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Development of a Novel Surgical Technique for autologous Bone Transfer to optimize Reconstruction of large Bone Defects in Long Bones

Presentation of the Results of the PhD Thesis

Dr. Andreas T. Bachmeier

Motivation

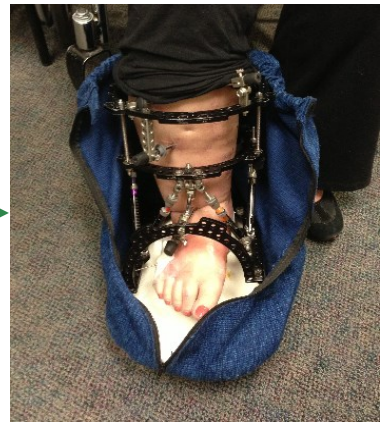
Bone Defect due to Infection or Tumor

*

Established Reconstruction

Bone Transport

→ Lengthy, expensive and complication-prone Treatment with External Systems



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Innovative Reconstruction with Fibula Expansion

Avital Bone Segment

1 *Resection*

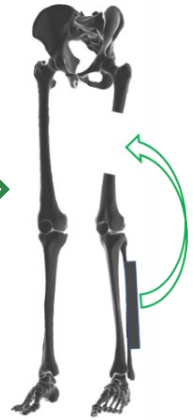
Bone Defect

2 *System Implantation Stabilization and Spacing Medication*

Stabilized Bone Defect

Fibula Expansion | System Explantation | Spacer Removal

3



Expanded Fibula

4 *Transplantation Defect Bridging Internal Stabilization*

Bridged Bone Defect

5 *Implant Removal*

Reconstructed Bone Defect

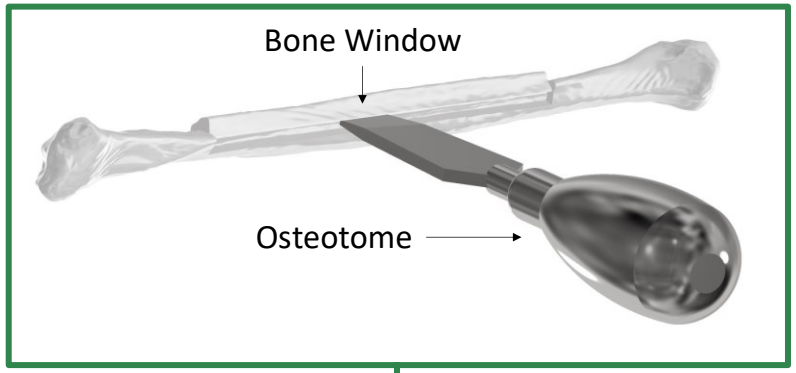
*A. Platz, C. M. L. Werner, W. Künzi, O. Trentz, und V. E. Meyer, „Rekonstruktion posttraumatischer Knochendefekte an den unteren Extremitäten: Kallusdistraktion oder freie mikrovaskularisierte Knochentransplantation?“, Handchir. · Mikrochir. · Plast. Chir., Bd. 36, Nr. 6, S. 397–404, Dez. 2004..

**http://jesse-doty.squarespace.com/activity/

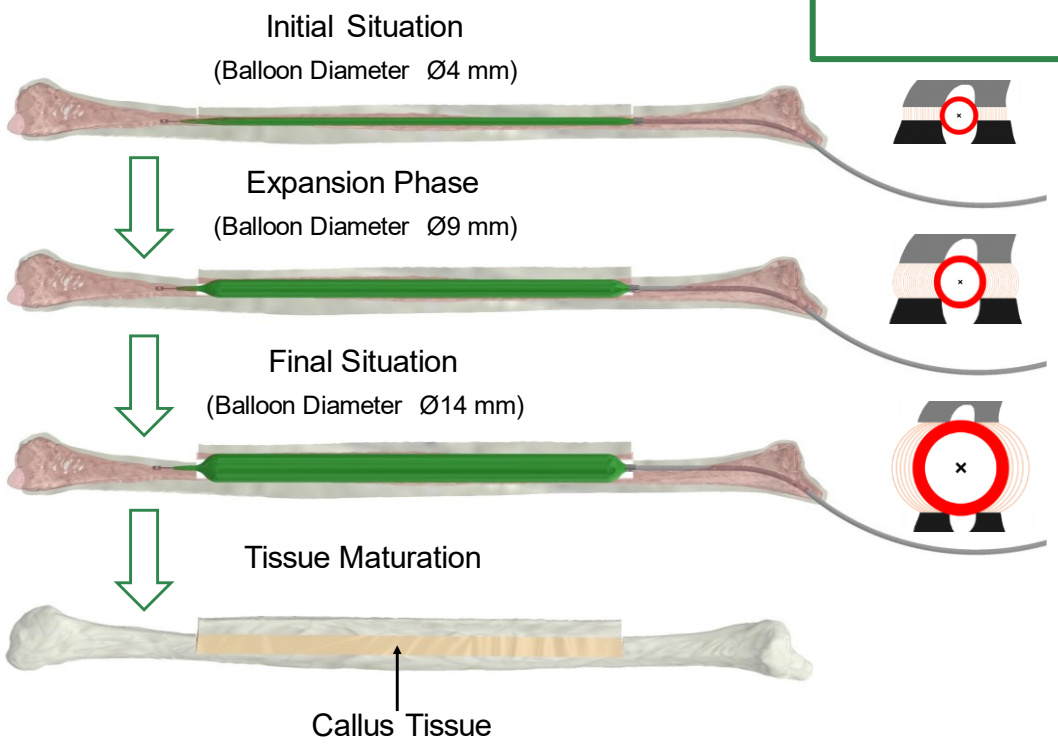
***R. D.-I. D. M. Baumgart, „Intramedullary nail for bone distraction“, EP1033112 (A3), 05-Juni-2002.

Defect Reconstruction

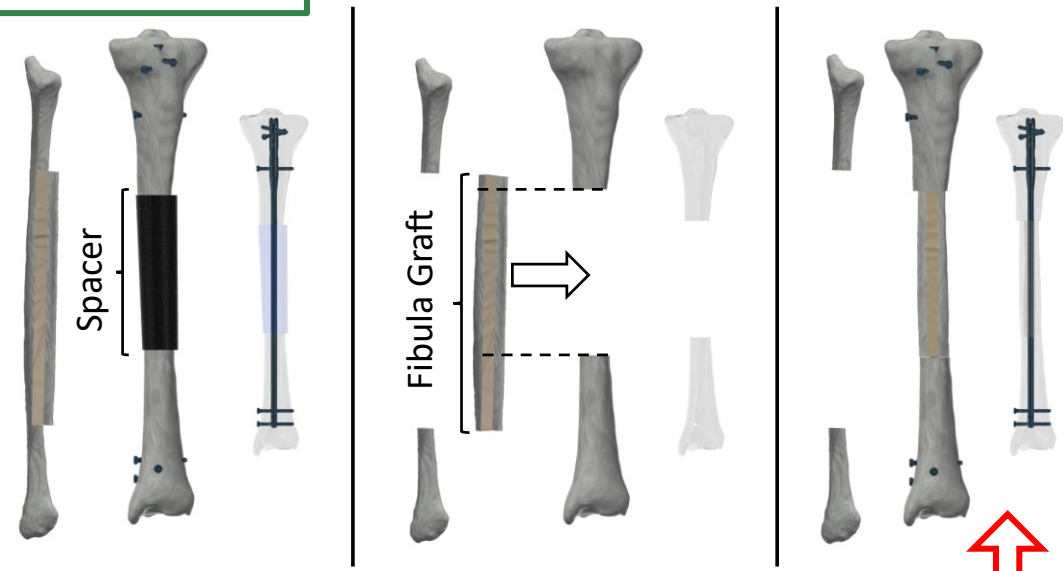
Detailed Surgical Technique



Expansion of the Fibula



Transplantation of the Fibula

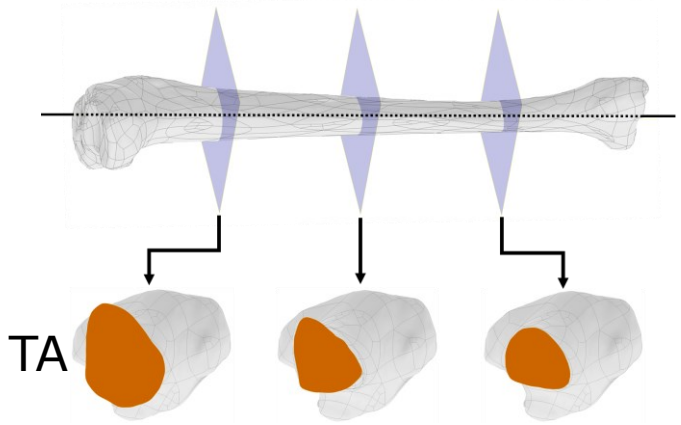


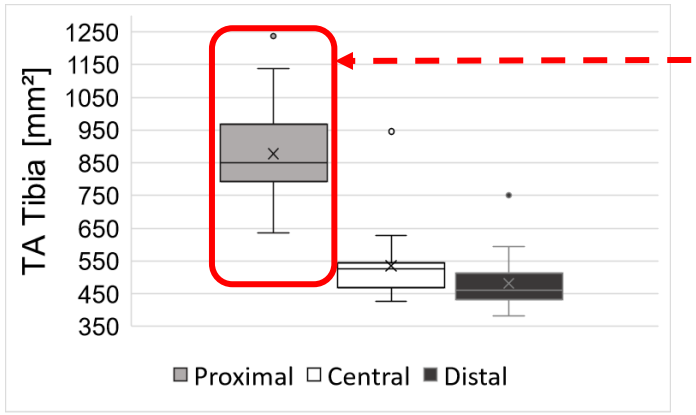
Bridging with complete internal Stabilization

Biomechanical Simulation

Total Distraction Area *TA* for longitudinal Distraction Osteogenesis

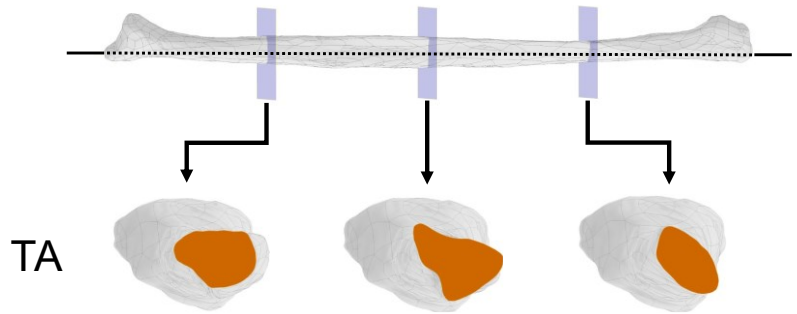
Tibia proximal central distal

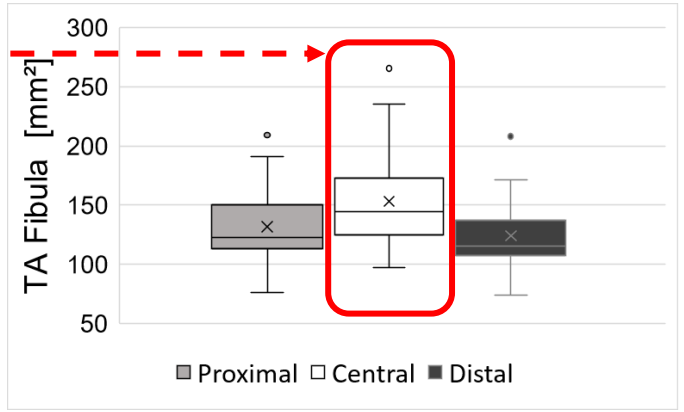




Utilization for Simulation

Fibula proximal central distal

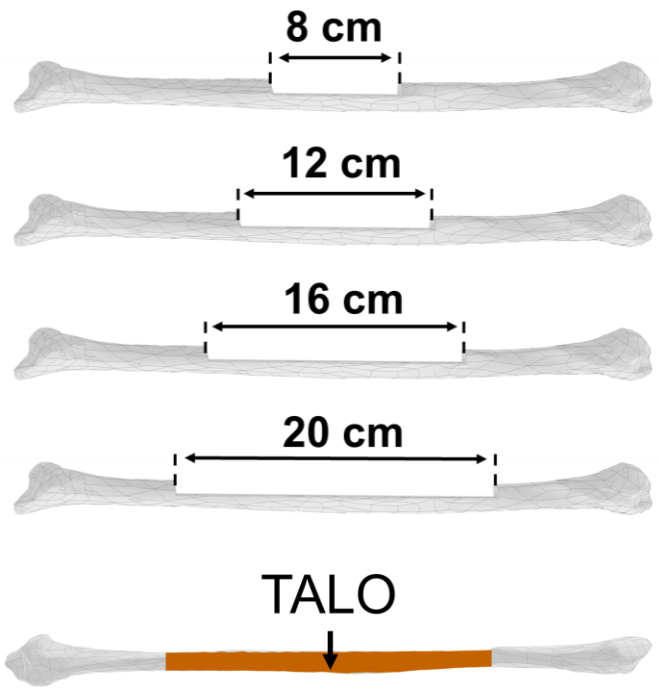


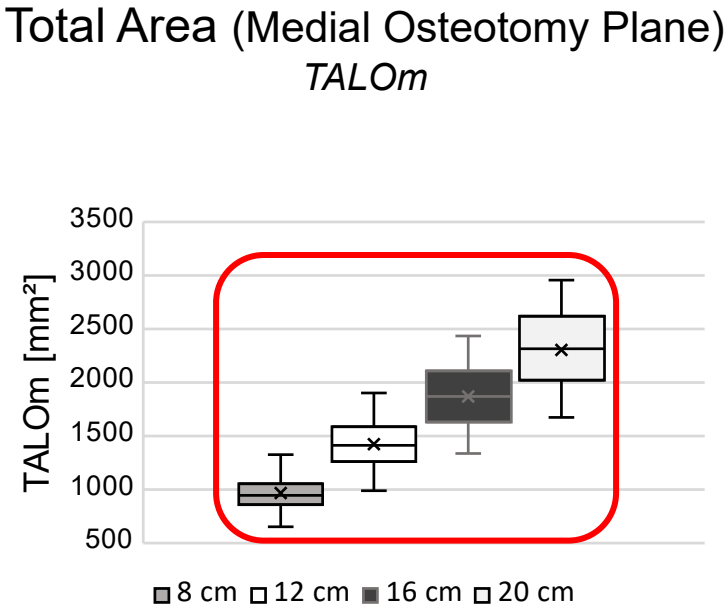


Biomechanical Simulation

Distraction Area for radial / transverse Distraction Osteogenesis

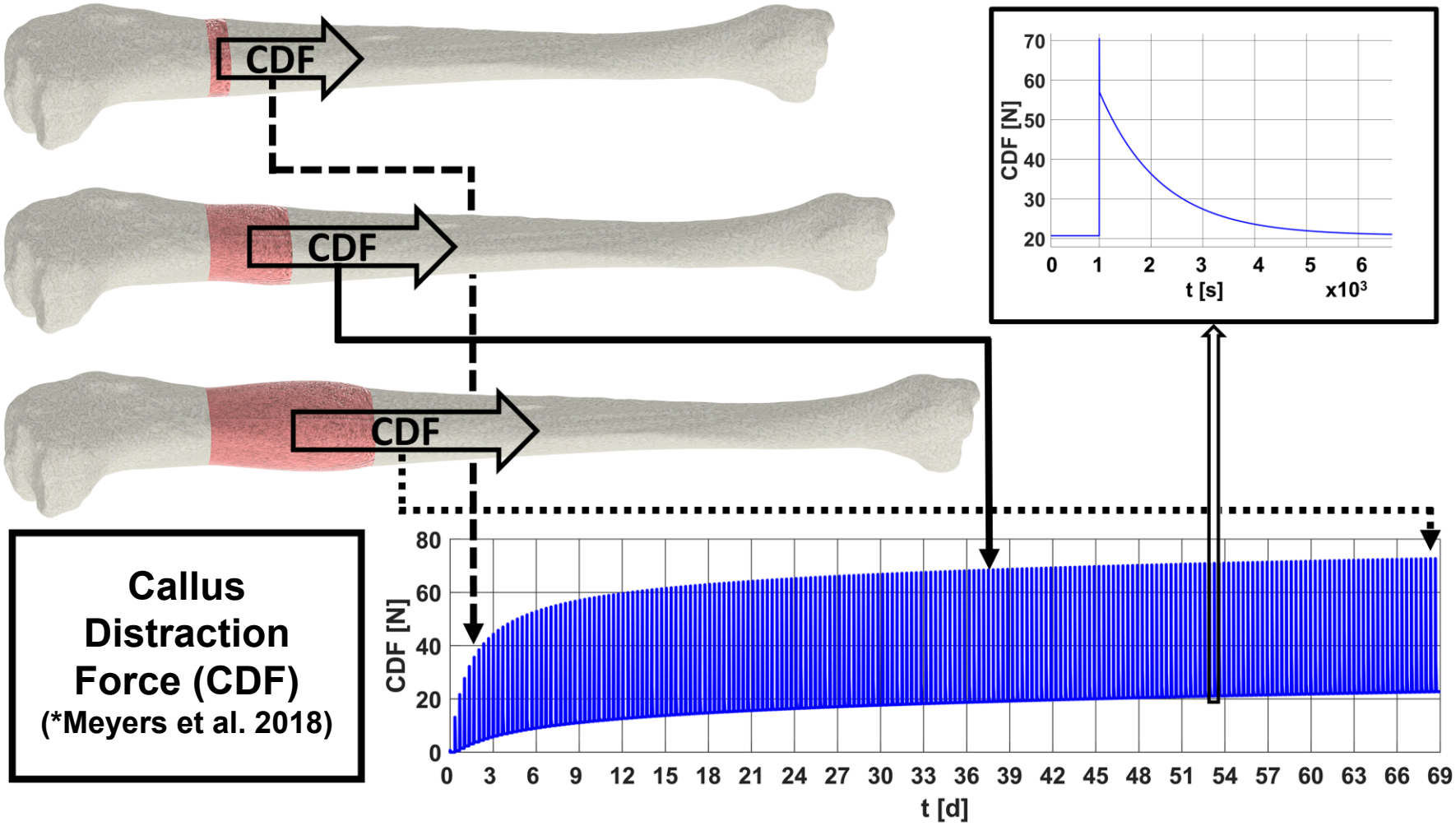
Fibula





Biomechanical Simulation

Distraction Forces for longitudinal Distraction Osteogenesis (LDO) in the Tibia

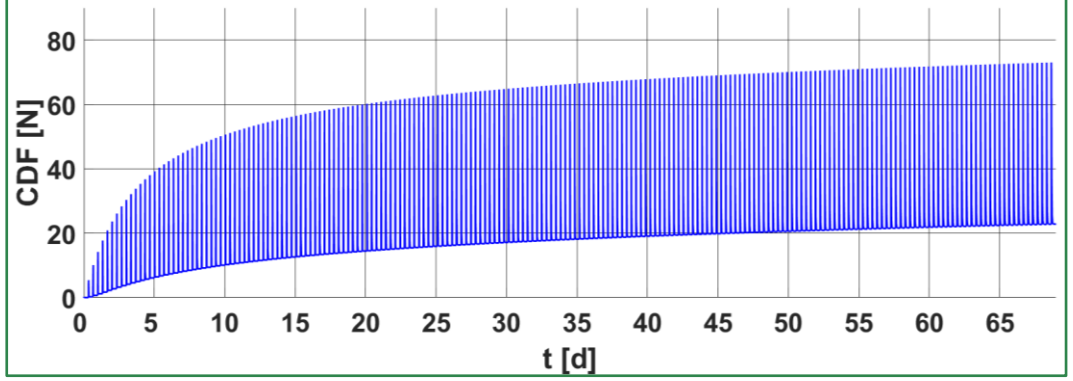


Biomechanical Simulation

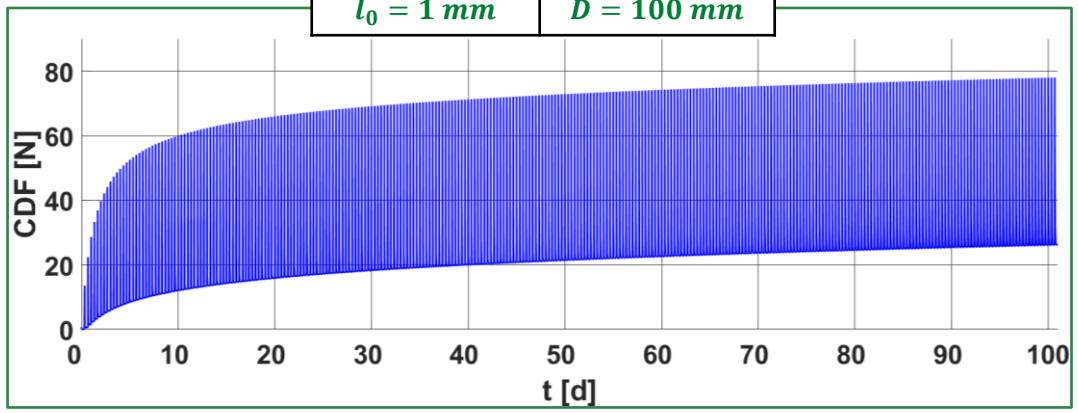
Distraction Forces for longitudinal Distraction Osteogenesis (LDO) in the Tibia

Callus Distraction Force (CDF) in LDO

$l_0 = 3\ mm$	$\Delta l = 0.33\ mm$	$T_s = 8\ h$	$D = 68\ mm$	$A = 878\ mm^2$



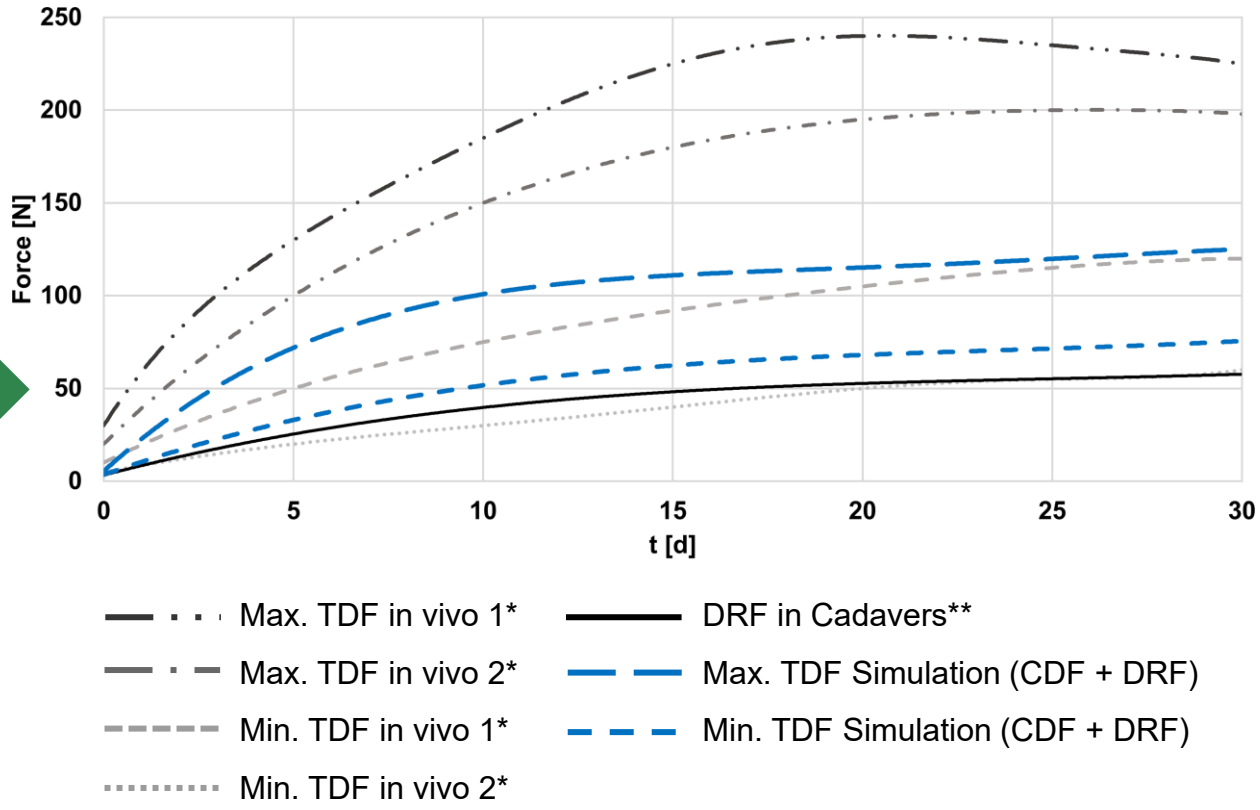
$l_0 = 1\ mm$	$D = 100\ mm$



*R. Baumgart et al. "Zugkraftmessungen beim knöchernen Segmenttransport – in vivo Untersuchungen am Menschen," *Biomed. Tech. Eng.*, vol. 49, no. 9, pp. 248–256, 2008, doi: 10.1515/BMT.2004.047.

Validation of simulated Forces TDF = CDF + DRF

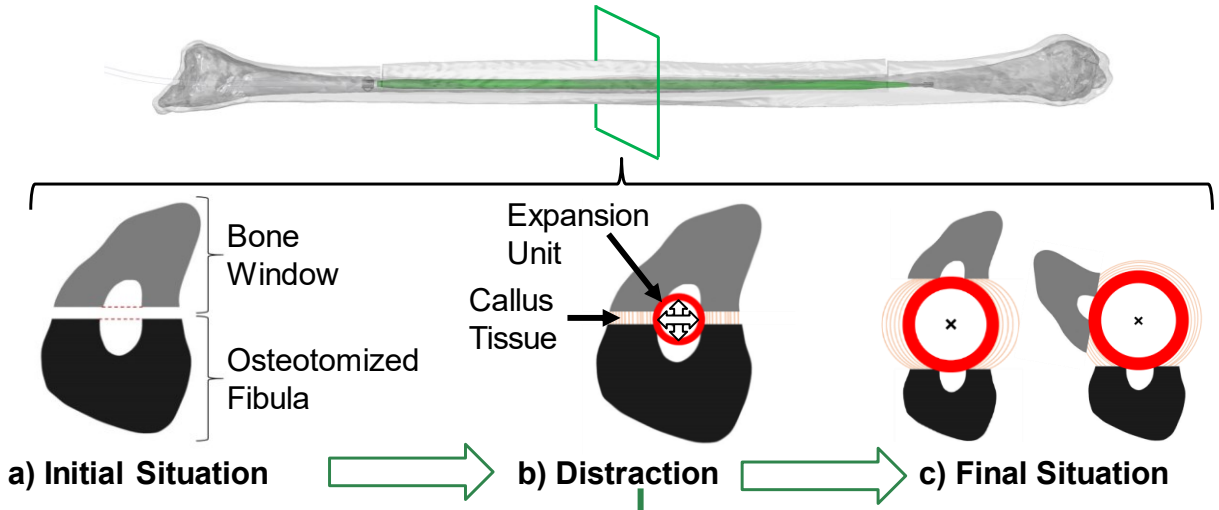
Total Distraction Force (TDF) & Distraction Resisting Force (DRF) in LDO



**K. Horas et al. "The role of soft-tissue traction forces in bone segment transport for callus distraction," Strateg. Trauma Limb Reconstr., vol. 10, no. 1, pp. 21–26, Apr. 2015, doi: 10.1007/s11751-015-0220-8..

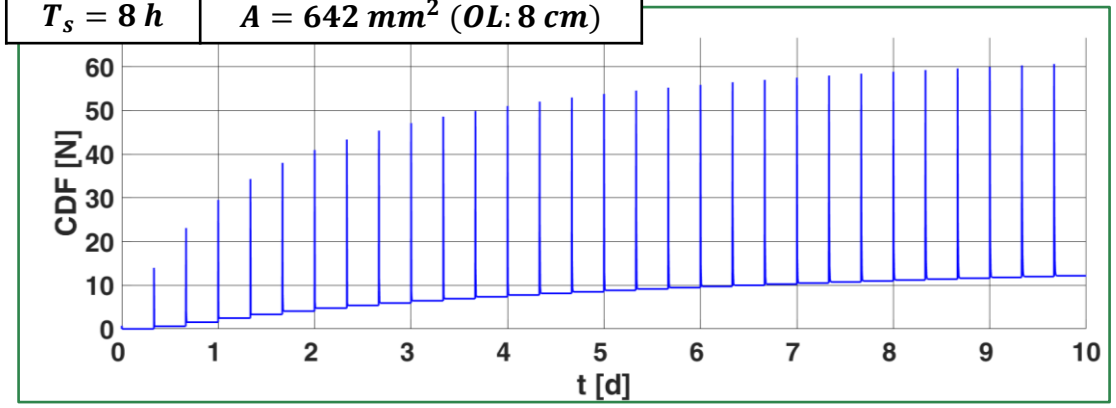
Biomechanical Simulation

Distraction Forces for radial Distraction Osteogenesis (RDO) in the Fibula

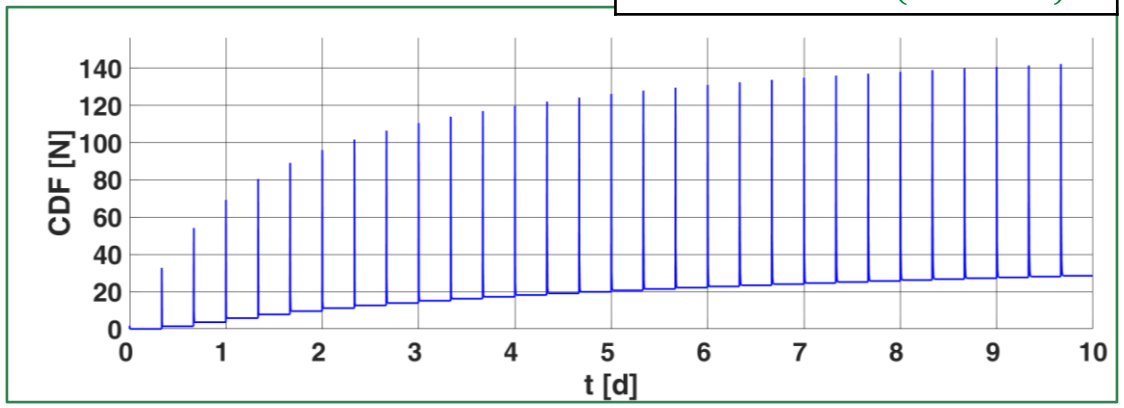


$l_0 = 1\ mm$	$\Delta l = 0.33\ mm$
$T_s = 8\ h$	$A = 642\ mm^2\ (OL: 8\ cm)$

Callus Distraction Force (CDF) in RDO

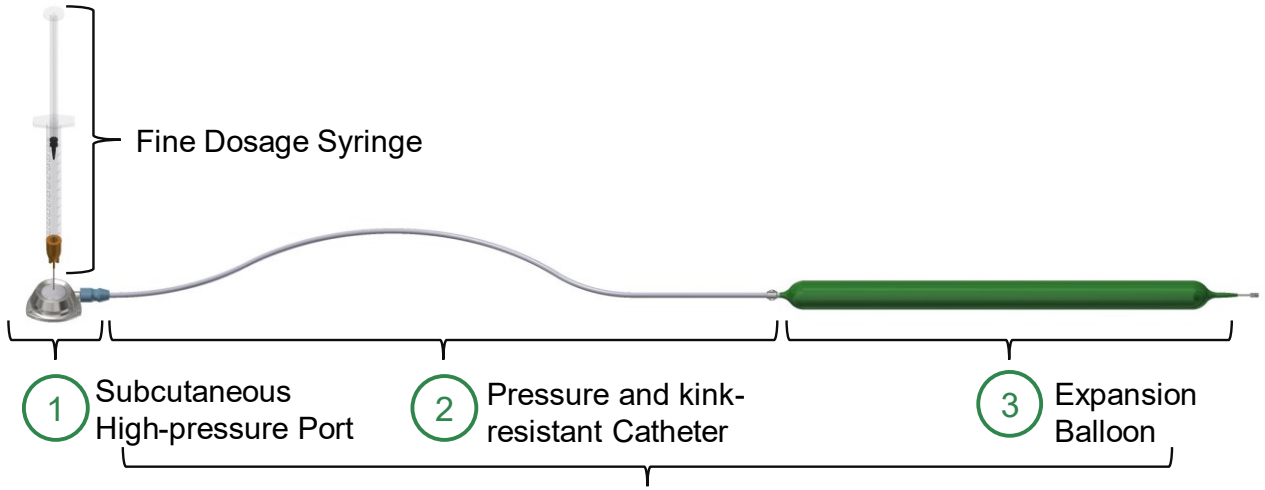


$A = 1506\ mm^2\ (OL: 20\ cm)$

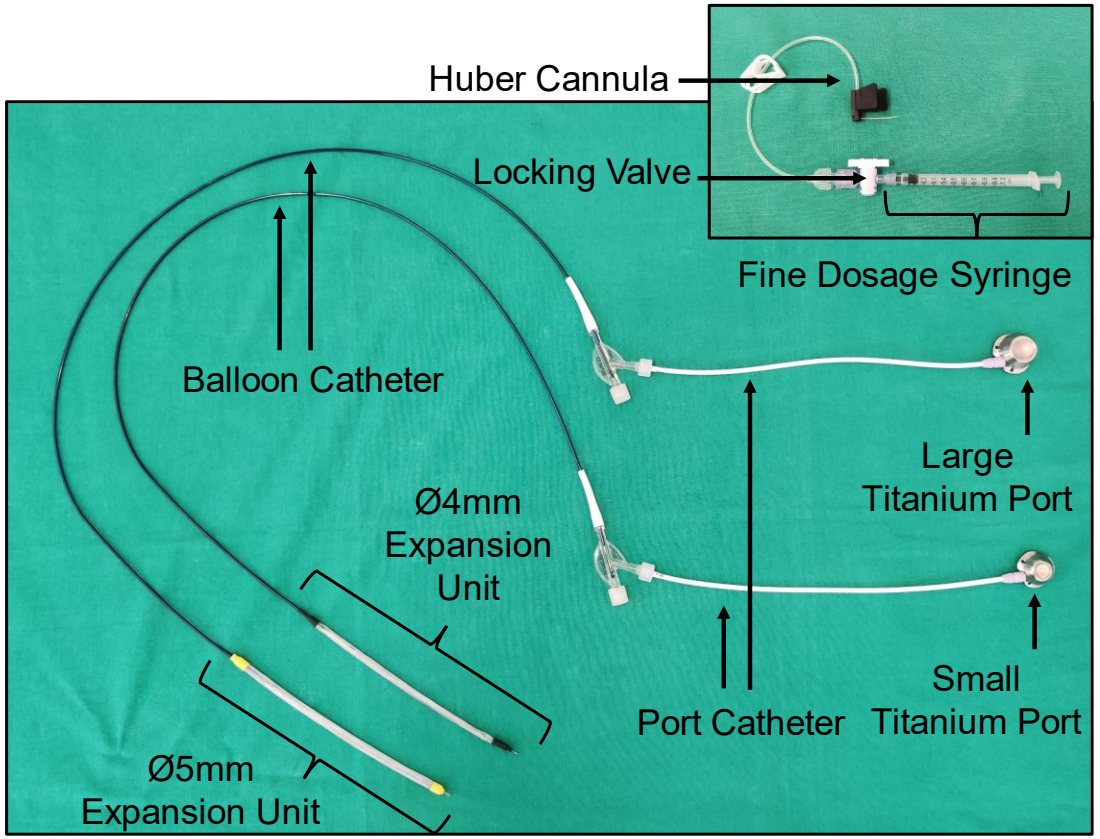


System Design

Expansion System to increase the Diameter of a human Fibula



Concept

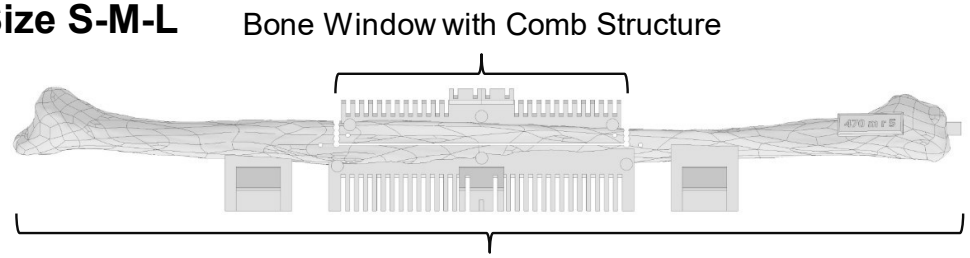


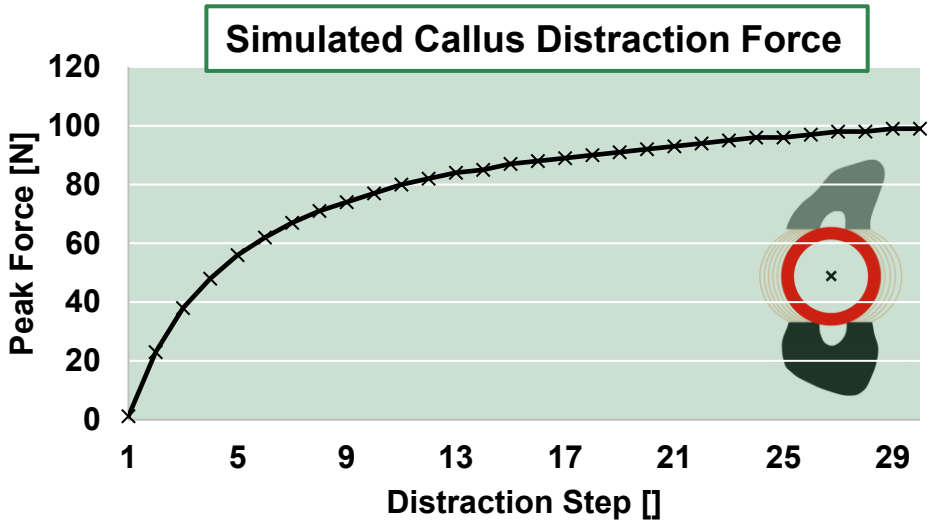
Physical Prototypes

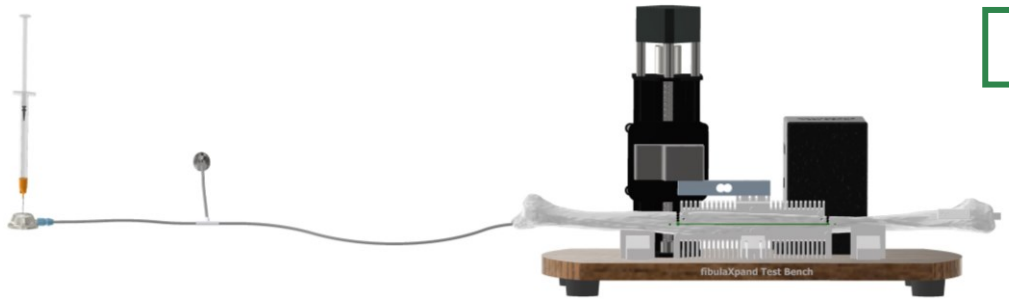
Test Setup and Modeling

Biomechanical Bone Models and physical Test Setup

Size S-M-L







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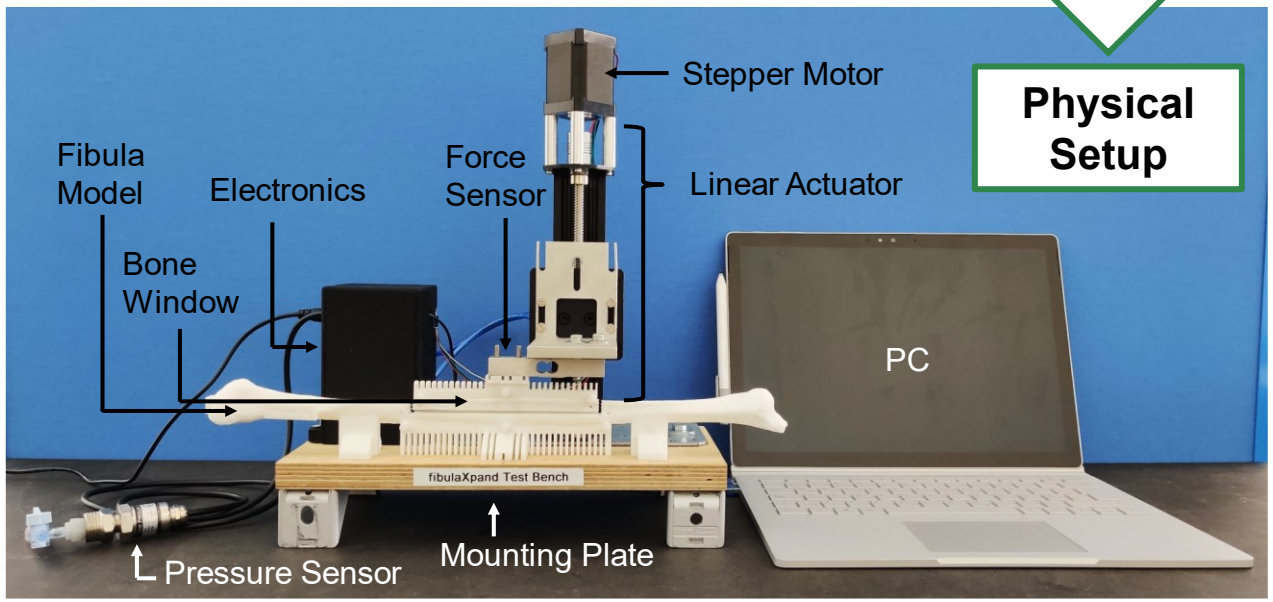
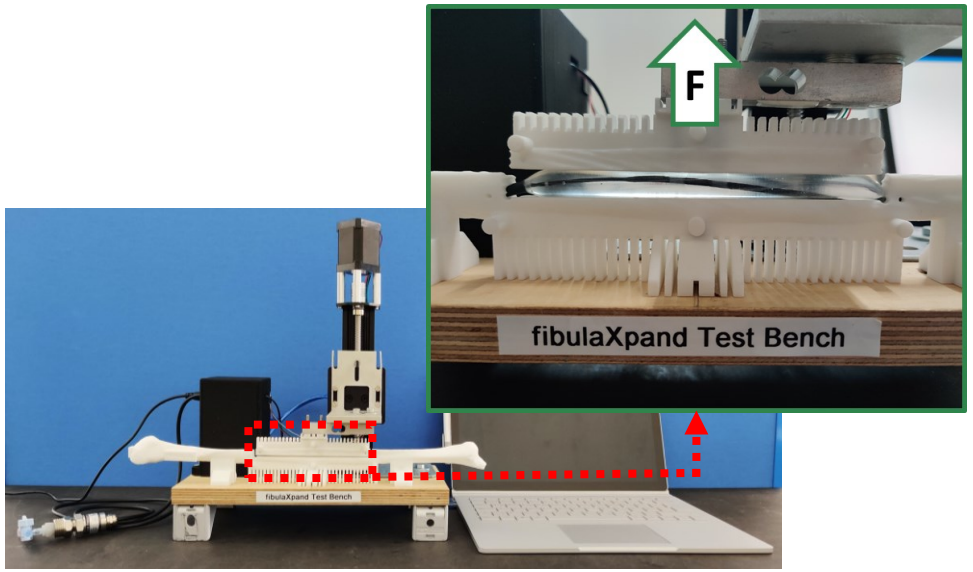
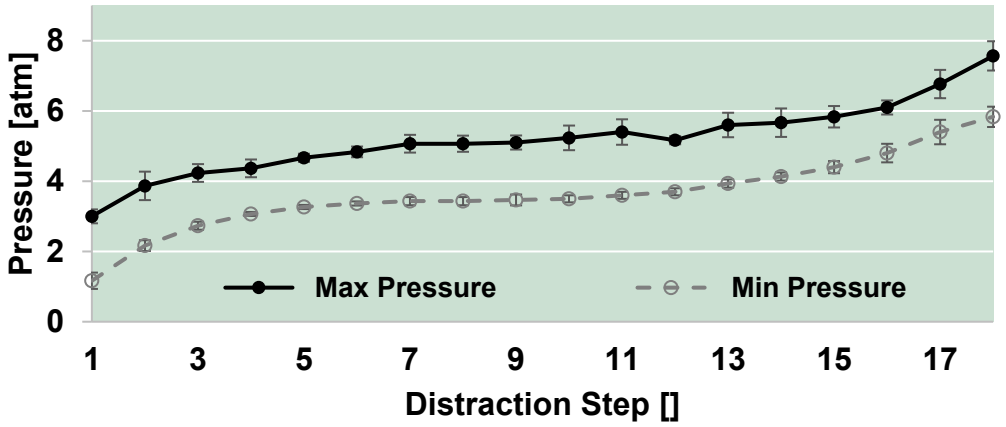


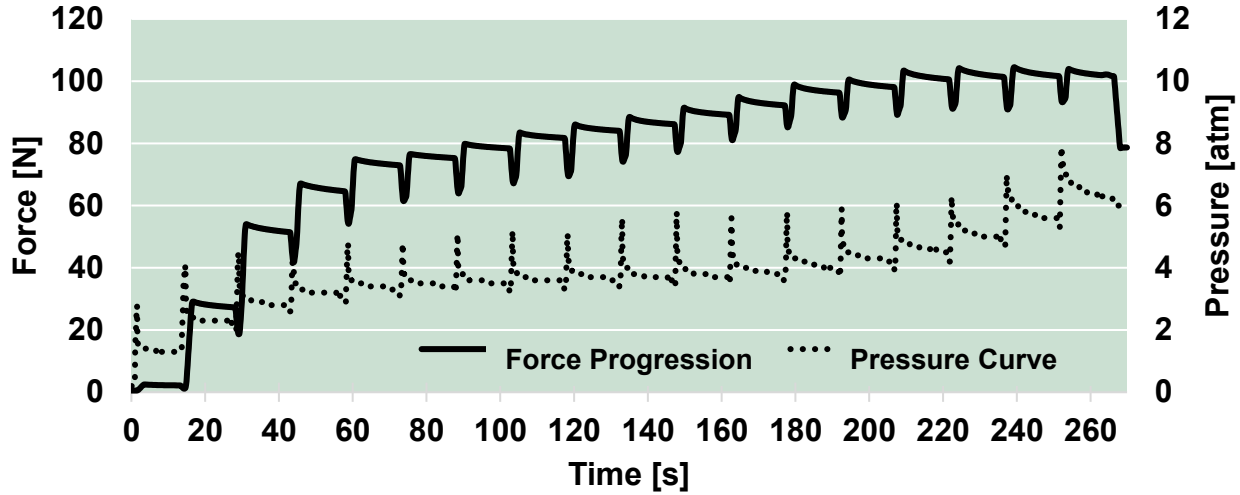
Physical Setup

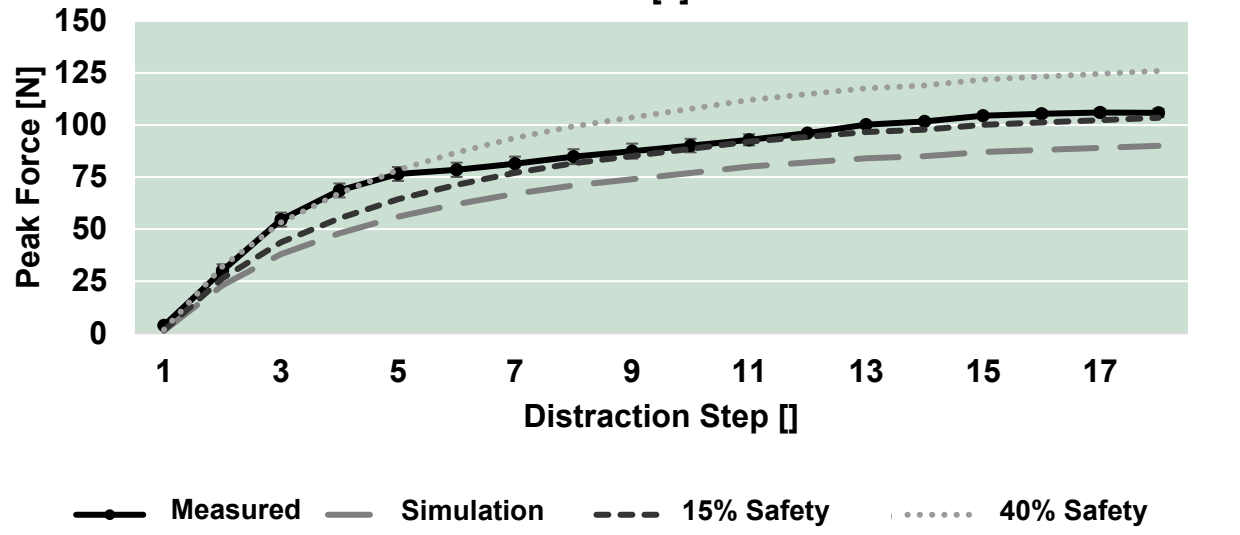
Mechanical Testing

Measurement of Force F and Pressure p during System Expansion



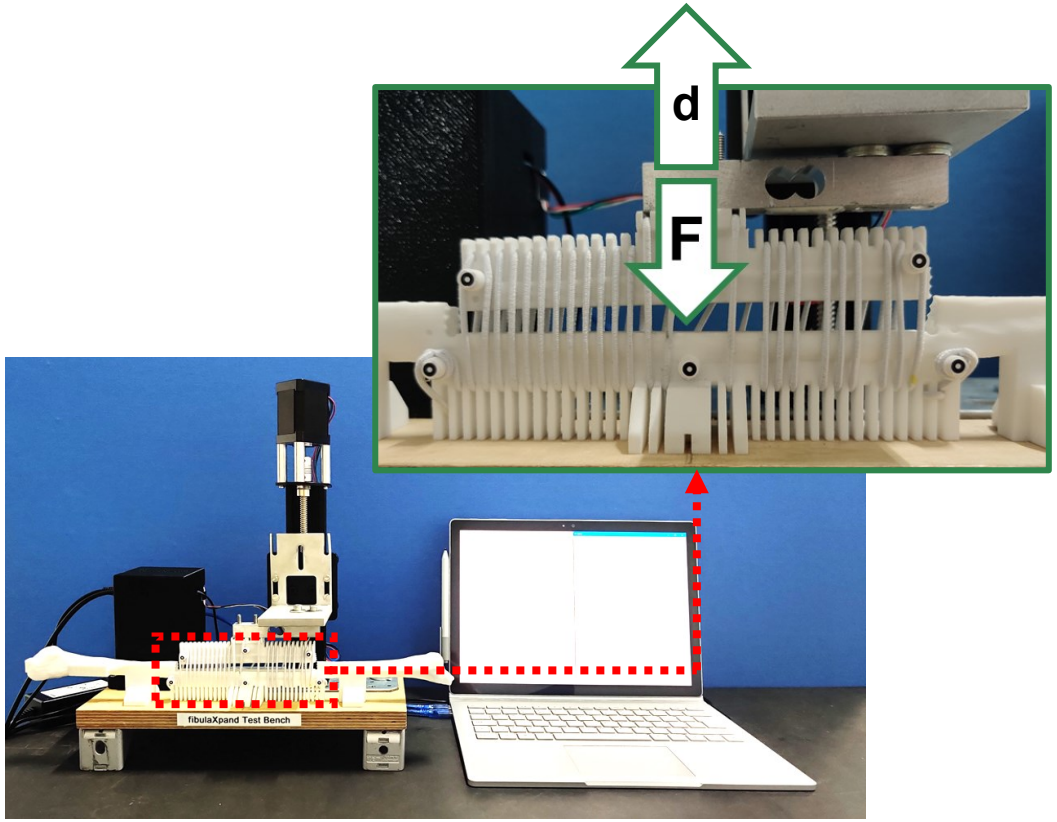


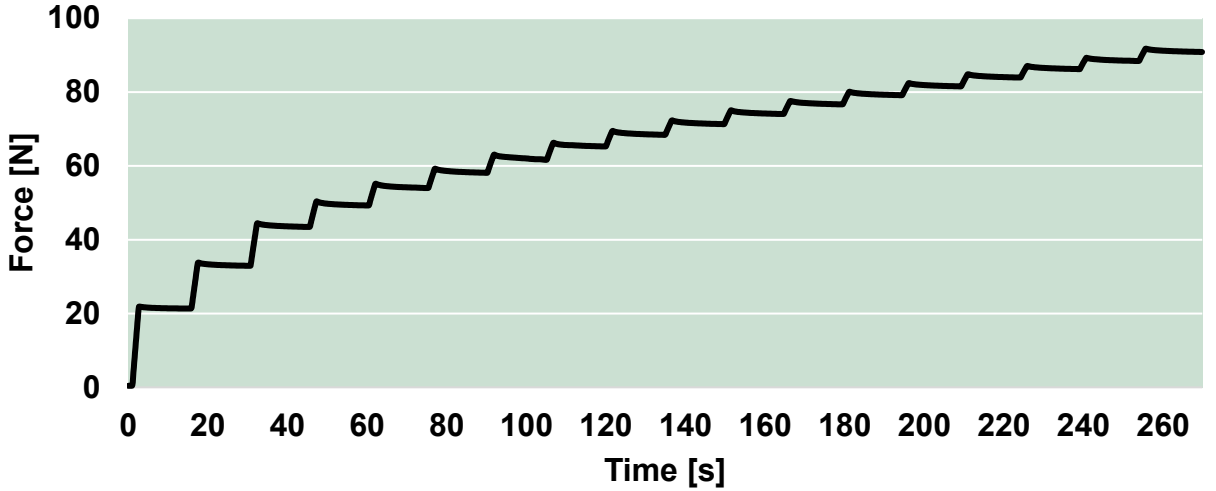


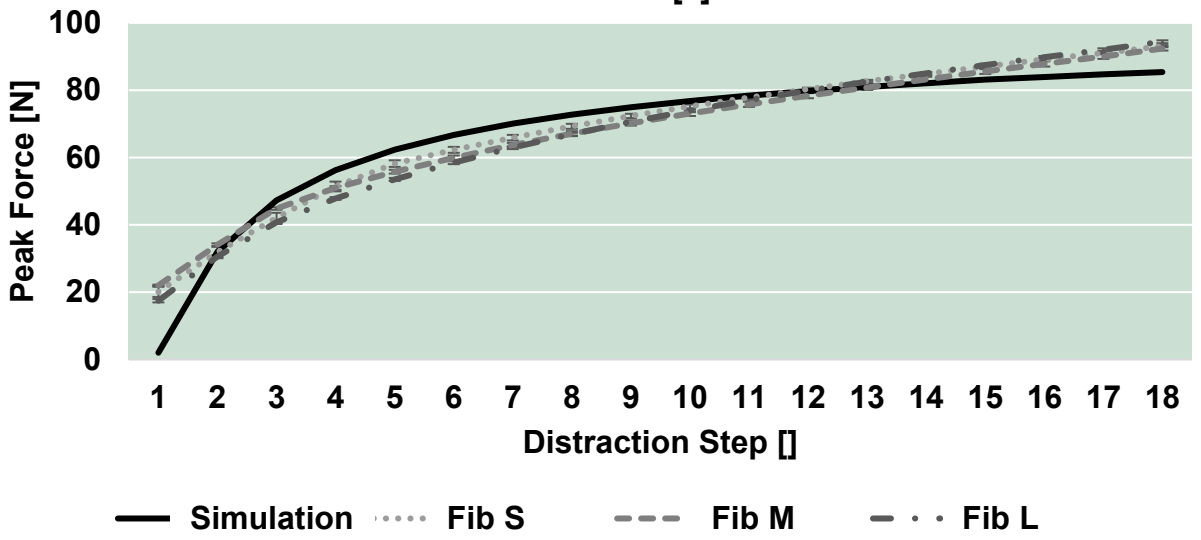


Biomechanical Testing

Measurement of Distraction Force F at Displacement d in a Model with simulated Callus



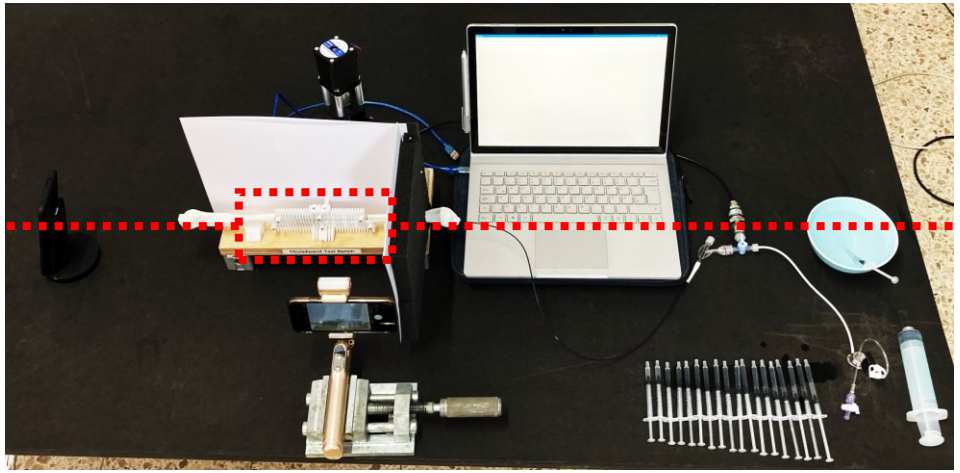




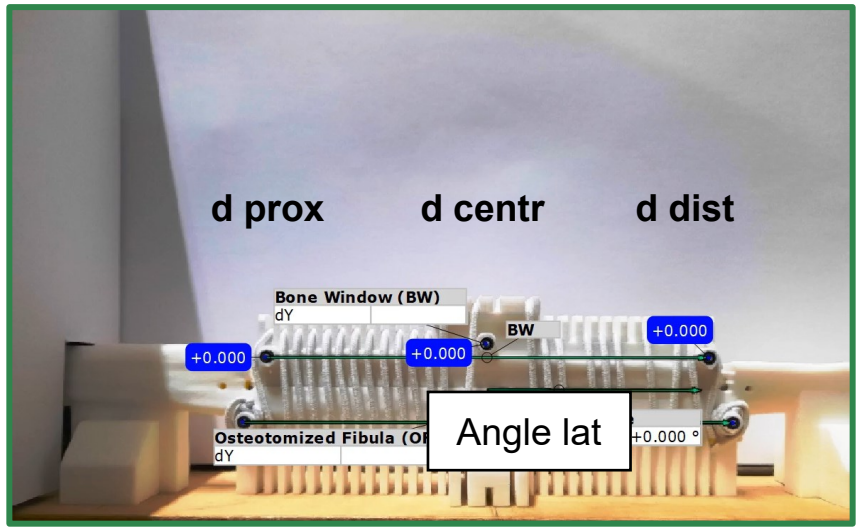
Biomechanical Testing

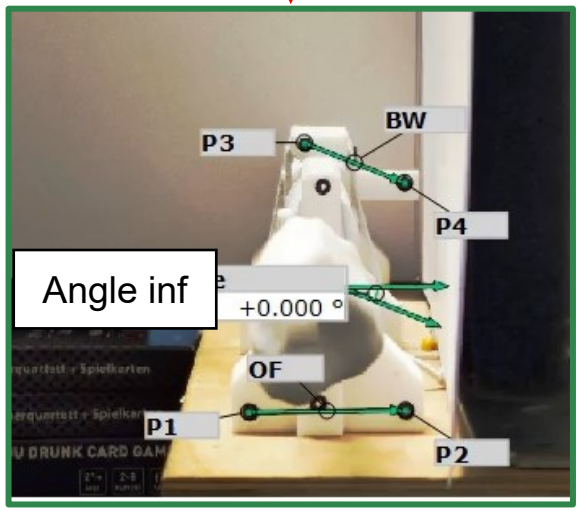
Optical Measurements to determine Displacement d and Tilt Angle lat / inf

Displacement & Tilt *lateral*



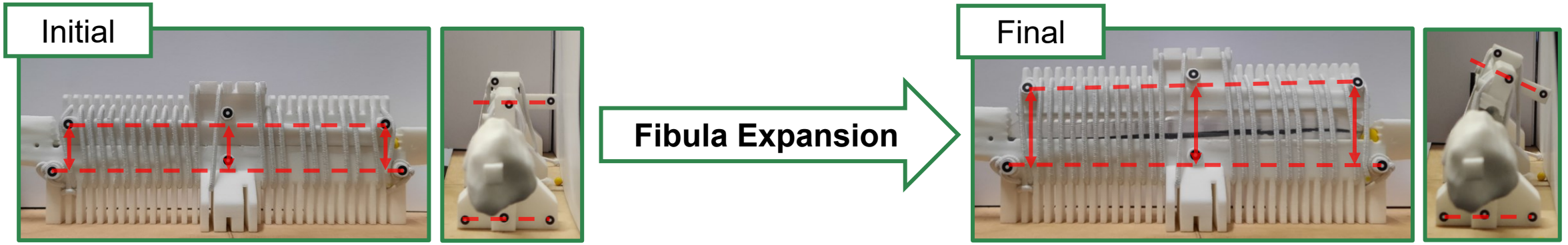
Tilt *inferior*

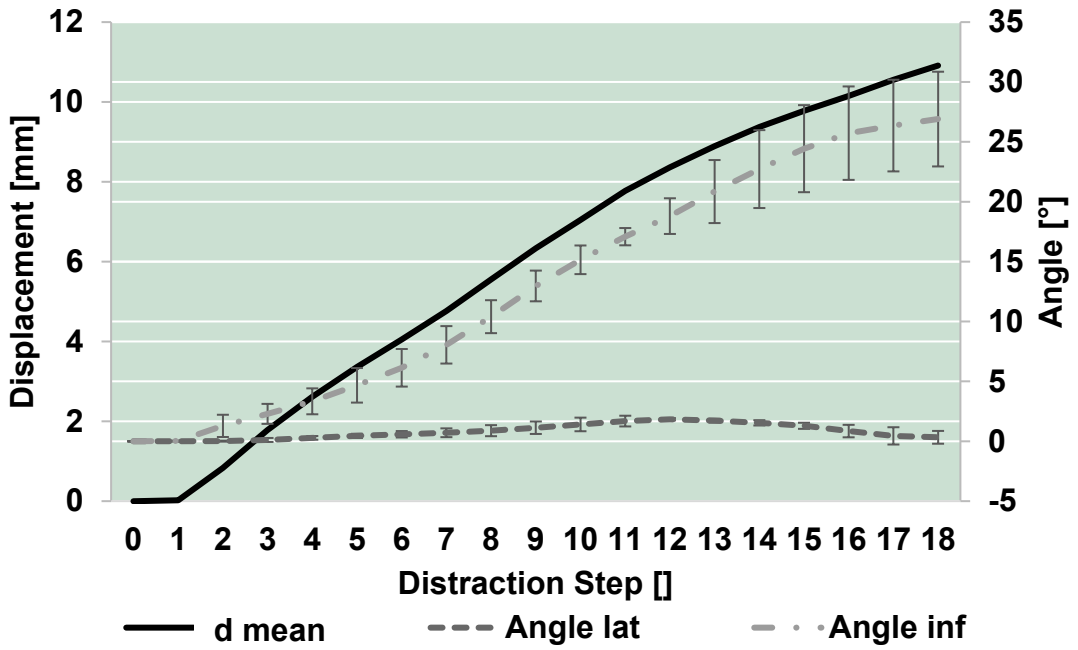


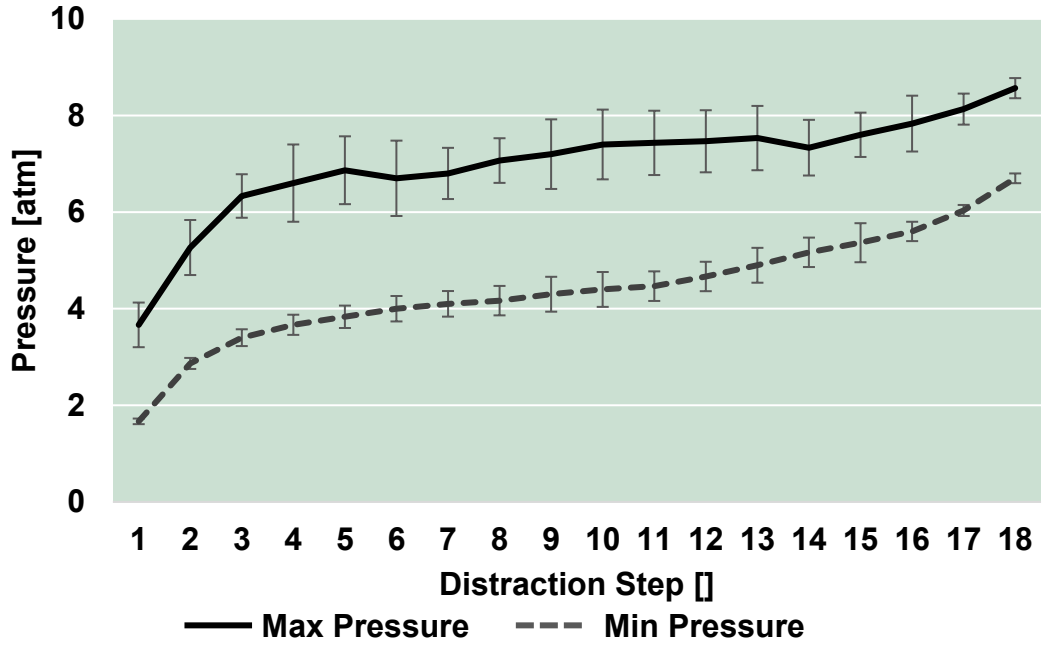


Biomechanical Testing

Optical Measurements to determine Displacement d and Tilt Angle lat / inf



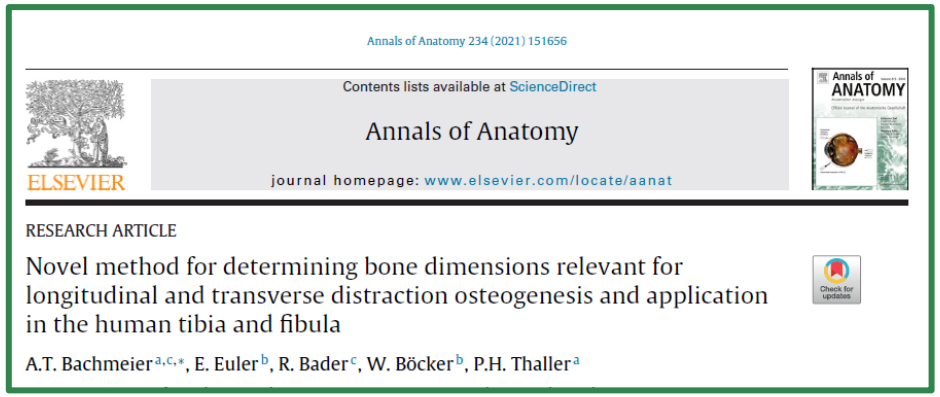




Discussion and Outlook

1)	**Surgical Technique for Fibula Expansion** → Demonstration of Feasibility of Radial Distraction in vivo (animal experiment) necessary
2)	**Morphological Parameters** → Distraction Areas not estimable based on Bone Length
3)	**Model to calculate Distraction Forces** → Model based on Animal Experiment (Transferability limited) → No Validation of the Radial Forces possible
4)	**Prototypes of the Expansion System** → Professional Manufacturing of the Expansion System
5)	**Mechanical Testing** → Long-term measurements with accredited Test Rigs → Check of further Parameters (Tightness, Radial Forces)
6)	**Biomechanical Testing** → Long-term measurements → Extension of Fibula Models with Soft Tissue Simulation

Pub. 1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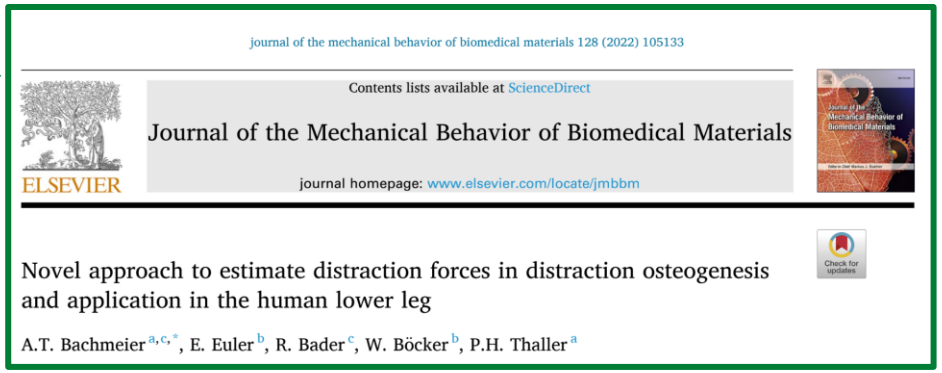
RESEARCH ARTICLE

Novel method for determining bone dimensions relevant for longitudinal and transverse distraction osteogenesis and application in the human tibia and fibula

A.T. Bachmeier[a,c,*], E. Euler[b], R. Bader[c], W. Böcker[b], P.H. Thaller[a]

Pub. 2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Novel approach to estimate distraction forces in distraction osteogenesis and application in the human lower leg

A.T. Bachmeier[a,c,*], E. Euler[b], R. Bader[c], W. Böcker[b], P.H. Thaller[a]

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Gemeinsam. Fürsorglich. Wegweisend.

Thank you for your Attention!

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