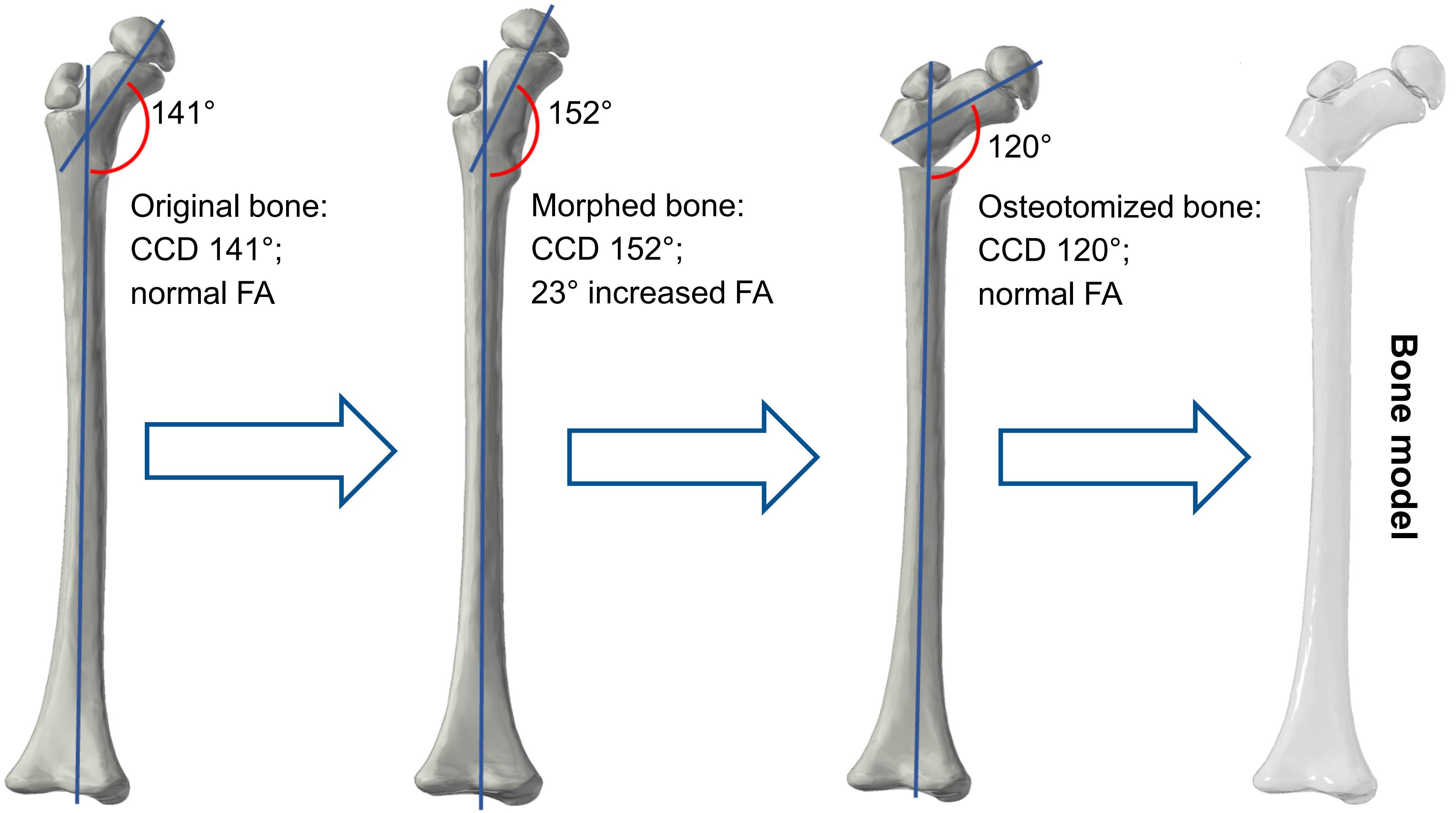
Locking Cap



Polyaxial Screw

Implant Evaluation:
Bone Model Development

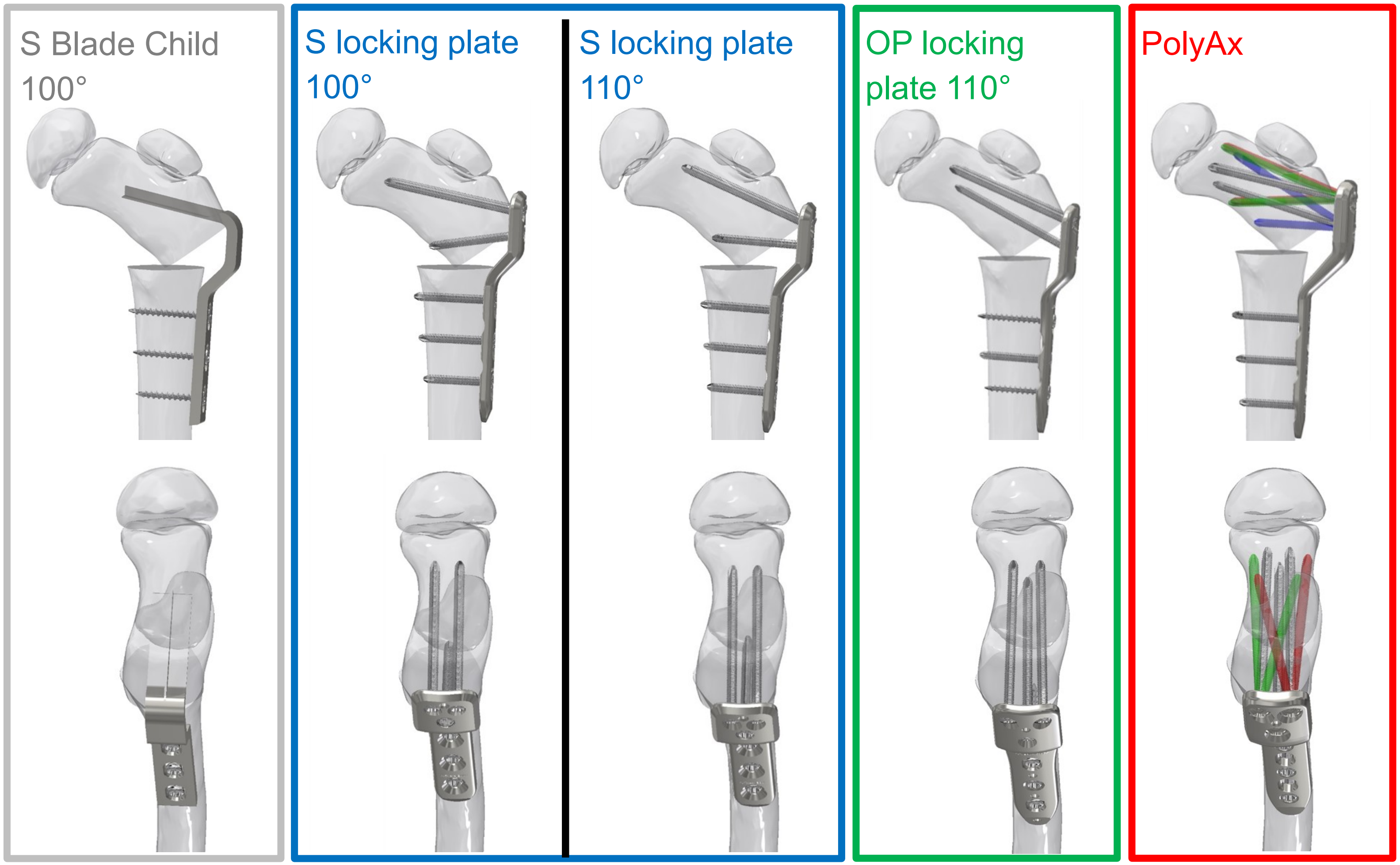
Modification and osteotomy of a segmented bone of a seven-year-old child



Implant Evaluation: Virtual Implantation

Anterior and superior views of the implanted systems

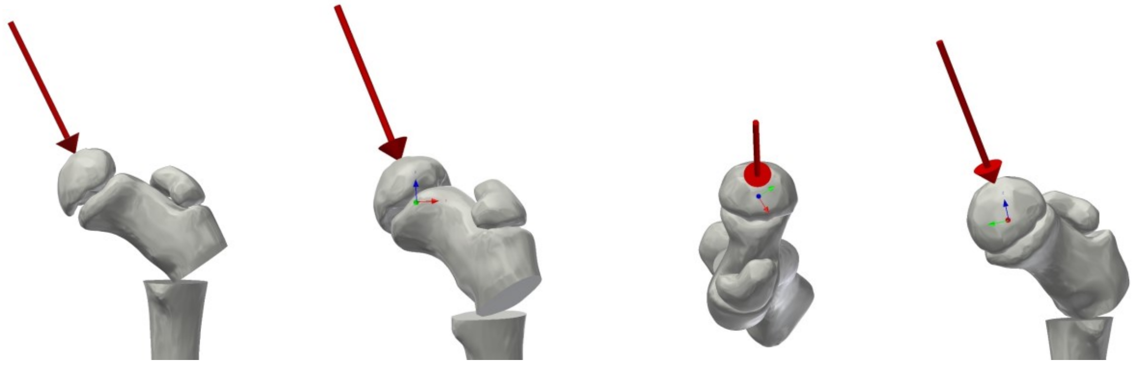
S: Synthes
OP: OrthoPediatrics



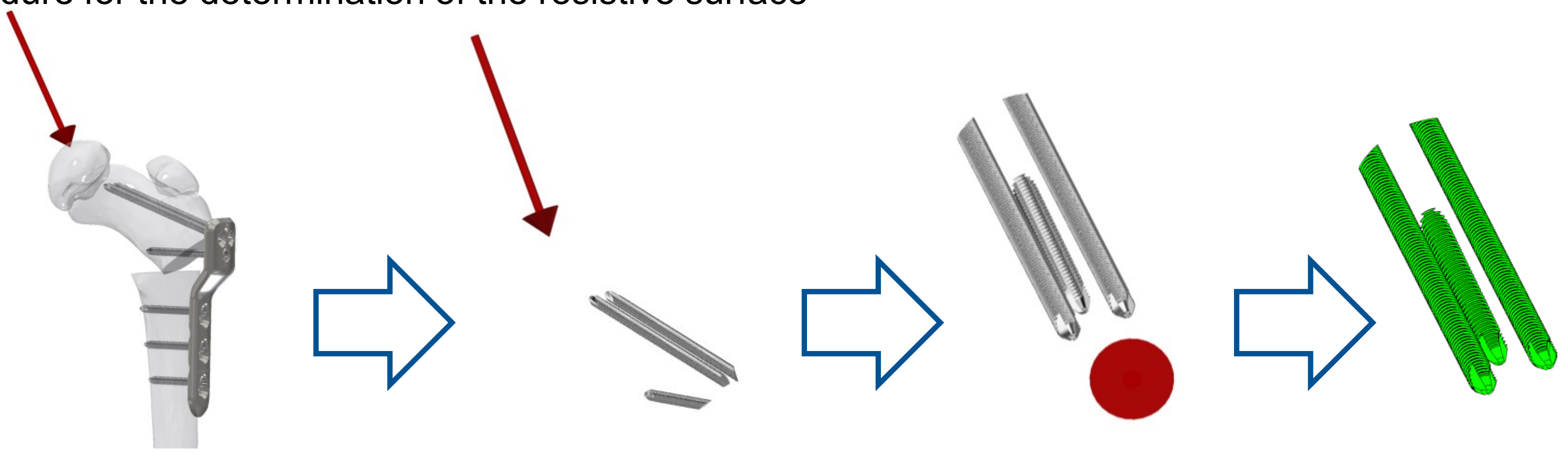
Implant Evaluation:
Biomechanical Cut-Through Resistance

Resulting force vector and resistive surface

Integration of the resulting force vector for the worst-case scenario (“Stairs Down”)

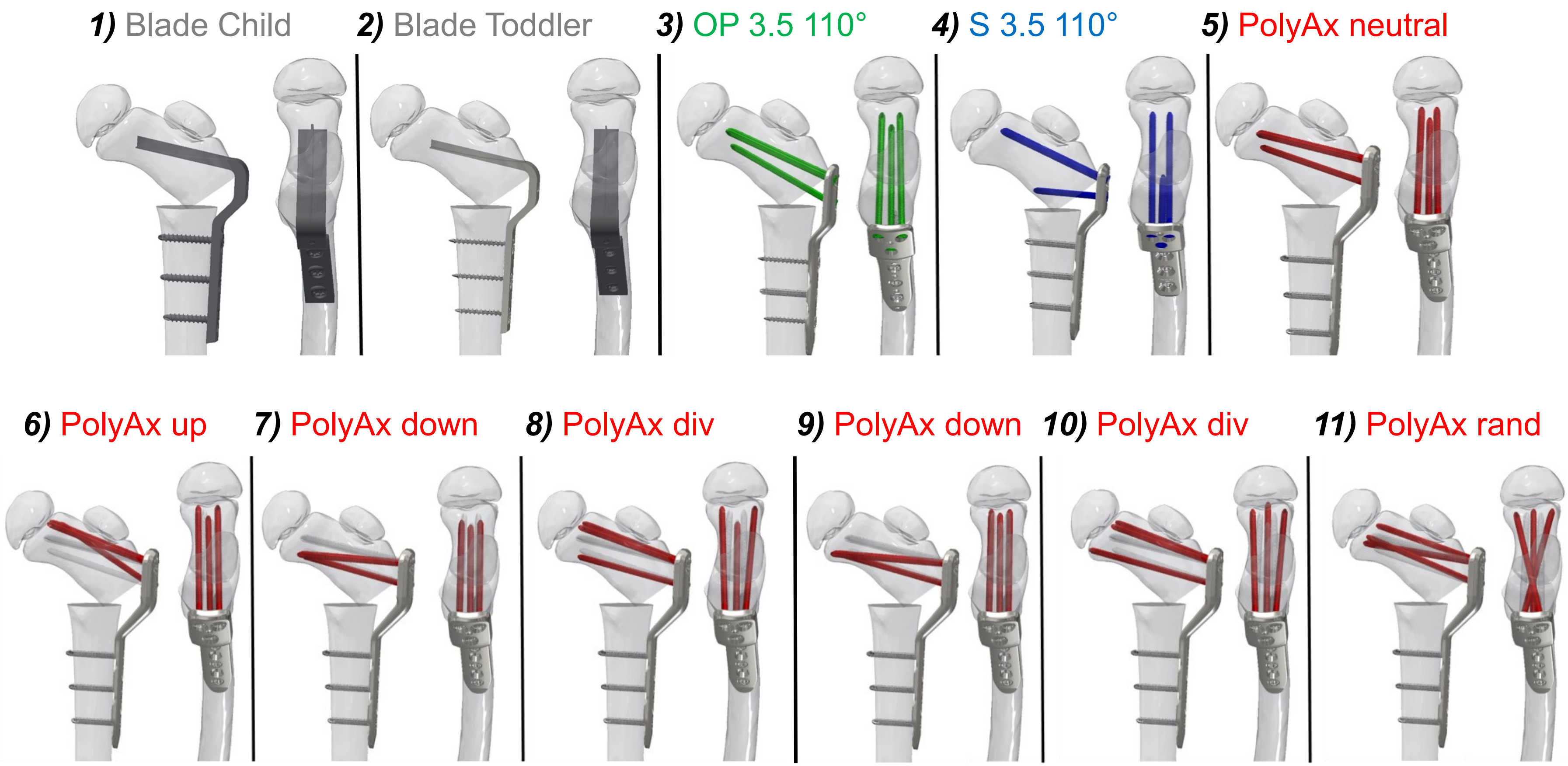


Procedure for the determination of the resistive surface



Implant Evaluation:
Biomechanical Cut-Through Resistance

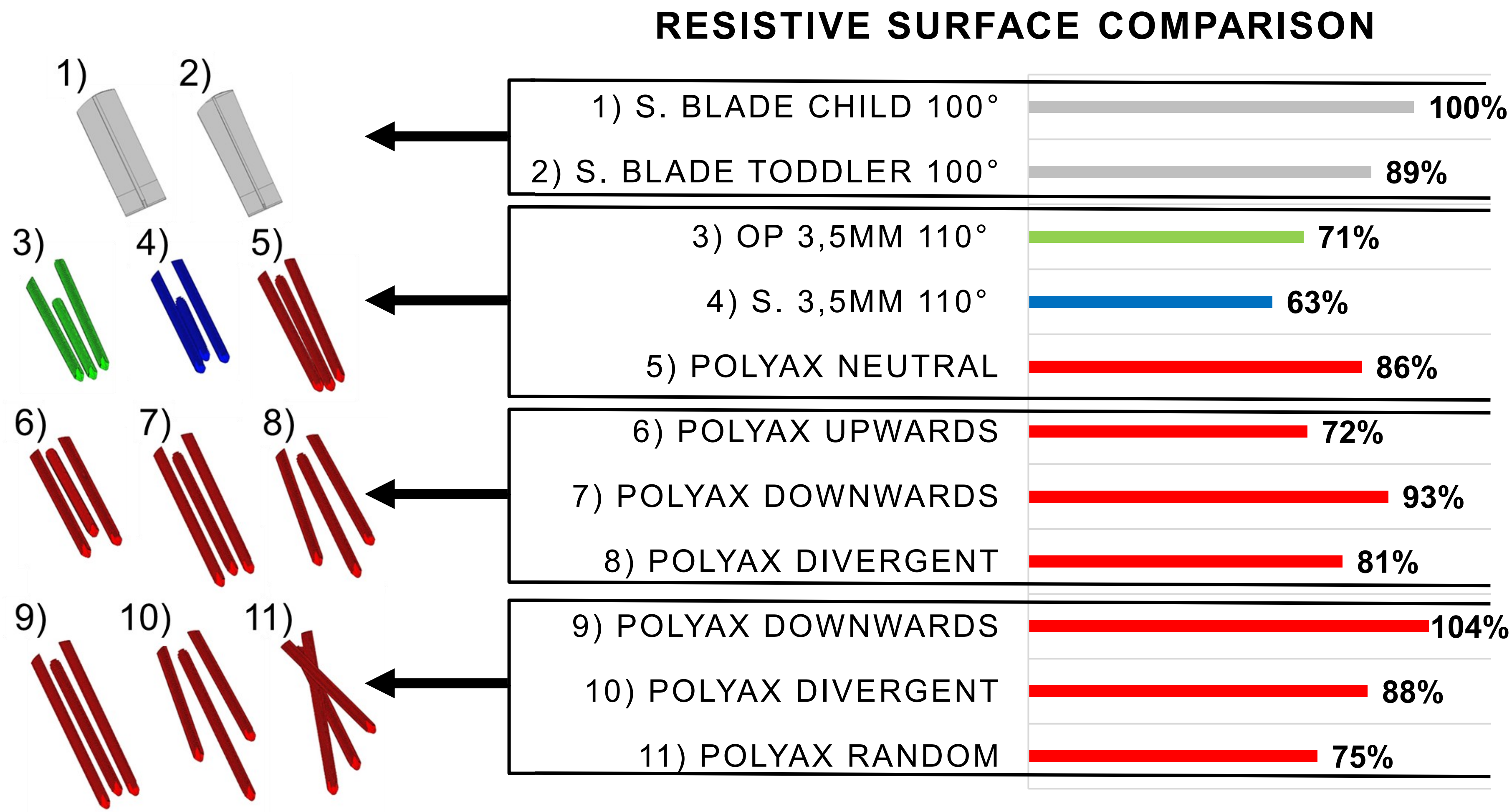
Virtual implantation of the systems with optimized screw length



div: divergent; up: upwards; down: downwards; rand: randomly crossed

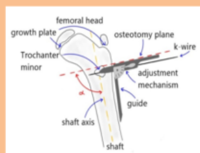
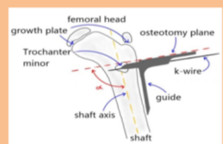
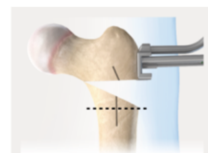
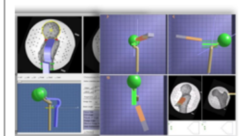
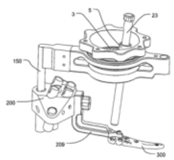
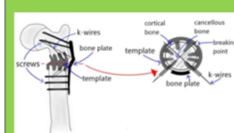
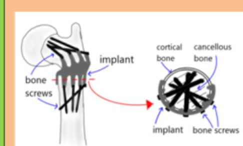
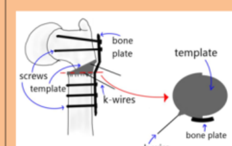
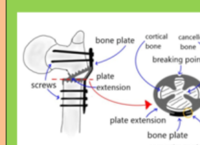
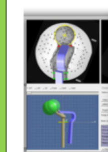
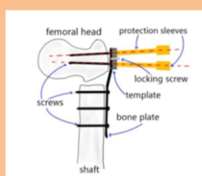
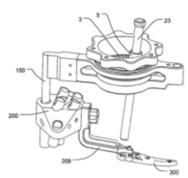
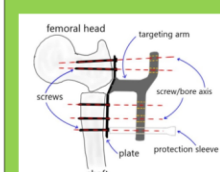
Implant Evaluation:
Biomechanical Cut-Through Resistance

Evaluation of the resistive surface



Concept Development: Creation

Concepts created by applying the Munich Procedure Model (Münchner Vorgehensmodell)

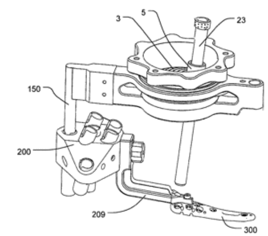
	Solutions						
subgoals	***Concept 1***	***Concept 2***	***Concept 3***	***Concept 4***	***Concept 5***	***Concept 6***	***Concept 7***
defined cutting plane (DCP)							
mechanically navigated alignment (MNA)							
polyaxial screw insertion (PSI)							

Concept Development:
Selection

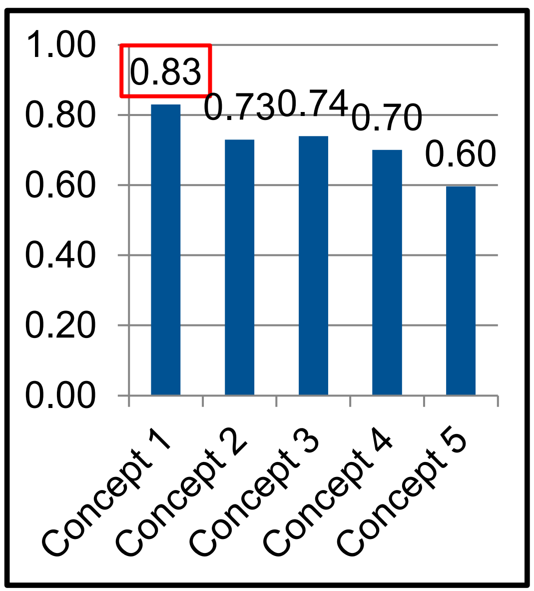
Weighted scoring and selection of the highest rated concepts

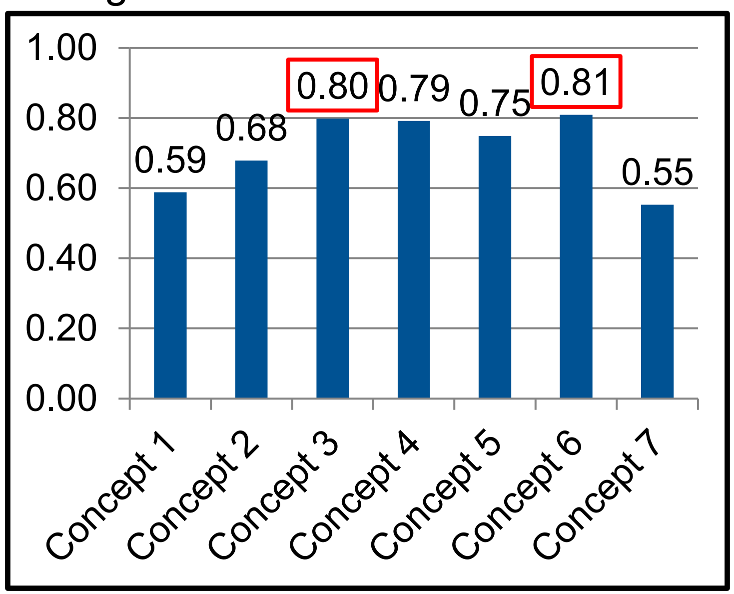
Defined Cutting Plane

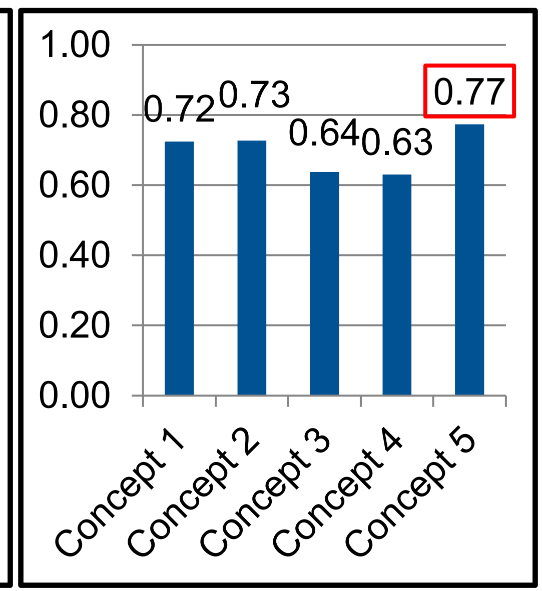
Mechanically Navigated Realignment



Polyaxial Screw Integration

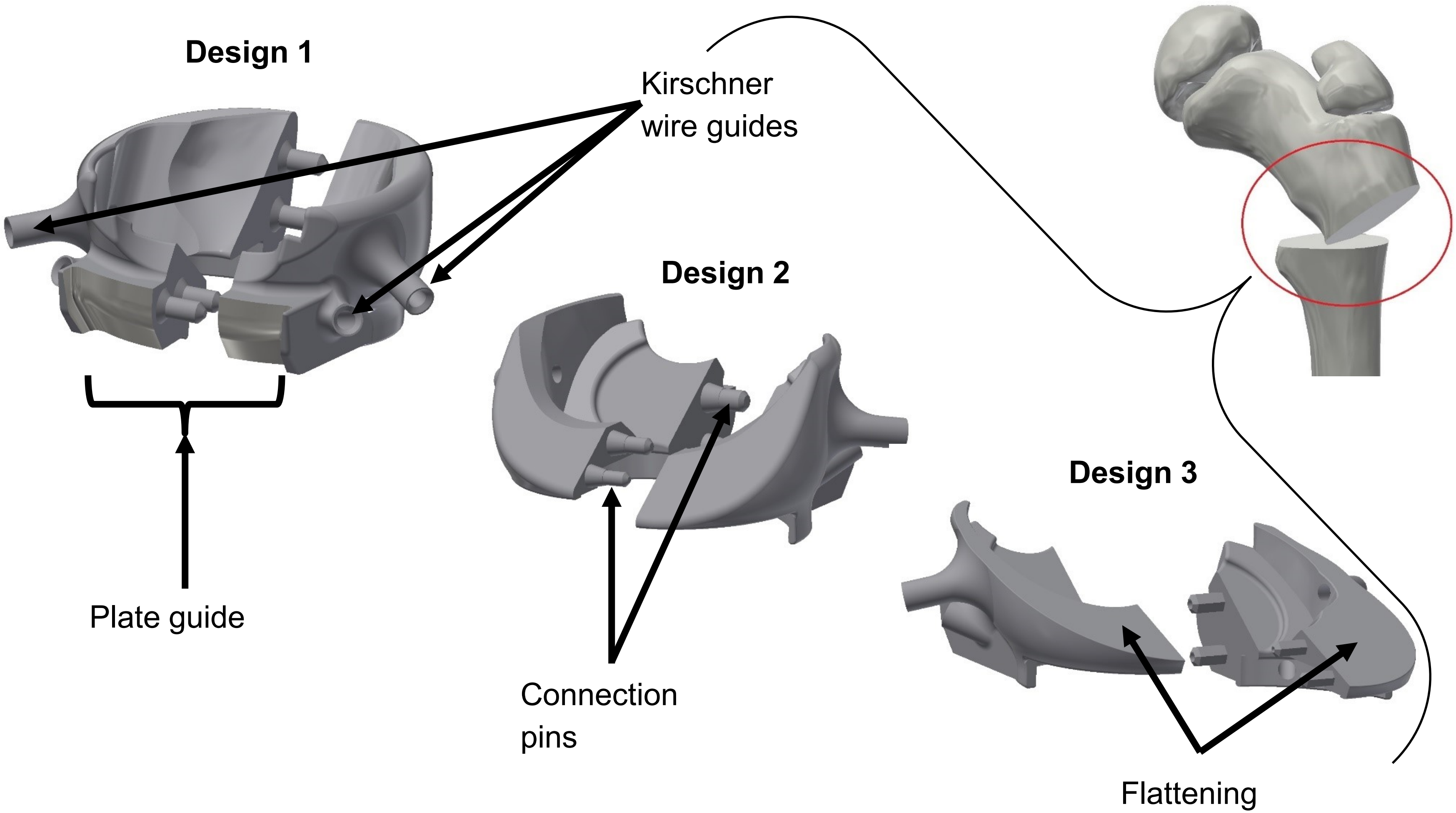






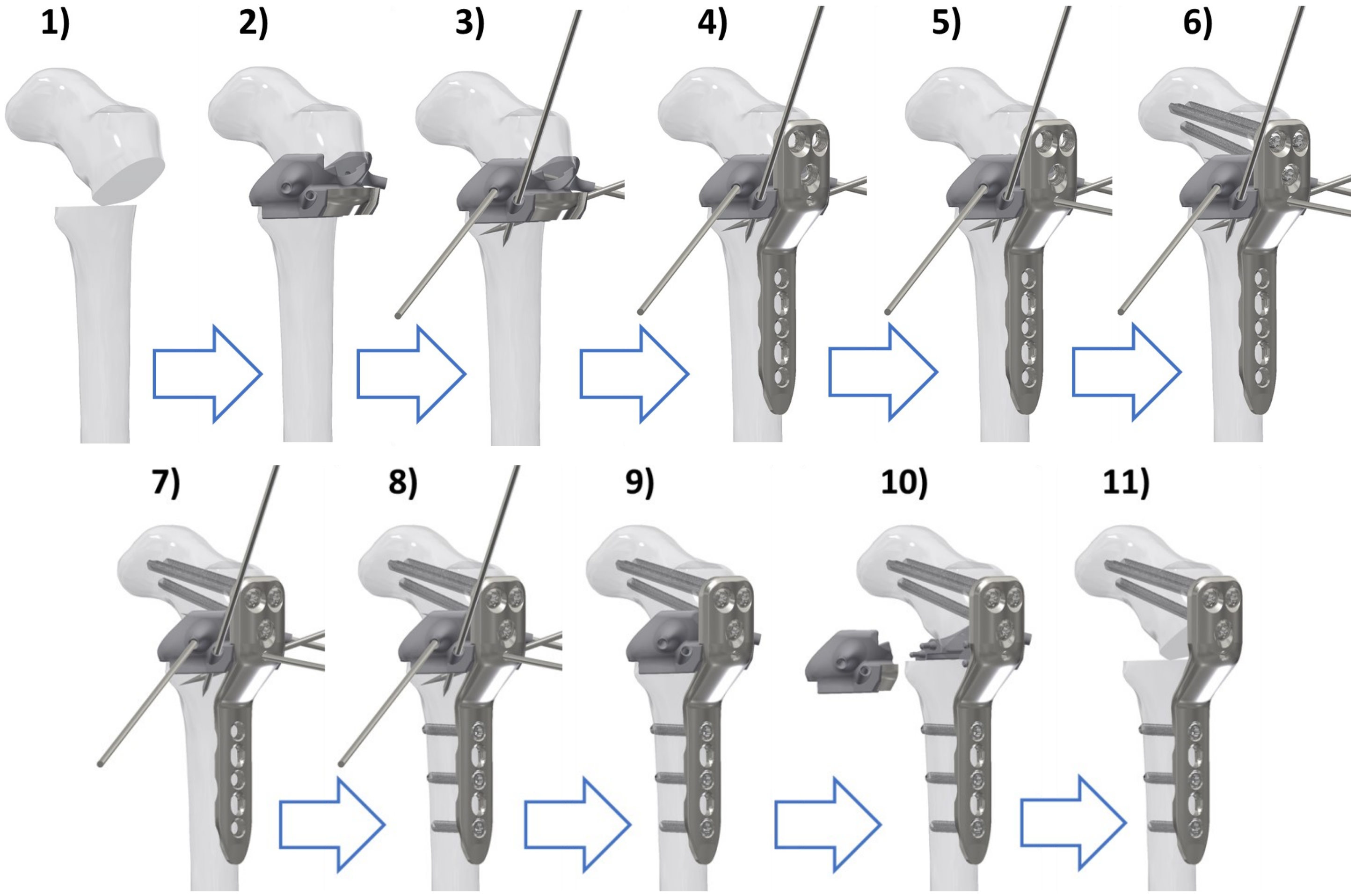
Concept Development:
Mechanically Navigated Realignment

Patient-specific osteotomy guide (combination of Concept 3 and 6)



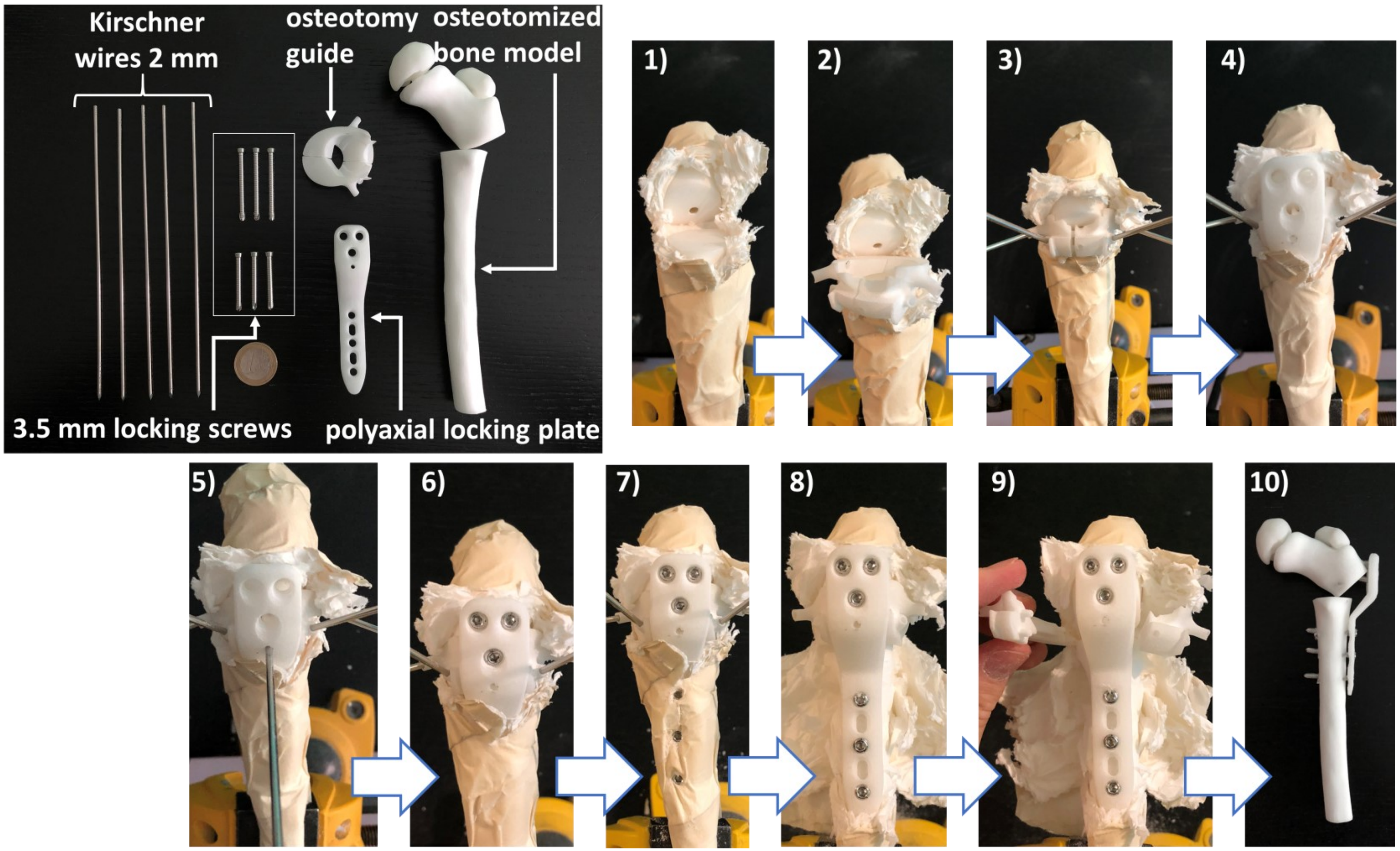
Concept Development: Final Surgery Technique

Procedure of the implemented surgery technique



Concept Evaluation: Physical surgery execution

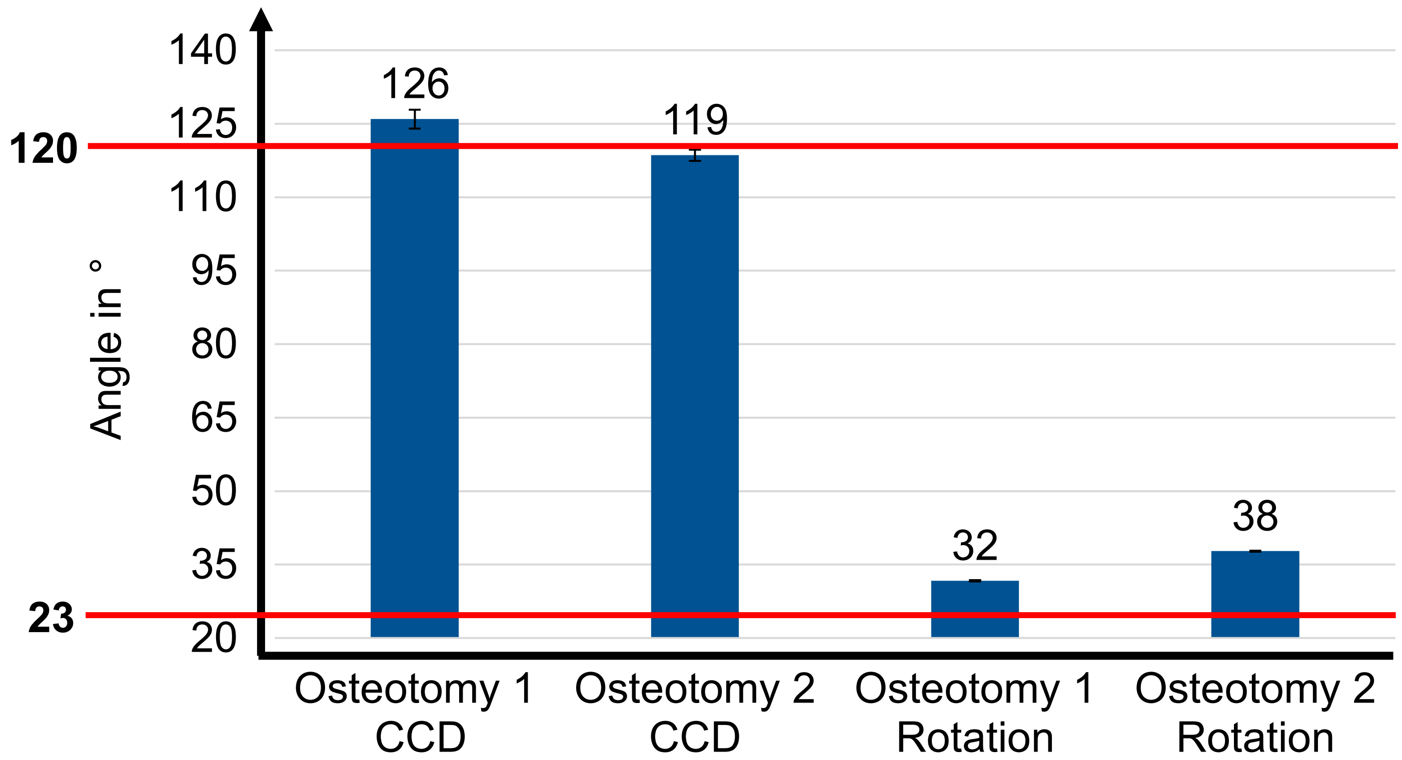
Additively manufactured system and osteotomy procedure



Concept Evaluation: Results

Resulting angles and errors

Preoperatively planned angles: **120°** CCD angle and **23°** relative rotation



Summary and Outlook

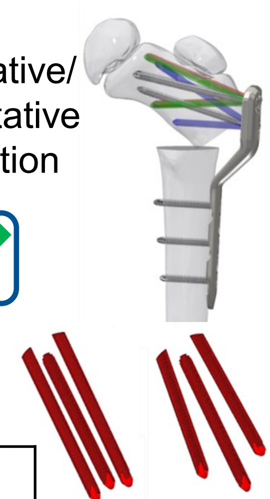
Target attainment and limitations of the applied methods

Mechanically guided realignment of the femur

Minimally Invasive Surgery

Polyaxial implant

Qualitative/ quantitative evaluation



Guided polyaxial screw integration	Concepts
Defined cutting plane	Concepts

Complete surgery technique

Limitations

1) Guide design based on CT data	**2)** Plastic parts for physical evaluation
3) Virtual implantation based on one bone	**4)** Transferability of cut-through evaluation

FOMIPU