3D PRINTING AND ADVANCES IN CRANIOFACIAL SURGERY

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Albert Einstein College of Medicine
Director of Craniofacial Surgery
Director of Aesthetic Surgery

MARCH 28, 2018
DISCLOSURES

• Consultant for Stryker CMF
• Shareholder in MirrorMe3D
• Shareholder in 3D Systems
BACKGROUND

1998-2010

NYU SCHOOL OF MEDICINE

NYU Langone MEDICAL CENTER

JOB SEARCH:

• Craniofacial surgery
• Apply the skills I learned in my training
  – Craniofacial surgery
  – Aesthetic surgery
  – Microsurgery
  – General plastic surgery
• Be busy!
The Craniofacial Center at The Children’s Hospital at Montefiore

- Internationally recognized physicians
- An experienced multidisciplinary team
- Cutting-edge craniofacial care

“I can’t believe I now have to work with a newbie after all these years”

“You will have an opportunity to do very complex, difficult cases right out of training”
3D TECHNOLOGY

3D PHOTOGRAPHY

3D PRINTING

VIRTUAL REALITY
3D TECHNOLOGY

3D PHOTOGRAPHY

3D PRINTING

VIRTUAL REALITY
3D PHOTOGRAPHY

CAD-CAM
Design
3D PHOTOGRAPHY

Montefiore
Inspired Medicine
A Novel Approach to Surgical Markings Based on a Topographic Map and a Projected Three-Dimensional Image

Jillian E. Schreiber, B.A.
Carrie S. Stern, M.D.
Evan S. Garfein, M.D.
Katie E. Weichman, M.D.
Oren M. Tepper, M.D.
3D TECHNOLOGY

3D PHOTOGRAPHY

3D PRINTING

VIRTUAL REALITY
Use of Computer-Aided Design and Computer-Aided Manufacturing to Produce Orthognathically Ideal Surgical Outcomes: A Paradigm Shift in Head and Neck Reconstruction

David L. Hirsch, DDS, MD, Evan S. Garfem, MD,‡
Andrew M. Christenson, BS,‡ Katherine A. Weimer, MS,f
Pierre B. Saddeh, MD,¶ and Jamie P. Levine, MD§

JOMFS: 2009
MANDIBULAR DISTRACTION

CHALLENGES

• Vector planning
• Osteotomies
  • Hypoplastic bone
  • Critical structures
• Positioning/placement:
  • Distraction devices
  • Screws
The Montefiore Health System invites you to join us in learning about

THE MONTEFIORE EINSTEIN 3D LABORATORY: WHERE SURGICAL VISION BECOME REALITY
3D TECHNOLOGY

3D PHOTOGRAPHY

3D PRINTING

VIRTUAL REALITY
January 2016
CONJOINED TWINS - SIAMESE TWINS

INCIDENCE: 1/50,000 BIRTHS

CRANIOPAGUS: 2% OF CONJOINED TWINS
1/2.5 MILLION BIRTHS

PERI-OPERATIVE MORTALITY
PRE-1974 WAS 67%

MORTALITY POST 1974 IS 36%

MORBIDITY - ENORMOUS!
SURVIVAL IN CRANIOPAGUS IN 116 CHILDREN

<table>
<thead>
<tr>
<th>TIME</th>
<th>% SURVIVAL</th>
</tr>
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<tbody>
<tr>
<td>2 days</td>
<td>79</td>
</tr>
<tr>
<td>1 week</td>
<td>68</td>
</tr>
<tr>
<td>1 month</td>
<td>53</td>
</tr>
<tr>
<td>6 month</td>
<td>41</td>
</tr>
<tr>
<td>1 year</td>
<td>28</td>
</tr>
<tr>
<td>5 year</td>
<td>15</td>
</tr>
<tr>
<td>10 year</td>
<td>11</td>
</tr>
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</table>

In the last 500 years there are only five cases where craniopagus twins reached adulthood.
Finding known among unknown
3D ANATOMICAL MODELS

2004

2016
CHALLENGES

• Neurovascular
• Reconstructive
Conjoined venous anatomy complicates every separation attempt.

Acute separation results in hemodynamic instability, cerebral edema, hemorrhage.

Gradual ligation of venous outflow allows for venous remodeling and collateralization.

Split the surgery into quartiles, to be performed over one year.
Reconstructive surgery key principle: replace like with like, but have limited autologous material.

Need to precisely understand the deficits and how much autologous material is available.

3D modeling with tissue expanders to generate the scalp needed for coverage.
SURGICAL SIMULATION

STAGED PROCEDURE

NATURAL DIVISION PLANE

ADEQUATE COVERAGE

SCALP

BONE
3D PRINTS – ANATOMIC MODELS

INCISION PLANNING

EXPOSURE PLANNING

MEASUREMENTS
STAGE 1 – MAY 2016
<table>
<thead>
<tr>
<th>Stage</th>
<th>Surgical goal</th>
<th>Virtual Surgical Planning</th>
<th>3D print reference models</th>
<th>3D printed guides and jigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ligate 1st quartile of bridging veins</td>
<td>Optimal incision pattern design</td>
<td>Soft tissue/skin envelope model</td>
<td>Soft tissue/skin envelope model</td>
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<tr>
<td>April 2016</td>
<td></td>
<td></td>
<td>Clear skull model with vasculature</td>
<td>Clear skull model with vasculature</td>
</tr>
<tr>
<td>2</td>
<td>Ligate 2nd quartile of bridging veins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 2016</td>
<td></td>
<td></td>
<td>Soft tissue/skin envelope model</td>
<td>Soft tissue/skin envelope model</td>
</tr>
</tbody>
</table>
| 3     | Ligate 3rd quartile of bridging veins  
Insert tissue expanders | Topographical analysis to determine scalp defect surface area  
Topographical modeling of tissue expanders Identification of optimal location for expanders  
Identification of optimal location for expanders | Soft tissue/skin envelope model | Soft tissue/skin envelope model |
| August 2016 | | | Clear skull model with vasculature | Clear skull model with vasculature |
| 4     | Ligate final shared vasculature and neural tissue  
Perform complete circumferential osteotomy and incision  
Reconstruct calvaria using split thickness bone grafts | Creation of morphologically normal baseline simulation  
Simulation of calvarial reconstruction using split-thickness calvarial bone grafts  
Simulation of scalp re-approximation and closure | Soft tissue/skin envelope model | Osteotomy cutting guides |
| October 2016 | | | Clear skull model with vasculature | Skull cap templates |
| | | | Color jet printed brain model | |
SOFT TISSUE EXPANSION
3 STAGES
VIRTUAL COMPUTER PLANNING

Anias & Jadon
McDonald
VIRTUAL COMPUTER PLANNING

Skin flap
Surface area: 240 cm²
Length: 16.5 cm

Cranial reconstruction
Normative base line
Surface area: 210 cm²
Length: 23 cm

Exposed cranium
Surface area: 59 cm²
INTRAOPERATIVE GUIDES
THE FINAL SEPARATION
Parenting

Carrie Stern, MD, on What It’s Like to Separate Conjoined Twins

Plastic surgery residents in training at Montefiore Medical Center in the Bronx, N.Y., have the opportunity to participate in all the many aspects of the discipline, including craniofacial surgery, complex reconstruction, hand surgery, and aesthetic surgery. But Carrie Stern, MD, a fifth-year postgraduate resident, had a once-in-a-lifetime experience when she made the final cut in the historic, 17-hour craniopagus surgery that successfully separated conjoined, 13-month-old twin boys Jadon and Anias McDonald last Friday.

The highly complex procedure — performed by pediatric neurosurgeon James T. Goodrich, widely acknowledged as the world’s expert on separating twins joined at the head — is rarely performed. Playing a key part in the surgery has left an indelible impression on Stern, and as the McDonald twins continued to recover in-hospital, she was able to reflect back on the historic operation and share her thoughts in an exclusive interview with Yahoo Beauty.
LOOKING BACK
LOOKING BACK

Mentors

Training

Technology

Colleagues

NYU SCHOOL OF MEDICINE
LOOKING FORWARD
REAL TIME COMMUNICATION
SOFT TISSUE PLANNING

9,081 mm$^2$
(50 cc)

23,156 mm$^3$
(250 cc)

Flap surface area
= 5,277 mm$^2$

129 mm
157 mm
Mixed Reality with HoloLens: Where Virtual Reality Meets Augmented Reality in the Operating Room

<table>
<thead>
<tr>
<th></th>
<th>Google Glass</th>
<th>Oculus Rift</th>
<th>Microsoft HoloLens</th>
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</thead>
<tbody>
<tr>
<td>Technology type</td>
<td>Augmented reality</td>
<td>Virtual reality</td>
<td>Mixed reality (augmented plus virtual)</td>
</tr>
<tr>
<td>Wearability</td>
<td>Eyeglasses-style</td>
<td>Adjustable headband</td>
<td>Adjustable headband</td>
</tr>
<tr>
<td>Battery life</td>
<td>1 hr of heavy use</td>
<td>Wired power consumption</td>
<td>2-3 hr of heavy use</td>
</tr>
<tr>
<td>HIPAA compliance</td>
<td>Yes; third-party applications</td>
<td>N/A</td>
<td>Not off the shelf</td>
</tr>
<tr>
<td>No-touch operation</td>
<td>Touchpad on right arm; can be voice-controlled</td>
<td>No</td>
<td>Controlled by gestures and voice command</td>
</tr>
<tr>
<td>True heads-up display</td>
<td>Yes</td>
<td>N/A</td>
<td>Yes; holograms can also be placed out of field of view</td>
</tr>
</tbody>
</table>
3D TECHNOLOGY

3D PHOTOGRAPHY

3D PRINTING

VIRTUAL REALITY
THANK YOU

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