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

**Context**

**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

Given a bone, how to generate it?

- 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**

<table>
<thead>
<tr>
<th>Plate position</th>
<th>Plate deformation</th>
<th>Fit criteria</th>
<th>Plate Set</th>
<th>Surgery ready</th>
<th>Anatomic constrains</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOTA</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>OURS</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

**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

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