A Population-based Implant Shapes Set for Fracture Surgery

Marilyn Keller[1], Michael Black[1], Sergi Pujades[2]

Annelie Weinberg[3], Marcell Krall[3], Hans-Gunther Clement[3], Andreas Gradishar[4], Christian Maier[5]

[1]Max Planck Institute for Intelligent Systems   [2]INRIA   [3]Medizinische Universität Graz   [4]CAE Simulation Solution   [5]Hofer Medical

Context

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

- Maintain pieces of bone together for healing
- Maintain a low plate-bone distance

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

- Imprecise
- Time consuming
- Fragilizes the plates

Objective

- Pre-bent plate shapes
- Better fit
- Set of shapes

Custom Plate

How to generate a custom plate for a bone?

- Build a statistical shape model of the bone using PCA
- Register each bone of our dataset with this PCA model
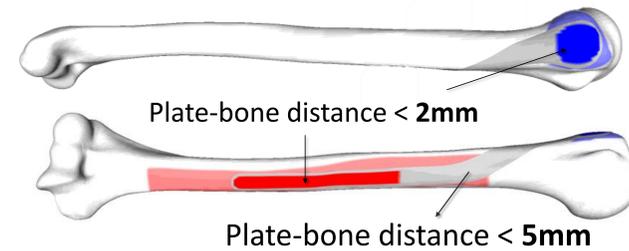- Design a plate shape on the mean bone surface

Registered bone

Plate designed on the mean bone

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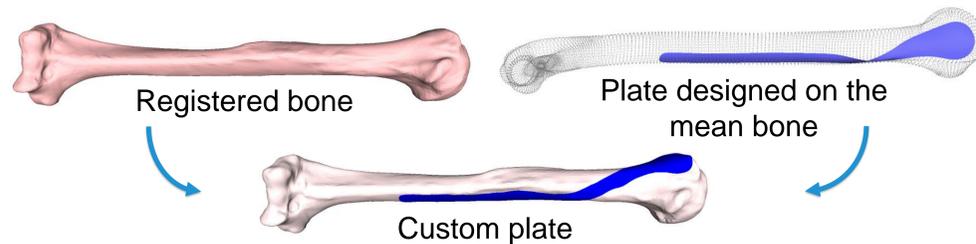
- Thanks to registration, we can **get a plate shape for any bone**
- From 96 bones we extract **96 plates**

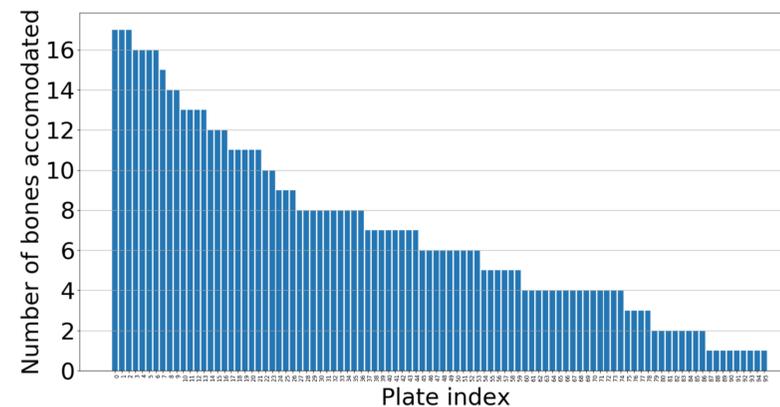## Generate a Plate Set

Can one plate fit several bones?

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

Plate-bone distance < **2mm**

Plate-bone distance < **5mm**

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

- Bring the plate close to the custom plate position
- Meet the fit criteria

Number of bones accomodated by each plate

- We then order those plates to maximize population accommodation

Results

Plate set population coverage

- The **5** first plates accommodate about **65%** of the bone population.

- Some plates only fit their target bone.

Plate fit

For a scanned bone, we compare:

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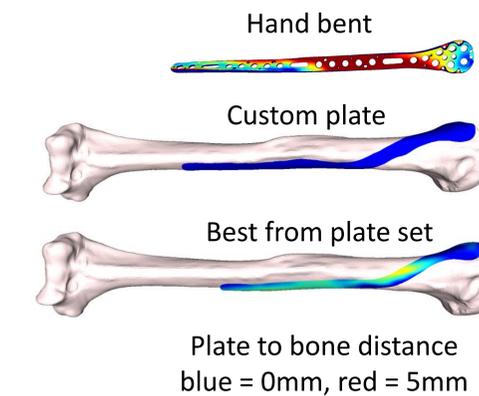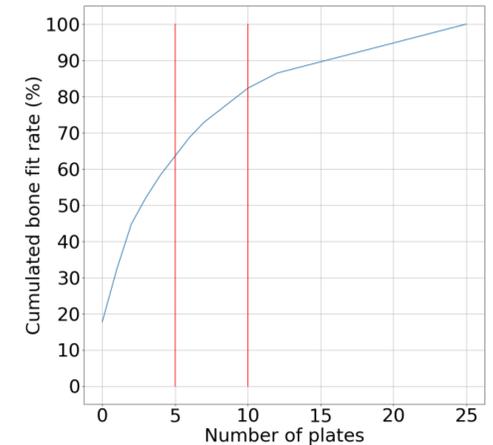- The best plate from the plates set of size 5

Plate set fit rate

Hand bent

Custom plate

Best from plate set

Plate to bone distance
blue = 0mm, red = 5mm

Plate to bone distance distribution

Discussion

Pre-contoured plate shapes vs hand bent plate

- In our experiment, with a limited set of shapes, we get a plate fit better than the hand bent plates. This will be evaluated on more bones for validation
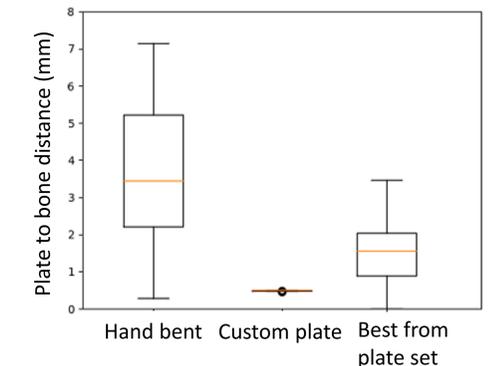
Custom 3D printed plates

- We show that some bones are only accommodated by their target bone, which shows the interest of custom printed plates

Ongoing work

- Mechanical and anatomical validation of the plate shapes
- Improvement of the fit function by adding anatomical constraints