

Context

Contoured spiral plates are a type of implant used to treat proximal and shaft humerus fractures. They aim to:

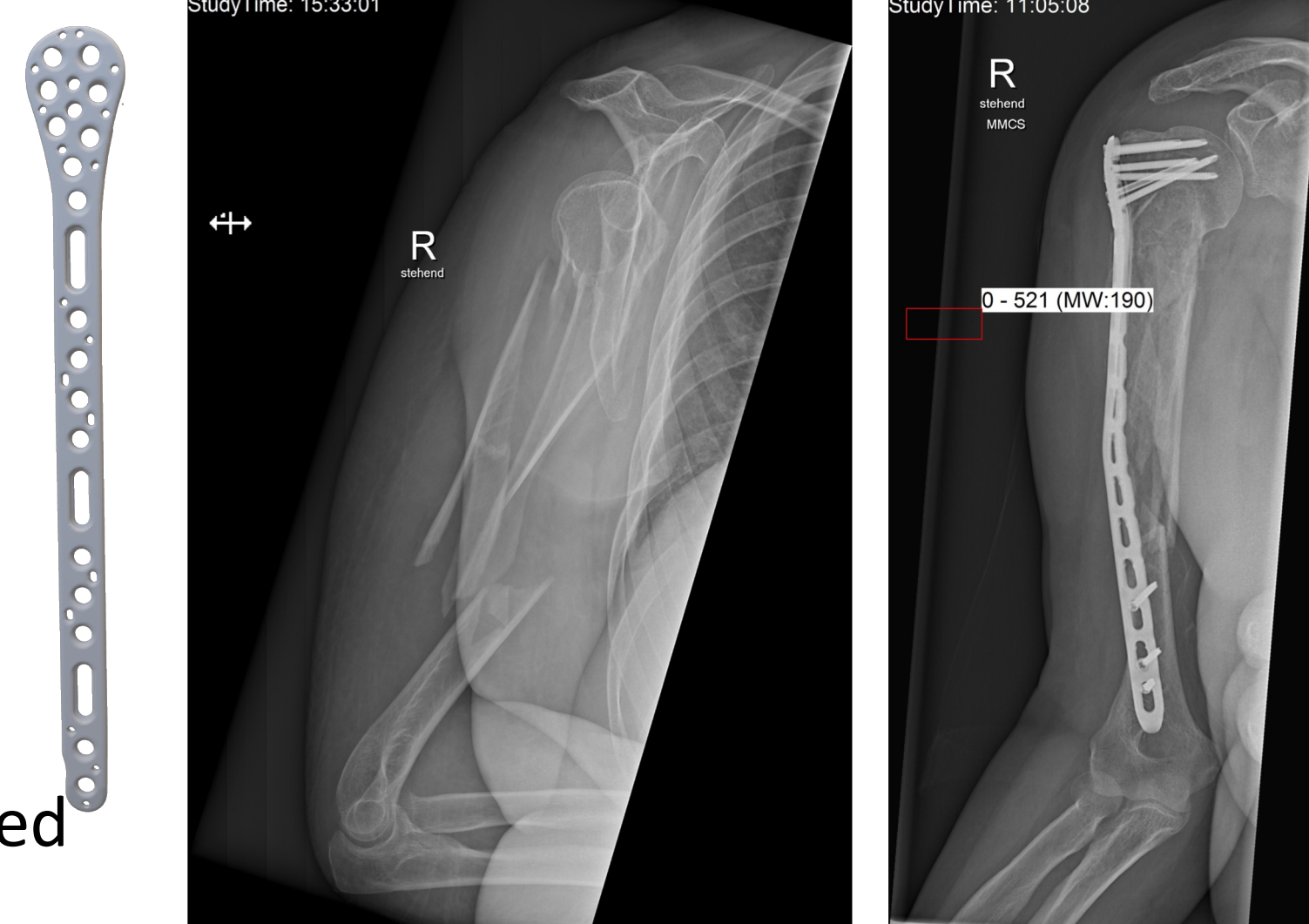
- Maintain pieces of bone together
- Achieve a small plate-to-bone distance, which is important for healing

During surgery the surgeon bends the plate to make it fit to the bone. This process is:

- Imprecise
- Time consuming
- Fragilizes the plates

Objective

- Personalized plate shapes
- Improved fit over bent plates
- Set of shapes – to be pre-printed



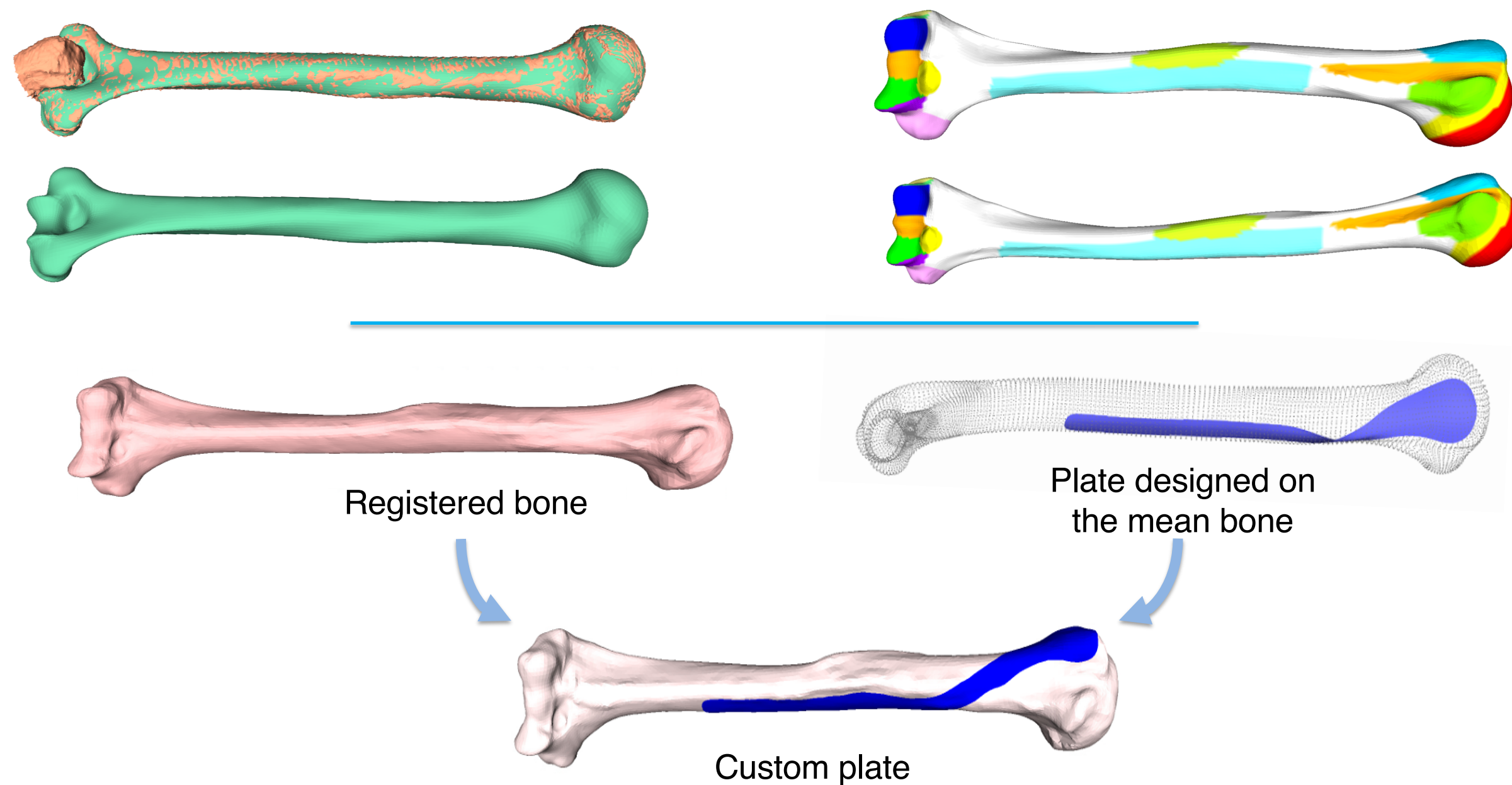
Custom Plate

Optimal plate defined by the surgeon

Given a bone, how to generate it?

Register a humerus template to each bone of our dataset

- Anatomic regions should be preserved (smooth shells [1])
- Build a statistical shape model of the bone using PCA



- From the registration, we can **get a plate shape for any bone**
- From 96 bones we extract **96 plates**

Generate a Plate Set

3D printing a personalized plate is long

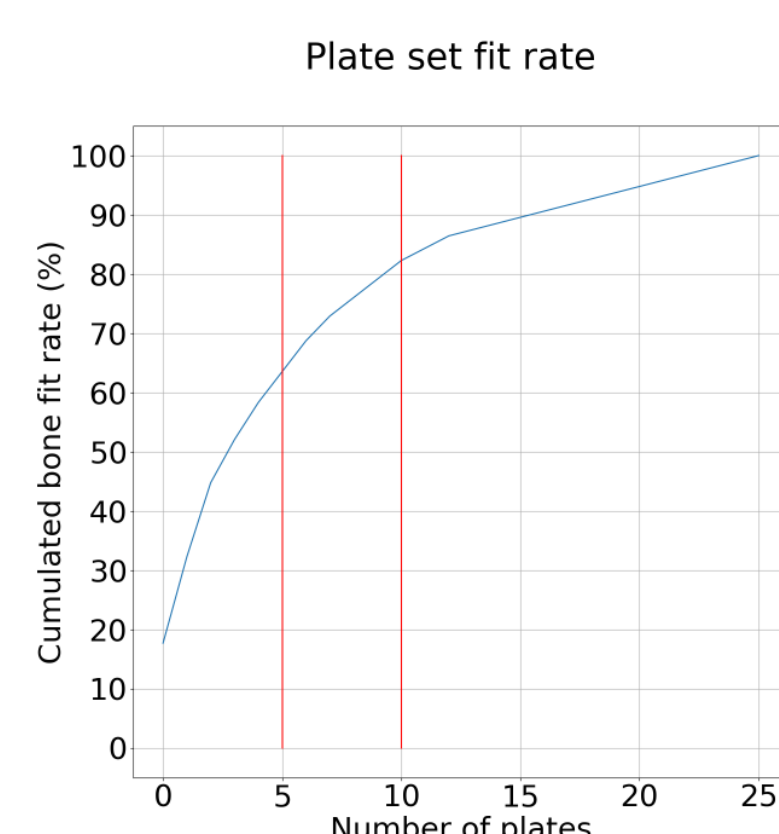
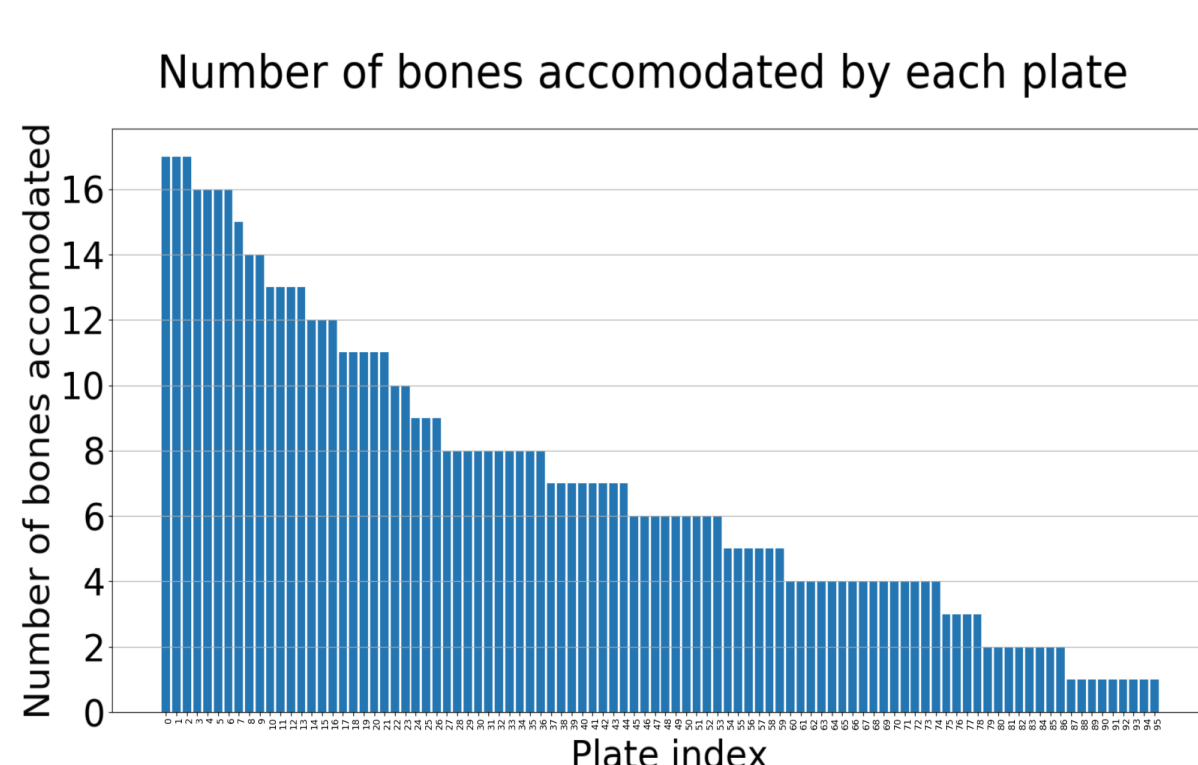
- Set of plates to choose from
- Readily available

Can one plate fit several bones?

We define a **fit criteria** for a plate on a bone.

We **position each plate** on a bone by minimizing a cost function to:

- Bring the plate close to the custom plate position
- Meet the fit criteria
- ✓ Most plates accommodate several bones.
- ✓ We order them to maximize population accommodation.
- ✓ We obtain a **reduced plate set**



Comparison with SOTA

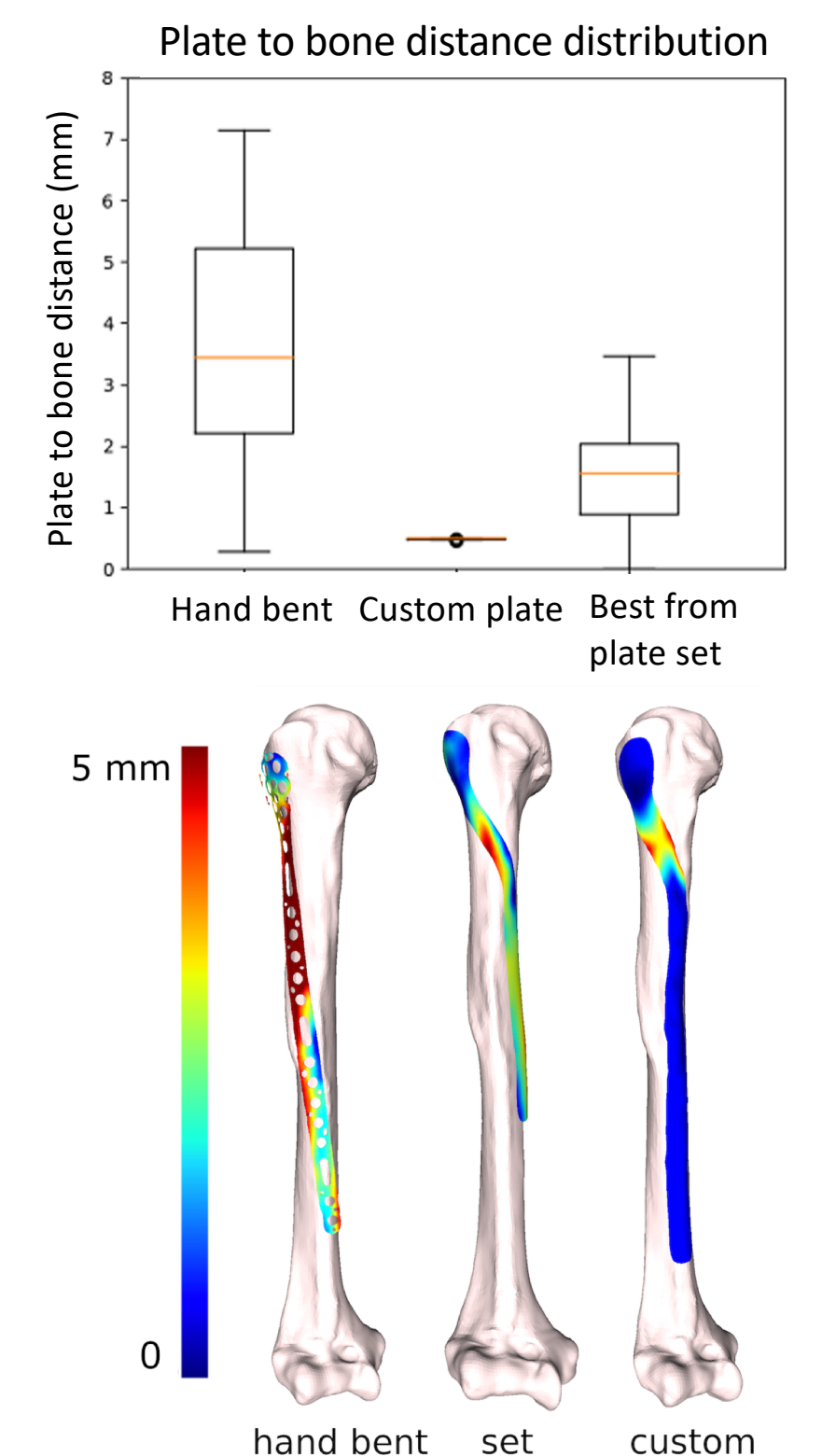
	Plate position	Plate deformation	Fit criteria	Plate Set	Surgery ready	Anatomic constrains
SOTA	✓	✓	✓	✗	✗	✗
OURS	✓	✓	✓	✓	✓	✓

Experiments and Results

1. Digital Evaluation

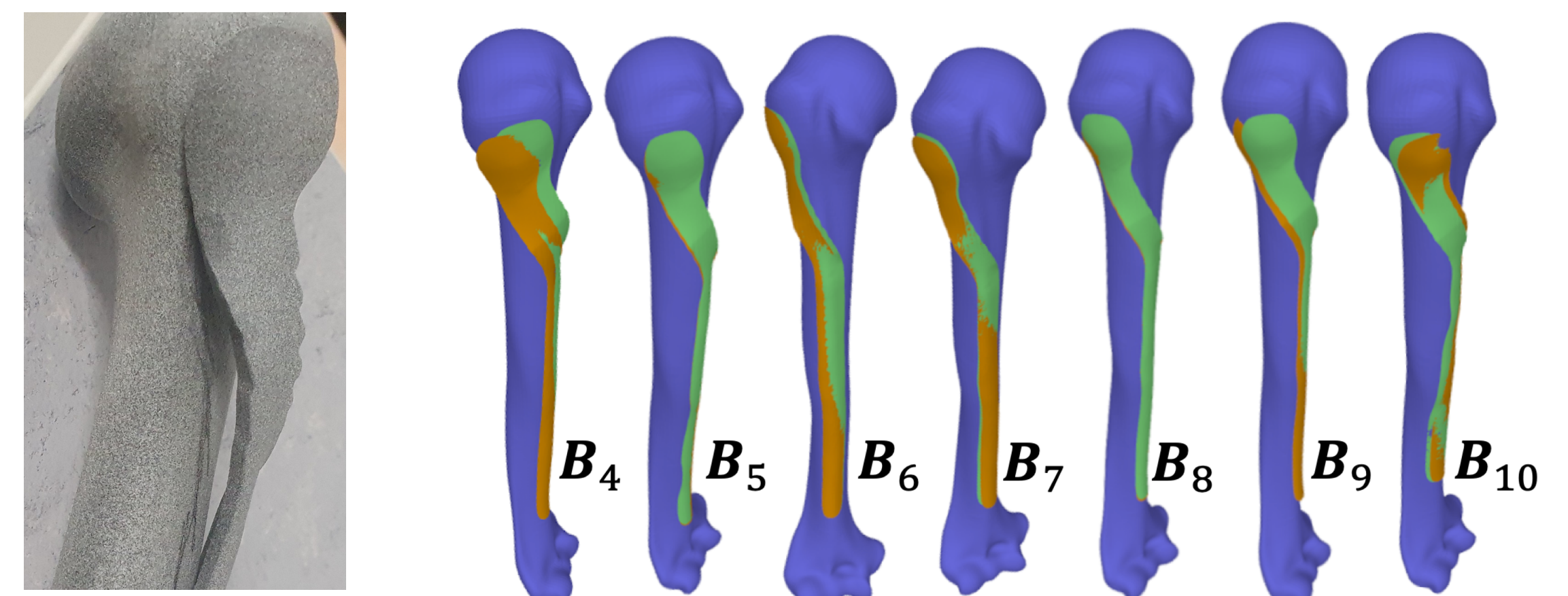
For a scanned bone, we compare:

- The **existing commercial plate** bent by the surgeon
- The **custom plate** extracted from the bone surface
- The **best plate from the plate set** of size 5



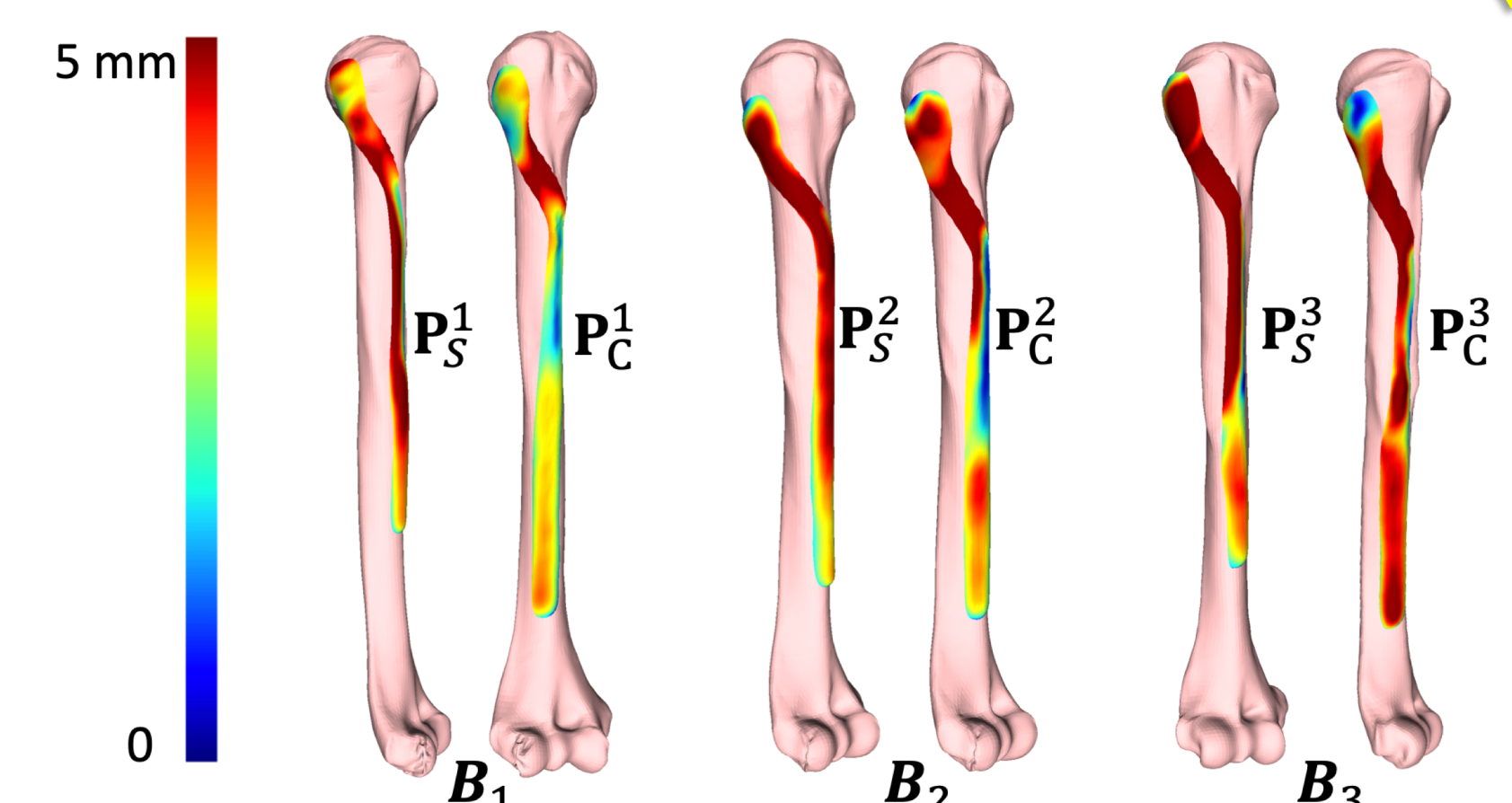
2. 3D printed

- 3D print the plates and bones
- Ask surgeon to **choose the best plate** and position it
- Compare with **our automatic plate selection and placement**



3. Ex-vivo

- Insert 3D printed plates inside the cadaveric arm
- CT scan and surgeon feedback for evaluation



Take Away

- Importance of Evaluation
 - On 3D Printed Bones
 - On Ex-Vivo Arms
- Theoretical fitting constraints can be relaxed

Code and Paper



<https://humerusplate.is.tue.mpg.de/>