UNIVERSITÄT LEIPZIG
Medizinische Fakultät

ZESBO
Zentrum zur Erforschung der Stütz- und Bewegungsorgane

titv

Fraunhofer IWU

Universitätsklinikum Leipzig
Anstalt öffentlichen Rechts

HELIOS Klinik Blankenhain

3D printing in orthopedics and neurosurgery

R Grunert[1,2] , C Rotsch[1], M Mueller[1], M Schmidt [2] , R Moebius[2], T Toeppel [1], T Prietzel[3] , D Winkler[2]

[1] Fraunhofer IWU Dresden, Germany
[2] University of Leipzig, Germany
[3] Helios Hospital Blankenhain, Germany

UNIVERSITÄT LEIPZIG
Medizinische Fakultät

ZESBO
Zentrum zur Erforschung der Stütz- und Bewegungsorgane

titv

Fraunhofer IWU

FTZ

Universitätsklinikum Leipzig
Anstalt öffentlichen Rechts

HELIOS Klinik Blankenhain

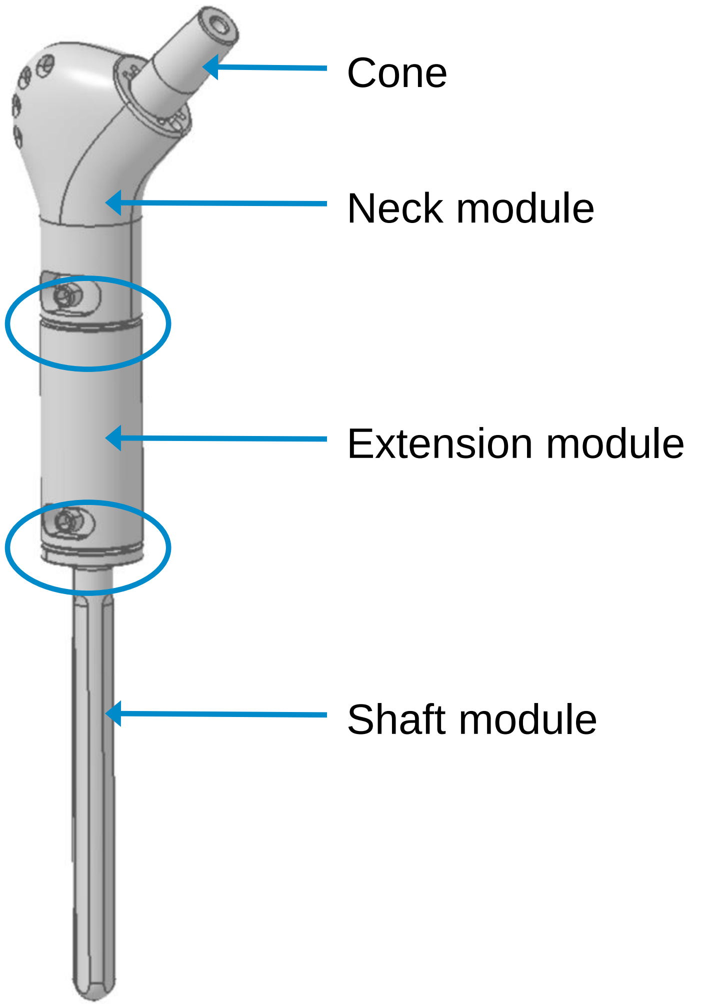
Modular femur replacement for tumor orthopedics

Motivation

- All examinations and optimizations were based on a current modular tumor endoprosthesis (MML system, ESKA)

Disadvantages:

- High dead weight
- Refixation of detached muscle groups is only possible to a limited extent
- Difficulties by separating the individual modular components, because of fixation by conical clamping



Weight reduction

- Topology optimization (neck module)
- Simulated load (1200 N)

  → illustrating dominant load paths
- Goal: Reduction of the implant weight

Topology optimisation by Fraunhofer IWU

Result

Weight reduction

- Based on the topology optimization a total of 3 versions of the new neck module were created
- Weight reduction

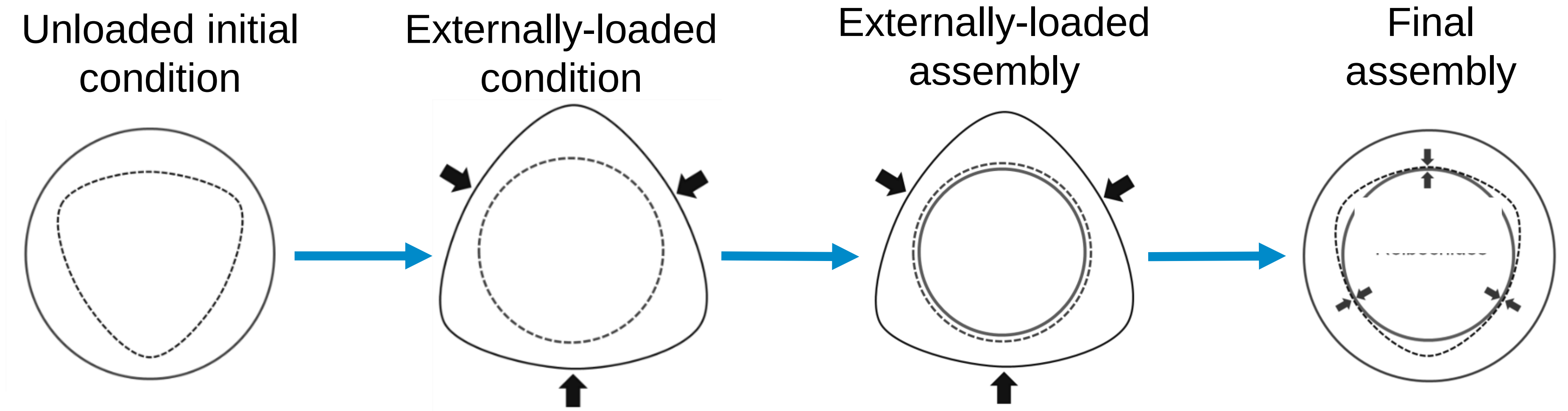
Version 1

Version 2

Version 3

Interface

- Polygon interface
- Based on the polygon clamping principle
- By external load application, a minimal elastic deformation is caused by a few hundredths of a millimeter

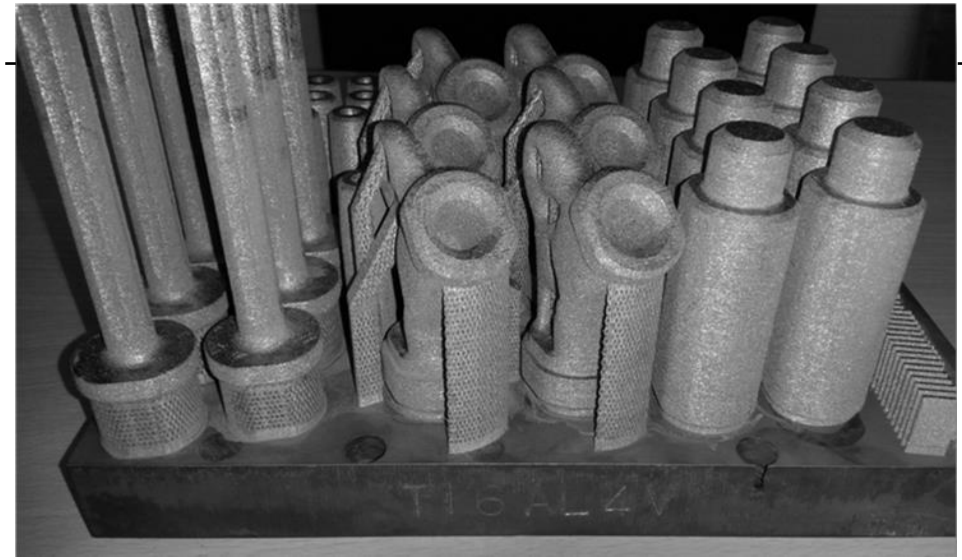


Generative production

- Production of individual components by means of laser beam melting
- Material: titanium alloy grade 5 (TiAl6V4)
- Subsequent heat treatment against susceptibility to cracking

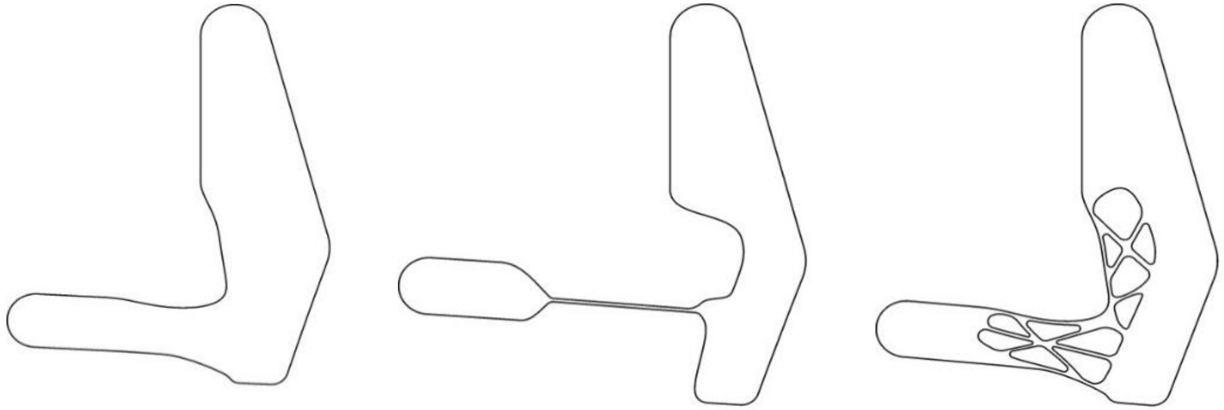
Result

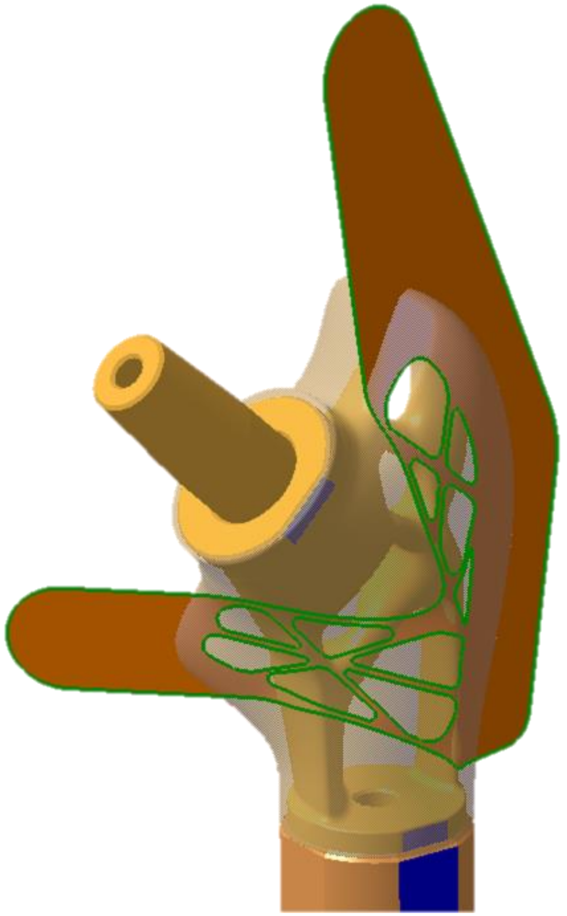
- Individual endoprosthesis parts for post processing



Textile attachment points

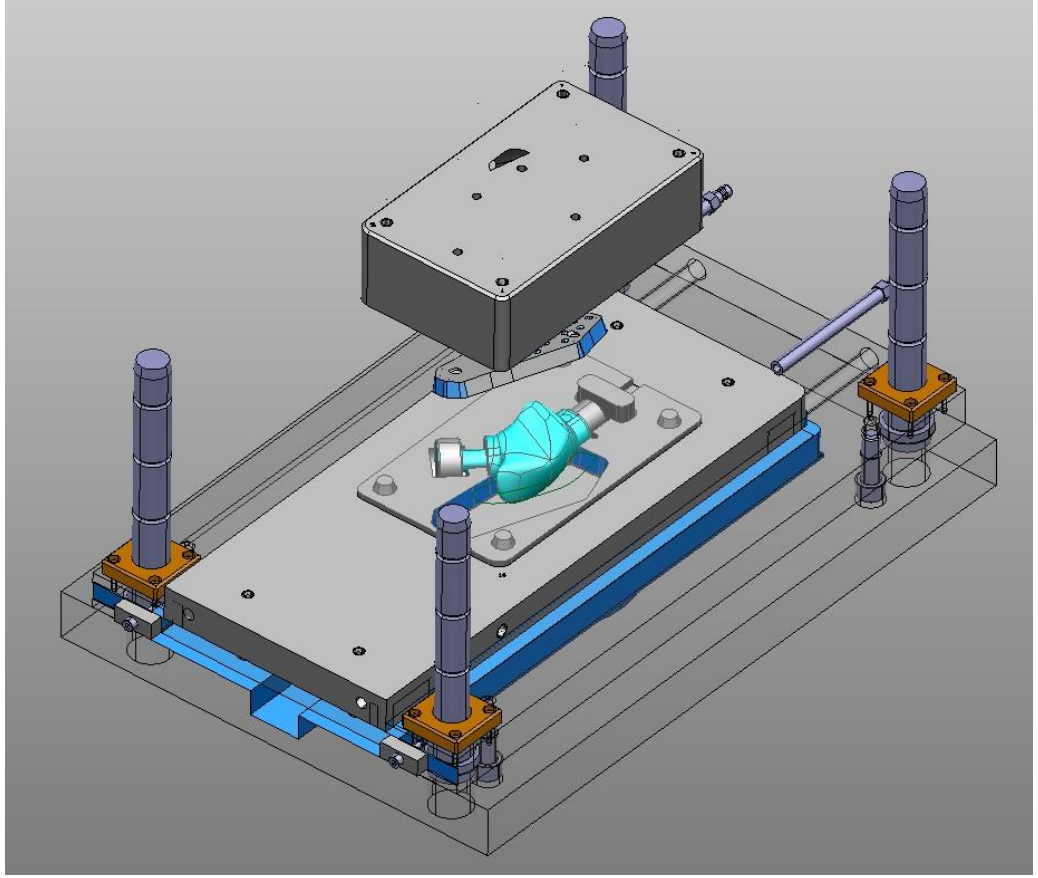
- Integration of two-dimensional textile structure for refixation of detached muscle groups
  → restoration of the function
- 3 textile variants were developed and implemented constructively
- Fixation by overmolding of the metal core and the textile with polyethylene

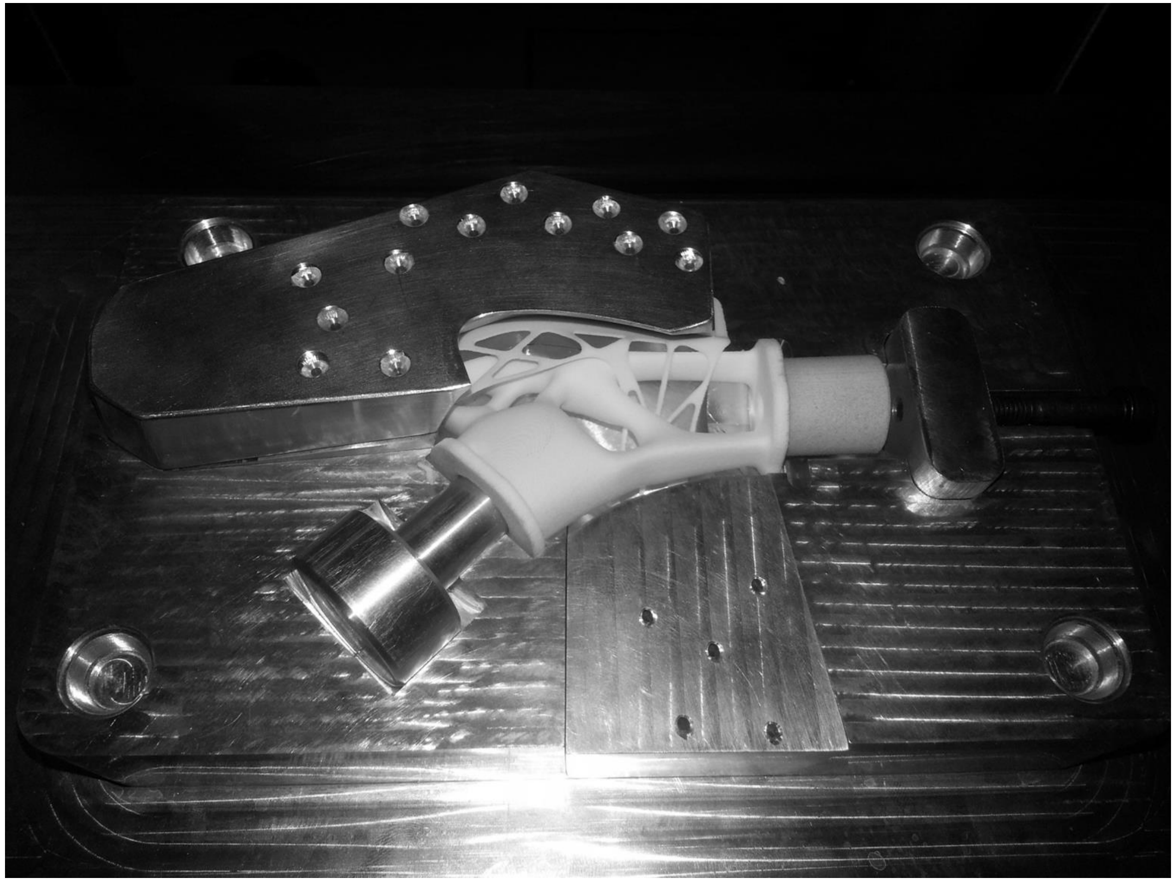




Fixing of the connection points

- By means of an injection molding tool
- Fixation of the textile to the neck module



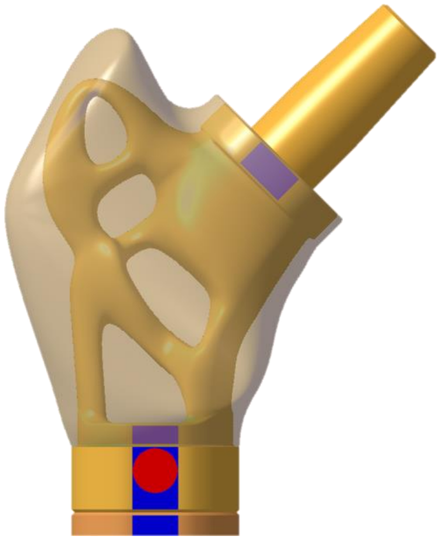
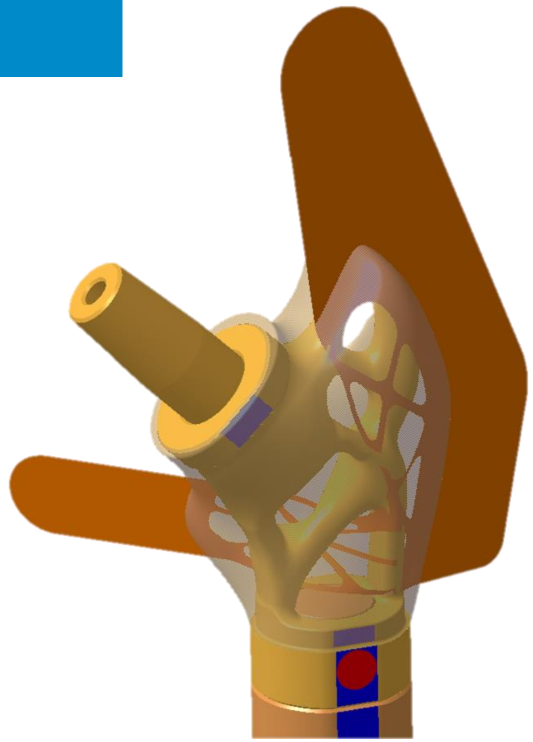


Result

Final prototype

- Weight-reduced endoprosthesis (743g → 397 g)
- Integrated connection points for refixation of detached muscle groups
- Modular design
- Coupling of the modules via novel interface



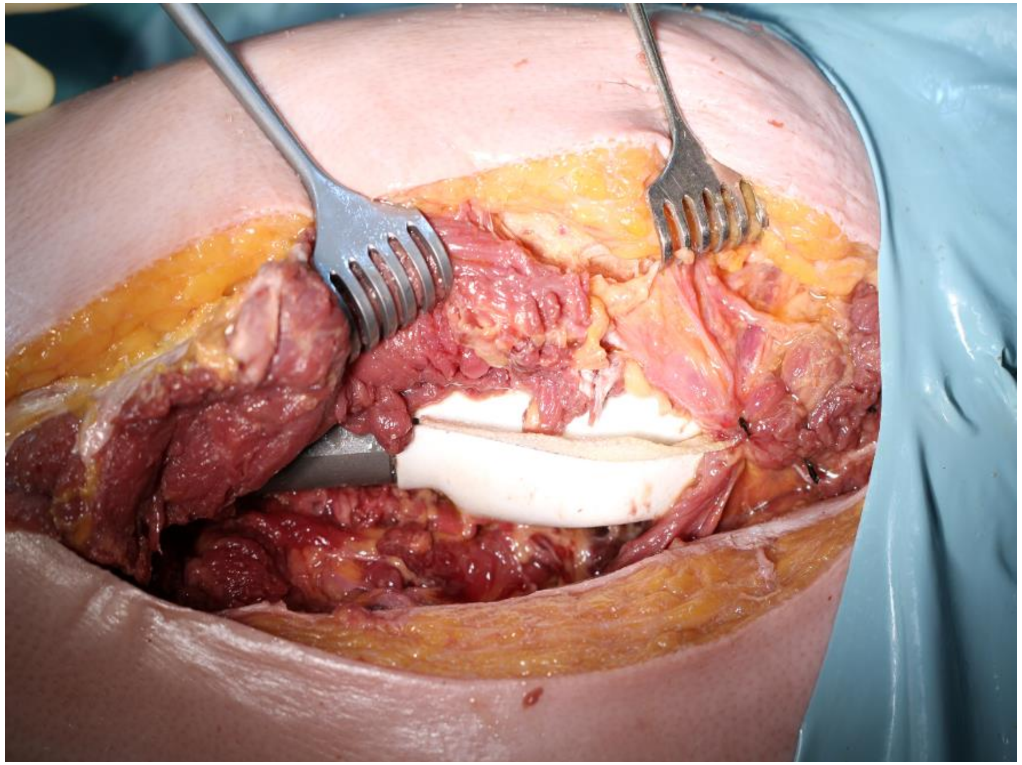
Final testing

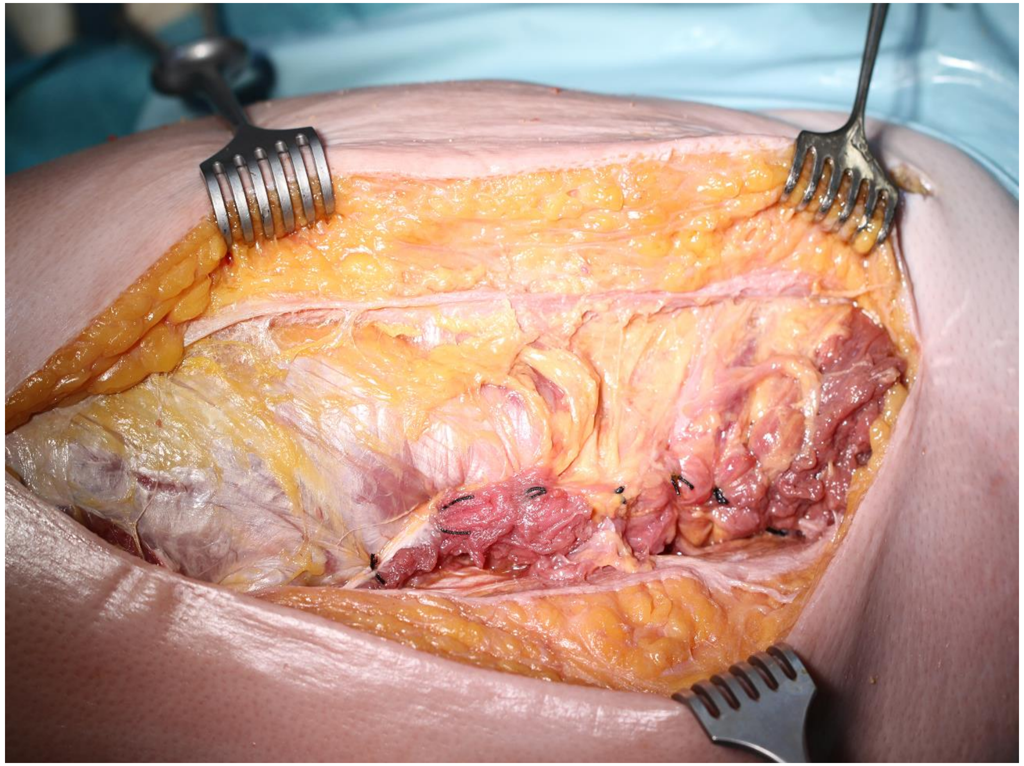
- 6 prototypes have been tested
- In the context of dynamic stress tests, the lightweight construction geometry was tested
- Test according to ISO 7206-4 (test of the shaft area)
- Test according to ISO 7206-6 (test of the neck area)
- All tests were completed successfully!




Final testing

- Body donor tests (in cooperation with the Institute of Anatomy)
- Lateral approach to the hip joint (modified according to Bauer)
- Implantation by use of bone cement (PMMA)
- Successful refixation of the muscles at the created attachment points





UNIVERSITÄT LEIPZIG
Medizinische Fakultät

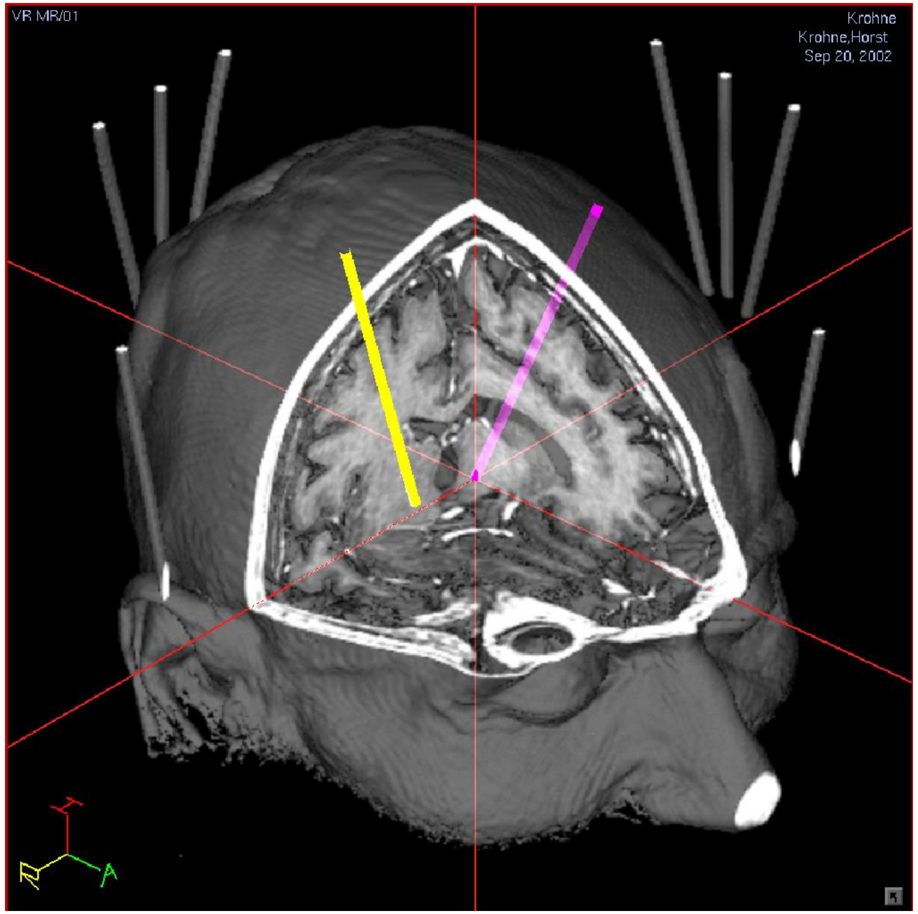
ZESBO
Zentrum zur Erforschung der Stütz- und Bewegungsorgane

Fraunhofer IWU

Universitätsklinikum Leipzig
Anstalt öffentlichen Rechts

High precision patient-individual brain biopsy

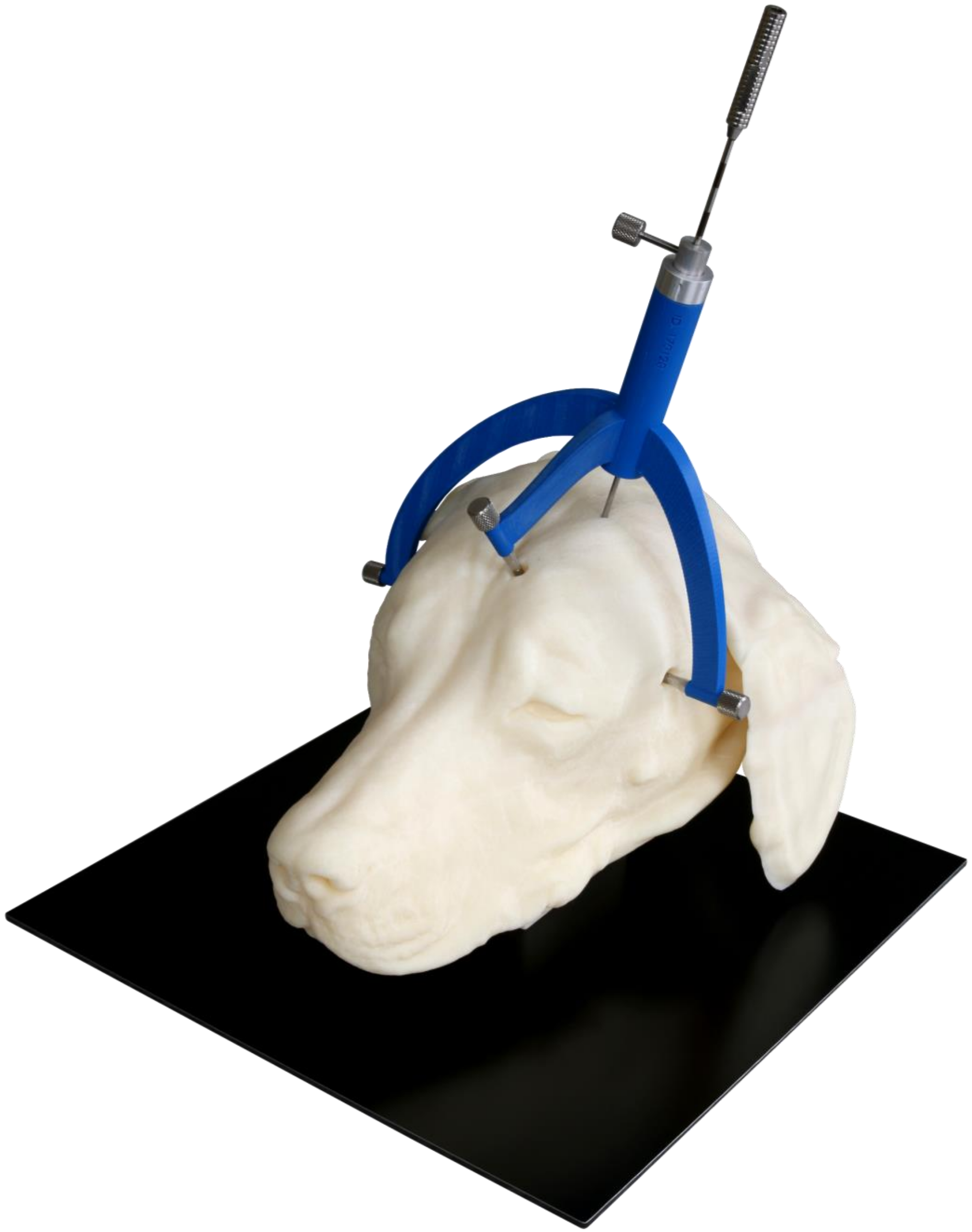
Stereotaxy



Problems in stereotactic surgery

- Traumatic and time-consuming
- Complex application
- Limited to high-specialized neurosurgical centers
- Difficult for beginners
- Complex sterilization and storage

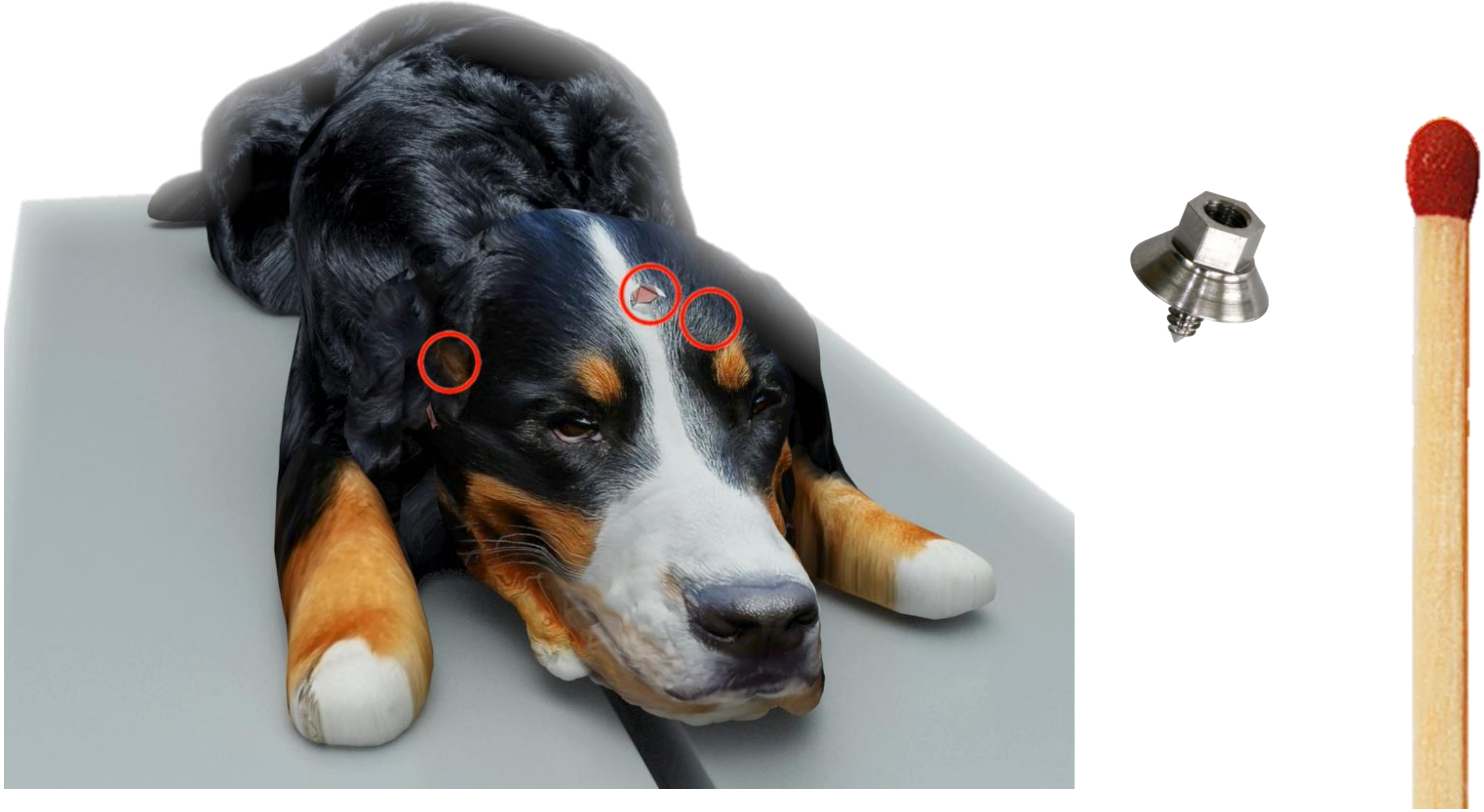
New approach



Video

Fraunhofer
IWU
Universitätsklinikum
Leipzig
Anstalt öffentlichen Rechts
High-precision instrument
for
brain biopsy
NEUROTEC
plavis

Placement of bone screws

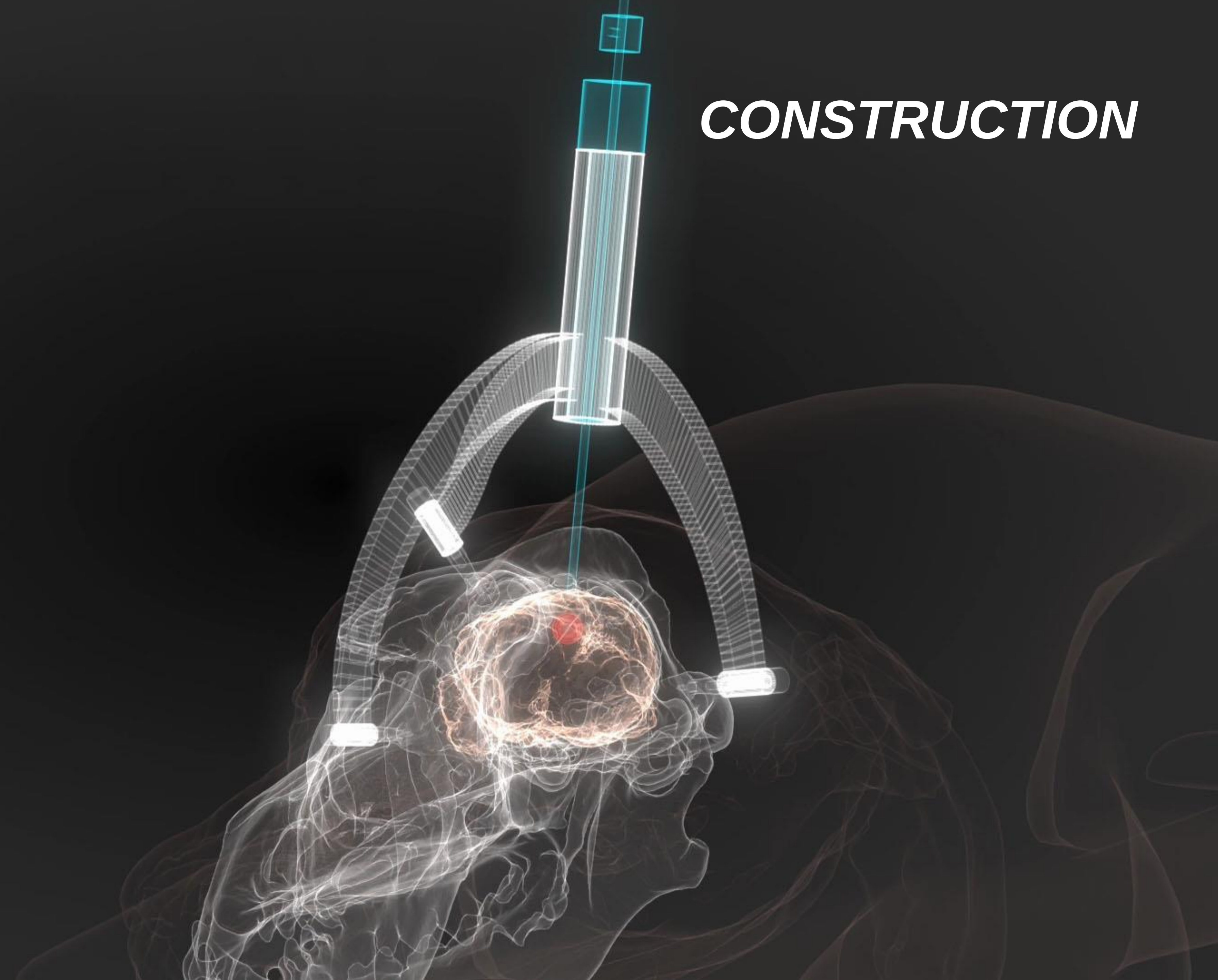


Placement of MRI markers

Image acquisition with MRI

NEUROTEC

CONSTRUCTION



3D Printing

Surgery

Diagnostic

Accuracy in comparison to the state of the art

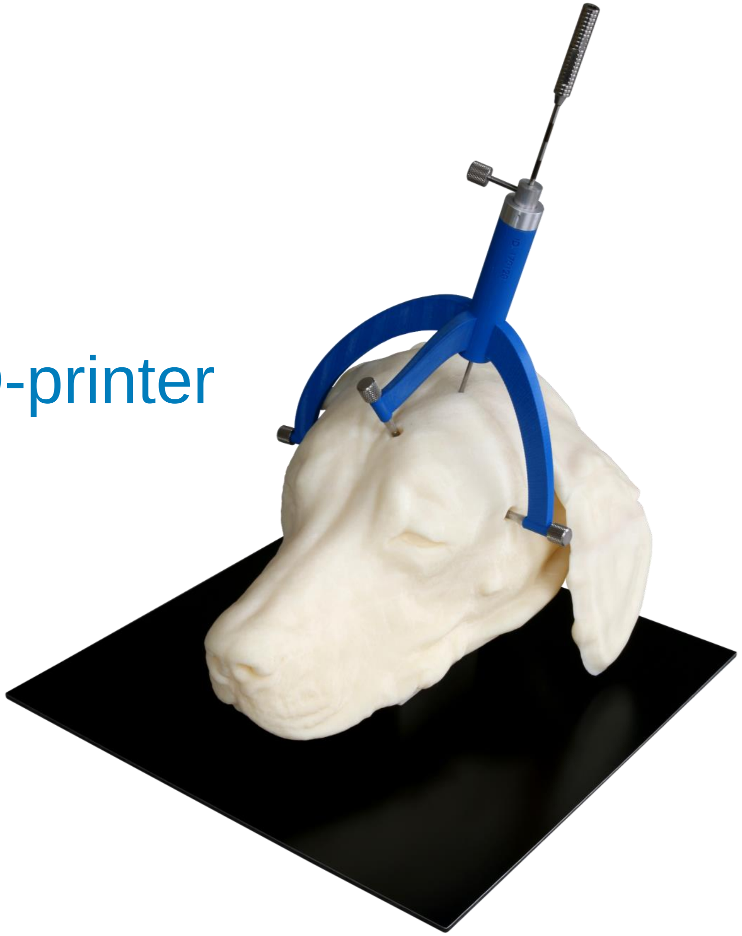
System	***Typ***	***RMS***	***Sample size***
OAS, Radionics	*Mechanic arm*	*2,9 mm ± 1,1 mm*	*n = 22*
SPOCS, Aesculap	*Infrared*	*2,9 mm ± 1,2 mm*	*n = 16*
OTS Radionics	*Infrared*	*3,2 mm ± 1,2 mm*	*n = 10*
MKM, Zeiss	*Microscope*	*2,1 mm ± 0,8 mm*	*n = 101*
Integrierter Z-Rahmen	*Frame*	*2,4 mm*	*n = 3*
Brainsight Frameless Stereotactic System	*Frame*	*4,6 mm ± 1,5 mm*	*n = 4*
microTargeting™ Platform, FHC	*3D- print frame*	*2,8 mm*	*n = 20*
Renaissance Guidance System, Mazor Robotics	*Robot*	*1,5 mm*	*-*
NeuroTec System	*3D- Print frame*	*0,45 mm ± 0,3 mm*	*n = 20*

→ 3 x accurate than robots

Transfer to human medicine

Advantages

- Most accurate and gentle brain biopsy
  (0,64 ± 0,42) mm, Max.=2,00mm, Min.=0,09mm
- MRI or CT based planning
- Patient-individual planning and production with 3D-printer
- No intraoperative image acquisition
- Triple precision and 1/50 of the costs
  than robots



UNIVERSITÄT LEIPZIG
Medizinische Fakultät

ZESBO
Zentrum zur Erforschung der Stütz- und Bewegungsorgane

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

ANATOMY OTAGO
www.anatomy-biomechanics.com

Fraunhofer
IWU

Universitätsklinikum Leipzig
Anstalt öffentlichen Rechts