NO CONFLICT OF INTEREST
INTRODUCTION

1. How to make an object?
2. History
3. Patient-specific
4. Methods of 3D printing
INTRODUCTION

1. How to make an object?
2. History
3. Patient-specific
4. Methods of 3D printing
HOW TO MAKE AN OBJECT?
HOW TO MAKE AN OBJECT?

TRADITIONAL MANUFACTURING
HOW TO MAKE AN OBJECT?
MANUFACTURING PROCESS
HOW TO MAKE AN OBJECT?
ADDITIVE MANUFACTURING
3D PRINTING

PROPERTIES
INTRODUCTION

1. How to make an object?
2. History
3. Patient-specific
4. Methods of 3D printing
HISTORY

ARTISTS

1964

Arthur C. Clarke

1972

Greg (Hergé)

Fifty years ago Arthur C. Clarke predicted "a replicator machine"
HISTORY

ENGINEERS

1984

JC André, O de Witte, A le Méhaute

1986

Charles Hull
Fig 2.  (A) Stereolithography skull model constructed from CT scan processing. Note the cleft upper palate and CT metal star artifact around the teeth. (B) Detail of the anterior portion of the skull base showing problems with floating contours (see text).

Mankovich
INTRODUCTION

1. How to make an object?
2. History
3. Patient-specific
4. Methods of 3D printing
PATIENT-SPECIFIC
ANATOMY

Anatomical and radiological study applied to distal radius surgery

N. Gasse · D. Lepage · R. Pem · C. Bernard ·
J. M. Lerais · P. Garbuio · L. Obert

DOI 10.1007/s00239-010-0754-x
PATIENT-SPECIFIC IMPLANTS PORTFOLIO
PATIENT-SPECIFIC IMPLANTS BENDING
PATIENT-SPECIFIC 3D PRINTING

Patient-specific distal radius locking plate for fixation and accurate 3D positioning in corrective osteotomy

J. G. G. Dobbe • J. C. Vroemen • S. D. Strackee • G. J. Streekstra
INTRODUCTION

1. How to make an object?
2. History
3. Patient-specific
4. Methods of 3D printing
3D PRINTING METHODS

5 STEPS
3D PRINTING METHODS

Acquisition .DICOM
3D PRINTING METHODS

Segmentation

Conversion .STL
3D PRINTING METHODS

Preparation before printing

- Materialise Magics
- Materialise Mimics
- blender
- MeVisLab
3D PRINTING METHODS

Slicing

Printing
3D PRINTING METHODS

Post-processing
3D PRINTING METHODS

PRINTERS

SLA

SLS
BJ

Polyjet

FDM
3D PRINTING METHODS

PRINTERS: StereoLithography Apparatus
3D PRINTING METHODS

PRINTERS: Selective Laser Sintering
3D PRINTING METHODS

PRINTERS : Binder Jetting
3D PRINTING METHODS

PRINTERS: Polyjet
3D PRINTING METHODS

PRINTERS: Fused Deposition Modeling
APPLICATIONS IN SURGERY

1. Research
2. Training
3. Preoperative planning
4. Intraoperative cutting guides
5. Implants
6. Splints
7. Prostheses
8. Future
APPLICATIONS IN SURGERY

1. Research
2. Training
3. Preoperative planning
4. Intraoperative cutting guides
5. Implants
6. Splints
7. Prostheses
8. Future
APPLICATIONS IN SURGERY

RESEARCH

Cadaver/Sawbone
APPLICATIONS IN SURGERY RESEARCH

Midcarpal Arthrodesis Biomechanics: Memory Staples versus Cannulated Screws.

Author information
1 The Sydney Hospital Hand Unit, Sydney Hospital, Sydney, Australia
2 †Surgical & Orthopaedic Research Laboratories, Prince of Wales Clinical School, Sydney, Australia
APPLICATIONS IN SURGERY

RESEARCH

BIO-PRINTING bones
APPLICATIONS IN SURGERY

1. Research
2. Training
3. Preoperative planning
4. Intraoperative cutting guides
5. Implants
6. Splints
7. Prostheses
8. Future
The addition of 3D printed models to enhance the teaching and learning of bone spatial anatomy and fractures for undergraduate students: a randomized controlled study.

Wu BF*, Wang SY*, Wang JS†, Chen CL†, Yang XD†, Ni WE†, Hu J‡

*Author Information
1. Department of Orthopedics, The Second Affiliated Hospital and Yuying Children’s Hospital of Wenzhou Medical University, The Second School of Medicine Wenzhou Medical University, Wenzhou 325000, China
2. Department of Anatomy, Wenzhou Medical University, Wenzhou 325000, China

Table 1: The comparison of summation scores between the two groups

<table>
<thead>
<tr>
<th>Sites</th>
<th>Traditional radiographic image group</th>
<th>3D printed model group</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper limb</td>
<td>7.24±1.51</td>
<td>7.47±1.50</td>
<td>-0.87</td>
<td>0.900</td>
</tr>
<tr>
<td>Lower limb</td>
<td>7.20±1.56</td>
<td>7.38±1.34</td>
<td>-0.588</td>
<td>0.563</td>
</tr>
<tr>
<td>Pelvis</td>
<td>4.33±1.79</td>
<td>6.80±1.39</td>
<td>-5.798</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Spine</td>
<td>4.76±1.81</td>
<td>6.90±1.51</td>
<td>-6.687</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Table 2: The comparison of test-taking times (seconds) between the two groups

<table>
<thead>
<tr>
<th>Sites</th>
<th>Traditional radiographic image group</th>
<th>3D printed model group</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper limb</td>
<td>190.2±42.2</td>
<td>189.3±29.5</td>
<td>0.523</td>
<td>0.803</td>
</tr>
<tr>
<td>Lower limb</td>
<td>190.6±42.6</td>
<td>188.2±31.1</td>
<td>0.325</td>
<td>0.746</td>
</tr>
<tr>
<td>Pelvis</td>
<td>250.6±49.4</td>
<td>246.4±38.9</td>
<td>5.269</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Spine</td>
<td>250.3±64.3</td>
<td>237.9±42.9</td>
<td>3.136</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Table 3: The comparison of visual analog scale of satisfaction scores between the two groups

<table>
<thead>
<tr>
<th>Visual analog scale</th>
<th>Traditional radiographic image group</th>
<th>3D printed model group</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfied</td>
<td>5.90±1.36</td>
<td>7.49±1.36</td>
<td>-5.973</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
APPLICATIONS IN SURGERY

TRAINING

Practice

<table>
<thead>
<tr>
<th>Variables</th>
<th>Unit</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Estimated difference</th>
<th>Confidence interval</th>
<th>Probability</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of the procedure</td>
<td>min</td>
<td>91</td>
<td>61</td>
<td>29</td>
<td>(11.4, 40.15)</td>
<td>&gt;99%</td>
<td>Significant</td>
</tr>
<tr>
<td>Final incision length</td>
<td>mm</td>
<td>29</td>
<td>21</td>
<td>7</td>
<td>(1.2, 14.7)</td>
<td>&gt;99%</td>
<td>Very large</td>
</tr>
<tr>
<td>Pronator quadratus respected</td>
<td>/5</td>
<td>2/5</td>
<td>5/5</td>
<td>3%</td>
<td>(0, 12)</td>
<td>97%</td>
<td>Very large</td>
</tr>
<tr>
<td>Ulnar nerve respected</td>
<td>/5</td>
<td>1/5</td>
<td>2/5</td>
<td>14%</td>
<td>(20, 55)</td>
<td>76%</td>
<td>No</td>
</tr>
<tr>
<td>The radial nerve respected</td>
<td>/5</td>
<td>2/5</td>
<td>5/5</td>
<td>43%</td>
<td>(1, 80)</td>
<td>77%</td>
<td>Very large</td>
</tr>
<tr>
<td>Plate did not exceed the watershed line</td>
<td>/5</td>
<td>3/5</td>
<td>5/5</td>
<td>43%</td>
<td>(1, 80)</td>
<td>77%</td>
<td>Very large</td>
</tr>
<tr>
<td>Plate was on the proximal screws</td>
<td>/5</td>
<td>1/5</td>
<td>5/5</td>
<td>17%</td>
<td>(13, 31)</td>
<td>&gt;99%</td>
<td>Significant</td>
</tr>
<tr>
<td>Plate in the axis of the radius</td>
<td>/5</td>
<td>1/5</td>
<td>5/5</td>
<td>15%</td>
<td>(1, 26, 54)</td>
<td>76%</td>
<td>No</td>
</tr>
</tbody>
</table>
APPLICATIONS IN SURGERY

1. Research
2. Training
3. Preoperative planning
4. Intraoperative cutting guides
5. Implants
6. Splints
7. Prostheses
8. Future
APPLICATIONS IN SURGERY

Preoperative planning

Implant choice
APPLICATIONS IN SURGERY

Preoperative planning

Training

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>operation time (min)</th>
<th>blood loss (ml)</th>
<th>number of Intraoperative fluoroscopy (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine group</td>
<td>55</td>
<td>65.73 ± 6.02</td>
<td>52.85 ± 9.28</td>
<td>5.85 ± 1.64</td>
</tr>
<tr>
<td>3D model group</td>
<td>52</td>
<td>56.58 ± 4.74</td>
<td>39.25 ± 8.72</td>
<td>4.85 ± 1.39</td>
</tr>
<tr>
<td>t</td>
<td></td>
<td>8.704</td>
<td>7.615</td>
<td>3.423</td>
</tr>
<tr>
<td>p-Value</td>
<td></td>
<td>0.000</td>
<td>0.000</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Treatment of Die-Punch Fractures with 3D Printing Technology.

Chen G1, Gai L1, Zhang G1, Wang J1, Gua X1, Zhou Y1.

1 Department of Orthopaedics, The Second Affiliated Hospital and Yuying Children's Hospital of Wenzhou Medical University, Wenzhou, Zhejiang, China.
APPLICATIONS IN SURGERY

Preoperative planning

Bending
APPLICATIONS IN SURGERY

1. Research
2. Training
3. Preoperative planning
4. Intraoperative cutting guides
5. Implants
6. Splints
7. Prostheses
8. Future
Intraoperative guides

Outside
- Pinning guide

Inside
- Pinning guide
- Osteotomy

Graft
- Reduction
  - Without landmark
  - With landmark
- Positive
- Negative
  - Without landmark
  - With landmark
    - Guide below the plate
    - Plate below the guide
Intraoperative guides

- Outside
  - Pinning guide
  - Osteotomy
    - Without landmark
    - With landmark
      - Outside
      - Inside
    - Guide below the plate
  - Reduction
    - Without landmark
    - With landmark
      - Guide below the plate
      - Plate below the guide
- Inside
- Graft
  - Positive
  - Negative
APPLICATIONS IN SURGERY

Intraoperative guides Outside

Pinning guide
APPLICATIONS IN SURGERY

Intraoperative guides Outside

Pinning guide
Intraoperative guides

- Outside
  - Pinning guide
  - Osteotomy
    - Without landmark
    - With landmark
      - Outside
      - Inside
- Inside
- Reduction
  - Without landmark
  - With landmark
    - Guide below the plate
    - Plate below the guide
- Graft
  - Positive
  - Negative
APPLICATIONS IN SURGERY

Intraoperative guides Inside

Pinning guide
APPLICATIONS IN SURGERY

Intraoperative guides

- Outside
  - Pinning guide
  - Pinning guide
  - Osteotomy
    - Without landmark
      - Outside
    - With landmark
      - Inside
  - Reduction
    - Without landmark
      - Guide below the plate
    - With landmark
      - Plate below the guide
  - Positive
  - Negative
- Inside
- Graft
APPLICATIONS IN SURGERY

Intraoperative guides Inside

Osteotomy without landmark
Osteotomy without landmark

Applications in Surgery

Intraoperative guides Inside

Accuracy and Early Clinical Outcome of 3-Dimensional Planned and Guided Single-Cut Osteotomies of Malunited Forearm Bones.

Roner S, Vlachopoulos L, Naeve L, Schweizer A, Frenstaedt R.

Author information:
1. Orthopedic Department, Balgrist University Hospital, University of Zurich, Zurich, Switzerland. Electronic address: simon.roner@balgrist.ch.
2. Computer Assisted Research and Development Team, Balgrist University Hospital, University of Zurich, Zurich, Switzerland.
3. Orthopedic Department, Balgrist University Hospital, University of Zurich, Zurich, Switzerland.
APPLICATIONS IN SURGERY

Intraoperative guides Inside

Osteotomy without landmark
Osteotomy without landmark
Osteotomy with outside landmark
Osteotomy with inside landmark

Intraoperative guides Inside
Intraoperative guides

Outside
- Pinning guide

Inside
- Pinning guide
- Osteotomy
  - Without landmark
  - With landmark
    - Reduction
      - Without landmark
      - With landmark
        - Guide below the plate
        - Plate below the guide

Graft
- Positive
- Negative
APPLICATIONS IN SURGERY

Intraoperative guides Inside

Reduction without landmark
APPLICATIONS IN SURGERY

Intraoperative guides Inside

Reduction without landmark

[Images of medical procedures and tools]
APPLICATIONS IN SURGERY

Intraoperative guides

- Outside
  - Pinning guide

- Inside
  - Pinning guide
  - Osteotomy
    - Without landmark
    - With landmark
      - Reduction
        - Without landmark
        - With landmark
          - Guide below the plate
          - Plate below the guide

- Graft
  - Positive
  - Negative
APPLICATIONS IN SURGERY

Intraoperative guides Inside

Reduction with landmark / guide below the plate
APPLICATIONS IN SURGERY

Intraoperative guides **Inside**

Reduction with landmark / plate below the guide
APPLICATIONS IN SURGERY

Intraoperative guides

- Outside
  - Pinning guide
  - Pinning guide
- Inside
  - Osteotomy
    - Without landmark
    - With landmark
  - Reduction
    - Without landmark
    - With landmark
      - Guide below the plate
      - Plate below the guide
- Graft
  - Positive
  - Negative
APPLICATIONS IN SURGERY

Intraoperative guides **Bone graft**

Positive
APPLICATIONS IN SURGERY

Intraoperative guides Bone graft

Negative
Intraoperative guides

Outside
- Pinning guide

Inside
- Pinning guide
- Osteotomy

Graft
- Positive
- Negative

Reduction
- Without landmark
- With landmark

Without landmark
- Guide below the plate
  - Outside
- Plate below the guide
  - Inside
APPLICATIONS IN SURGERY

Perfect Intraoperative guide

Specification

Osteotomy
in & out landmark

Reduction
plate below the guide

Graft
negative

Control
≠ pre/post-op
APPLICATIONS IN SURGERY

1. Research
2. Training
3. Preoperative planning
4. Intraoperative cutting guides
5. Implants
6. Splints
7. Prostheses
8. Future
APPLICATIONS IN SURGERY

IMPLANTS

Plates
Arthroplasty
Arthroplasty

3D printing lunate prosthesis for stage III Kienböck's disease: a case report.

Author Information
1. Third Military Medical University Southwest Hospital, Chongqing, China.
2. Third Military Medical University Southwest Hospital, Chongqing, China. tangkangjie@hotmail.com.
Arthroplasty

APPLICATIONS IN SURGERY

IMPLANTS
Arthroplasty
APPLICATIONS IN SURGERY

1. Research
2. Training
3. Preoperative planning
4. Intraoperative cutting guides
5. Implants
6. **Splints**
7. Prostheses
8. Future
Applications in Surgery

Splints

Table 2. Statistical Comparison of Performance During Tasks Utilizing the Jebsen Hand Function Test.

<table>
<thead>
<tr>
<th>Mean time to complete task(s)</th>
<th>Fiberglass cast</th>
<th>3D cast</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(low numbers demonstrate better result)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifting large, light objects</td>
<td>21.51</td>
<td>17.38</td>
<td>.801</td>
</tr>
<tr>
<td>Lifting large, heavy objects</td>
<td>5.88</td>
<td>5.83</td>
<td>.898</td>
</tr>
<tr>
<td>Lifting small, common objects</td>
<td>8.69</td>
<td>10.55</td>
<td>.307</td>
</tr>
<tr>
<td>Simulated feeding</td>
<td>13.04</td>
<td>12.09</td>
<td>.533</td>
</tr>
<tr>
<td>Simulated page turning</td>
<td>4.51</td>
<td>3.91</td>
<td>.947</td>
</tr>
<tr>
<td>Stacking checkers</td>
<td>4.94</td>
<td>4.78</td>
<td>.446</td>
</tr>
<tr>
<td>Writing</td>
<td>4.63</td>
<td>4.69</td>
<td>.269</td>
</tr>
</tbody>
</table>


Conventional vs 3-Dimensional Printed Cast Wear Comfort.
Graham J¹, Wang M², Frizzell K², Watkins G², Benediktian P¹, Rivlin M¹.

Author information
1 1 Rothman Institute and Jefferson Medical College, Philadelphia, PA, USA.
2 2 Philadelphia College of Osteopathic Medicine, PA, USA.
# APPLICATIONS IN SURGERY

| 1. | Research |
| 2. | Training |
| 3. | Preoperative planning |
| 4. | Intraoperative cutting guides |
| 5. | Implants |
| 6. | Splints |
| 7. | **Prostheses** |
| 8. | Future |
APPLICATIONS IN SURGERY

PROTHESES

Mechanical
APPLICATIONS IN SURGERY

PROTHESES

Myoelectric
APPLICATIONS IN SURGERY

1. Research
2. Training
3. Preoperative planning
4. Intraoperative cutting guides
5. Implants
6. Splints
7. Prostheses
8. Future
Augmented reality
Robots

APPLICATIONS IN SURGERY

FUTURE
CONCLUSION

- INFANCY
- TRENDY technology
- SUPERIORITY over conventional techniques?
- DEPENDENT on engineers and/or industry?
SOCIÉTÉ FRANÇAISE DE LA CHIRURGIE DE LA MAIN

PRÉSIDENT: PHILIPPE LIVERNEAUX

55ème CONGRÈS

Palais des congrès
Porte Maillot - PARIS
19 AU 21 DÉC. 2019