Touch the Next Digital Era
CongresSquare, Nihonbashi
Tokyo, Japan
MatrixMANDIBLE™

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Table of Contents

Welcome Address ................................................................. 2

Conference Sponsors / Exhibitors ......................................... 7-9

Supporting Organizations / Institutions ................................... 9

Program Committees .......................................................... 11

Conference Venue .............................................................. 11

Social Activities ................................................................. 11

Featured & Invited Speakers.................................................. 12-14

Conference Program Schedule ............................................ 15-17

Abstracts ............................................................................

Oral Abstracts & Biographies............................................... 19-56
Poster Abstracts .................................................................. 57-80

Workshops .......................................................................... 82
Welcome Address

Welcome to Tokyo, Japan for the 7th Triennial International Conference of the ADT Foundation.

The conference vision is to exchange scientific ideas, develop best practice, and create interdisciplinary networks between medical specialists, academia, industry and regulatory authorities as well as between young and established scientists and professionals.

The ADT is a collaboration between professionals and industry partners to identify advanced technologies in head and neck reconstruction. An important aspect of the ADT is that the clinical, industry and the science world all have an equal role to play in Advanced Digital Technology. This mandates that our Industry Partners actively participate in the ADT to present their technology development.

We encourage companies to join the ADT Foundation as an Industry Partner. Industry Partners receive discounted exhibit booth rates and delegate registration at ADT meetings, branding opportunities on ADT websites and literature, access to opinion leaders in the field of digital technology and potential to conduct workshops.

The ADT Foundation has a history of encouraging industry to present research and development work at the Congress. The only stipulation is that presentations are scientific in nature with no product promotion.

Yours Sincerely,

ADT President
Dr. Gerald Grant

ADT Secretary
Dr. Peter Evans

ADT Treasurer
Dr. Dominic Eggbeer

Tokyo, Japan

Tokyo, Japan’s busy capital, mixes the ultramodern and the traditional, from neon-lit skyscrapers to historic temples. Nihonbashi is a business district of Chūō, Tokyo, Japan which grew up around the bridge of the same name which has linked two sides of the Nihonbashi River at this site since the 17th century. With a Euro-Japanese design, this bridge is the starting point from which all distances from Tokyo are measured.
ADT Mission

The ADT Foundation was created to help identify and explore the future role of innovative digital technologies in reconstruction of the head and neck.

The ADT Foundation is a corporation founded in Canada, July 14, 2010 by the Canada Corporation Act. The missions of the ADT Foundation are:

1. To advance education by improving the quality of knowledge in the fields of medicine related to head and neck reconstruction
2. To organize and present conferences, workshops and symposia for professional development related to head and neck reconstruction, including the conference known as "Advanced Digital Technologies in Head and Neck Reconstruction".

ADT Industry Partners

The ADT is collaboration between professionals and industry partners to identify advanced technologies in head and neck reconstruction. An important aspect of the ADT is that the clinical, industry and the science world all have an equal role to play in Advanced Digital Technology. This mandates that our Industry Partners actively participate in the ADT to present their technology development. In this manner the ADT brings together colleagues from industry, clinicians, clinical scientists and basic scientists into a synergistic environment.

We encourage our Industry Partners to participate with ADT Foundation and our Associates. We hope that the following benefits will be of interest to our Industry Partners and wish to develop a long lasting "Partnership", beyond the exhibit booth.

ADT Meetings

Triennial Conferences

6th Triennial International ADT Conference Amiens, France | May 31-June 3, 2018

5th Triennial International ADT Conference Beijing, China | September 6-8, 2014

4th Triennial International ADT Conference Freiburg, Germany | May 5-8, 2011

3rd Triennial International ADT Conference Cardiff, Wales UK | June 28-July 1, 2008

2nd Triennial International ADT Conference Banff, AB Canada | March 10-13, 2005

1st Triennial International ADT Conference Edmonton, AB Canada | March 10-13, 2002

Regional Leadership Groups

United Kingdom 2018 Leadership Group Swansea, UK | June 15, 2018

United Kingdom 2017 Leadership Group Cardiff, UK | February 17-18, 2017


Scandinavian 2015 Leadership Group Denmark | August 20-22, 2015

United Kingdom 2014 Leadership Group Loughborough University, UK | July 24, 2014

North American 2013 Leadership Group La Jolla, CA USA | January 25-26, 2013

Japan 2013 Leadership Group Tokyo, Japan | November 10, 2013

Japan 2011 Leadership Group Tokyo, Japan | December 3, 2011

North America 2010 Leadership Group Vail, CO USA | February 4-6, 2010
Implant dentistry from A to X

性別や年齢を問わず、歯を失ったすべての人はそれぞれの幸せやQOL（生活の質）向上のため、信頼できる治療を求めて来院します。患者さんが自信や笑顔を取り戻すためには、緻密な術前プランニング、注意深い挿入手術、患者さん固有の補綴物の作製、そしてその後のフォローアップが必要です。

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デントスプライシロナ株式会社
本社／〒106-0041 東京都港区麻布台1-8-10 麻布僑成ビル Tel: 0120-461-868
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Nobel Biocare Japan K.K.
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140-0001, Japan
Tel:+81-3-6408-4207
E: den-nb-tyo-cosponsorship@nobelbiocare.com

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www.materialise.com/en/
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Washiesu Medical
2-31-8 Hongo
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Supporting Organizations & Institutions

The ADT appreciates the support of the following Regional Groups:

China ADT Regional Leadership Group
Japan ADT Regional Leadership Group
North America ADT Regional Leadership Group
Scandinavia ADT Regional Leadership Group
United Kingdom ADT Regional Leadership Group
L字鈎
G-220-25 L字鈎 長さ25mm (前歯部の手術など)
G-220-35 L字鈎 長さ35mm (インプラント手術など)
G-220-50 埋伏歯L字鈎 長さ50mm
G-222-50 埋伏歯L字鈎 先端1爪 長さ50mm
G-221-11 埋伏歯L字鈎 吸引管付 長さ50mm

G-220-60 L字鈎 長さ60mm 曲がり
G-220-70W L字鈎 口角ワイド 長さ70mm 最大巾35mm
G-220-50S L字鈎 先端ストレート 長さ50mm

有限会社フォーメディックス TEL03-5292-2455
Program Committee

DIRECTORS
Gerald T. Grant, Peter Evans, Dominic Eggbeer, David Côté, Chuanbin Guo, Ola Harrysson, Sylvie Testelin, Sabine Girod, Masayuki Takano, Rosemary Seelaus, Julien Davrou

ADVISORY PROGRAM COMMITTEE
Richard Bibb, David Cote, Julien Davrou, Dominic Eggbeer, Peter Evans, Tym Forouzanfar, Sabine Girod, Liam Grover, Gerald Grant, Chuan-Bin Guo, Ola Harrysson, Tomoki Itamiya, Tsuyoshi Kaneko, Pedro Martinez Seijas, Mika Salmi, Rosemary Seelaus, Robert M. Taft, Masayuki Takano, Yasutomo Yajima.

Conference Venue & Social Events

**CongresSquare Nihonbashi**
2F, 3F Tokyo Tatemono Nihonbashi Building
Nihonbashi 1-3-13, Chuo-ku, Tokyo, 1030027, Japan

**Inquiries:**
TEL: 03-3275-2090
FAX: 03-3275-2089

**Poster Session & Exhibit Reception**
**Thursday, June 20th (17:15-19:30)**
Join us for the opening event reception, viewing of poster presentations and networking with industry partners. Light appetizers and beverages will be served.
Cost: No cost to conference delegates (included in registration fees)

**Social Outing / Dinner at MEIJI-KINENKAN**
**Friday, June 21st (17:00-20:30)**
Join your colleagues for an evening of networking and experience the local food and entertainment at Meiji Kinenkan.
Cost: $150 USD/person
HONORARY CONFERENCE CHAIR & KEYNOTE SPEAKERS

Lawrence E. Brecht, DDS
New York, NY United States
Honorary Conference Chair

Takahiro Nozaki, PhD
Hiyoshi, Kohoku, Yokohama, Japan
Keynote Speaker

Liam M. Grover, BMedSc (Hons), PhD, FIMMM
Birmingham, United Kingdom
Keynote Speaker

INVITED SPEAKERS

Tadashi Akamatsu
Kanagawa, Japan
Invited Speaker

Claas Albers
Davos, Switzerland
Invited Speaker

Lee Alkureishi
Chicago, IL United States
Invited Speaker
INVITED SPEAKERS

Julien Davrou
Amiens, France
Invited Speaker

Dominic Eggbeer
Cardiff, Wales United Kingdom
Invited Speaker

Michael Grant
Baltimore, MD United States
Invited Speaker

Alex Greenberg
New York, NY United States
Invited Speaker

Tomoki Itamiya
Gamagori City, Aichi Japan
Invited Speaker

Toshinori Iwai
Yokohama, Japan
Invited Speaker

Tsuyoshi Kaneko
Tokyo, Japan
Invited Speaker

Takahiro Kanno
Izumo, Shimane, Japan
Invited Speaker

Hiromasa Kawana
Kanagawa, Japan
Invited Speaker
INVITED SPEAKERS

Lin Liu
Beijing, People’s Republic of China
Invited Speaker

Xiaojing Liu
Beijing, China
Invited Speaker

Marc Christian Metzger
Freiburg, Germany
Invited Speaker

Pravin Patel
Chicago, IL United States
Invited Speaker

Hadi Seikaly
Edmonton, Alberta, Canada
Invited Speaker

Rainer Schmelzeisen
Freiburg, Germany
Invited Speaker

Adrian Sugar
Morriston, Swansea, Wales
United Kingdom
Invited Speaker

Robert Taft
San Antonio, TX United States
Invited Speaker

Linpeng Zhao
Chicago, IL United States
Invited Speaker
### Conference Program Schedule

#### Wednesday, June 19th

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
</table>
| 13:30 - 17:30 | Pre-Conference Elective Workshop  
**Room: A1/A2**  
The Impact of Virtual Reality (VR) on CranioMaxillofacial Surgery: The Future is Here  
**Instructors:**  
Pravin K Patel MD, Lee Alkureishi MD, Jay Banerjee MBA, Linping Zhao PhD, Rosemary Seelaus MAMS, Christopher Micallef MD |

#### Thursday, June 20th

| Time       | Session 1- Moderators: M. Takano & G. Grant  
**Room: HALL C/D** |
|------------|------------------------------------------------|
| 09:00      | Keynote Speaker- Liam Grover:  
*Using Additive Layer Manufacturing to Enhance Functional and Biological Performance* |
| 09:30      | Invited Speaker- Pravin Patel: The Impact of Virtual Reality (VR) on CranioMaxillofacial Surgery: The Future is Here |
| 10:00      | Questions & Discussion |
| 10:15 - 10:45 | Exhibitor Break |

| Time       | Session 2: AUGMENTED REALITY & SIMULATION  
**Room: HALL D**  
**Moderators: T. Itamiya & R. Seelaus**  
|---|---|
| 13:30      | Invited Speaker- Tomoki Itamiya:  
*Practical use of Augmented Reality Smart Glasses in Oral and Maxillofacial Surgery: Tips & Pitfalls* |
| 13:50      | Rinde Johansson:  
*Haptic Virtual Fixtures to Guide Fibula Osteotomies in Mandible Reconstruction Surgery* |
| 14:00      | Keisuke Sugahara:  
*VR/MR Technology* |
| 14:10      | Gang Wu:  
*A Novel Osteoinductive Peptide* |
| 14:20      | Marco N Helder:  
*A Novel Photo-Crosslinkable, Tissue-Specific, Extracellular Matrix Bioink for Elastic Cartilage Bioprinting* |
| 14:30      | Invited Speaker- Julien Davrou:  
*The Role of Haptic Feedback in Virtual Simulation for Skills Training* |
| 15:00      | Questions & Discussion |

| Time       | Session 3: TISSUE ENGINEERING, BIOMATERIALS & 3D TECHNOLOGY  
**Room: HALL C**  
**Moderators: T. Iwai & TBD** |
|------------|------------------------------------------------|
| 13:30      | Invited Speaker- Toshinori Iwai:  
*Computer Assisted Oral and Maxillofacial Surgery* |
| 13:50      | Tymour Forouzanfar:  
*Maxillary Sinus Floor Elevation as a Model for Stem Cell Research* |
| 14:00      | Keisuke Sugahara:  
*VR/MR Technology* |
| 14:10      | Gang Wu:  
*A Novel Osteoinductive Peptide* |
| 14:20      | Marco N Helder:  
*A Novel Photo-Crosslinkable, Tissue-Specific, Extracellular Matrix Bioink for Elastic Cartilage Bioprinting* |
| 14:30      | Invited Speaker- Julien Davrou:  
*The Role of Haptic Feedback in Virtual Simulation for Skills Training* |
| 15:00      | Questions & Discussion |

| Time       | AUGMENTED REALITY & SIMULATION  
**Room: HALL D**  
**Moderators: A. Katakura & R. Taft** |
|------------|------------------------------------------------|
| 15:45      | Hyung Jun Kim:  
*Virtual Surgery to improve the Completeness of Mandibular Reconstruction* |
| 15:55      | Amir Abdi:  
*Deep Virtual Reconstruction of Mandibular Defects* |
| 16:05      | Invited Speaker- Linping Zhao:  
*Accuracy and Reproducibility of Measurements in State-of-Art Virtual Reality (VR) Environment: Validation* |

| Time       | TISSUE ENGINEERING, BIOMATERIALS & 3D TECHNOLOGY  
**Room: HALL C**  
**Moderators: K. Yamauchi & D. Eggbeer** |
|------------|------------------------------------------------|
| 15:45      | Lawrence Dovgalski:  
*Comparison of Commercially Available Surgical Planning Softwares* |
| 15:55      | Shilei Zhang:  
*3D Printing Customized Titanium Plates Associated with Surgical Navigation Guided Precise Correction of Complex Midfacial Post-Traumatic Deformities* |
| 16:05      | Invited Speaker- Adrian Sugar:  
*New Technologies and Planning Strategies for Treatment of Acute Complex Facial Fractures* |
16:25 | Invited Speaker- Lee Alkureishi: Virtual Reality in Surgical, Dental and Orthodontic Rehabilitation | Invited Speaker- Marc Metzger: Automatization and Modern Planning Strategies in CMF Trauma Cases
---
16:45 | Questions & Discussion | Questions & Discussion
17:00 | Session Adjourns | Poster Session & Exhibit Reception

### Friday, June 21st

08:45 | Opening Remarks | Moderators: T. Kanno & A. Sugar
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09:00 | Invited Speaker- Takahiro Kanno: Navigation- and Computer-Assisted Orbital Trauma Reconstruction | Invited Speaker- Lin Liu: Oral Health Data Analytics: Challenges and Possible Directions
09:20 | Invited Speaker- Rainer Schmelzeisen: Digital Technologies in Skull Base Surgery | Biao Li: Clinical Accuracy of Patient-Specific Implants in Genioplasty
09:30 | Jie Liang: Developing a Navigation System Based on Opti-Track System | Angela Ridwan-Pramana: The Faceprint Service
09:50 | Rie Osako: Feasibility of Navigation-Assisted Orbital Trauma Reconstruction in Pediatric Patients using u-HA/PLLA Sheet | Chao Huang: Preliminary Calculation and Simulation of Three-Dimensional Motion Trajectory of Mandibular Condyle Function Surface
10:00 | Questions & Discussion | Questions & Discussion
10:15 | Exhibitor Break | Moderators: T. Kobayashi & J. Davrou
11:05 | Xiaojing Liu: A Surgical Assisting Robotic System for Orthognathic Surgery | Fan Li: An Animal Experiment of a Custom-Made Tempromandibular Joint Condyle Prosthesis Replacement
11:15 | Satoe Okuma: Computer-Assisted Navigation Surgery for High Complexity Orbital Trauma reconstruction | Xiangliang Xu: Biomechanical Analysis of Contralateral Temporomandibular Joint (TMJ) with an Individually Designed Custom-Made TMJ Prosthesis
12:05 | Questions & Discussion | Questions & Discussion
12:20 | Conference Lunch | ADT Business Luncheon Meeting- ADT Foundation Members only
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17:15-19:30 | Poster Session & Exhibit Reception |
### Conference Program Schedule Continued

#### Session 6B: IMAGING TO DEVICES

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
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<tbody>
<tr>
<td>14:00</td>
<td>Invited Speaker - Robert Taft</td>
<td>Future of Digital Technologies in Medicine</td>
</tr>
<tr>
<td>14:20</td>
<td>Fumi Yoshioka</td>
<td>Novel Methodology for Fabricating Nasal Prostheses using 3D Facial Expression Models</td>
</tr>
<tr>
<td>14:30</td>
<td>Anne Marie Riedinger</td>
<td>Designing Innovative Facial Prostheses in the 3D World</td>
</tr>
<tr>
<td>14:40</td>
<td>Lindsay McHutchion</td>
<td>Simulation of Tissue-Prosthesis Margin Interface using Surface Scanning and Digital Design for Auricular Prostheses</td>
</tr>
<tr>
<td>14:50</td>
<td>Peter Evans</td>
<td>Immediate Temporary Prosthetic Rehabilitation using Pre-Operative CT Data</td>
</tr>
<tr>
<td>15:00</td>
<td>Rosemary Seelaus</td>
<td>Facial Prosthetics and Our Mobile Future</td>
</tr>
<tr>
<td>15:10</td>
<td>Invited Speaker - Tadashi Akamatsu</td>
<td>A Blinking Periorbital Prosthesis Using Surface Electromyographic Signals of the Orbicularis Oculi Muscle</td>
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<tr>
<td>15:30</td>
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<td>Questions &amp; Discussion</td>
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<tr>
<td>15:45</td>
<td></td>
<td>Session Adjourns</td>
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<tr>
<td>17:00</td>
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<td>Transportation Departs for Social Dinner</td>
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<tr>
<td>18:00</td>
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<td>Social Dinner</td>
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#### Saturday, June 22nd

#### Session 7: ADT OUTCOME MEASURES

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<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
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<tbody>
<tr>
<td>09:00</td>
<td>Invited Speaker - Marc Metzger</td>
<td>Automatization and Modern Planning Strategies in CMF Trauma Cases</td>
</tr>
<tr>
<td>09:30</td>
<td>Invited Speaker - Hadi Seikaly</td>
<td>The Cost Effectiveness of Occlusion-Driven and Digitally Based Jaw Reconstruction with Immediate Osseointegrated Implant Installation</td>
</tr>
<tr>
<td>10:00</td>
<td>Invited Speaker - Dominic Eggbeer</td>
<td>ADT Outcome Measures</td>
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<tr>
<td>10:30</td>
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<td>Coffee Break</td>
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<td>11:00</td>
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#### Moderators: Y. Kizu & C. Wallace

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
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<tbody>
<tr>
<td>11:00</td>
<td>Frank Leusink</td>
<td>Accuracy of Computer-Assisted Surgery in Mandibular Reconstruction: Multi-Center Validation of a Post-Operative Evaluation Guideline</td>
</tr>
<tr>
<td>11:15</td>
<td>Invited Speaker - Claas Albers</td>
<td>Technology Innovation in a Global Surgical Organization</td>
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<tr>
<td>11:35</td>
<td></td>
<td>Questions &amp; Discussion</td>
</tr>
<tr>
<td>11:50</td>
<td>Honorary Conference Chair - Lawrence Brecht</td>
<td>Meeting Summary Speaker</td>
</tr>
<tr>
<td>12:20</td>
<td></td>
<td>Announcements</td>
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<tr>
<td>12:30</td>
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<td>Meeting Adjourns</td>
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#### 13:30-17:30 Pre-Conference Elective Workshop

<table>
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<th>Time</th>
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<th>Room: A1/A2</th>
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<tr>
<td>13:30</td>
<td>Pre-Conference Elective Workshop</td>
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</table>

Instructors:
Pravin K Patel MD, Lee Alkureishi MD, Jay Banerjee MBA, Linping Zhao PhD, Rosemary Seelaus MAMS, Christopher Micallef MD
USING ADDITIVE LAYER MANUFACTURING TO ENHANCE FUNCTIONAL AND BIOLOGICAL PERFORMANCE

Liam M. Grover *
Professor
School of Chemical Engineering
University of Birmingham
Edgbaston, Birmingham, United Kingdom

In this talk, I will discuss how we are exploiting the capabilities that Additive Layer Manufacturing offer to allow us to structure orthopaedic and maxillofacial implants. We are currently exploring how we can structure implants using ALM to reduce imaging artefacts or introduce structural features that can be used to prevent or control infection. Furthermore, we have developed a novel method that allows for the additive manufacturing of complex cell-bearing structures, which may ultimately enable the better biological integration of implant materials.

Biography: Professor Liam Grover is a Professor in Biomaterials Science, Deputy Head of the School of Chemical Engineering and the Director of the Healthcare Technologies Institute at the University of Birmingham. Professor Grover has been at the University of Birmingham since 2006. Prior to this time he was a Skeletal Health Scholar at McGill University, Montreal. His group (www.TRAILab.net) focuses on the application of materials science and chemical engineering to the design of novel technologies for the regeneration of tissues. He is also interested in the fundamental science behind the mechanical performance of both ceramics and soft solids and how they may be influenced by physiological conditions.

His research has been funded by numerous funding agencies, including the UK research councils (EPSRC, BBSRC, MRC), the EU (FP6 and FP7), the regional development agency (AWM), the CIHR, the Furlong Charitable Foundation, the Malaysian Government, the NSF (China), Smith and Nephew, Boots, and JRI.

He has published more than 150 full peer reviewed papers, 20 extended conference papers, more than 70 reviewed conference abstracts, three book chapters and has filed seven patent applications. His work has been cited on more than 3500 occasions. He is also serving on the editorial board of Scientific Reports, Journal of Biomaterials Applications, Advances in Applied Ceramics and have guest edited two special editions of the journal. His work has been featured in Nature Materials, Materials World, and on the BBC. In addition, He is a Fellow of the IOM3 and have given more than fifty invited talks internationally, and maintains active collaborations with the University of Wuerzburg, McGill University, UC Davis, Central South University (China), Scuola Superiore Santa Anna (Pisa), and the Italian Institute of Technology.

THE IMPACT OF VIRTUAL REALITY (VR) ON CRANIOMAXILLOFACIAL SURGERY: THE FUTURE IS HERE

Pravin K Patel MD*; Lee Alkureishi MD, Jay Banerjee MBA, Linping Zhao PhD, Rosemary Seelaus MAMS, Christopher Micallef MD
Craniofacial Center, UIC
Industrial Engineering and Design
UIC and Immersive Technologies

For nearly half-a-century, reconstructing patients with craniofacial deformities has relied primarily on two-dimensional photographic images and radiographs. It was the surgeon’s eye and experience that integrated the two-dimensional records to generate the virtual three-dimensional image for surgical planning. In the last decade of the twentieth century, multi-dimensional visualization of the skeletal deformity became possible with the emergence of computerized tomography (CT). This allowed the surgeon the ability to visualize the complexity of the deformity but not the ability to simulate surgery. It is only within the last several years that rapid advances in computational software began to transform the pure visual imagery of CT to allow the surgical simulation to become a reality. Today surgeons and orthodontists are beginning to have the tools to simulate orthodontic movement, various craniofacial skeletal osteotomy patterns and the ability to manipulate each of the bony elements. However, the limitation of true simulation has always been the inability to fully visualize the third dimension on two-dimensional flat screen displays. Thus, surgeons relied on 3D printed models for tactile feedback and to visualize depth. With the recent introduction of immersive virtual reality (VR), augmented reality (AR) and haptic feedback (HF), true three-dimensional surgical simulation becomes a possibility.
This presentation will review currently accessible technology for the practicing surgeon and dentist through a series of cases studies for patients who required various components of craniofacial surgery. This will include pre- and post-processing of diagnostic 3D surface and skeletal records; integrated orthodontic-surgical planning, 3D relevant software for both orthodontic and skeletal manipulation, translation from virtual to physical environment with CAD/CAM 3D printed models and guides. This presentation will also showcase the technology of the future where resident training and patient-specific planning for the surgeon will be done in an immersive VR environment that will closely simulate the operating theater.

**Biography:** Dr. Pravin K. Patel, is Professor of Surgery and Chief of Craniofacial Surgery at University of Illinois, Chicago. For more than a quarter of a century he has been caring for children with cleft and craniofacial conditions. Dr. Patel studied quantum electrodynamics and differential topology at Johns Hopkins University, worked for IBM in laser optics and graduate studies in physics at Brown University. Dr. Patel received his medical training at Drexel University Hahnemann Medical School, his general surgical training at the Mayo Clinic, research and clinical fellowships in plastic surgery at the University of Chicago and at Northwestern University, followed by a fellowship in craniofacial surgery at the University of California at Los Angeles. With a background in electrical engineering and computer science, Dr. Patel’s interest has been the development and application of digital technology to Cranio-Maxillofacial surgery.

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**INNOVATION OF MICROSURGERY REALIZED BY ADVANCED DIGITAL TECHNOLOGY**

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Skillful doctors can perform complex and delicate tasks by dexterous and adaptive procedures. The key point making this possible is tactile sensation. This speech explains how important the tactile information is and introduces the world’s most advanced haptic technology referred to as “real-haptics” developed in our research team. Furthermore, innovations of microsurgery brought by the real-haptics will be shown with actual examples.

**Biography:** Dr. Takahiro Nozaki received the B.E. degree in system design engineering and the M.E. and Ph.D. degrees in integrated design engineering from Keio University, Yokohama, Japan, in 2010, 2012, and 2014, respectively. He was with Yokohama National University, Yokohama, Japan, from 2014 to 2015 as a Research Associate. He is currently with Keio University as an Assistant Professor, and also with the Kanagawa institute of Industrial Science and Technology, Japan, as a Researcher. He is engaged in the practical application of tactile technology referred to as “real-haptics”. His activities are featured in Nature, Forbes, and IEEE SPECTRUM.
A SURGICAL ASSISTING ROBOTIC SYSTEM FOR ORTHORGNATHIC SURGERY

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Background: The key procedure of orthognathic surgery is the reposition of mandibular-maxilla complex (MMC), which mainly depends on double or single template technique now a days. However, Condyle flexibility, errors of model surgery and unrealized bony contact during surgery will decrease the accuracy in realization of preoperative design and thus cause dissatisfactory from patients. The object of this study is to develop surgical assisting robotic system which help doctors hold and reposition the MMC, visualize its final position and detect bony contact. Another object is to validate its accuracy and feasibility for clinical application.

Methods: The robotic system contains preoperative design system, a motion capture system and a 6-DOF robotic arm. The validation test were performed using 6 3D printed skull models. 20 Rigid reference points were applied on each model by titanium screws. Corn beam CT (CBCT) scan was acquired and DICOM data was transferred into virtual designed system developed by our team. Data processing include segmentation, 3D reconstruction, virtual osteotomy of BSSRO and Le-Fort I. Final positions of MMC was decided considering movement along horizontal, sagittal and vertical axis and pitch roll yaw rotation. During the test, the model skull was registered into the navigation system using a set of registration frame. The registration accuracy was tested by observing the distance between a predicted coordinate base and the actual coordinate after matrix transformation. The MMC was repositioned by robotic arm following the preoperative virtual design. A postoperative CBCT scan was acquired after reposition of MMC. The reposition accuracy was tested by the comparison of MMC area on virtual design and postoperative CT scan.

Results: The feasibility of this robotic surgery system was proved with a high accuracy test result of both robotic and navigation parts. The error of navigation was less than 1 mm, and the systemic error including navigation and reposition was less than 1.5 mm.

Conclusion: Surgical assisting robotic system is useful for MMC reposition in orthognathic surgery. Further phantom test needs to be performed to give an overall accuracy of the system.

Biography: Dr. Xiao-jing Liu Associate chief physician; Dean of Laser and Plastic center, Department of Oral and Maxillofacial Surgery, Peking University School of Stomatology, Beijing, China. Appointments: Member of Chinese Society of Digital Stomatology, Member of Chinese Society of Vascular Malformation, Member of Chinese Society of Plastic and Reconstruction Surgery, Member of Digital Advanced Technologies in Head and Neck Reconstruction. Research interests and Publications: Clinical Major interests include craniofacial surgery, orthognathic surgery, medical cosmetic and laser treatment. Major interests in research work include computer assisting surgical simulation, mixed virtual visual for skeleton and soft issue in head and neck region and surgical assisting robotic system.
PRACTICAL USE OF AUGMENTED REALITY SMART GLASSES IN ORAL AND MAXILLOFACIAL SURGERY: TIPS & PITFALLS

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Using transparent smart glasses is very useful for surgical navigation because a surgeon does not need to move his/her line of sight from the operative field. We propose a new software development method that is able to show a stereoscopic vision of highly precise 3D-CG medical models and 3D-CG surgical instruments using transparent smart glasses for surgical navigation. We use Mixed Reality smart glasses Microsoft ® HoloLens™. Once a 3D-CG medical model is placed in an environment, it is fixed to the place and does not move on its own. A 3D-CG medical model and 3D-CG surgical instruments can be displayed simultaneously in the operative field. The movement of 3D-CG surgical instruments can be linked with actual surgical instruments. The 3D-CG medical model made from an actual patient’s CT/MRI image data is superimposed on the actual patient position using a cubic marker with a QR code. Multiple persons can see one 3D-CG model at the same time using multiple HoloLens. A user can make the software within only 10 minutes by preparing an STL file using our method. Therefore, a surgeon and dentist and clinical staff can make the content easily by oneself. As a result, the method can be utilized daily for routine medical treatment and education. Some Cranio-maxillofacial surgeons are using our method for his daily operation, for instance, Zygomatic bone fracture and mandibular cysts sequestrectomy. The accuracy of registration between the 3D-CG medical model and the surgical field is about 1 mm. However, the accuracy of the alignment between the surgical field and 3D-CG still have some issues. The position of the marker placed in the operative field needs to find the optimal position according to the case. It is also effective to attach a marker to the mouthpiece where the patient bites. It is necessary to take measures because the brightness of the operating light affects the recognition of the marker. Although the field of view angle of the HoloLens is insufficient, it will be doubled in the next version HoloLens 2, making it more practical.

Biography: Prof. Tomoki Itamiya graduated from Keio University, Kanagawa, Japan in 2004 and received the Master of Media and Governance degree and the Ph.D. in Media and Governance both from Keio University, Kanagawa, Japan in 2006 and 2010. He worked at School of Design, Tokyo University of Technology, Tokyo, Japan as an assistant professor from 2010 to 2014. He is an associate professor of School of Engineering, Aichi University of Technology, Gamagori, Japan from 2014 to 2018 and became a full professor in 2018. He is a visiting academic of institute for Reconstructive Sciences in Medicine (iRSM), Misericordia Community Hospital, University of Alberta, Edmonton, Canada from 2012. He is researching applications of Virtual Reality and Augmented Reality for surgical navigation and training. He is collaborating with multiple surgeons and dentists to advance the clinical application of smart glasses. He is also developing the software by himself.
HAPTIC VIRTUAL FIXTURES TO GUIDE FIBULA OSTEOTOMIES IN MANDIBLE RECONSTRUCTION SURGERY

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Keywords: Robotics, Surgery, Fibula

Purpose/Aim: The purpose of this study is to explore the possibility of using haptic virtual fixtures as an alternative to rapid-prototyped surgical templates to guide fibula osteotomies for mandible reconstruction surgery. Head and neck surgeons performing fibula mandibular reconstruction currently use rapid-prototyped surgical templates to transfer the surgical plan from a computer into the operating room. Rapid-prototyped cutting/drilling guides that are fabricated preoperatively based on CT image data significantly improve functional outcomes. Unfortunately, creating rapid prototyped models and templates for surgery is a time-consuming, logistics-intensive, and inflexible process. Haptic virtual fixtures would allow the surgery to be re-planned or adjusted without the need to fabricate new cutting, drilling and reconstruction guides. Unlike rapid prototyped guides, haptic virtual fixtures could lead to time and cost savings due to the elimination of the need for printing and sterilization of rapid prototyped surgical guides. The objective of this study is to evaluate the accuracy of haptic virtual fixtures in assisting participants to perform fibula osteotomies for mandible reconstruction.

Materials and Methods: Ten participants used a haptics-enabled robotic system and a digital surgical cutting plan programmed as a haptic virtual fixture to complete eight fibula osteotomies on rapid-prototyped fibula models, creating four fibula segments each. Each participant completed the fibula osteotomies using the same rapid-prototyped fibula model, surgical plan, haptic virtual fixtures, and robotic system. The fibula segments created by the participants were collected and measured using digital calipers.

Results: The longest and shortest length of each fibula segment were recorded. The recorded lengths were analyzed using mixed effects models. The residual error was 3.7 mm, reflecting the efficacy of the haptic system to guide participants to complete fibula osteotomies accurately. The standard deviation between random intercepts was 2.0 mm, indicating the variability between participants.

Conclusions: Haptic virtual fixtures show potential to guide fibula osteotomies. The haptic robotic system and virtual fixtures developed for this study were suitable tools to support the surgical saw, access and register the fibula to the haptic robotic system, and guide the user to the position of the fibula segmenting planes. The accuracy of the system is not yet sufficient for clinical use; however, this is a first step towards guiding fibula osteotomies using haptic virtual fixtures. This study showed the feasibility of the proposed idea through proof-of-concept experimentation. Future work will focus on improving tactile feedback and registration accuracy to work towards clinical adoption.
THE ROLE OF HAPTIC FEEDBACK IN VIRTUAL SIMULATION FOR SKILLS TRAINING

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Purpose: At the age of neural networks and deep learning, the complexity of the learning processes in human has to be addressed with fresh concepts. In order to obtain the best retention of information possible, a medical trainee has to activate multiple channels of data including his own basic fundamental knowledge in combination with visual, perceptual, kinesthetic, hearing, and emotional inputs. There is a widespread recognition that the traditional system of skill development in front of the patient, and in the operating room, is no longer adequate. The simulation of medical scenario, serious games, and virtual reality environments, becomes capable to transcribe different modalities of interaction, and to create with various senses of immersion and degrees of distractors, the conditions for a student to acquire specific and technical skills. These learning modalities are also excellent tools for objective student assessment and task analysis. Some of the reasons why simulation-based training programs, which were initially only "add-ons" to traditional surgical training, are more and more incorporated into curricula, such as for laparoscopic surgery certification for example.

Materials and Methods: It needs multiple surgery to correct mandible body’s asymmetry. We have published a modified methods of proximal segment alignment after sagittal split ramus osteotomy – intentionally flared out the proximal segment on mandible’s hypoplastic side after the distal segment was rotationally set back, with the help of computer-aided surgical simulation. To better evaluate the effect of this procedure, we used 3dMD (3 months and 6 months post-surgery) and computer-aided surgical simulation system to study the outcome of our modified surgery retrospectively. 21 patients, who undergo the modified surgery, were included. Patients’ 3dMD and CT were used to measure the distances between mandible body and facial mid-line.

Conclusion: Most physicians believe that a simulator that looks like real patient anatomy is a good simulator. This is not a believe we hold to.

Biography: Julien Davrou currently works as a surgeon at the Cranio-Maxillo-Facial Surgery Department, Pitié-Salpêtrière University Hospital of Paris (head. Prof. Chloé Bertolus). Julien does research in Maxillo-Facial and Facial Plastic Reconstructive Surgery. He is also currently involved as PhD Student in the development of a new platform that includes 3D virtual reality scenarios and double-robotic arms haptic feedback to be used in surgical education (CEA LIST/Facing Faces Institute/SimUSanté).
VIRTUAL SURGERY TO IMPROVE THE COMPLETENESS OF MANDIBULAR RECONSTRUCTION

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Case Presentation: Virtual surgical planning by using CT data to reconstruct a wide range of defects of the mandible caused by tumor resection has long been used. It is well known that the advantages of this procedure are increased accuracy of reconstruction and shortening of operation time. However, in order to complete the dental rehabilitation following mandibular reconstruction more effectively, the benefits of having a dental implant plan considering maxillo-mandibular relationship should not be overlooked. In this lecture, we will introduce the virtual surgical procedure of tumor resection, mandibular reconstruction, prosthetic restoration using dental implants, which is performed in Yonsei Oral and Maxillofacial Surgery. Including the result of prototype navigation surgery which is experimentally conducted to increase the accuracy of virtual surgery, we would like to propose how to solve the problems we met during navigation surgery.

DEEP VIRTUAL RECONSTRUCTION OF MANDIBULAR DEFECTS

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Keywords: reconstructive surgery, shape modeling, deep learning

Purpose/Aim: In reconstructive mandibular surgery, the bony geometry, as well as the function of the masticatory system, need to be restored. Recent developments in three-dimensional (3D) imaging and computer-aided design and manufacturing (CAD/CAM) have enabled computer-assisted guidance for assessment and treatment planning in surgical interventions. Despite these advances, segmental mandibular reconstruction remains challenging when the normal pre-morbid mandibular form is unknown. This can be a consequence of either the disease process or its treatment and complicates surgical planning both in reconstructive surgeries and scaffold design for tissue engineering.

Materials and Methods: We are proposing a machine learning approach towards estimating the original shape of the mandible from its partial unaffected representation. In this approach, we created a synthetic dataset of defected mandibles from a set of healthy bones by randomly removing different bone segments. A 3D convolutional deep learning model was then trained on this dataset to reconstruct the original shape before the virtual bone removal. We then tested the model on a separate independent validation set which had gone through the same virtual bone removal. The final reconstructions on the validation set were evaluated based on the similarity of the reconstructed bone to the original healthy bone. The algorithm was also tested on clinical patients whose mandibles were virtually reshaped as part of the virtual surgical planning based on the cutting planes decided by the surgical team. These reconstructions were analyzed qualitatively based on expert's assessment.

Results: A total of 103 healthy mandibles were collected and split into 75%-25% subsets for training and validation. Mandibular surface meshes were coregistered using group-wise student's-t mixture algorithm. A deep auto-encoding model was trained to reconstruct the shapes from their incomplete representations. The preliminary results show that a deep 3D convolutional neural network is able to generate mandibles of different shapes and sizes.

Conclusions: This study confirms the applicability of machine learning approaches in the estimation of mandibular shapes from partial observations. This is a step towards a more digitized workflow for virtual reconstruction of mandibular defects.
ACCURACY AND REPRODUCIBILITY OF MEASUREMENTS IN STATE-OF-ART VR ENVIRONMENTS: VALIDATION
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Keywords: Validation, Virtual Reality, Linear and angular measurements, Accuracy, Reproducibility, Equivalency

Objectives: State of art virtual reality (VR) environments are capable of presenting three-dimensional medical images such as computed tomography (CT), computed tomography angiography (CTA) and cone beam computed tomography (CBCT) scans to users with a high degree of versatility and flexibility in an immersive, interactive and highly controlled fashion. Such enhanced 3D visualization empowers clinicians to study patient specific anatomy with details. The built-in linear and angular measurement tools provide essentially virtual measurements and thus assist quantified analysis during such exploration. However, validation of the accuracy and reproducibility of such virtual measurements is still lacking. This presentation will review a series of validation studies we recently conducted at both The Craniofacial Center, UIC and Shriners Hospitals for Children-Chicago. The hypotheses to be tested are: (1) the virtual linear and angular measurements are equivalent to the physical measurements in terms of accuracy, and (2) the reproducibility of virtual measurement is statistically high and equivalent to that of physical measurements.

Materials and Methodology: A set of representative objects with fiducial markers was used for physical measurements, and their CT and CBCT scans were used for virtual measurements. Their comparison was conducted statistically in a systematic fashion. The effects of objects, raters, and rater background were investigated using a general linear model (GLM).

Results: Paired t-test between virtual and physical measurements yielded p-values larger than 0.05, which suggests that the equivalence between the virtual measurements and the physical measurements cannot be rejected. Bland-Altman plots revealed a high level of agreement between virtual and physical measurements. Further, Two One Sided t-tests (TOST) of equivalence shows that both linear and angular measurements in virtual environments are within a pre-defined range, which provides an estimate to the accuracy of VR measurements. Reproducibility in both physical and virtual measurements were high as evidenced by an ICC of approximately 1 and 0.99 for linear and angular measurements, respectively. The effects of objects, raters and rater background are insignificant.

Conclusion: Linear and angular measurement made within these two VR environments are equivalent to those made physically.

Biography: Dr. Linping Zhao is a Senior Research Specialist and Biomedical Engineer at Shriners Hospitals for Children –Chicago, and a Research Assistant Professor at Department of Surgery, Division of Plastic, Reconstructive and Cosmetic Surgery, University of Illinois Medical School. He serves as the Director of Research, The Craniofacial Center, UI Health. Dr. Zhao received his BS Eng and MS Eng in Material Processing from University of Science and Technology Beijing (USTB), China, and PhD in Mechanical and Industrial Engineering from Marquette University, United States. He further trained in craniomaxillofacial reconstructive surgery specializing in computer aided surgical simulation and planning. For the past two decades, he has dedicated his work to bridging the state-of-art technology of computer aided design and crani-maxillofacial surgery. His efforts focus primarily on the development and application of computer assisted surgical and treatment simulation and planning, while his research interest extends from biomechanics and biomaterials to digital data acquisition, medical image analysis, modeling and simulation, additive manufacturing (including 3D printing), virtual/augmented reality (VR/AR), machine learning. Working closely with a group of plastic surgeons, Dr. Zhao has been contributing to lab development, patient care, student education and training. He is author and co-author of a number of peer-reviewed journal articles, book and book chapters, and presentations. He is a member of several professional organizations and currently serves as Education Committee member of American Cleft Palate-Craniofacial Association (ACPA).
VIRTUAL REALITY IN SURGICAL, DENTAL AND ORTHODONTIC REHABILITATION

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Introduction: The ability to visualize 3-dimensional imagery within a completely immersive virtual reality (VR) environment is not a new concept, with roots in the mid 20th century. VR has found application in many arenas ranging from 3D gaming and cinema to education and training, astronautical and military. To date, VR use within the medical field has been relatively limited by comparison. With recent advances in hardware and software capabilities, it is now feasible to leverage the myriad benefits of VR visualization with respect to true 3D surgical planning and simulation, dental and orthodontic treatment planning, patient education, and medical/dental education.

Material and Methods: Patient-specific imaging data is imported from standard DICOM images into a volume comprising a grid of scalar values in 3D space. The reconstructed 3D-VR volume is rendered by the graphics processing unit (GPU) to a head-mounted display with ultrafine resolution, rapid framerate and minimal latency. Changes made to rendered volumes are updated in real-time and reflected immediately on the 3D rendering. Discrete anatomical structures can be identified and segmented from source CT/CBCT data, and each segmentation can be converted into a polygon mesh. Meshes and segmented structures can be manipulated, allowing the surgeon to cut, move or otherwise manipulate the models to achieve the desired goal. Normative data or standardized models from a library can be overlaid as needed, providing guidance for reconstruction or rehabilitation.

Results: Virtual-reality based surgical planning has been used in our institution for all orthognathic, craniofacial and trauma cases over a 12 month period. This presentation will present our experience with the technique and its many benefits over more traditional surgical planning modalities. We will focus on complex facial reconstruction, maxillary and mandibular bony reconstruction, integrated orthodontic-skeletal manipulation, osseointegrated implant planning, and translation from the VR space to physical models, guides and surgical aides for the operating room.

Discussion: The immersive VR environment provides the surgeon with the ability to plan complex surgical cases with a high level of precision and efficiency, while also providing an ideal setting for resident and student education and patient engagement.

Biography: Lee Alkureishi, M.D., was born and raised in Scotland, where he completed his early medical training at the University of Glasgow. He completed his residency in plastic surgery at the University of Chicago, followed by a pediatric and craniofacial surgery fellowship at NorthShore University Health System and Shriners Hospitals for Children — Chicago. He practices at Shriners Hospitals for Children – Chicago and the University of Illinois at Chicago. His areas of interest include cleft lip and palate, orthognathic (jaw) surgery, ear reconstruction and otoplasty, and microsurgery. His training includes extensive experience in free tissue transfer, burn reconstruction and scar revision, and tissue expansion for congenital defects. He is a member of the American Cleft Palate Association, American Society of Maxillofacial Surgeons, and the American Society of Plastic Surgeons.
SESSION 3
TISSUE ENGINEERING, BIOMATERIALS & 3D TECHNOLOGY

COMPUTER ASSISTED ORAL AND MAXILLOFACIAL SURGERY
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Recently, computer assisted surgery has been applied in oral and maxillofacial surgery. Some simulation software such as Dolphin 3D surgery (Dolphin Imaging & Management Solutions) and PROPLAN CMF (Materialise) can allow three-dimensional (3D) hard and soft tissue simulation including evaluation of bony interferences and correction of asymmetry. Navigation surgery enables accurate and safe surgery for facial asymmetry in patients with maxillofacial fracture or fibrous dysplasia. Occlusal splint with references can allow mandibular navigation surgery. Additionally, 3D printer can provide surgical guide and wafer as well as 3D skeletal model after preoperative planning (virtual osteotomy and repositioning of bony segment). In this lecture, I present computer assisted oral and maxillofacial surgery in Yokohama City University Hospital.

Biography: Dr. Toshinori Iwai is an oral and maxillofacial surgeon and clinical assistant professor, and has about 130 publications of international journals. My interest fields are computer assisted surgery and minimally invasive surgery in oral and maxillofacial region, such as endoscopic and navigation surgery.

MAXILLARY SINUS FLOOR ELEVATION AS A MODEL FOR STEM CELL RESEARCH
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Keywords: maxillary sinus floor elevation, stromal vascular fraction

Purpose/Aim: In patients undergoing maxillary sinus floor elevation (MSFE) for dental implant placement, bone substitutes are currently evaluated as alternatives for autologous bone. However, bone substitutes have only osteoconductive properties and lack osteoinductive potential. Therefore, this phase I study evaluated the potential additive effect on bone regeneration by the addition of freshly isolated, autologous but heterologous stromal vascular fraction (SVF), which is highly enriched with adipose stromal/stem cells when compared with native adipose tissue

Materials and Methods: From 10 patients, SVF was procured using automatic processing, seeded on either β-tricalcium phosphate (n = 5) or biphasic calcium phosphate carriers (n = 5), and used for MSFE in a one-step surgical procedure. Primary objectives were feasibility and safety. The secondary objective was efficacy, evaluated by using biopsies of the augmented area taken 6 months postoperatively, concomitant with dental implant placement. Biopsies were assessed for bone, graft, and osteoid volumes

Results: No adverse effects were reported during the procedure or follow-up (>3 years). Bone and osteoid percentages were higher in study biopsies (SVF supplemented) than in control biopsies (ceramic only on contralateral side), in particular in β-tricalcium phosphate-treated patients. Paired analysis on the six bilaterally treated patients revealed markedly higher bone and osteoid volumes using microcomputed tomography or histomorphometric evaluations, demonstrating an additive effect of SVF supplementation, independent of the bone substitute

Conclusions: This study demonstrated for the first time the feasibility, safety, and potential efficacy of SVF seeded on bone substitutes for MSFE, providing the first step toward a novel treatment concept that might offer broad potential for SVF-based regenerative medicine applications.
A NOVEL OSTEOINDUCTIVE PEPTIDE

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Keywords: transforming growth factor-beta (TGF-β), bone morphogenetic proteins (BMPs), osteoinductivity

Purpose/Aim: The repair of large-volume bone defects is still challenging in the fields of orthopedics and oral and maxillofacial surgery. Osteoinductive proteineous growth factors, such as bone morphogenetic proteins (BMPs) and transforming growth factor-beta (TGF-β), are widely applied due to their osteoinductivity - a unique capacity to induce de novo bone formation even in non-osseous microenvironments. However, the application of these proteineous growth factors is also limited due to their high cost, low yielding rate and potential biological contamination during production. As a viable alternative to growth factors, bioactive peptides can be efficiently synthesized chemically with much lower cost, higher yielding rate and no risk of biological contamination. In this study, we designed and developed a novel TGF-β3-derived peptide with a strong osteoinductivity.

Materials and Methods: By analyzing the crystallographic structure of TGF-β3, we made 9 different peptides containing the amino acid sequence of the extracellular ligand-binding domain of TGF-β3 in complex with human TGF-β3 type II receptor. We screened the 9 peptides by testing their effects on the metabolic activity, osteogenic differentiation of bone marrow mesenchymal stem cells (BMSCs) using TGF-β3 and BMP-2 as positive controls. We adopted western blot and real-time polymerase chain reaction to analyze the signaling pathways of the novel peptide. An intramuscular ectopic bone induction model was adopted to test their osteoinductivity and an orthopedic calvarial bone defect (5-mm in diameter) was adopted to test their bone-defect-healing capacity.

Results: All the nine peptides showed no toxicity to BMSCs compared to negative control (no peptide or growth factors). No.4 peptide showed a very strong capacity to enhance in-vitro cell matrix mineralization, which was even superior to BMP-2. The No.4 peptide significantly enhanced the phosphorylation of Smad1/5 and JNK. In vivo results showed that only No.4 peptide, BMP-2 and TGF-β3 showed a capacity to induce de novo bone formation in the intramuscular ectopic bone induction model. The healing capacity of this peptide was similar to BMP-2 and TGF-β3 in the orthopedic calvarial bone defects.

Conclusions: This novel peptide bore a strong osteoinductivity as BMP-2, which is highly promising for clinical application to treat large-volume bone defects.
A NOVEL PHOTO-CROSSLINKABLE, TISSUE-SPECIFIC, EXTRACELLULAR MATRIX BIOINK FOR ELASTIC CARTILAGE BIOPRINTING

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Purpose/Aim: Clinical reconstruction of a severely deformed ear is a very challenging surgical procedure with high donor site morbidity. Bioprinting technology could be used to develop patient-specific cartilage grafts for clinical ear reconstruction. The objective of this study was to develop a photo-crosslinkable tissue-specific bioink from decellularized xenogeneic cartilage for ear cartilage bioprinting. We hypothesized that this cartilage-specific bioink provides tissue-specific molecular, structural, and mechanical signals to regulate chondrocyte cell behavior and cartilage tissue formation.

Materials and Methods: To develop a cartilage-specific bioink, we first decellularized elastic cartilage powder from porcine ears using Triton X-100, DNase, and multiple washing steps. The composition of this powder was then analyzed using a proteomic approach, DNA analysis, and label-free multiphoton laser scanning microscopy. The decellularized cartilage powder was subsequently solubilized using pepsin and processed into a photo-crosslinkable bioink by reaction with a methacrylic anhydride to form decellularized cartilage extracellular matrix – methacrylate (cdECMMA) bioink. Both the printability and rheological properties of the cdECMMA bioink were assessed, as well as biocompatibility and chondrogenic capacity. Gelatin methacrylate (GelMA) served as control bioink.

Results: Decellularized ECM derived from pig ear cartilage was methacylated (Fig. 1a). Compared to native elastic cartilage, decellularized cartilage contained approximately 50% of the total identified protein hits (427 ± 129 for decellularized versus 1063 ± 54 for native cartilage), while containing a higher percentage of proteins related to the ECM. Double-stranded DNA content was significantly lower (p<0.05) in decellularized cartilage (9.4 ± 0.8 ng/mg versus 142.5 ± 6.0 ng/mg) and analysis of collagen bundles revealed no difference in second harmonic generation signal. After the printing process, cdECMMA showed higher cell viability when compared with GelMA (95% versus 86%, p<0.05) (Fig. 1b) The compression modulus of cdECMMA was significantly higher than that of GelMA (10.4 ± 1.3 kPa versus 0.4 ± 0.04 kPa; p<0.05). The printability of cdECMMA bioink was tested (Fig. 1c). Histological analyses for neocartilage formation using primary rabbit auricular chondrocytes are currently being performed.

Conclusions: We successfully developed a novel photo-crosslinkable auricular cartilage-specific ECM bioink. The results show that decellularized cartilage tissue may be processed into a suitable bioink for bioprinting of elastic cartilage that favors cell survival and mechanical properties, while also attaining chondrogenic capacity. Long-term in vivo studies are required to determine the clinical applicability of this bioink.

Figure 1. Development of decellularized cartilage extracellular matrix – methacrylate (cdECMMA) bioink: (a) Entire process for cdECMMA bioink, (b) live/dead staining assay of cdECMMA with different concentrations. (c) Printed construct using cdECMMA.
SIMULATIONS OF BONE RECOVERY AFTER DISUSE: THE ROLE OF OSTEOCYTE VIABILITY

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Keywords: Osteocyte viability, Bone remodeling, Osteoporosis

Purpose/Aim: Bone loss in gravitational unloading has been recognized as an important physiological problem affecting astronauts’ health in long-term space flight. The averaged 1–1.5% bone loss per month in crew members is almost equivalent to the loss per year in post-menopausal women. More seriously, load-bearing bone especially in trabecular sites fails to recover to its pre-flight value upon return to earth. Bone remodeling is believed to be regulated by osteocytes, former osteoblasts that have been buried in bone matrix. Osteocytes, as professional mechanosensors of bone, respond to strains with biochemical signals to inform osteoclasts for resorption or osteoblasts for deposition on trabecular surface. Mechanical loading at a physiological level is necessary for maintaining osteocyte viability. Unloading results in decreased osteocyte viability and enhances osteocyte apoptosis, while overloading induces microcracks in bone, which also causes osteocyte apoptosis. This biological phenomenon is known as osteocyte’s U-shaped survival response to mechanical loading. In this study, we developed an osteocyte-viability-based trabecular bone remodeling (OVBR) model and simulated bone loss and microstructural deterioration in microgravity and subsequent bone recovery in reloading.

Materials and Methods: Three femoral neck and three vertebral trabecular bone samples were used to do remodeling simulations. Six voxel-based micro finite element models were directly generated from µCT data by converting each voxel to an eight-node brick element. An element-by-element and preconditioned conjugate gradient algorithm was applied to do the parallel finite element analysis for calculating strain, stress, and strain energy density of each voxel in trabecular bone. The so-called individual trabecula segmentation (ITS) technique was applied to calculate the morphological parameters characterizing the microstructural change of trabecular bone. 10% of physiological forces were assumed as the forces in microgravity. Bone mass density and trabecular morphological parameters were analyzed in disuse and subsequent reloading.

Results: Unloading had dramatic effect on bone mass and microstructures, characterized by severely reduced trabecular thickness and loss of trabeculae. The amount of bone loss and microstructural deterioration correlated with the magnitude of unloading. Bone loss mainly occurred in trabecular plates, which made osteoporotic bone more rod-like. The restoration of bone upon the reloading was achieved by thickening the remaining trabecular architecture, while the lost trabecular plates and rods could not be recovered by reloading. Although the reloading force induces bone recovery, it may also cause overloading-induced resorption, leading to even more microstructural deterioration.

Conclusions: In this study, a novel 3D bone remodeling model was developed that considers osteocyte’s U-shaped survival property. It can simulate bone loss and microstructural deterioration in gravitational unloading and subsequent recovery by reloading. The OVBR model might be translated to clinical applications for quantitative prediction of bone loss during long-term bed rest or space flight as well as bone recovery after return to normal activity.
AUTOMATIZATION AND MODERN PLANNING STRATEGIES IN CMF TRAUMA CASES

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As a principle, ideas and visions constantly become real after a period of time. Affected by an incredible fast moving evolution within the digital world quantum jumps can be recorded in all kind of technologies. Internet communication offers a fast immeasurable platform bundling and designing knowledge in a self-learning process moving in an exponential spiral. One consequence at the moment is that software itself more and more is moved in server based internet application presenting better computer performance than the own PC. Even all web-based plugins for browsers will soon appear as Stone Age. A wonderful level of diagnostic and planning tools in the medical world already exist. An increasing number of production technologies such as titanium laser melting procedures are going to determine new treatment standards. However, the interexchange and the communication are still located in the analog era. In this presentation we intend to demonstrate ideas and visions to solve this problem.

Biography: Since 2004 he is attending the cranio-maxillofacial department Freiburg. In 2010 he finished his PhD in “Shape analysis of anatomical structures and development of preformed plates”. Since 2016 he is vice chairman of the CMF department in Freiburg, Germany.

COMPARISON OF COMMERCIALLY AVAILABLE SURGICAL PLANNING SOFTWARES

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Keywords: digital, surgical, planning

Purpose/Aim: The digital planning of maxillofacial surgery procedures such as bony free flaps and mandibular/maxillary osteotomies is now an accepted technique and could be regarded as routine/essential to achieve the optimal result for the patient.

Materials and Methods: We compare two of the most widely used commercially available software packages for craniofacial surgical planning; IPS Case Designer ® (KLS Martin) and ProPlan CMF ® (Materialise NV).

Results: Comparisons are made in regards to ease of use, thresholding, suitability for simple and complex cases, cost and guide production using 6 case studies. Bilateral Sagittal Split, Le Fort 1, Bi-maxillary Osteotomies, Genioplasty, 1 and 2 part fibula reconstructions.

Conclusions: Purchasing software is a daunting and expensive task and we hope that our results will guide those going through the process to make the correct decision for their patient cohort. We also examine other software that can complement these packages.

3D PRINTING CUSTOMIZED TITANIUM PLATES ASSOCIATED WITH SURGICAL NAVIGATION GUIDED PRECISE CORRECTION OF COMPLEX MIDFACIAL POST-TRAUMATIC DEFORMITIES

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Purpose/Aim: To evaluate the effectiveness of 3D printing customized titanium plates associated with surgical navigation guided precise correction of complex midfacial post-traumatic deformities.
Materials and Methods: Ten patients with midfacial post-traumatic deformities from 2017.01 to 2017.12 were involved in the present study. The preoperative planning and simulation data sets, including the generation of virtual models with the mirror tool, were used for a virtual template to design the surgical guides in case osteotomy is needed and customized fixation plates for all cases with Geomagic Studio 6.0 software (Raindrop Geomagic, Research Triangle Park, NC, USA)[1]. The customized fixation plates were made using a 3D printing technique for guiding repositioning the fracture fragments during operation. Furthermore, the AccuNav-A navigation system (UEG Medical Devices Co. Ltd., Shanghai, China) was used to confirm the reduction of the fracture fragments, ensuring that the ideal positioning was achieved as virtually planned preoperatively. The outcome was checked by both deviation chromatography analysis and clinical examination.

Results: All the operations were successfully performed. There were no complications in positioning the osteotomy guides, the reduction and fixation. With the guidance of 3D printing customized titanium plates, which is confirmed by surgical navigation, the average differences between the virtual plans and the postoperative results were less than 1 mm. The deviation chromatography analysis was completed by superimposing the postoperative 3D computed tomography model onto the preoperative planning model[2]. The 3- to 6-month follow-up evaluation showed that the clinical complaint symptoms were alleviated, and the postoperative function and esthetics improved remarkably.

Conclusions: 3D printing customized titanium plates was able to improve the surgical accuracy and the surgical navigation played a role of double-checking during this procedure. This technique could be regarded as an ideal and valuable option for this potentially complicated procedure.

NEW TECHNOLOGIES AND PLANNING STRATEGIES FOR TREATMENT OF ACUTE COMPLEX FACIAL FRACTURES

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3D planning and printing have had huge impacts on reconstructive and congenital maxillofacial surgery for more than 10 years. However, time-to-treat pressures and inadequate in-house hospital facilities have impeded the application of these technologies to primary facial injuries in the acute setting.

This presentation will outline with clinical case examples the application of Materialise Mimics® Innovation Suite and 3D Systems Geomagic Freeform®, in the in-house hospital setting of a dedicated 3D planning and printing maxillofacial laboratory with fully trained departmental staff, to some complex facial fractures. 3D printing in this context usually has to be within 24 hours, normally making external commercial commissioning impossible and necessitating in-house facilities fully in the control of the clinical department.

Biography: Adrian Sugar was Consultant Cleft and Maxillofacial Surgeon and Senior Lecturer at Swansea University Medical School at St Lawrence Hospital, Chepstow and Morriston Hospital, Swansea. With main surgical interests in Cleft, Craniofacial Deformity and Trauma, he was clinical director of the Wales Centre for Cleft Lip and Palate for 11 years. He has a major interest in 3D imaging and planning for facial reconstruction and remains Chair of the Centre for Applied Reconstructive Technologies in Surgery (CARTIS), a collaboration between Morriston Hospital and the design engineers at Cardiff Met Univ. He co-founded the ADT Foundation with John Wolfaardt and Rainer Schmelzeisen.

He chaired NHS England’s Clinical Reference Group for Cleft Lip and Palate from its inception and the UK Cleft Development Group. He is an elected trustee of the AO Foundation having sat on its Academic Council, the International Board for CranioMaxillofacial (CMF) surgery, chaired AO’s international Research Fund for all specialties and its research committee for CMF surgery. He has been President of the Craniofacial Society of Great Britain and Ireland and is now an honorary fellow for life. He has been training programme director for OMFS in Wales and chair of its Specialty Training Committee. He chaired his health board’s Paediatric Surgery Ctte and Morriston Hospital’s Medical Staff. He has more than 80 peer reviewed publications in the literature as well as 10 book chapters and 170 lectures by invitation. He has been awarded the international Tjellstrom Award for excellence in rehabilitation of the head and neck and the Down Surgical Prize of the British Association of Oral and Maxillofacial Surgeons. He is now an honorary consultant at Morriston Hospital.
Orbital fractures with orbital wall defects are common facial fractures encountered by oral–maxillofacial surgeons, because of the exposed position and thin bony walls of the midface. The primary goal of surgery is to restore the pre-injury anatomy and volume of hard tissue, and to free incarcerated or prolapsed orbital tissue from the fracture by bridging the bony defects with reconstructive implant material and restoring the maxillofacial–orbital skeleton. Numerous studies have reported orbital fracture repair with a wide variety of implant materials such as autogenous bone and artificial materials that offer various advantages and disadvantages. The ideal orbital implant material will allow conformation to individual patients’ anatomical characteristics, remain stable over time, and are radiopaque, especially for the reconstruction of relatively large and/or complex bony walls. Recent innovations, such as computer-assisted surgical planning and intraoperative navigation, could improve the efficacy, precision, and predictability of surgical treatments of such orbital trauma reconstruction. Multi-planar CT scans, associated with 3-D reconstruction software, show variability in anatomy among individuals and help the surgeon identify a specific bone area to resect or reconstruct. The reconstruction abilities of the software could also be used to virtually display the patient's anatomy throughout the case, allowing for stereotactic navigation. Further, computerized navigation involves a virtual interface between the intraoperative position of the surgical instruments and reconstruction of patient anatomy, which is performed using CT scans. During the surgery, the navigation system controls the position of the implants or the mobilized bone and verifies the final location. Intraoperative navigation enhances the surgeon’s ability to measure the extent of resection, to identify important anatomical landmarks, and to confirm the orientation of bone grafts. Using this approach, it is possible to reduce human error, promoting greater adherence to the preoperative plan. Furthermore, intraoperative navigation could reduce the incidence of postsurgical complications due to incorrect positioning or orientation of bone grafts, plates, or fixation screws.

I would like to share with you, ADT active members, “the up-to-date feasible applications of navigation- and computer-assisted surgery to relatively large and/or complex/complicated orbital trauma reconstruction”.

**Biography:** Dr. Takahiro Kanno, DDS, PhD, FIBCSOMS, FIBCSOMS-ONC/RECON graduated from School of Dentistry and Graduate School, Kyushu Dental College in 2001 (DDS) and obtained PhD degree (Maxillofacial Surgery) from Graduate School of Kyushu Dental College in 2005. He worked at The Department of Oral and Maxillofacial Surgery of Kyushu Dental College (2001-2005) and at The Division of Oral-Maxillofacial Surgery of Kagawa Prefectural Central Hospital (2005-2012). He studied abroad for clinical fellowships (AO fellow and IBRA fellow) at The Department of Oral and Maxillofacial Surgery, Ludwig-Maximilians-Universität Munich, Germany (2006) and at The Department of CranioMaxillofacial Surgery, University of Bern, Switzerland (2007). He is now employed by Shimane University Faculty of Medicine as a fulltime medical faculty (2012-present). He is Director and Associate Professor of The Department of Oral and Maxillofacial Surgery, the Chief of Maxillofacial Trauma Center. He has more than 160 scientific papers published, among them 100 published in international journals.
DIGITAL TECHNOLOGIES IN SKULLBASE SURGERY
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Navigation aided procedures have been routinely used at the Maxillofacial Clinic for Surgery at the University of Freiburg since 1997. Very early navigation allowed mirroring of data from the unaffected to the affected side and position control of bone segments in trauma. The use of navigation meanwhile also has been extended to tumour and especially to skullbase surgery. Resection boundaries have been defined, additional intraoperative procedures can be performed with higher safety reducing the risk for intraoperative complications.

Computer aided planning using cone beam CT, CT and MR data allow for an intraoperative quality control with image fusion. Intraoperative results can be corresponded with preoperative planning’s, corrections therefore can be made during the surgical process.

Today the biggest advantages come from data sharing and technology translation. Resection margin are marked and tumour activity differences within the tumour are elected. Data alignment with pathology allows for the precise terminology of tumour locations between surgeon and pathologist. Tumour activities can be identified in three dimensions and prognoses on a possible future grows direction / activity can be made.

Data transfer to the radiotherapist can further make radiotherapy much more individual and precise therefore reducing radiation dosage. Radiation dosage, further surgical steps can be coordinated according to a much better understanding of the tumour.

Digital technologies therefore provide intraoperative quality control and allow for foreseeing courses of diseases and as well as individualization of treatment protocols.

Biography: Born Sep 11, 1957 in Eltville / Rhine Valley.

DEVELOPING A NAVIGATION SYSTEM BASED ON OPTI-TRACK SYSTEM
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Keywords: Navigation surgery, robotic surgery

Purpose/Aim: The traditional optical tracking navigation system are mostly based on binocular stereo vision principle and composed a device that two cameras located on a fixed position, the use in operation room sometimes yield to the shielding due to patient position and the surgeons. Opti-track is an optical tracking system mainly used in motion tracking fields, while users can decide the numbers and positions of cameras, which can be more flexible during surgery, give less restriction to the surgeons. The aim of this study is to test the feasibility and accuracy of a navigation system based on Opti-track system.
Materials and Methods: The navigation system is composed of 6 cameras, a backstage software was developed to give the coordinate of interest objects. After setting up the camera, a calibration process was done and the overall reprojection error of this tracking system was 0.077mm. A standard testing plate was designed, with 15 x 17 holes spacing in 12.50mm, and machining in the precision of 0.01mm. The testing plan was to simulate real surgery registration and tracking plans, a rigid body A (RBA) composed of 6 markers and a rigid body B (RBB) composed of 4 markers were designed, each were asymmetrical. The transformation matrix (TRANS/A-B) between the geometric center of these two rigid bodies can be acquired from the topology structure and programmed. The registration error was defined as the deviation between the real-time position of RBB(P-track) tracked by opti-track system and the position (P-trans) calculated from TRANS A-B based on the real-time position of RBA. The tracking error was defined as the deviation between P-track and P-trans, while recorded at random motion in the tracking area. Both tests took a sample in a consecutive 1000 frames with a speed of 120fps, the deviation of degree and distance was calculated separately.

Results: The deviation of registration is 0.007±0.004mm?(7.6±3.7)e-5 rad. The deviation of tracking is 0.048±0.035mm?(6.2±4.3)e-5 rad.

Conclusions: The navigation system workflow is smooth, deviation of registration and tracking are precise enough for craniofacial surgery. The system is flexible for multiple surgery scenario. Meanwhile, using rigid body tracking protocol avoids the deviation caused by a single marker and human hands and can simplify the tracking procedure during surgery, is promising in the next level application.

FEASIBILITY OF NAVIGATION-ASSISTED ORBITAL TRAUMA RECONSTRUCTION IN PEDIATRIC PATIENTS USING U-HA/PLLA SHEET
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Purpose/Aim: Orbital fractures with orbital wall defects are common facial fractures encountered by oral-maxillofacial surgeons. The primary goal of surgery is to restore the pre-injury anatomy and volume of hard tissue, and to free incarcerated or prolapsed orbital tissue from the fracture by bridging the bony defects with reconstructive implant material and restoring the maxillofacial-orbital skeleton. Numerous studies have reported surgical repair with a wide variety of implant materials that offer various advantages and disadvantages. The ideal orbital implant material will allow conformation to individual patients’ anatomical characteristics; remain stable over time; and be radiopaque. Based on these requirements, novel uncalcined and unsintered hydroxyapatite (u-HA) particles and poly-L-lactide (PLLA; u-HA/PLLA) composite sheets could be used as innovative, bioactive, and osteoconductive/bioresorbable implant materials for orbital reconstruction. In addition, intraoperative navigation is a powerful tool. Navigation- and computer-assisted surgery have improved execution and predictability, allowing for greater precision, accuracy, and minimal invasiveness during technically demanding orbital trauma surgery with ophthalmological malfunctions and deformities. We retrospectively evaluated our pediatric, orbital, trauma reconstruction cases focusing on the feasibility of navigation-assisted orbital reconstruction using the u-HA/PLLA system.

Materials and Methods: We retrospectively reviewed data on patients under the age of 16 years old who underwent navigation-assisted, orbital trauma reconstruction employing the u-HA/PLLA system from 2013 to 2018. Orbital fractures combined with orbital wall defects were diagnosed both clinically and via computed tomography (CT). All patients were evaluated by ophthalmologists at the Department of Ophthalmology, Shimane University Hospital, in terms of diplopia, restricted eye motility, and enophthalmos status before and after surgery and during follow-up.

Results: Five male patients with orbital wall fracture(s) (medial orbital wall in one, orbital floor in two, and complex orbital floor-to-medial orbital wall in two) met the inclusion criteria. The mean age was 12.6 years (10–14 years) old. No patients experienced intraoperative complications. For all patients, postoperative CT revealed anatomically correct reduction of orbital contents, with full bony suspensions spanning the combined defects in the orbital floors/medial walls. No patients exhibited enophthalmos, diplopia, or an eye movement disorder during 12 months of follow-up. In terms of implant position and orbital volume, the reconstructed sheets remained in place at 1, 3, and 6 months after surgery. The preoperative mean orbital volumes of the injured and uninjured sides were significantly different (p<0.05), but postoperatively, the difference became nonsignificant (p>0.05).

Conclusions: Navigation-assisted technology improves the safety and functional and aesthetic outcomes of pediatric patients receiving orbital trauma surgery. The u-HA/PLLA sheet system affords stable and satisfactory ophthalmological and functional results after reconstruction with no intra- or postoperative complications.
FACIAL COSMETIC IMPLANTS USING DIGITAL TECHNOLOGIES

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Problem: Facial contour deformities can be post surgical or developmental. Chin, mandibular angle, and zygomatic alloplastic augmentation are commonly performed procedures.

Materials and Methods: A method for custom fabrication of chin, mandibular angle and zygomatic implants from solid silicone utilizing 3D stereolithographic models is described. Wax is utilized to form the implant on the 3D model and it is carved to the desired contours which is converted to solid silicone by a laboratory.

Results: A total of 12 patients had custom chin implants placed, 5 for revision cosmetic chin surgery, and 7 for primary cosmetic chin augmentation. One patient had an immediate exchange for custom chin implant for removal of a medpor chin implant. A total of 13 patients had 25 custom mandibular angle medium hardness solid silicone implants placed. 4 patients had bilateral mandibular angle and chin implants. These implants are especially helpful in cases of revision for mandibular ramus osteotomy contour irregularities.

A total of 4 patients had 6 custom zygomatic implants placed. Two of these implants were combined maxillo-malar implants in a single patient with a dish face deformity and mandibular prognathism secondary to acromegalis.

Our preferred style of chin implant is a variation of the shelf type in which there is a wrap around the anterior mandible so as to create the anterior projection and horizontal inferior portion that blends with the inferior border of the mandible to provide a smooth jaw line with the geniomandibular regions.

All implants were placed through intraoral incisions and had screw fixation.

Conclusion: Custom chin, mandibular angle, and zygomatic implants based on 3D stereolithographic models can provide cosmetic augmentation with finely adapted “feathered” edges in a more predictable manner with a superior outcome, precise fit, ease of placement and screw fixation, and decreased operating time. Complications can include mandibular angle masseter muscle atrophy, dehiscence with loss of implant which requiring reoperation and replacement of implant, bone erosion, and patient dissatisfaction.

Reference: Greenberg AM Custom Facial Implants Based on 3D CT Models in Greenberg AM Ed Digital Technologies in Craniomaxillofacial Surgery Springer Verlag New York 2018

A SURGICAL ASSISTING ROBOTIC SYSTEM FOR ORTHOGRNATHIC SURGERY
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Keywords: robotic surgery, orthognathic surgery

Purpose/Aim: The key procedure of orthognathic surgery is the reposition of mandibular-maxilla complex (MMC). In common procedures of modern technique, the reposition of MMC is depended on two template or single template technique, whether handmade or 3D printed. The flexibility of condyle structure, the errors of model surgery and unrealized bony contact will decrease the accuracy of the surgery. The object of this study is to develop a visualization system which could facilitate doctors to observe the final position of MMC and a robotic assisting system which could reposition the MMC by automatic control and master-slave control modules.

Materials and Methods: The robotic system contains preoperative design system, a motion capture system and a 6-DOF robotic arm. The validation test was carried out using a skull model with referencing Titanium screws on it. Corn beam CT (CBCT) scan is acquired from a region of skull base to lower border of the mandible. Data processing include segmentation, 3D reconstruction, and virtual osteotomy of BSSRO and Le-Fort I. Final positions of MMC were decided virtually. During the test, the model skull was registered into the navigation system using a set of registration frame. The registration accuracy was tested by observing the distance between a predicted coordinate base on a transformation matrix and the actual coordinate recorded in the navigation system. The final MMC position was located by robotic arm, then the surgeon fix the MMC accordingly. A postoperative CBCT scan was acquired after reposition of MMC. The accuracy of robotic a was tested by the comparison of virtual design and postoperative CT scan.

Results: The feasibility of this robotic surgery system is proved with a high accuracy test result of both robotic and navigation parts.

Conclusions: The accuracy and feasibility of this robotic surgery system has been proved. Further phantom test needs to be performed to give an overall accuracy of the system.

COMPUTER-ASSISTED NAVIGATION SURGERY FOR HIGH COMPLEXITY ORBITAL TRAUMA RECONSTRUCTION
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Keywords: Orbital fractures, a three-dimensional model, navigation system

Purpose/Aim: Orbital fractures with orbital wall defects are common facial fractures encountered by us, oral-maxillofacial surgeons, because of the exposed position and thin bony walls of the midface. The primary goal of surgery is to restore the pre-injury anatomy and volume of hard tissue, and to free incarcerated or prolapsed orbital tissue from the fracture by bridging the bony defects with reconstructive implant material and restoring the maxillofacial-orbital skeleton. The aim of this clinical study was to retrospectively evaluate the feasibility of computer-assisted navigation surgery for complex orbital trauma reconstruction suffering from relatively large and high complexity orbital wall defects of type IV with ophthalmological malfunction and deformities.

Materials and Methods: The study included three consecutive fresh midfacial trauma patients (3 Males, mean age: 47.3 years) with all large and high complexity orbital wall defects of type IV. The patients were treated at the Maxillofacial Trauma Center in the Department of Oral and Maxillofacial Surgery, Shimane University Hospital, Shimane, Japan. The mean follow-up period was 7.1 months (range, 6 to 8 months). We first created a three-dimensional (3-D) precise preorbit to orbital grove model that was mirrored by computer-assisted simulation and determined the anatomical form of reconstruction implants (autogenous bone harvested from calvaria or mandible, or u-HA/PLLA sheet) according to the 3-D shape of the orbits to be reconstructed (Yasoijima Proceed Co., Ltd. Osaka, Japan). An intraoperative navigation system (BrainLab, Feldkirchen, Germany) was used to determine the extent of orbital wall defects and confirm the accurate placement and adaptation of reconstruction implants.
Results: The application of this computer-assisted navigation surgery provided precise, stable 3-D orbital trauma reconstruction and satisfactory ophthalmologic functional results with no intraoperative or postoperative complications in all the patients. The boney regenerative optimal healing was further confirmed at the complicated orbital fracture reconstructed sites at 6 months’ follow-up CT (computed tomography) evaluation.

Conclusions: Orbital trauma surgery is a technically sensitive and a challenging operation, accessed by a limited operative field with difficulty in visualization of the vital anatomy and the 3-D defect. Recent innovations such as computer-assisted surgical planning and real time intraoperative navigation could potentially improve the efficacy, precision, and predictability of such surgical treatment workflow. Moreover, another advantage of using precise 3-D models using a mirroring technique and the manufactured guides could further improve the accuracy of the surgical management reducing the operation time and be applied for the design of custom patient-made anatomic implants preparation for highly complex orbital trauma reconstruction and midfacial defects.

DEVELOPMENT OF DRILLING ROBOT USING HAPTIC TECHNOLOGY IN ORAL AND MAXILLOFACIAL SURGERY

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Objectives: Correct skill to handle the cutting device is indispensable to any surgeons. The lack of this may bring on overcuts and damages to the surrounding tissue. This situation has risks of causing the subsequent complications or life-threatening accidents by heavy bleeding and nerve damage. In order to solve these problems, we developed a remote controlled haptic robot drilling system in oral and maxillofacial field.

Materials and Methods: The system consists of a master and a slave connected with computer. The master is a robot that surgeons operate, and the slave is a robot that interacts with the cutting target. The force and position of robots are transmitted in both directions by bilateral control. White pine and balsa wood were used as phantoms. They have similar hardness of porous cortical bone and dense trabecular bone as mentioned in Misch’s bone density classification. Both woods were bonded and drilled continuously. The value of the force scaling function was calculated from the maximum motor torque and the cutting force by using computer.

Results: As the force of master was increased, the force scaling function of slave decreased automatically in order to avoid overcutting. It made the slave stop at the position of limitation and the error was in 60 μm. It was only 2.5 % of 2 mm margin. The situation of continuous drilling from starting point of pine surface, through pine and balsa, to stopping point after penetration was displayed visually on a display screen.

Conclusion: The drill could successfully stop within safe position at the position of limitation. Higher accuracy was expected by fine adjustment in force scaling.


Biography: Dr. Hiromasa Kawana graduated Tohoku University, School of Dentistry and joined postgraduate course of Keio University, School of Medicine, Dept. of Dentistry and Oral Surgery in 1988. He received Ph.D. from Tokyo Women’s Medical University, Dept. of Oral and Maxillofacial Surgery, in 2001. He studied abroad as a guest researcher at Johannes Gutenberg University Mainz in Germany from 1993 to 1994. After his return, he joined Keio University again, where he worked as an associate professor of same department and chief manager of Div. of Oral and Maxillofacial Surgery. He is currently the chief professor of Dept. of Oral and Maxillofacial Implantology, Kanagawa Dental University and guest professor of Keio University. His research interests include haptic technology for medical use. He is now board specialist and instructor of Japanese society of oral and maxillofacial surgeons, director, board specialist and instructor of Japanese academy of maxillofacial implants, and director of JADT.
DEVELOPING RESILIENCE AND LOCAL SUPPLY CHAINS FOR ADVANCED DIGITAL TECHNOLOGY IN RESOURCE CONSTRAINED ENVIRONMENTS

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3D advanced digital technologies offer the potential to reduce the cost of fabrication as well as improve accessibility to patient specific devices through distributed manufacturing. The provision of such methods in resource constrained countries are, however, severely limited. Production methods require highly skilled specialists to hand make each piece which limits availability by both proximity to a specialist centre and high manufacturing costs.

Working with partners in the UK and India, appropriate methods that utilise local skills, supply chains and potential production methods can be developed. This requires collaboration with key stakeholders including: patients, medical professionals, academia, industry and community representatives. The methods presented can be applied to many healthcare scenarios across the world.

Biography: My work focusses on the effective implementation of design methodologies and technologies to overcome barriers, improve outcomes, and increase efficiency in healthcare. Throughout my career I have developed world leading, application-led research, knowledge exchange and enterprise activities. This has enabled me to make significant contributions to academia, professional practice, economic growth, health and wellbeing. This approach has been acknowledged nationally and internationally through prizes, awards and other esteem indicators, including a highly prestigious Queen’s Anniversary Prize for Higher and Further Education in 2016. I lead a team that develops research projects, knowledge exchange and enterprise activities. I also supervise and examine PhD research; am a member of the EPSRC Peer Review College; have produced 30 peer reviewed journal articles; and have delivered presentations and workshops at numerous international conferences.

I work with healthcare specialists, industry and academics to translate research into clinical practice. My research was initially focused in the area of maxillofacial prosthetics. My PhD in this field resulted in six peer reviewed journal papers and numerous conference presentations. Since, I have translated methods developed for facial prosthetics into dental technology, maxillofacial surgery and orthothotics. I have supervised PhD research in these fields, published widely and contributed to numerous workshops, and conferences that develop best practice.

In 2006 I became a founding member of the Centre for Applied Reconstructive Technologies in Surgery (www.CARTIS.org). This was built on existing links between PDR and the Abertawe Bro Morganwg University Health Board (ABM UHB). The Centre, which also extends to other NHS units in South Wales and includes collaborators in Loughborough University, advances the use of technologies that improve healthcare outcomes. Close relationships with the UK NHS has helped to ensure my research is focussed on meeting healthcare needs and is transferred effectively into practice. I have also been heavily involved with the ADT since 2008, where I helped organise the triennial conference in Cardiff. Since then, I have contributed to workshops and presented at all of the global conference, established the UK Regional ADT Group, and been Treasurer of the ADT Foundation. I relish the opportunity to contribute to the advancement of knowledge in the field of head and neck reconstruction.
ORAL HEALTH DATA ANALYTICS: CHALLENGES AND POSSIBLE DIRECTIONS

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We are witnessing a radical change of attitude towards health information management – the adoption of data analytics to help people monitor and predict health conditions proactively. Most hospitals have aggregated clinical data which are yet to be analysed to provide valuable insights. Many medical doctors are developing data repositories of their own specialty so that evidence-based clinical decisions can be made, and valuable data for medical research can be exploited efficiently. Health analytics projects need to have a clear objective, which includes dealing with the right data set, provide the right operations in right ways, and the distribution of results for right purpose. The end products of a health analytics project will be a set of business and user requirements both functional, and nonfunctional, revealing stakeholders’ needs of the analytics results. This talk shares our observations on the status quo in this area, present the problems and challenges encountered, report the experience and findings in smile mouth oral health data analytics projects, and discuss some possible future directions in this area.

Biography: Dr. Lin Liu is an Associate Professor of School of Software at Tsinghua University since 2004. She received her PhD in Computer Science from the Chinese Academy of Sciences in 1999. Her research interests include requirements engineering, knowledge management, software engineering methodologies for emerging applications in big data and intelligence systems, and analysis techniques for system security, privacy and trust. She has authored or co-authored more than 100 articles in journals, and conference and workshop proceedings. She is a Principal Investigator in research projects on software requirements engineering, clinical decision support systems and medical big data platforms. Currently, she is serving as the Associate Editor of International Journal of Information System Modelling and Design, Editorial Board Member of the Requirements Engineering Journal of Springer, and Journal of Software in Chinese. She is also the on the program committee of Conferences and Workshops on Requirements Engineering and Information Systems Engineering.

CLINICAL ACCURACY OF PATIENT-SPECIFIC IMPLANTS IN GENIOPLASTY

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Keywords: genioplasty, patient specific implants, clinical accuracy

Purpose/Aim: Chin plays an important role in the lower facial harmony. Osseous genioplasty has been widely used to solve various kinds of chin deformities for half a century. As the location of the ostectomy and the movement of the chin segment directly impacts surgical outcomes, an optimal surgical plan is critical for the genioplasty. With the advances in computer-aided surgical simulation (CASS) technology, surgeons are now able to simulate surgical procedures in the computer to achieve the best possible surgical plan. However, CAD/CAM surgical templates do not maximize the potential of CASS technique. Patient specific implants (PSI) has rapidly developed in cranio-maxillofacial surgery in the past few years. However, few studies have introduced PSI technique in osseous genioplasty. The purpose of this study was to assess the accuracy and clinical validation of patient specific implants (PSI) technique in genioplasty for positioning and fixation of the chin segment.
Materials and Methods: Twelve patients with chin deformities were enrolled. Virtual planning was performed with the computer-aided surgical simulation method. The 3D printing titanium cutting guide and patient specific plate was involved in this PSI method. The cutting guide was designed to guide the osteotomy and screw holes drilling for the following patient specific plate. And the patient specific plate was used to simultaneously complete the reposition and fixation of the chin. During the operation, the osteotomy/ostectomy were performed guided by the cutting slot in the guide. Then the patient specific plate was fixed on the chin segment using the pre-drilled holes by the cutting guide. Then, the positioning and fixation of the chin segment was simultaneously completed as planned. A postoperative CT scan was routine acquired within 6 weeks after the operation to represent the actual surgical outcomes. The actual postoperative outcomes were compared with the virtual plan to assess the surgical accuracy.

Results: All operations were successfully completed with PSIs. There was no difficulty in using patient specific plate. The largest root-mean-square (RMSD) differences of the chin position was 0.61 mm in anteroposterior direction and 1.46° in pitch orientation.

Conclusions: Compared with the traditional method, intraoperative marker lines and measurements and holding screw for chin manipulation are no longer required. Compared with CAD/CAM genioplasty templates, intraoperative procedures were simplified. Moreover, indicated by the cutting guide, the osteotomy/ostectomy were accurately performed as planned. Therefore, injuries caused by repeat grind for bone collision removal could be greatly reduced. Operative procedures were greatly simplified, and the operation time was reduced.

The results of the study indicated that the PSI technique was an ideal method of transferring the virtual plan to the operation field with great accuracy and efficiency in genioplasty.

THE FACEPRINT SERVICE
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Purpose/Aim: Around 20,000 auricular and nasal prostheses are needed in Europe due to maxillofacial defects caused by cancer, trauma or congenital diseases. Facial prostheses can restore the function of facial organs, appearance, and improve social, emotional status, and overall QoL. The conventional way of the fabrication process is costly and the necessary craftsmanship is not widely available. This could result in high psychological stress and reduced quality of life of the patient. The FacePrint project will develop a rapid and low-cost worldwide available 3D printing service designed for maxillofacial clinicians that delivers biocompatible auricular and nasal prostheses.

Materials and Methods: A cloud-based interface is used to design the patient-specific ear and nose prosthesis. Subsequently, a unique 3D print process and biocompatible material is used to construct the prosthesis. The clinician is capable of adjusting several parameters (shape, stiffness, colour, etc.) to adjust it to the patient and clinician’s preference. After satisfaction, the file is stored on a cloud database and sent to the 3D print facility where it is 3D printed. The last step includes shipping the prostheses in 72h to the hospital where it is fitted to the patient.
Results: Our first version looks promising. It weighs much less than a conventional silicon prosthesis and will cost less than 10 Euro instead of a couple of thousand Euro's.

Conclusions: This low-cost and simple fabrication modality could be a good solution for patients in countries where there are less anaplastologist.

STOMATOGNATHIC FUNCTION IN PATIENTS WITH HEMIMANDIBULAR TUMOR AND VALIDATION OF SIMULATED SURGICAL MODEL OF UNILATERAL MASTICATORY MUSCLE RESECTION

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Purpose/Aim: To study the clinical characteristics of mandibular movement and masticatory muscle function in preoperative and postoperative patients with unilateral mandibular by combining digital mandibular movement records with electromyography. To validate authenticity and reliability of simulated surgical model indicating the relationship of jaw movement and muscle activation.

Materials and Methods: Six preoperative patients with tumor in unilateral body and ramus of mandible were included, and three postoperative patients with unilateral segmental resection and reconstruction of mandibular bone were included. The mandibular movement recording system and surface electromyography system were used to collect the movement trajectory of the patients' mandibular marginal movement and chewing movement, and the surface electromyography of bilateral masseter and temporalis was recorded concurrently. A surgical model which simulates jaw movement when certain muscle deactivated was established on the platform of Artisynth. Two normal volunteers were recruited whose unilateral masseter were experimentally deactivated by nerve blockage. Jaw movements and electromyogram (EMG) activity were recorded before and after masseter deactivation. In the virtual model unilateral masseter was deactivated and simulated jaw movements was calculated. Compensatory alterations showed by muscle activation curves were analyzed and compared with actual muscle activation in the two volunteers.

Results: Three patients had mild mouth opening limitation, and all the patients' mouth opening trajectory was skewed to the affected side. During lateral movements, the mean range of motion of the affected side (10.34±1.27 mm) and that of the healthy side (6.94±2.41 mm) were significantly different. The maximum opening of the postoperative patients was (30.65±17.32) mm, and the mandibular marginal movement characteristics were consistent with those of the patients before surgery. In postoperative patients, individualized changes occurred. Some patients suffered from weakened electromyographic activity on the affected side, while some other ones showed hyperelectromyographic activity on the affected side. In the muscle deactivation experiment, open and close trajectories showed deflection to the deactivated side in both simulation model and volunteers. In volunteers, the deflections were less obvious and to the direction of the control side. However, in the simulation model, the deflections were to the direction of the deactivated side. Compensated trajectory turned out to be more similar to the real trajectory.

Conclusions: Both benign and malignant tumors as well as surgery can cause abnormal mandibular movements and change of electromyographic activity of bilateral masseter and temporalis muscles. Variable and complicated jaw movements and muscle activation were observed in patients of mandibular tumor. Simulation model of certain muscle deactivation is oversimplified and need to be improved.
PRELIMINARY CALCULATION AND SIMULATION OF THREE-DIMENSIONAL MOTION TRAJECTORY OF MANDIBULAR CONDYLE FUNCTION SURFACE

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Keywords: Mandibular condyle; Jaw relation record; Digital technology; Three-dimensional

Purpose/Aim: To calculate the three-dimensional trajectory and motion morphology of condyle by combining the trajectory of the mandible movement and the three-dimensional model of the mandible.

Materials and Methods: Cone beam CT (CBCT) scanning was performed on the volunteer. The mandible three-dimensional model was built with image data transferred to the graphical user interface of the computer workstation. The novel virtual articulator PN300 recorded the three-dimensional trajectory of mandible. All these data were transferred to software system of computer workstation calculating the three-dimensional trajectory of condyle. The motion morphology of condyle was simulated by merging function surface at each point.

Results: When the mandible moves in a open and closed position, the recorded data was calculated and it was shown that: the condylar functional surface moved downwards in advance, and in the process of continuously increasing the opening degree, the function faced forward and upward. The straight-line distance between the started position and the final position was 8.34mm. During the forward movement of the mandible, the coracoid process slided forward and downward with a sliding distance of 8.64 mm. During lateral movement, the range of the working side condyle function surface motion was small, only slight rotation, the maximum range of motion was 1.97 mm; in the process of row side movement, the non-working condyle function surface had a larger movement range than the working side, the movement direction was the lower front, and the movement distance was 7.65 mm.

Conclusions: The novel virtual articulator PN300 and digital technology can achieve the accurate measurement of three-dimensional trajectory of the condyle, and furthermore simulate the motion morphology of the condyle.
A Brief History and Current Concerns of Simulation Surgery (Computer-Assisted Surgery): Plastic Surgeon’s Perspectives

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A Brief History and Current Concerns of Simulation Surgery (Computer-Assisted Surgery): Plastic Surgeon’s Perspectives. The origin of use of computer technology in plastic surgery can be traced to Professor Toyomi Fujino of Keio University in 1974. He tried to demonstrate his “actual bony structure stress theory” of blow-out fracture of the orbit in collaboration with Professor Takeshi Sato, Institute of Technology of Keio University. They used state-of-the-art computer analysis at that time, however, because of insufficient computer power and primitive software technology, it was difficult to obtain sufficient data for this complex 3D analysis. The 1983 paper titled “Three dimensional computer graphics of craniofacial surgical planning and evaluation” by Jeffrey L Marsh and Micheal W Vannier literally opened new dimension in craniofacial surgery. Professor Fujino was among the people who was inspired with this paper and soon became aware of need for establishing a universal platform on which multidisciplinary researchers gather and exchange their ideas. He established the Japan Society for Simulation Surgery in 1991 and the International Society for Simulation Surgery in 1992. The Inaugural meeting of International Society was held at Keio Plaza Hotel in Tokyo and Shonan-Fujisawa Campus of Keio University with more than 200 participants both from Japan and abroad, representing many fields. The Japan Society has been held in consecutive years so far and this year the 29th meeting of this society will be held at Takamatsu, Kagawa prefecture by Professor Nagasao. The International Society for Simulation Surgery changed its name to the World Society for Simulation surgery (WSSS) and 10th meeting was held last year in conjunction with the American Society of Plastic Surgery where Professor Arum Gosain of North Western University presided. At first, these two societies have dealt mostly with 3D modeling and its clinical application such as surgical planning. Current topics include, but not limited to, finite element analysis both in soft and hard tissues and AR/VR application in the operating room. One of the remarkable results is that these societies worked the insurance approval of 3D modelling in craniofacial surgery in conjunction with the Japan Society of Plastic and reconstructive surgery. Initially my personal interest was the computer assistance for microtia ear reconstruction during surgery such as 3D template of contralateral ear and 3D modeling of costal cartilage. Recently we are trying computer simulation of tongue reduction surgery for Beckwith-Wiedemann Syndrome and to create standardized 3D data of cranium of Japanese healthy infants from birth to 15 months of age. The summary of these study will be shown and discussed.

Biography: Dr. Tsuyoshi Kaneko is a Certified Pediatric Plastic Surgeon of the Japanese Society of Plastic and Reconstructive Surgery and Deputy Director and Chief of Surgical Specialties of National Center for Child Health and Development in Tokyo, Japan. Besides his main concern in craniofacial anomalies including microtia, cleft lip and palate, jaw anomalies, craniosynostosis and most recently, deformational plagio/brachycephaly, he has been involved in Simulation Surgery (Computer-assisted surgery) for nearly thirty years and presided the 2nd JADT and 25th Japan Society of for Simulation Surgery in 2016. He is also known as a specialist of insurance approval of drugs and medical devices in Japanese health care system. He has been a chairman of social and insurance Insurance Committee of the Japan Society of Plastic and Reconstructive Surgery for 16 years and vice-chair of the Drug/Device Insurance Eligibility Evaluation Committee, Japan Medical Association and chairman of Central Institutional Review Board, Japan Pediatric Clinical Trials Network.
AN ANIMAL EXPERIMENT OF A CUSTOM-MADE TEMPROMANDIBULAR JOINT CONDYLE PROSTHESIS REPLACEMENT

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Keywords: Tempromandibular Joint, TMJ prosthesis, Animal Experiment

Purpose/Aim: To evaluate a custom-made tempromandibular joint (TMJ) condyle prosthesis by performing the TMJ replacement surgery on Beagle dogs.

Materials and Methods: The TMJ replacement surgery were performed on three adult Beagle dogs. The right condyles were replaced by the custom-made TMJ condyle prosthesis, which were manufactured on the basis of selective laser melting (SLM) 3D-printed technique. The CT scan of the Beagle's opening position was taken before surgery, one week after surgery, three months and half a year after surgery, to observe the trajectories of the condyle movement, and the osseointegration of the condyle prosthesis after the joint replacement surgery.

Results: After the joint replacement surgery of the Beagle's right condyle, the maximum opening degree is slightly restricted. The growth of the bone tissue could be seen in the part of the open-porous scaffold of the TMJ condyle prosthesis. When the trajectories of the condyle movement were examined, it was observed that the custom-made condyle prosthesis could adapt to the movement of individual TMJ properly.

Conclusions: The custom-made alloplastic TMJ condyle prosthesis could adapt the functional movement of TMJ and show good osseointegration after replacement of Beagle dogs' condyles.

BIOMECHANICAL ANALYSIS OF CONTRALATERAL TEMPROMANDIBULAR JOINT (TMJ) WITH AN INDIVIDUALLY DESIGNED CUSTOM-MADE TMJ PROSTHESIS

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Keywords: Temporomandibular joint, Joint prosthesis model, Finite element analysis

Purpose/Aim: The aim of this study is to analyze biomechanical character of contralateral TMJ when an individually designed custom-made TMJ prosthesis was replaced in the finite element model (FEM).

Materials and Methods: The head of an adult beagle dog was scanned to get the CT image used for the total TMJ replacement model. The mandible, bilateral discs and bilateral temporal bone were reconstructed using ANSYS software. The total TMJ prosthesis was comprised of two parts, the condyle component and the fossa component. The materials of the mandibular condyle component and fossa component were titanium-6 aluminum-4 vanadium (Ti-6Al-4V) and ultra-high molecular weight polyethylene (UHMWPE), respectively. The condyle component was designed on the basis of selective laser melting (SLM) 3D-printed manufacture technique. An optimized tetrahedral open-porous scaffold with combined connection structures, an inlay rod and an onlay plate, between the prosthesis and remaining mandible was designed as the mandibular condyle component. The biomechanical behaviors of the contralateral TMJ and the mandible in two models, intact mandible and mandible with prosthesis, were compared after the bite force had been applied.

Results: The biomechanical behaviors of the contralateral TMJ could be analyzed in FEM models. The strain of mandibular condyle, disc and temporal bone in the contralateral TMJ was reduced after the TMJ prosthesis was replaced. The strain changes for the condyle and temporal bone were much larger than the disc. The strain of the ipsilateral TMJ increased after the prosthesis was utilized.

Conclusions: Replacement of TMJ prosthesis could not only change the strain of the ipsilateral TMJ, but also the strain of the contralateral TMJ. The strain change of the contralateral TMJ should be considered during the design of the TMJ prosthesis.
CUSTOMISED FOOT FOR SINGLE VECTOR MANDIBULAR DISTRACTOR

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Keywords: Distraction

Case Presentation:

Background: The success of surgical distraction procedures for the treatment of congenital mandible anomalies relies on the trajectory of the distraction device. Digital technologies have been used to predict the optimal distraction and deliver the plan into surgery with the design of customise cutting and drilling guides (Gateno et al 2000).

Technique: We describe a complex paediatric case where the optimal vector of distraction could not be achieved despite using digital planning with Proplan CMF 3.0 software (Materialise, Leuven, Belgium). This was due to the anatomy of the condyle having been reconstructed with a costochondral graft in the past. Consequently, a novel component was designed as a spacer in between the mandible and the distractor to deliver a customised optimal direction of distraction. This “spacer” was designed in Geomatic Freeform Plus (3D Systems, United States) to lock by friction onto the inferior footplate of the monoaxial distractor (Depuy Sinthes, United States) which geometry was obtained by reverse engineering the part with Solidworks 2010 (Dassault Systèmes, France). The resulting designs of the spacer as well as the cutting and drilling guides were additive manufactured by titanium alloy powder bed fusion technology (Renishaw, United Kingdom) and successfully used into theatre.

Results: The presentation describes the design process of the patient specific guides and implant, their application during surgery, the post-operative results and the challenges encountered during the whole process.

Clinical Applications: The novelty of this study has further applications for other distraction cases enabling any possible direction of distraction according to patient’s needs as well as a more stable device without physical bending of the distractor required.

REGISTRATION TEMPLATE: A NOVEL METHOD FOR COMPUTER-ASSISTED NAVIGATION IN ORAL AND MAXILLOFACIAL SURGERY

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Keywords: navigation,3D printing,registration

Case Presentation:

Background: Patient-to-image registration is the most important procedure of computer-assisted navigation technology, which determines the tracking accuracy. This research is to introduce a novel registration method and evaluate its effectiveness in navigation-guided oral and maxillofacial surgery.

Technique: In this retrospective study, 7 patients whose operation should be completed under the guidance of navigation were admitted from January through December in 2018. Before operations, CT scans were performed in all patients, and data were saved as DICOM format. Bimaxillary dental casts were obtained, then scanned by laser scanner and transferred to virtual dental casts in STL format. Secondly, skull models were calculated and their upper and lower dentures were replaced by those of the virtual dental casts. Then, registration templates (Fig 1) were designed individually according to the updated skull model, which consists of occlusal splint, flanges and virtual registration points (cones located discretely in the lateral surface of splint and flanges). Thirdly, the individual registration templates were transferred to the 3D printer and manufactured. Through preoperative planning and simulation, the ideal treatment plan was determined, including 5 cases of contouring of fibrous dysplasia, 1 case of intraoral condylectomy and 1 case of removal of foreign body in the parapharyngeal space. Then, the original and virtual data sets were imported into the AccuNavi-A navigation system. Intraoperatively, dynamic reference frame was mounted to the frontal bone or mandible, depending on the surgical area. Though our method, registration procedure was completed successfully by locating the registration points of the templates one by one (Fig 1). Under the guidance of the navigation
Conclusions: Through this registration method, accurate match between the actual intraoperative position and the CT images was achieved successfully by one time in each case. The systematic error was 0.67±0.11mm and target errors satisfied the surgical demands. Intraoperative navigation were initially used to confirm the resection margins and vital structures. Under the guidance of the navigation system, the surgeons could recognize the accurate real-time 3D locations of the dysplastic bone, foreign body and the surrounding anatomic structures. The surgical outcomes illustrated that the dysplastic bone and foreign body were removed successfully.

Clinical Implications: Registration template combines the computer-assisted navigation with the 3D printing technique. It is non-invasive because there is no need to implant titanium screws as registration makers before operation, and highly accurate by using the discrete registration points. The patients undergo one-time CT scanning and avoid redundant radiation injury. And the robustness of the registration method can meet the clinical demands.

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DIGITAL WORKFLOW IN FUNCTIONAL ORBITAL RECONSTRUCTION
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Over the past 20 years, accuracy in reconstruction of boney orbital defects has improved tremendously, however, the ability to correct functional problems, primarily double vision has lagged behind. Reconstruction of secondary orbital defect, defined as residual defects following attempted primary reconstruction, presents a challenging set of functional and aesthetic clinical problems. Patients frequently have symptomatic double vision in combination with enophthalmos, or other global malposition. Using a digital workflow, we have developed an algorithm for secondary orbital reconstruction combining patient selection techniques to stratify functional problems with patient specific (custom) implant. Specifically, these patients all undergo a rigorous pre- and postoperative ocular motility analysis in order to define a subset of patient with a clear restrictive strabismus. Employing this algorithm, we were able to correct symptomatic double vision in the large majority of patients. Workflow, screening examination and multiple patient examples will be presented to illustrate concepts.

Biography: Michael P. Grant, MD, PhD, FACS is the Paul N. Manson Distinguished Professor, Chief of Plastic, Reconstructive and Maxillofacial Surgery and Director of the Maxillofacial Trauma Service, at the R Adams Cowley Shock Trauma Center, University of Maryland Medical Center, and Professor of Surgery (Plastic) and Ophthalmology, University of Maryland School of Medicine in Baltimore Maryland. Previously, he served as Director of Oculoplastic Surgery (2008-2016), Wilmer Eye Institute, Johns Hopkins University School of Medicine as well as the chief of the Eye and Orbital Trauma Center at the Johns Hopkins Hospital (2004-2016). Dr Grant was selected as a trainee in the Medical Scientist Training Program at Case Western Reserve University, receiving a M.D., and Ph.D. in neurosciences. He completed the Ophthalmology residency at the Wilmer Eye Institute, Johns Hopkins Hospital, followed by a General Plastic Surgery residency in the Johns Hopkins/University of Maryland Training Program; and is board certified in both disciplines.
FUTURE OF DIGITAL TECHNOLOGIES IN MEDICINE
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The focus of this presentation will be to highlight the various platforms advanced digital technology is being integrated into the healthcare delivery system. Specific areas to be addressed will include: Recognition of 3D modeling services as an integral part of Radiology Scope of Care Advances in Bio-printing for regeneration, Research (test drugs- liver), islet cells (for loss of pancreas), skin, etc… Advances in print technology – printing of electronics, plastics, metals and combinations of each, Increased speed of Printers (Carbon 3D, NewPro3D), Materials advancement in 3D printing. Complete denture and removable prosthesis Pre-Planning software. Applications of Artificial Intelligence (AI) in custom design.

Biography: Dr. Taft received his D.D.S. degree from Emory University School of Dentistry in 1983. He entered the Navy in 1983 following graduation and was commissioned as a Lieutenant in the U. S. Navy Dental Corps.

Following graduation, Dr. Taft’s first duty station was a one-year general practice residency (GPR) at Portsmouth Naval Hospital, Portsmouth Va. In July of 1984 he reported to Naval Communication Station San Miguel in the Philippines as Department Head for Dental Services. His next duty station was at Naval Air Station Brunswick, Maine, where he served as the clinic Prosthodontist and Division Officer.

In 1988, Dr. Taft entered the Prosthodontic residency program at the Naval Postgraduate School in Bethesda, MD receiving a certificate in 1990. Dr. Taft then entered a fellowship program in Maxillofacial Prosthetics at Wilford Hall Medical Center, Lackland Air Force Base, San Antonio, TX receiving a certificate in 1992. Following his specialty training, Dr. Taft served in various clinical and leadership positions at Naval Medical Center San Diego, CA. Dr. Taft next served as Chairman and Program Director for the Maxillofacial Prosthetics Fellowship Officer program, Naval Postgraduate Dental School from 1997 – 2001 and later as professor in the Naval Postgraduate Prosthodontics Residency Program, 2002. He then was assigned to the Navy Medicine Education and Training Command, Bethesda, MD, as Director, Graduate Programs and was the Medical Joint-Service Education Director, for the 2005 BRAC process. Dr. Taft served as Dean of the Naval Postgraduate Dental School and Specialty Leader to the Surgeon General for Postgraduate Dental Education from June 2006 to June 2011, Deputy Chief, United States Navy Dental Corps from June 2011 to June 2013, Department Chair, Prosthodontics, Naval Postgraduate Dental School from June 2013 to June 2016 and is currently Chairman, Comprehensive Dentistry Department, UT Health, San Antonio, School of Dentistry, San Antonio Texas.

Dr. Taft is a Diplomate, Board Examiner and Past President of the American Board of Prosthodontics, Fellow/Immediate Past President of the American College of Prosthodontists, Fellow, Academy of Prosthodontics, Past President of the American Academy of Maxillofacial Prosthetics, Director of ADT North America, CODA site visitor, and past Specialty Leader to the Surgeon General for Maxillofacial Prosthetics and Implant Dentistry. His personal awards include two Legions of Merit, three Meritorious Service medals, two Navy Commendation medals and two Navy and Marine Corps Achievement medals, Professor Emeritus, Uniformed Services University of the Health Sciences, Presidents Exceptional Service Award, Deans Award for Teaching Excellence, Andrew J. Ackerman Award and the Judson C. Hickey Scientific Writing Award (JPD)
NOVEL METHODOLOGY FOR FABRICATING NASAL PROSTHESES USING 3D FACIAL EXPRESSION MODELS

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Keywords: facial prosthesis, 3D modeling

Purpose/Aim: Facial prosthesis is fabricated for the patient who have the facial defects owing to cancer, trauma and congenital disease. It is conventionally fabricated on the cast made from either conventional or digital impressions. Successful facial prosthetic rehabilitation can be achieved when patients can appear in public without fear of attracting unwanted attention. However, patients often suffer from anxiety that their facial prostheses may fall off because of complex movement with facial expressions. The marginal sealing of a facial prosthesis should be successfully acquired. In order to fabricate well-fitted facial prostheses, we tried to manufacture “3D facial expression models” which include the movement involved with facial expression by using a process known as morphing and tried to fabricate facial prostheses based on the 3D facial expression models.

Materials and Methods: Seven normal subjects and seven patients who has nasal defect participated in this study. Informed consent had obtained prior to the study. Facial surface with two kinds of facial expression (neutral expression and smiling) were scanned using 3D scanner. Scanned data were trimmed to fabricate scanned models. A template model, which is obtained by scanning selected volunteer whose face is comparably average and flat and editing it symmetrical and smooth, was fabricated simultaneously. The template model was digitally deformed to the same shape as the respective scanned model. The deformed models were defined as homologous models. The 3D facial expression model was fabricated based on the two homologous models using morphing methodology that is defined as the object’s motion with time-varying global topology. Accuracy of 3D facial expression models was evaluated. Then facial prostheses were fabricated using the models with five selected facial expressions, which are neutral expression, 30% smile (S30), 50% smile (S50), 70% smile (S70) and smile (S100). Fitting of five kinds of facial prostheses in each patient were evaluated by both visual inspection and the falling off test. This project was approved by the AGU ethics committee (No. 497).

Results: 3D facial expression models were successfully fabricated. Smooth and natural transition of facial expressions were achieved in the computer simulation in normal subjects and defected patients. Accuracy of the homologous models was evaluated by comparison to the scanned models. The mean percentage of differences < 0.1 mm between the models were shown in averagely 93.0% percent for both neutral expression and smile. The facial prostheses fabricated on the cast of 3D facial expression models were hard to fall off compared to the facial prosthesis fabricated on the cast of neutral expression.

Conclusions: The nasal prosthesis fabricated using 3D facial expression model was well fitted with complicated facial movement and marginal sealing was highly obtained. Further study is necessary to apply this method to the auricular or orbital prostheses fabricated using the 3D facial expression model.

DESIGNING INNOVATIVE FACIAL PROSTHESES IN THE 3D WORLD

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Head and Neck Pole
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Case Presentation:

Background: The Centre for Facial Epithetics in Strasbourg, France, works since 30 years + in collaboration with a team of surgeons from the University Hospital Center as well as the University of Strasbourg.

A review of 30 years collaboration between surgeons and anaplastologists for bone anchored prostheses has been made in our clinic. It shows the tremendous changes in the evolution and new perspectives offered by 3D tools. It made possible reconstructive solutions of complex patient cases which were not achievable before. Also, the major steps for the fabrication of facial prostheses are therefore completely revolutionized.

Technique: Collaborative surgery - We use CT scans combined with an Artec Spider surface scanner to digitally designing a surgical guide for implant insertion to be brought into the operating room. The accuracy and precise placement of the implants are capital for the success of the future bone anchored facial prosthesis. But eventually, surgical navigation is used for real time planning of complex cancer cases using also donor surface scans for the design of the missing facial parts.
Discussion: Designing the prosthesis - The surface scanner of metrological precision enables the virtual design of the prosthesis, and 3D printing of the patient’s model and mould.

For an orbital prosthesis for example, the defect side is completed with the virtual image of the orbital. The scan captures the eye orientation so that the ocular piece is then perfectly positioned into the future prosthesis with the precise details of the skin texture and folds.

Conclusion: 3D world has improved many aspects in our workflow with efficiency, quality and predictability. Also virtual planning is the new approach in which patients are more closely involved. They understand realistic prosthetic outcomes for the transition to a new facial identity. Whereas the workflow of the traditional method gave more importance to time spent with the patient for the slow acceptance of its self image.

SIMULATION OF TISSUE-PROSTHESIS MARGIN INTERFACE USING SURFACE SCANNING AND DIGITAL DESIGN FOR AURICULAR PROSTHESES

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Keywords: Facial prosthetics, surface scanning, soft tissue

Purpose/Aim: Digital technology has been incorporated into facial prosthetic treatment pathways, leading to predictable outcomes and efficient care. One of the current limitations to digitally designing facial prostheses lies in the challenge of determining how a prosthesis will fit a patient through a range of facial movements from a static 3D model.

Materials and Methods: A series of surface scans was recorded with different facial expressions and mandible positions. A technique for simulating the soft tissue deformation in the temporal region by overlaying these scan was developed.

Results: This simulation was used to digitally design an anterior prosthetic margin that would remain in intimate contact with the tissue through a range of facial movements.

Conclusions: Digitally simulating tissue deformation is a critical step in furthering not only digital prosthesis design, but medical modeling as a whole.
IMMEDIATE TEMPORARY PROSTHETIC REHABILITATION USING PRE-OPRATIVE CT DATA

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Keywords: nasal prosthetics, CT, rhinectomy

Case Presentation:

Introduction: Cancer ablative rhinectomies are extremely disfiguring surgery. Craniofacial implants for prosthetic retention can be placed at time of surgery or at a secondary procedure but the patient will still wait a minimum of 6 weeks without a prosthesis.

Method: We have developed a protocol for patients undergoing a rhinectomy to ensure that they have a silicone prosthesis immediately following surgery and through the dressing stages until their final implant retained prosthesis is fitted. The initial nasal shape is acquired from the pre operative planning CT and modified using Freeform Plus Software (Geomagics US). This allows the tumour distorted tissues to be modified into a symmetrical form. The form surface is used to create a high consistency silicone prosthesis that can be surgically stitched into place over the post operative dressings. At later dressing changes the prosthesis can be spectacle mounted.

Results/Conclusion: The technique was developed in response to patient feedback that their appearance profile was so dramatically altered it was difficult to face family and friends. The protocol has been well received and helps to rehabilitate patients prior to surgery.

Clinical Implications: The techniques have been applied in other instances such as partial rhinectomies where surgical reconstruction is planned following the biopsy results with good patient feedback and is a useful adjunct to treatment.

FACIAL PROSTHETICS AND OUR MOBILE FUTURE

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Digital technologies continue to change the way we provide facial prosthetic treatment. Increased access to lower cost technologies have engaged more users contributing to greater development of innovative techniques and exponential growth in the development of ever evolving techniques. From advanced digital imaging techniques through device fabrication, users have embraced the use of technology-driven methods to provide facial prosthetic care to more patients with lower costs, improved efficiency and accuracy and greater predictability of outcomes. We now are observing the transition and mimicking of high-cost systems by lower cost methods and more accessible mobile applications. With limited resources worldwide for patient care services and similarly likely fewer professional education resources, providers are seeking technology-driven solutions that are not only accessible and affordable, but that are also mobile. We have seen already the adoption of many in both medicine and dentistry, and witnessed the development of similar pursuits for the fabrication of facial prosthetics. Considering a snapshot perspective of these developments, this presentation will consider the potential for mobile applications and systems in defining the future of facial prosthetic rehabilitation through mobile technology-driven developments worldwide.
A BLINKING PERIORBITAL PROSTHESIS USING SURFACE ELECTROMYOGRAPHIC SIGNALS OF THE ORBICULARIS OCULI MUSCLE
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Background: Recent advances in human-machine interface technology have enabled the development of multifunctional myoelectric prostheses as reported mainly in the orthopedic field. We developed a blinking periorbital prosthesis that could be synchronized with blinking of the intact eyelid by using surface electromyographic signals of the orbicularis oculi muscle noninvasively.

Methods: Myoelectric potential of the orbicularis oculi muscle at blinking were measured with surface electrodes on the eyelid in 4 healthy adults. Possible crosstalk introduced via the electrodes were also measured and assessed to determine whether crosstalk would affect surface electromyographic measurement at blinking.

Results: The amplitude of surface myoelectric potential of the orbicularis oculi muscle was sufficiently high for the practical use of blinking prostheses. Our blinking model was successfully synchronized with blinks of subject’ eyelid under the conditions without crosstalk between the orbicularis oculi muscle and other muscles.

Conclusion: Although our study revealed several problems, the use of surface electromyographic signals would be a useful technique for synchronizing blinking of the prosthetic eyelid with blinking of the intact eyelid, and would be the most promising approach to practical use. In future, we should be developing a smiling or eye moving facial prosthesis, facial movements of which can be synchronized with facial movements on the intact side. Facial prostheses with expressive abilities will improve the uncanny appearance of the prosthesis.

THE COST EFFECTIVENESS OF OCCLUSION-DRIVEN AND DIGITALLY BASED JAW RECONSTRUCTION WITH IMMEDIATE OSSEOINTEGRATED IMPLANT INSTALLATION

Background: Segmental resection of the jaw without formal reconstruction or rehabilitation is a devastating condition that condemns the patient to a life of social isolation, unintelligible speech, and poor oral feeding. The advent of free tissue transfer containing vascularized bone has significantly improved the patients’ outcomes, enhancing the overall quality of life in survivorship. The ideal jaw reconstruction involves the restoration and maintenance of the jaw relations, continuity, facial contour, joint alignment, nasal patency, lacrimal function, orbital integrity, and occlusal reconstruction with dental reconstruction. The procedures accomplishing these reconstructions should also be effective at providing a timely reconstruction that is cost effective. The Alberta Reconstruction Technique (ART) is a protocol of occlusion-driven reconstruction with digital planned immediate osseointegrated implant installation. This jaw reconstruction allows expedited jaw and dental rehabilitation.

Objective: The purpose of the present study is to evaluate the new ART in terms of the effectiveness, timeliness and cost of reconstruction, in comparison with the standard bone-driven and delayed osseointegrated implant installation (BDD) protocol.

Methods: A prospective cohort case controlled study was conducted. Two groups of 15 patients were matched. A comparison of effectiveness, timeliness of reconstruction and direct, health-related costs between ART and BDD surgeries were performed. The difference in quality-adjusted life-years gained between ART and BDD was also assessed based on published utility values of patients with and without dentition.

Results: The ART procedure was more effective at achieving full occlusal reconstruction and oral rehabilitation, with significantly fewer procedures performed and significantly reduced total operative time to full occlusal reconstruction and rehabilitation. The ART cohort of patients also had a reduced treatment time to achieve oral rehabilitation, with the time to complete dental reconstruction being 21.4 months as compared to 73.1 months for the BDD cohort. The cost analysis showed that ART cost an average of $22004 less than BDD and we calculated the QALYs gain to be between 2.14 and 4.04 in favor of ART.

Conclusion: The ART is a good option for patients with jaw defects. It provides a cost-effective reconstruction that restores function and form in a timely manner.

Keywords: mandibular, maxillary, reconstruction, digital surgical planning, surgical design and simulation, occlusion-driven reconstruction, fibular free flap, and osseointegrated implants, Alberta Reconstruction Technique.

Biography: Dr. Hadi Seikaly is a professor of the departments of Surgery and Oncology at the University of Alberta in Edmonton. He is the Director of the division of Otolaryngology – Head and Neck Surgery and the Edmonton Zone Clinical Section Head for Alberta Health Services. Dr. Seikaly is the Co-editor of the Journal of Otolaryngology Head and Neck Surgery and president of the Canadian Association of Head and Neck Surgical Oncologists. Dr. Seikaly graduated from the University of Toronto medical school and completed his residency training at the University of Alberta in Otolaryngology Head and Neck Surgery. He then obtained fellowship training at the University of Texas Medical Branch in advanced head and neck oncology, and microvascular reconstruction. Dr. Seikaly completed a Masters of the Arts in Leadership from the Royal Roads University in 2014. Dr. Seikaly has a large practice dedicated to head, neck, and skull base oncology and reconstruction. His research interests include functional surgical and reconstructive outcomes, microvascular head and neck reconstruction, submandibular gland transfer, and digitally driven complete occlusal reconstruction. Dr. Seikaly is the director of the Head and Neck Research Network. He has been a PI or collaborator on numerous research grants receiving funding from various agencies, including CIHR, Terry Fox Foundation and Alberta Cancer Foundation. He has published over 190 peer reviewed papers and book chapters. Dr. Seikaly is the recipient of the many prestigious awards including the Edmonton Zone Medical Staff Association researcher of the year, the Canadian Society of Otolaryngology Head and Neck Surgery award for national educational excellence, the Ernest Skakun award for service to medical education, and the Mentor of the year. He is a member of numerous surgical societies, nationally/internationally and has been invited as a visiting professor to over 90 institutions lecturing on all aspects of Head and Neck Oncology and reconstruction.
This presentation reports on a study that reviewed the computer aided design (CAD) and metal additive manufacture (AM) literature for implant and guide design, focusing on detailed justifications for design decisions, economic impacts, and production methods. This review showed that the fidelity of reporting in the literature was low; with opportunities to report crucial design decisions, engineering parameters, and how these relate to clinical results being frequently missed. We propose the low fidelity in reporting is due to a combination of: reporting for different specialisms, resulting in a lack of expert knowledge in certain areas and assumed knowledge in others; commercial sensitivity of design and manufacturing methods; low volume of clinical cases; and a large gap in translating research to clinical applications. This presentation concludes that higher fidelity in reporting methods are required when discussing the use of advanced digital technologies for medical implant production. This would allow comparisons between studies, provide evidence to support design quality, and enable evidence-based decision-making.

**Purpose/Aim:** Superior Quality of Life outcomes regarding aesthetics and dental rehabilitation can be achieved with computer-assisted surgery (CAS), compared with conventional surgery for patients needing mandibular reconstruction. High accuracy is needed for guided placed dental implants to become functional which is reason for many surgeons to refrain from guided implant placement during initial reconstruction, resulting in prolonged dental rehabilitation time (6-18 months). A recent systematic review on accuracy of CAS for mandibular reconstruction illustrated high heterogeneity in planning and evaluation methodologies among studies, which limited the ability to perform a meta-analysis comparing accuracy measurements. Subsequently, a guideline was published to create uniformity in planning and evaluation methods. This guideline, contains measurement of the axial, coronal, and sagittal mandibular angles, and an evaluation method of the postoperative positions of virtually planned dental implants. Acceptable outcome ranges (angle and dental implant deviations) and their consequences for functional outcome in mandibular reconstruction using CAS still need to be determined.

**Keywords:** accuracy, mandibular reconstruction, computer-assisted

**Biography:** My work focuses on the effective implementation of design methodologies and technologies to overcome barriers, improve outcomes, and increase efficiency in healthcare. Throughout my career I have developed world leading, application-led research, knowledge exchange and enterprise activities. This has enabled me to make significant contributions to academia, professional practice, economic growth, health and wellbeing. This approach has been acknowledged nationally and internationally through prizes, awards and other esteem indicators, including a highly prestigious Queen’s Anniversary Prize for Higher and Further Education in 2016. I lead a team that develops research projects, knowledge exchange and enterprise activities. I also supervise and examine PhD research; am a member of the EPSRC Peer Review College; have produced 30 peer reviewed journal articles; and have delivered presentations and workshops at numerous international conferences. I work with healthcare specialists, industry and academics to translate research into clinical practice. My research was initially focused in the area of maxillofacial prosthetics. My PhD in this field resulted in six peer reviewed journal papers and numerous conference presentations. Since, I have translated methods developed for facial prosthetics into dental technology, maxillofacial surgery and ortho-orthotics. I have supervised PhD research in these fields, published widely and contributed to numerous workshops, and conferences that develop best practice.

In 2006 I became a founding member of the Centre for Applied Reconstructive Technologies in Surgery (www.CARTIS.org). This was built on existing links between PDR and the Abertawe Bro Morganwg University Health Board (ABM UHB). The Centre, which also extends to other NHS units in South Wales and includes collaborators in Loughborough University, advances the use of technologies that improve healthcare outcomes. Close relationships with the UK NHS has helped to ensure my research is focussed on meeting healthcare needs and is transferred effectively into practice. I have also been heavily involved with the ADT since 2008, where I helped organise the triennial conference in Cardiff. Since then, I have contributed to workshops and presented at all of the global conference, established the UK Regional ADT Group, and been Treasurer of the ADT Foundation. I relish the opportunity to contribute to the advancement of knowledge in the field of head and neck reconstruction.
**Purpose:** The aim of this study is to validate this new evaluation guideline to determine tolerable outcome ranges in a large multicenter cohort.

**Materials and Methods:** Standard patient data, the STL pre-op revised to the virtual plan and a DICOM of the postop CT-scan per patient were collected from eleven head and neck oncological centers spread around the globe. Deviations of the mandibular angles and the dental implants were analyzed with the guideline. Accuracy was assessed on the whole cohort (n=345), and on subsets divided by the mandibular defect classification of James Brown (I-IVc). Ability of dental implants to become functional was used to determine acceptable outcome ranges.

**Results:** Overall, deviations of the mandibular angles ranged between 0.44°-3.64° (axial), 0.51°-6.32° (coronal), and 0.72°-7.59° (sagittal). A higher mandibular defect classification correlated with a lower accuracy and higher deviations of mandibular angles.

**Conclusions:** The postoperative evaluation guideline is a feasible tool and contributes to a much more systematic and uniform approach to objectify the relationships between tolerable outcome ranges in mandibular reconstruction using CAS and their consequences for functional outcome.

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**TECHNOLOGY INNOVATION IN A GLOBAL SURGICAL ORGANIZATION**

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The AO Foundation was established 60 years ago, in Switzerland, by a group of visionary surgeons. They introduced a new protocol for the surgical treatment of fractures, which quickly became the gold standard of what we know as trauma care today, thereby setting the groundwork for a global medical specialty and accompanying multi-billion-dollar industry. Quickly growing to become the largest and most influential network of its kind in the world, the AO incorporated standardized methodology to evaluate and introduce technology to hospitals, and opened up to specialists in other surgical fields, including oral and maxillofacial surgery. Determined to stay at the forefront of innovation, AO has consistently been quick off the mark in adopting new technologies and adapting them to the AO's specific needs. The opportunities offered by today's rapid advances in technology seem almost unlimited, but this increasingly complex environment also presents organizations like the AO, and health care providers, with a number of uncertainties and challenges. This talk will look at the organizational and strategic steps an organization like the AO should take in order to successfully embrace these opportunities.

**Biography:** Claas Albers has been with the AO Foundation, the world's largest network of health care professionals specializing in trauma and musculoskeletal disorders, for over 15 years. As a member of the Executive Management, he is responsible for the organization's Technical Commissions and Innovation Platform, where new ideas generated by the network are evaluated, developed, and certified before they enter the market. He is responsible for the successful launch of AORecon, a global program for education in arthroplasty, and several new business developments at the AO. He holds degrees in law from the Free University of Berlin and the Berlin High Court. Before joining the AO, he worked as a marketing manager in a number of industries.
1. TRACKING ACCURACY OF A STEREO CAMERA-BASED AUGMENTED REALITY NAVIGATION SYSTEM FOR ORTHOGNATHIC SURGERY

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Purpose/Aim: Tracking accuracy is critical to successful augmented reality (AR) in the diagnosis and surgical correction of maxillofacial deformities. The present study investigated the tracking accuracy of an AR navigation system combined with a stereo camera during repositioning of the maxilla after a Le Fort I osteotomy using a 3-dimensional skull model and compared the tracking accuracy with that of an existing infrared (IR)-based optical tracking system (OTS).

Materials and Methods: Five maxillary surgery plans were designed using a 6 degrees-of-freedom articulator that allowed maxillary movement to be set up quantitatively (target distance, 5 mm). To evaluate the accuracy of the stereo camera AR navigation system, it was compared with a commercially available and commonly used IR-based OTS.

Results: The mean error was 0.0584 mm in the IR-based OTS and 0.0596 mm in the AR navigation system. The mean accuracy was 98.83% in the IR-based OTS and 98.81% in the AR navigation system.

Conclusions: In this study, the stereo camera-based AR navigation system fabricated and analyzed by the authors was designed for accuracy. The experiments showed its reliability and accuracy. The hardware developed for this AR navigation system displayed accuracy similar to that of existing high-cost imported devices at a substantially lower cost. In addition to surgery, potential applications of the AR navigation system include patient communication and training for novice clinicians.
2. SIMPLIFIED AND ACCURATE METHOD IN FIBULA/JAW IN A DAY-TECHNIQUE AND INNOVATION

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Keywords: fibula/ jaw in a day

Case Presentation:

Introduction: Fibula/Jaw in a day is using digital technology under computer design tumor cutting, fibula bone osteotomy cutting, dental implant drilling guide and custom made reconstruction plate in one stage jaw bone reconstruction by fibula bone flap and dental implants supported prosthesis placement. It is a new technique but presurgical design prepare is need spend time and higher cost paid by patient, so we present the simplified and accurate technique in one stage surgery.

Method: A stereolithographie mode (STmode) fabricated. The buccal side expanded area was trimmed to symmetric morphology, the reconstruction plate was pre-bend to passive fit in trimmed ST mode and marking the predictive drilling hole at tumor excision after safe margin of proximal and distal segment site at STmode. The tumor cutting guide was made by dental resin, drilling the predictive hole in resin made cutting guide. When tumor osteotomy was performed, the pre-bend reconstruction plate placement the native mandible and reconstruction screw fixation the plate in predict drilling hole of mandible and assistant cheek the final interarch occlusal relationship, no need intermaxillary fixation at post operative surgery. We use wooden tongue depressor as fibular bone ostectomy cutting guide. According the upper teeth dentition marking implant placement position at osteotomies fibula bone segment and placement the dental implant in fibula bone flap at side table, the implant-fibula construct connect with rector guide, transfer the construct to mandible defect area, using moskito forcep instrument holding the vector guide of the construct correct the proper interarch relationship and final fixation the implant-fibula construct to reconstruction plate by reconstruction screws. Transfer the vector guide with scan sensor guide, using intra-oral scanner (Sirona omnican®) for digital impression, under CAD/CAM design and milling the prosthesis by milling machine, about 40’ the implant supported prosthesis can be seat. We select occlusal contact free in first operative, 6 month later replace by permanent implant Supported prosthesis for patient, when the milling implant supported prosthesis procedure, we can do vessel anatomeies and extra oral wound closed.

Discussion: In the visual surgical plane (VSP) technique with 3D guided reconstruction included custom made osteotomy guide and custom made reconstruction plate area associated with additional high costs. Recently several papers was published, and successful results with immediate placement of implants with provisional restorations, but all have required intra-operative prosthetic work, it is need bonding of acrylic or resin to titanium sleeves after inset of the flap, it is risk of contamination recently. We use intra-operative impression technique digital impression technique, under computer design and milling machine fabrication implant supported screw type prosthesis for oral functional rehabilitation in one stage surgery.

Conclusion: In this article, we described the simplified and accuracy method for fibula / Jaw in a day.
Case Presentation:

**Background:** The clinical practice of dentistry has changed significantly in the past 10 years due to advances in dentofacial imaging. The introduction of cone-beam computed tomography (CBCT), specifically dedicated to imaging the maxillofacial region, is a major shift from two-dimensional to three-dimensional (3D) approach and has opened up new vistas in the use of 3D imaging as a diagnostic and treatment planning tool in dentistry. In addition, 3D stereophotogrammetry and intraoral dentition scanning have allowed dentists to acquire 3D surface scans of the face and dentition, complementing CBCT scans to allow 3D-guided diagnosis and treatment in the field of dentistry. About 8 years ago, the National Dental Centre Singapore (NDCS) made the decision to create a 3D unit to coordinate and support centre-wide implementation of digital innovation in dentistry into daily clinical practice.

**Description:** Central to the formation of the unit is to have a core group of clinical engineers who are dedicated to drive this mission. Working with dentist, radiology colleagues and vendors, the engineers acquired competencies in 3D planning and printing to support complex dentofacial treatment. Today, the unit works very closely with the oral and maxillofacial surgeons to provide 3D printed maxillofacial anatomic models as well as 3D guided virtual orthognathic surgical planning and 3D printing of surgical guides. The unit also works with prosthodontists and periodontists on complex dental implant planning, head and neck cancer surgeons on jaw resection and reconstruction cases and maxillofacial prosthodontists on maxillofacial prosthetics.

**Discussion:** Instead of outsourcing, NDCS has invested in creating in-house capability to do 3D planning and printing for complex maxillofacial treatment. With an in-house facility, one should get faster turnaround time which is critical in cancer cases. The in-house facility also facilitates experimentation and innovation in the use of 3D technology for dental and surgical applications. However, there must be sufficient case volume for financial sustainability.
4. ULTRASOUND ELASTOGRAPHY AND AESTHETIC OUTCOMES FOLLOWING FAT GRAFTING TO RADIATED CERVICAL SKIN

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Keywords: Elastography, radiation, fibrosis

Purpose/Aim: The purpose of this study is to evaluate the functional and aesthetic outcomes of autologous adipocyte-derived stem cell fat grafting in previously radiated head and neck cancer patients.

Materials and Methods: This is a prospective pilot study in a tertiary head and neck cancer facility. Ten major head and neck cancer patients treated with external beam radiation to the neck were enrolled in the study. Patients were a minimum of 5-years post radiation treatment with self-reported complaints of post-radiation fibrosis. Patients received two treatments of fat transplantation to their neck, separated by three months. Following the second autologous adipose transplantation, each patient were evaluated at 3, 6, 9 and 12 months. The primary outcome measurement was the Patient and Observer Scar Assessment Scale (POSAS). Secondary outcomes include 3-dimensional volume assessment, neck range of motion, histological assessment using tissue microarray of punch biopsies from the cervical skin, and ultrasound elastography of the cervical skin to assess for tissue stiffness and tension.

Results: Preliminary results show improved POSAS scores for both patients and the expert observers at 6 month follow up. Elastography scores similarly showed decreased tissue stiffness and tension. Neck range of motion was minimally improved.

Conclusions: Autologous fat grafting shows promise to improve aesthetic and functional range of motion in patients with radiation related skin and soft tissue fibrosis. This pilot study could guide a larger prospective cohort study assessing functional and cosmetic outcomes in patients with radiation induced fibrosis. With improved oncologic outcomes for head and neck cancer, survival alone is not enough. Understanding the long term sequelae of radiation therapy and identifying ways to manage symptoms may allow clinicians to intervene earlier to minimize morbidity and optimize patients’ quality of life. Ultrasound elastography is a new frontier of imaging, with little clinical application as of yet. Understanding the clinical, as well as histologic tissue correlations could help to understand the potential of this innovative modality.

5. CREATING A PLATFORM FOR IN-HOSPITAL QUALITY MANAGEMENT SYSTEMS

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Tightening regulations around the use of patient specific medical devices mean that a robust quality management system is required for both hospitals and companies. Developing quality management systems is time consuming and challenging, especially in resource constrained environments and for small businesses. This poster presents practical steps towards creating essential components of quality management system that could be incorporated in-hospital.
6. AN IMAGE IS AN IMAGE UNTIL YOU HAVE THREE-DIMENSIONAL GLASSES: A POTENTIAL APPROACH FOR VISUALIZATION

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Keywords: 2D Image, 3D glasses, visualization

Purpose/Aim: A poster presentation is one of the ways to convey research outcomes in conferences. In most of the cases, it contains three-dimensional (3D) data, but due to the nature of the poster, only two-dimensional (2D) images are presented. This may prevent readers from expanding their access to the most important aspects of the 3D data information. Visualizing 3D structures of maxillofacial defects within a single poster offers great opportunities for the readers to visualize these structures with in-depth 3D perception (X, Y, and Z). The aim of this poster presentation is to highlight a potential approach for visualizing 2D images of maxillofacial defects in 3D mode within a poster presentation using 3D glasses.

Materials and Methods: To highlight the capability of this approach in the field of maxillofacial prosthetics, 3D maxillofacial defect examples are presented in this poster; Maxilleltomy and orbital skull defects. Each 3D data was opened by 3D viewer software, screenshotted and saved as JPEG image format. Each image was imported to Photoshop Adobe image editing software separately to add the 3D effect which include original image layer, cyan layer, and red layer. Both original images and 3D effect images were imported to a poster designed framework and placed in position using Power Point Microsoft Office software. The poster was then printed on A0 size paper poster format. Blue and red 3D glasses were used to visualize the 3D effect images within the poster.

Results: Two-dimensional images were successfully edited to add 3D effect, printed within a poster, and visualized in 3D mode using 3D glasses. Using 3D glasses showed enhanced visualization for maxillofacial defects especially in the depth direction (Z).

Conclusions: The use of 3D glasses with added 3D effect to 2D images have effectively utilized in the field of maxillofacial prosthetics. Such approach would be used to improve the 3D visualization of 2D images within poster presentations, resulting in a better visualization and improved learning experience.
APPLICATION OF VARIOUS INTRAORAL SCANNERS FOR DIGITIZING A NOSE MODEL.

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Keywords: prosthodontic treatment, maxillofacial rehabilitation, facial prosthesis

Purpose/Aim: Maxillofacial prostheses are used for the rehabilitation after head and neck cancer resection. Facial impressions are made using dental impression materials to fabricate maxillofacial prostheses. However, making a conventional impression of a face is a complicated procedure and often causes discomfort to the patients. Making impressions on the supine position also can create distress because of the weight of the material and the different direction of gravity from standing or sitting position. It also has the risk of foreign body impaction or suffocation. The use of a facial scanner is an alternative approach for digital “impression taking”: However, such a device is not always available in dental clinics while intraoral scanners are more common to be used in dental clinics. The purpose of this in vitro study was to evaluate the application of intraoral scanners for maxillofacial prosthodontics in digitizing a nose model.

Materials and Methods: A skin colored head model made by soft acrylic was used. The model was scanned with an industrial scanner as a reference. Three intraoral scanners were used in this study as test groups. The nose part of the model was scanned with the intraoral scanners simulating the situation of taking impressions before maxillofacial surgery for designing a nasal prosthesis. Five scans were performed with each scanner according to the instructions of the manufacturers. Conventional impressions were also made five times using irreversible hydrocolloid impression material and then poured using type 3 dental stone. The stone models were scanned by using a desktop dental scanner. All scans were saved in STL files, imported into a three-dimensional analyzing software (Geomagic control) and matched with the reference data using the best fit algorithm. Trueness and precision values were calculated for each approach. A linear mixed model was used for statistical analysis.

Results: Scanning was successful with True Definition scanner and CaraTrios-3 scanner. With Cerec scanner, scanning stopped frequently, and no image was obtained. The trueness and precision for the intraoral scanner and conventional impression are shown on the figure 2 and 3. Statistically significant differences were observed for trueness and precision values between conventional and digital impressions (P < 0.05). Both scanners showed significantly smaller mean trueness and precision values comparing to conventional impressions meaning the impressions made by scanners were more accurate.

Conclusions: Two intraoral scanners showed their feasibility for digitizing a nose model efficiently. The scanners presented better trueness and precision values compared to conventional impressions. It is concluded that it is possible to digitize noses effectively using intraoral scanners.
8. AESTHETIC OUTCOMES OF PATIENTS WITH MANDIBULAR RECONSTRUCTION

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Keywords: mandibulectomy, aesthetics, reconstruction

Purpose/Aim: Surgery to reconstruct mandibular defects has become a viable option with the introduction of microvascular osseous free flap reconstruction. Although restoring function is of paramount importance when managing mandibular defects, patient satisfaction will also depend on the aesthetic outcome of the treatment. The objective of this study was to evaluate facial aesthetic outcomes after mandibulectomy with functional free flap reconstruction. This technique of reconstruction typically results in the fibula being positioned slightly superior to the lower border of the mandible to promote optimal prosthetic space and occlusion.

Materials and Methods: Using digitized photographs, facial attractiveness was rated on a 10-point scale by naïve judges in a tertiary head and neck cancer referral center. Nineteen patients that underwent functional fibular free flap reconstruction of the mandible were included. These patients typically underwent mandibulectomy as part of their treatment for head and neck tumors. Using digitized photographs, facial attractiveness was rated on a 10-point scale by naïve judges comparing pre-and-post operative images. The main outcome measured was facial attractiveness scored on a 10-point scale.

Results: Nineteen patients were evaluated. All of the patients had fibular free flap reconstructions with an average of 2.8 dental implants placed at the time of surgery. The position of the fibula from the lower border of the mandible ranged from 0.2-1.1cm. There were no significant differences found on facial attractiveness ratings.

Conclusions: This study found no difference between pre-and post-operative facial attractiveness when functionality-driven positioning is used for reconstruction after mandibulectomy as assessed by naïve raters. Functional reconstructions of the mandible are aesthetically appealing.

9. TECHNICAL REPORT OF LE FORT I OSTEOTOMY USING MICROSOFT®HOLOLENS AND 3D DEVICES

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Keywords: Virtual reality, orthognathic surgery, Le Fort I osteotomy

Purpose/Aim: Virtual reality (VR) allows for interactive manipulation of high-resolution representations of patient-specific imaging data. VR assisted surgery is being conducted at digestive region, but it is not being conducted at oral surgery region. Conventional Le Fort I osteotomy did not have reproducibility, osteotomy line and transfer of maxillary was different from operator and case. Many cases used bite splint made from preoperative plaster cast for transfer of maxillary. In this study, we report highly-reproducible Le Fort I osteotomy using HoloLens and 3D devices.

Materials and Methods: We present the novel use of VR and 3D devices for the presurgical planning and surgery of Le Fort I osteotomy. We used pre-operation CT data and carried out virtual operation for deciding cutting line by Materialise Mimics® and Materialise 3-matic to make cutting device and 3D device which reproduced transfer of maxillary. 3D devices and bite splint had junction for switching devices. We made polygon model from virtual operation data and we projected that on patient by HoloLens.

Results: After mucoperioveal flap abrasion, we adapted splint to upper arrangement of the teeth. We jointed cutting device and carried out osteotomy. Then we switched cutting device for 3D device which reproduced transfer of maxillary. The device in osteotomy section, its enabled to fix plate planed preoperatively. We projected VR which reproduced transfer of maxillary on patient and confirmed the correspondence.
**Conclusions:** Using VR which was prepared before operation and 3D devices was made possible to reproduce osteotomy and plate fixing planned preoperatively by virtual operation. In the near future, we will establish novel technique for high reproducibility orthognathic surgery without laboratory work.

**OBJECTIVE**

In the image-assisted surgery in the conventional Le Fort I osteotomy, there are few reports to confirm three-dimensionally whether the maxilla could be moved as planned during the surgery. In recent years, it has been reported in various fields that the introduction of Microsoft® Hololens, which is a head mounted display equipped with Mixed Reality (MR) technology, during surgery improves the safety and accuracy of surgery and shortens the surgery time. We have reported a method to confirm the reproducibility of the three-dimensional position of the maxilla during surgery by combining MR and CAD/CAM techniques for Le Fort I osteotomy. In the present study, we verified the accuracy of reproducibility.

**MATERIALS AND METHODS**

![Diagram of the methodology](image)

1. **Acquisition image**
   - CT
   - CBCT model scan

2. **Treatment planning**
   - STL importing
   - Virtual operation
   - CAD design

3. **Fabrication of 3D devices**
   - Surgical splint
   - Osteotomy guide
   - Repositioning guide
   - Registration marker

4. **Microsoft® Hololens application**
   - Create Microsoft® Hololens applications
   - Onsite test
   - Visualized community
   - Paperless VR system
   - Registration marker

5. **Operation**
   - CAD/CAM assisted surgery
   - Mixed reality assisted surgery

6. **Outcome evaluation**
   - The comparison between virtual operation and postoperative CT

**RESULTS**

![Diagram of the results](image)

<table>
<thead>
<tr>
<th>Case</th>
<th>Gender</th>
<th>Diagnosis of Angle</th>
<th>Error (mm)</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>Class II</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>Class II AS</td>
<td>83</td>
<td>83</td>
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<tr>
<td>3</td>
<td>M</td>
<td>Class II AS</td>
<td>95</td>
<td>95</td>
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<td>4</td>
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<td>6</td>
<td>F</td>
<td>Class II AS</td>
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</table>

A total of 6 patients who underwent either HSSRO and of Le Fort I osteotomy between January 2019 and April 2019 were included in this study. One male and six females, with an average age of 25.9. Preoperative virtual operation and postoperative 1 month CT superposition were performed semi-automatically with reference to the cranial bone which did not change in surgery.

**DISCUSSION AND CONCLUSIONS**

In general, image guided surgery requires expensive equipment, and there have been past reports that patient specific implants, on average, cost about $850 per case. In this method, expensive equipment was not required, and it was possible to make 3D devices at an average cost of about $90 per case.

The accuracy of Le Fort I osteotomy combined with image guided surgery or patient specific implant has been reported to be the error average is 3.8% - 97.6%, suggesting the effectiveness of this method.

In the future, we expect that hardware development will further improve the accuracy and safety of surgery.

**Acknowledgement**

We thank Hololens Inc. for the Mixed Reality technical support.

**Disclosure of Conflict of Interest**

None of the authors have a conflict of interest.
10. MAXILLARY RECONSTRUCTION USING 3-D PRINTED IMPLANT

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Keywords: Maxillary reconstruction, 3-d printed implant

Case Presentation: A patient who has very large maxillary defect was treated with 3-d printed implant with particulated iliac bone. This implant was fit very well to the defect and can hold the autogenous bone well within its mesh structure. PCL(Polycaprolactone) was used as a materials for 3-d printing. This material is biodegradable so will be disappeared. There are no foreign reactions and wound dehiscences.

11. SURVIVAL PREDICTION OF ORAL CANCER PATIENTS USING DEEP LEARNING

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Keywords: Oral Squamous Cell Carcinoma, Survival Analysis, Artificial Intelligence

Purpose/Aim: We applied a deep learning-based survival prediction method in oral squamous cell carcinoma (SCC) patients and validated its performance.

Materials and Methods: Medical records of patients who had undergone surgical treatment of oral SCC in our department from January 2000 to November 2018 were retrospectively reviewed. 255 patients’ records were suitable for analysis. The statistical analysis was performed using the R programming language (R Core Team, Vienna, Austria, 2018). To estimate the prognostic effect of the features, univariate and multiple CPH regression analysis were done. Survival prediction using DeepSurv, a deep learning based-survival prediction algorithm, was compared with random survival forest (RSF) and the Cox proportional hazard model (CPH). Random survival forest models were trained using the RandomForestSRC R package. DeepSurv by Katzman et al. was implemented as an open-source Python module. Prior to constructing machine learning models, the data set was split into two mutually exclusive sets. 70% of the overall dataset was assigned as the training set, which was utilized to generate the prediction model. The remaining 30% of the data was designated as the testing set, for use in estimating the model’s accuracy. Harrell’s c-index was used to compare the performance of the proposed methods.

Conclusions: Deep learning-based survival prediction may improve prediction accuracy and guide clinicians both in choosing treatment options for better survival and in avoiding unnecessary treatments.
12. DIGITAL EVALUATIONS USING FLUORESCENCE VISUALIZATION DEVICE FOR DIFFERENTIATION BETWEEN SUPERFICIAL ORAL SQUAMOUS CELL CARCINOMA AND ORAL LICHEN PLANUS

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Keywords: fluorescence visualization device, autofluorescence, oral squamous cell carcinoma

Purpose/Aim: There are various diseases in the oral mucosa, which makes diagnosis difficult. Fluorescence visualization (FV) devices allow non-invasive screening for oral squamous cell carcinoma (OSCC). Although its usefulness has been reported using subjective evaluations, this study aimed to clarify its utility in screening oral mucosal diseases using subjective and objective evaluations.

Materials and Methods: Fifty patients with superficial OSCC or oral lichen planus (OLP) treated at Tokyo Dental College between April 2016 and March 2018 were investigated. Subjective evaluation involved discriminating FV retention from FV loss (FVL), while objective evaluation involved calculation of luminance and luminance rate (LR) as luminance of the lesion/luminance of control, and border change rate (BCR) using image-processing software. We calculated the area under the curve (AUC), sensitivity, and specificity using receiver operating characteristic (ROC) analysis.

Results: In subjective evaluations, FVL was observed in all cases. In objective evaluations, luminance tended to be higher for OSCC than for OLP, but the difference was not significant. LR was significantly higher for OSCC than for OLP. BCR was significantly lower for OSCC than for OLP. In ROC analyses, AUCs for luminance, LR, and BCR were 0.613, 0.864, and 0.913, respectively; cut-offs were 97.0, 69.0, and 27.2; sensitivities were 85.0%, 90.0%, and 85.5%; and specificities were 36.7%, 70.0%, and 93.3%.

Conclusions: Objective evaluations, such as LR and BCR using the FV device, appear to be useful for discriminating between OSCC and OLP.
13. APPLICATION OF NAVIGATION-GUIDED SYSTEM AND CAD/CAM SPLINT FOR ORTHOGNATHIC SURGERY

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Keywords: Orthognathic surgery, Navigation system, CAD/CAM sprint

Case Presentation:

Background: The benefit of computer-assisted planning in orthognathic surgery has been reported over the last decade. However, the use of simulation software to the treatment planning of orthognathic surgery, it is difficult to accurately reflect the surgical results. Here, we show a digital workflow for two-jaw orthognathic surgery using navigation-guided system combined with CAD/CAM sprint.

Methods: A virtual surgical planning was achieved by the combination of a 3D skull model acquired from computed tomography (CT) and surface scanning of the dental arch respectively and final occlusal position. Surgical simulation were simulated by ProPlan CMF® ver. 3.0 (Materialise, Leuven, Belgium). The surgical plan was transferred to surgical splints fabricated by means of Computer Aided Design/Computer Aided Manufacturing (CAD/CAM), and also transferred to navigation guided system (Kick Navigation system® BRAINLAB, Feldkirchen, Germany). The maxillary segment was moved to the target location by checking the position three dimensionally using a navigation system, and the mandible was moved to articulate with the maxilla.

Results: There is no significant error in the comparison of planned amount of movement by computer simulated analysis and surgery amount of movement by using real-time three-dimensional navigation surgical management. The results of our treatment to both lack and excess of facial convexity were accurate and safer, and no surgical complications were detected.

Conclusion: Using surgical navigation system and CAD/CAM sprint is a promising tool aiming to improve the safety and precision of orthognathic surgery.

14. LINGUAL APPLICATION OF PRE-BENT RECONSTRUCTION PLATE FOR SEGMENTAL MANDIBULAR DEFECT

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Keywords: Computer-assisted surgery, virtual surgical simulation, surgical guides

Case Presentation: To prevent or treat for complications of reconstruction plate, such as metal plate fracture, plate exposure, and formation of skin fistula, the use of reconstruction plates on the mandibular lingual aspect has been introduced. However, this method increases the difficulty of surgery and lengthens the surgery time. In this study, we aimed to present a method to apply for reconstruction plates on the lingual side of the mandible to overcome the complications associated with the use of these plates. In the proposed method, the reconstruction plate was bent and fixed by specially designed screws on a three-dimensional model created through a pre-operative virtual surgical simulation. Next, the model, prebent reconstruction plant, and screw were 3-dimensionally scanned and then superimposed precisely onto the three-dimensional model generated through the virtual surgical simulation. After extracting the three-dimensional path of the screws on the superimposed model, a surgical guide was prepared to drill screw holes in the buccal side of the mandible by transferring the extracted paths. The proposed surgical method using virtual surgical planning and surgical guides makes mandibular lingual application of the prebent reconstruction plates convenient, fast, and precise through drilling in the buccal side of the mandible. This research was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number : HI18C1224).
15. ON LINE, ON DEMAND, SERVICE IN ORTHOGNATHIC SURGERY

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Keywords: on line, on demand, service

Purpose/Aim: Planification in orthognathic surgery is of tremendous importance. Ideally this step must generate a surgical splint allowing to precisely concretise the planification during surgery. This step can be tedious, especially when using mechanical articulators. Complex and costly 3D software solutions are available but are they always adapted?

Materials and Methods: The authors present a classical internet site developed by the ONE ORTHO/Globad D company based in Lyon France.

Results: The result in an, on line, on demand, service allowing to precisely plan the surgery and to generate either the surgical splint or the virtual reciprocal position of the dental arches in a mandible first approach for further exploitation. Two 2D pictures and two dental STL in therapeutic occlusion are manipulated in a 3D environment helped by Delaire's reverse cephalometry landmarks.

This service runs in a simple web browser even in low end computers. All the steps can be done by the surgeon, some, or all steps can be delegated to ONE ORTHO upon surgeon's needs.

Conclusions: This, fast, efficient and inexpensive, solution is already used routinely by the authors.
Service in orthognathic surgery

Surgical planning software is run on high-end computers and needs a long and tedious setup of the cases: creation of the 3D models, generation of the 3D orthognathic slices, synchro- ization of the dental STL models with these volumes, virtual simulation of the 2D and 3D pictures, virtual simulation of the osseous resections, virtual repositioning of the segmented jaws, etc. This approach can be heavy time consuming and not necessarily useful or precise in the absence of adequate cutting guides. Beside this, is there any advantage to perform the osseous resection by a computer, and then again in the operating room where the jaws, which don’t know anything about virtual surgery, won’t necessarily split where simulated?

It is presented an enhanced virtual articulator running online as a service that simplifies the planning process by using merged dental 3D models in a calibrated virtual space. This service allows, with the minimum of data, to easily and quickly, get the 3D printed surgical splint by delegating some or all of the planning stages.

It runs in a web browser from everywhere in the world

1. **Online work**: calibration and synchronization of the 2D pictures
   - Calibration of the 2D picture using a 2D producer marker.
   - Setting of the facial plane and digital salivary of the bony structure.
   - Determination of the hinge axis of the mandible.

2. **Reverse cephalometry (RC)** giving the ideal theoretical area of the maxillary
   - Scale of the 2D orthognathic with the digital scaling system.
   - RC 3D digital images.

3. **Importation and calibration of the maxillary STL model in the virtual calibrated space**
   - The complete virtual maxillary model is imported into the RC software.
   - Determination of the ideal theoretical area of the maxillary.

4. **Spatial corrections to reach the theoretical facial area**
   - The VRD the virtual area defined by the RC and the planned area.
   - The VRD is used to simulate different cuts in the virtual area.

5. **Elimination of the interferences. Get the burr. Get the surgical split**
   - Tree virtual models of the mandible are used to simulate different cuts in the virtual area.
   - The virtual burr is used to simulate the surgical split.

This solution is online, on demand, service in orthognathic surgery planning.
- It simply runs in a web browser, needs a short learning time and focuses on the essentials.
- It is based on Okuda’s principles allowing to define in space the patient’s ideal facial architecture.
- Synchronization of the 2D and 3D data is purposely limited to the necessary minimum.
- The conclusion can be finely set on physical models and the generated split be controlled on a mechanical articulator.

The surgeon can focus on the goal more than on the means!

For further details contact: online.orthognathic.planning@gmail.com
16. DIGITAL PLANNING AND SURGICAL SIMULATION IN THE RECONSTRUCTION OF CHRONIC MANDIBULAR DEFECTS

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Keywords: Reconstruction, Simulation, Mandible

Purpose/Aim: Background: Chronic mandibular defects due to cancer surgery, trauma or osteoradionecrosis (ORN) are difficult to reconstruct with regular intuitive intraoperative technique. This is due to the resultant displacement of the mandibular segments and malpositioning of the temporomandibular joints (TMJ) following the initial insult. The use of surgical design and simulation (SDS), also known as virtual surgical planning (VSP), has increased over the past decade. These surgical planning and simulation adjuncts involve the digitization of the facial bones and the bony free flap donor site chosen to reconstruct the jaw. Through the digital process, surgery is planned and simulated virtually. This technology allows for accurate repositioning of the mandibular segments and the TMJ.

Objective: To report on two cases of chronic mandibular defects reconstructed with free fibular flaps using SDS.

Materials and Methods: A high-resolution helical CT scan of the facial bones and the bony free flap donor site were obtained. These files were imported into Mimics Medical software and three-dimensionally rendered, virtually analyzed, and surgically planned using the tools provided by the software. 3D representations of the patient’s head and neck anatomy were generated (figure 1), and virtual surgery was performed. The jaw segments and TMJ were virtually repositioned and virtual occlusion was then developed on screen (figure 2). The virtual plan was then used to digitally design the required surgical tools, including resection guides, a fibula implant installation drilling guide that incorporates the flap osteotomy cutting guide, and a transfer template to be used to inset the bone containing free flap into the correct spatial relationship as guided by the occlusion (figure 3). Once completed, the SDS plan was translated back to a physical plan that could be used in the operating room through guides and tools (figure 4).

Results: Two patients were identified, each with a previous history of either ORN or trauma. The SDS plan was executed in the operating room without change. Both patients had occlusion reestablished with repositioning of the mandibular segments and TMJs (figures 5 and 6). Post operatively, each patient reported good satisfaction with their functional and cosmetic result. Furthermore, despite the extensive nature of the surgery, both returned to an acceptable level of functioning with no reported deficits.

Conclusions: SDS provides the technological innovation to reconstruct chronic mandibular defect with excellent cosmetic and functional results.
17. DETECTING SKELETAL DEFORMITY IN UNILATERAL CORONAL CRANIOSYNOSTOSIS – PERCEPTIONS OF THE GENERAL PUBLIC

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Keywords: Craniosynostosis, FOA

Purpose/Aim: Unicoronal synostosis (UCS) affects the shape of an infant’s skull, often resulting in an asymmetric forehead. As a result, children with untreated UCS may face psychosocial discrimination. Cranial vault remodelling (CVR) surgery aims at improving the aesthetic appearance of the infant by reshaping the bones that form the contour of the forehead. Common methods to assess surgical outcomes following CVR rely on expert surgeons’ perceptions of peoples’ appearances. However, studies have shown that patients’ perceptions may not always correlate with experts’ perceptions. There are no outcome measurements described that relate surgical outcome with laypersons’ perception of skull normality. In addition, there is limited data on public perceptions of craniosynostosis deformities. Therefore, purpose of this study is two-fold: 1) determine if laypersons are able to distinguish between normal and abnormal skulls when displayed images for a brief period, and 2) determine if laypersons’ responses can be predicted by an objective value of skull deformity.

Materials and Methods: 24 normal and 21 UCS skulls between ages 0 and 24 months were identified. 3D surface models were created for each skull from 1 mm slice CT head scans using 3D Slicer open source software. Maximum surface distances between each UCS skull and an age and sex-matched normal skull at the frontal bones were calculated. Using this method, a larger distance was used to represent more severe deformity. 40 participants from the general public with non-surgical backgrounds were recruited. Each participant was shown a presentation that included a short training session on normal infant skull anatomy, followed by the study session where they were shown the 45 skulls for 300 milliseconds each. Participants rated their perception of each skull as normal or abnormal. A chi-square analysis was used to compare response data, and logistic regression was calculated to predict raters’ response based on objective value of skull deformity.

Results: Members of the general public were good at distinguishing between normal and abnormal skulls (?2 (1) = 281.97, p < 0.001). Raters were more likely to rank normal skulls as normal (69%) and UCS skulls as abnormal (71%). In addition, the raters’ responses were predicted by the surface distance values assigned to the UCS skulls (F, (1,838) = 0.09, p = 0.016 [CI: 0.02-0.17]).

Conclusions: This is the first study investigating the relationship between objective skull deformity in UCS and public perception. Layperson raters were effective at correctly categorizing normal and abnormal infant skulls based on their perceptions. Layperson’s perceptions of normality were predicted by an objective value of skull deformity, determined by maximum surface distance values measured at the forehead region. The brevity of interaction between the raters and the skull images simulates a first impression scenario.
Detecting skeletal deformity in patients with unilateral coronal craniosynostosis – perceptions of the general public

Emilie Robertson, MD1,2, Peter Kwan, MD, PhD1, Gorman Louie, MD1, Pierre Boulanger, PhD3, Daniel Aalto, PhD1,4

Introduction

- Unilateral coronal synostosis (UCS) affects the shape of an infant's skull, often resulting in an asymmetric forehead.
- Children with untreated UCS may face psychosocial discrimination.1,2
- Cranial suture remodeling (CSR) surgery aims at improving the aesthetic appearance of the infant by reshaping the bones that form the contour of the forehead.3
- Surgeon's perceptions of patients' appearance is a frequently used method to report surgical outcomes following CSR surgery.4
- However, studies have shown that patients' perceptions may not always correlate with experts' perceptions.5

The Problem

There are no outcome measurements described that relate surgical outcome with laypersons' perception of skull similarity. In addition, there is limited data on public perceptions of craniosynostosis deformities.

Objectives

1) Determine if laypersons are able to perceive the difference between normal and abnormal skulls when displayed briefly.
2) Determine if laypersons' responses can be predicted by an objective value of skull deformity.

Methods and Materials

- 40 participants from the general public with non-surgical backgrounds were recruited as layperson skull raters, and asked to rate a series of skull images as 'normal' or 'abnormal'.
- Minimum surface distance between each UCS skull and an age and sex-matched normal skull at the frontal bones were calculated.
- Logistic regression was performed to predict raters' response based on surface distance values.

Results and Discussion

- Layperson raters were able to distinguish between normal and abnormal skulls.
- Raters' predictions were predicted by the surface distance values assigned to the UCS skulls (OR:1.138, 95% CI:1.00-1.29, p=0.048).
- A 10% threshold value of 2.8 mm (OR: 2.0-3.8) was derived from the regression model.
- This data suggests that the use of surface distance measurements between UCS and age-sex matched normal skulls to determine an objective value of deformity predicts layperson raters' responses of skull perception.

Conclusions

- This is the first study investigating the relationship between objective skull deformity as UCS and public perception.
- Layperson raters were effective at correctly categorizing normal and abnormal infant skulls based on their perceptions.
- Laypersons' perceptions of normality were predicted by an objective value of skull deformity, determined by maximum surface distance values measured at the frontal region.
- The brevity of interaction between the raters and the skull images simulates a first impression scenario, and this information may be helpful when counselling patients.

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Figure 1: Laypersons assessed each skull 3D model twice for 30 seconds, followed by 1 second to review responses. Normal and abnormal skull groups were balanced in terms of age (2-4 months) and sex.

Figure 2: The method used to assign objective values of deformity to the UCS skulls. Minimum headstuff surface distances were automatically calculated between the UCS and normal frontal bone segments.

Figure 3: The distribution of surface distances calculated by surface distance values within the UCS skull group. (h: headstuff = more severe deformity).

Figure 4: Laypersons' perceptions of normal and abnormal skulls with a Chi-square analysis.
18. THE CHANGE OF THE PHARYNGEALE AIR FLOW AFTER THE MAXILLOMANDIBULAR ADVANCEMENT

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Keywords: maxillomandibular advancement (MMA), Computational Fluid Dynamics (CFD)

Purpose/Aim: The change of the pharyngeal airway after the maxillomandibular advancement (MMA) is well known. However, little is known about the pharyngeal airflow change after MMA moreover the most effective amount of movement of MMA. In order to establish a method to determine the most effective amount of movement for each case in obstructive sleep apnea patients, we are researching a noninvasive method to identify pharyngeal airflow characteristics in OSA patients using Computational Fluid Dynamics (CFD) analysis in the first stage.

Materials and Methods: All patients who had MMA underwent CT and rhinomamometry before and 1 year after surgery. Airway images were extracted and converted to standard triangulated language (STL) data using Intage Volume Editor (version 1.1; Cybernet Systems Co., Ltd., Tokyo, Japan) from DICOM data. A mesh was prepared from the STL data using HEXPRESS (version 5.2; NUMECA International Company, Brussels, Belgium). The computational mesh was prepared with the inlet boundary in the anterior region of the face, and the outlet boundary in the lower part of the airway. To analyze air flow from the nasal airway to the upper airway, a numerical simulation method based on Navier-Stokes equations for compressible fluids was used. For this analysis, fluid simulation was conducted using FINE/Open with OpenLabs (version 5.2; NUMECA Co).

Results: The nasal patency measurements by rhinomamometry and the simulation results during inhalation were consistent. When the flow rate was 500 cm³/s or more, the simulation results deviated from the actual measurements however, at lower flow rates, the simulation results were mostly distributed in or near the error range.

Both the rhinomamometry and simulation, the static pressures were lower after surgery than before surgery. The axial velocity was also decelerated at vicinity of external nostril and epiglottis. The axial velocity was equalized at whole nasal cavity after surgery.

Conclusions: Thus, this finding confirmed that, in qualitative terms, the simulation tended to be close to the actual measurements. These findings suggest that (1) patients’ actual respiratory dynamics can be approximately reproduced, based on the simulation presented in this report; (2) the ability to ascertain preoperatively the regions of the airway with constrictions and/or high static pressure would provide warnings about the potential for airway obstruction; The findings of the current study suggested that surgery resulted in negative pressure developing less readily.

19. EVALUATION OF NAVIGATION-GUIDED SYSTEM FOR ORTHOGNATHIC SURGERY

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Tokyo, Ota-Ku, Japan

Purpose/Aim: Surgical navigation systems are now widely used in oral and maxillofacial surgery. It is also not an exception in orthognathic surgery. Recently, the development of simulation software has allowed preoperative prediction for the treatment of orthognathic surgery including of the site and degree of bone interference during bony segment movement, as well as the maxillofacial skeletal morphology after bony segment movement. However, the use of simulation software to the treatment planning of orthognathic surgery, it is difficult to accurately reflect the surgical results. Here, we show a computer-guided surgical navigation approach for Le Fort 1 osteotomy, and evaluation the accuracy of the present surgical method by superimposed of postoperative CT image and the simulated image.
Materials and Methods: 20 patients who were underwent navigation-guided orthognathic surgery at our hospital were examined. Preoperative virtual surgeries were performed for two-jaw orthognathic surgery by simulation software, and transfer these results for navigation-guided system. The maxillary segment was moved to the target location by checking the position three dimensionally using these systems. The preoperative simulation image and the postoperative three-dimensional image were superimposed, and the difference between the two images were measured to evaluate the accuracy of the surgery.

Results: 20 patients who were underwent navigation-guided orthognathic surgery at our hospital were examined. Preoperative virtual surgeries were performed for two-jaw orthognathic surgery by simulation software, and transfer these results for navigation-guided system. The maxillary segment was moved to the target location by checking the position three dimensionally using these systems. The preoperative simulation image and the postoperative three-dimensional image were superimposed, and the difference between the two images were measured to evaluate the accuracy of the surgery.

Conclusions: Surgical navigation system is a promising tool aiming to improve the safety and precision of orthognathic surgery.

20. CASE SERIES EVALUATION OF THREE DIMENSIONAL RECONSTRUCTION OF NASAL SEPTAL PERFORATIONS WITH OBTURATOR PROSTHETICS

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Division of Otolaryngology Head and Neck Surgery
Edmonton, Alberta, Canada

Case Presentation:

Background: Nasal septal perforations (NSP) arise from a multitude of underlying etiologies to occur at an estimated 1-2% prevalence in the general population. Symptoms can manifest as epistaxis, nasal crusting, whistling and irritation impairing quality of life. Conservative measures often yield minimal relief, directing primary treatment to septal buttons and surgical flap reconstruction, often limited by larger and irregular perforations. Recent contemporary innovations have expanded the scope of digitally aided printing reconstruction to construct tailored septal obturators. There is currently a paucity of literature exploring this novel approach. In this study we aim to further evaluate the outcomes following digitally facilitated reconstruction of NSP obturators.

Technique/Case Report: We conducted a prospective case series on six adult patients with NSPs who failed conservative management and proceeded with 3-D printed reconstruction of a silicone based septal obturator unique to the individual. We compared SinoNasal Outcomes Test-22 (SNOT-22) scores and Acoustic Rhinometry measurements prior to and following obturator insertion.

Discussion: Successful closure of the septal perforation was obtained in all patients, confirmed with rigid nasal endoscopy. SNOT-22 scores were reduced to 38.8 percent (95 percent CI, 18.4 to 54.8 percent; p < 0.05) and 22.6 percent (95 percent CI, 8.9 to 34.4 percent; p < 0.05) of baseline symptoms at 4 weeks and 12 weeks following insertion respectively. Acoustic rhinometry consolidated perforation closure and depicted a 78.6 percent (95 percent CI, 62.1 to 94.4 percent; p < 0.05) reduction in cross-sectional nasal area from baseline.

Conclusion: This is the first study to demonstrate both subjective and objective measures of NSP improvement following insertion of 3-D reconstructed septal obturators, showing strong promise as a viable alternative to surgical interventions in repairing large complex perforations.

Clinical Implications: 3-D printing reconstruction has a burgeoning utility in rhinology, with the possibility of designing custom septal obturators to optimize compliance and mitigate symptoms.
21. A FOUR-DIMENSIONAL SCANNING APPROACH TO OBTAIN SURFACE DATA OF THE FACE

Sumita, Yuka *, Hattori Mariko, Wiebke Semper-Hogg, Gao Yuan, Zhang Manjin, Elbashiti Mahmoud E. Tokyo Medical and Dental University, Tokyo, Japan. Medical Center, University of Freiburg, Faculty of Medicine, University of Freiburg, Freiburg, Germany. Department of Maxillofacial Prosthetics. Department of Oral and Craniomaxillofacial Surgery. Tokyo, Japan

Keywords: Facial prosthesis, Maxillofacial prosthetics

Purpose/Aim: Digital scanning of a face is useful for head and neck surgery and prosthetic rehabilitation. Three-dimensional (3D) facial scanners have been used for digitizing faces. However, they usually require patients to be motionlessness while scanning and it is difficult for some patients especially children and elderly to keep their head stable. Nowadays, four-dimensional (4D) scanners are used for capturing the motion of a face while functioning and the movie data consist of multiple captured 3D data. Thus, this study aimed to use a 4D scanner to capture a 3D facial data and evaluate its accuracy.

Materials and Methods: A head model was used as a scanning object in this study. It was firstly scanned by an industrial scanner for the reference. The head model was then scanned by the facial scanner (3dMD) in a 4D mode for twenty seconds. 200 images were captured and 10 of them were randomly selected. The images were saved in STL file format and matched with the reference scan using the best fit algorithm of a 3D evaluation software (SpGauge). The 3D deviation was numerically examined and the color mapping was also observed.

Results: The mean distance and distance standard deviation were +0.02 mm, and -0.17 mm respectively. The color mapping showed that most parts of the face data had smaller difference compared to the reference data within the range of ± 0.100 mm except for eye balls or nostrils. The eye balls showed the minimum distance while the nostrils showed the maximum distance.

Conclusions: A 4D scanning approach was used to capture a face model and the acquired 3D data were accurate. It was suggested that a 4D scanner is useful to acquire the face data of patients who have postural instability.

22. OBJECTIVE EVALUATION OF NASAL VALVE OBSTRUCTION USING COMPUTED TOMOGRAPHY


Keywords: nasal valve, CT, nasal cavity

Purpose/Aim: The aim of this study is to evaluate the potential of computer tomography (CT) assisted intranasal volume measurements as an objective diagnostic measuring method for NVO.

Materials and Methods: This is an retrospective observational study including 15 patients with NVO having been diagnosed previously at the The Jikei University Hospital. CT images were taken pre-interventional in resting position as well as under forced inspiration in supine position, and intranasal volumes were measured by using ProPlan CMF®.

Results: The mean intranasal volumes change amounted to 1.94ml, ranging from 0.712 – 4.27ml between individual patients.

Conclusions: In this study CT has shown to be useful for precisely identify and objectify NVO. The images also provide useful information for surgical planning of the rhinoplasty, the current gold standard for treatment of NVO. Further studies are needed to determine this method’s practicability for routine diagnostic evaluation of NVO.
23. TWO CASES OF IMAGE-GUIDED NAVIGATION IN ORAL SURGERY - EFFICIENT DISPLAY METHOD OF NAVIGATION IMAGE

Usuda, Shin*, Endo, Tomoki**, Asoda, Seiji* Kawana, Hiromasa*** Kizu, Hideki**
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Shinjyuku-Ku, Tokyo, Japan

Keywords: Navigation Surgery, 3D printer, Computer aided Surgery

Case Presentation:

Background: Navigation surgery also has many reports in oral surgery, and many perform model surgery on a computer and import the data into a navigation system. We apply the model surgery based on the model created by the open software DICOM viewer and 3D printer, and construct a system to display a 3D image that is easy to see even on the old navigation system, and report it as a clinical application.

Technique: Create DICOM data drawn with osteotomy lines, tumor tissue and anatomical landmarks using Horos 4.0, perform model surgery on 3D models created with a 3D printer if necessary, and display the results in DICOM. Then, the processed DICOM data was read into a navigation system (Navigation Cart II System manufactured by Striker), a navigation screen was drawn on a head mounted display (BT-30E manufactured by Epson), and surgery was performed.

Case 1: The patient was an 18-year-old woman who complained of maxillary protuberance and lip insufficiency and visited our department in September 2018. Before surgery, model surgery with a 3D model was performed. As a result, the procedure was decided to be maxillary anterior alveolar osteotomy. The DICOM data which drew the bone cutting line was displayed on the navigation screen, and the anterior alveolar bone cutting and the posterior movement of the anterior tooth part were carried out as planned, and good results were obtained.

Case 2: The patient was a 41-year-old woman with a bulge in the left upper jaw. The patient visited our department in October 2018. The result of pathological diagnosis was myxoma. The surgery planned was a maxillary partial resection. An excision range was set using CT and MRI images, and an image emphasizing the excision range including the tumor tissue was created with a DICOM viewer and displayed on the navigation screen. The operation was performed by the intraoral method, and the resection of the upper margin, especially when the operation area was bad, could be confirmed by this system.

Discussion: The model surgery in the 3D model was able to faithfully reproduce the bone fragment movement. The planned osteotomy, bone fragment movement, and tumor resection were possible by reflecting the osteotomy line and the tumor resection range in the navigation system. The head mounted display did not disturb the operative field, and it was possible to perform efficient surgery with less gaze movement.

Conclusion: This system can easily reflect the preoperative plan to surgery, and we plan to improve it and cope with many surgeries in the future.
24. CBCT IMAGE SEGMENTATION OF MANDIBLE, MAXILLA AND TEETH FOR ORTHODONTIC TREATMENT USING ARTIFICIAL INTELLIGENCE

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Amsterdam, Netherlands

Keywords: Cone-beam computed tomography, convolutional neural network, orthodontics

Purpose/Aim: Cone-beam computed tomography (CBCT) is commonly used nowadays for orthodontic diagnosis, treatment planning, and outcome assessment. For the evaluation of orthodontic treatment, CBCT scans are acquired at different timepoints. These CBCT scans are subsequently segmented into different regions of interest, such as mandible, maxilla and teeth. 3-dimensional (3D) surface models of mandible, maxilla, and teeth at the different timepoints are then created and superimposed to visually and quantitively demonstrate the orthodontic changes. Moreover, these 3D surface models allow for finite element analysis to study the stress distribution in mandible, maxilla and teeth. Currently, the most difficult step in the orthodontic evaluation is the image segmentation. To date no fully-automated algorithm has been developed that can reliably segment the different bony structures in CBCT scans. Therefore, a large amount of manual work is required to reconstruct 3D surface models of mandible, maxilla, and teeth. Consequently, the patient-specific orthodontic treatment is hampered by this time-consuming task. Artificial intelligence (AI) has become increasingly utilized in medical image analysis. In order to reduce the work of image segmentation, this study aimed to develop and train a convolutional neural network (CNN) to segment mandible, maxilla, and teeth in CBCT scans.

Materials and Methods: With well informed consent, CBCT data of 20 patients who previously had orthodontic treatment were used for CNN training purpose. The CNN was trained to segment CBCT scans into four regions of interest, namely, the mandible, the maxilla, the teeth, and the background. For this purpose, gold standard labels were manually created by a medical engineer. The CNN was trained using a leave-2-out scheme. All segmented CBCT scans were subsequently transformed into standard tessellation language (STL) models and compared to gold standard STL models which were made by medical engineer.

Results: The CBCT scans of mandible, maxilla and teeth segmented by CNN demonstrated a large overlap with the gold standard segmentation. The CNN-based STL models of mandible, maxilla and teeth showed minor surface deviation when compared to the gold standard STL models.

Conclusions: Mandible, maxilla, and teeth in CBCT scans can be accurately separated by CNN. CNN makes patient-specific orthodontic treatment feasible by dramatically reducing the time-consuming segmentation task.
SWELLING OF THE EXTERNAL NOSE AFTER SEPTORHINOPLASTY – 3D IMAGING ANALYSIS

Wiederkehr, Iris *, Kawabata, Yuya; Tsumiyama, Shinya; Moriyama, So; Maki, Masatoshi**; Umeda, Go; Miyawaki, Takeshi
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Keywords: Septorhinoplasty, swelling, 3D analysis

Purpose/Aim: The final examinations following septorhinoplasty commonly take place at around 3 months after surgery. From experience, patients occasionally report remaining sensations of swelling of the nose and objectively it is unclear, if such symptoms are based on an actual persistent swelling or due to changes of the nasal shape after surgery. The aim of this study is to objectify the postoperative swelling resolution to define the point of no further significant volume decrease after septorhinoplasty by undertaking a 3D imaging analysis.

Materials and Methods: Pictures of 5 ethnic Japanese patients having undergone septorhinoplasty between January 2017 and March 2018 were taken using a 3D camera (VECTRA® by Canfield Scientific, Inc.). Due to immediate postoperative intense swelling and common application of thermoplastic splints, pictures were taken 1, 3 and 6 months after surgery. For the imaging analysis, the anatomical landmarks, nasion, subnasale and the alar base were used to define the general outline needed for the comparative volume analysis (output in millilitre). Percentage calculations were made in relation to the value of the 1 month follow-up examinations.

Results: On average the swelling reduction between the 1 and 3 month follow-up amounted to 0.14ml (reduction by 0.4%) and between the 3 and 6 month follow-up to another 0.87ml (reduction by 7.1%). 3D images visualized a lowering and thinning out of the nasal dorsum as well as an anterior-caudal drop of the tip of the nose.

Conclusions: Results are concurrent with a prior study on Caucasians by Pavri S. showing a prolongation of the swelling resolution process succeeding the initial 3 months after surgery. However, for this reason further long-term examinations are needed for clear confirmation of no remaining significant swelling. The use of 3D imaging has shown to be a useful method to objectify and visualize a subtle process such as swelling resolution.
Swelling of the External Nose after Septorhinoplasty - 3D Imaging Analysis

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INTRODUCTION

Final examinations following septorhinoplasty commonly take place at around 3 months after surgery, from experience remaining sensations of swelling of the nose are reported.

In the past there have been few studies using CT analysis (1) or 3D stereo photogrammetry (2) for postoperative volume measurement.

Nevertheless, there is a lack of understanding of the course of time of the postoperative remodeling process and previous research was limited to the Caucasian ethnicity.

OBJECTIVES

Using 3D Image analysis to...

- Objectify post-operative swelling resolution process
- Visualize post-operative nasal shape transformation
- Establish database for further research on the topic for Asian ethnicity

METHODS

IMAGING ANALYSIS

3D camera VECTRA® by Canfield Scientific, Inc.

INCLUSION

- Septorhinoplasty
  1/2017-2/2018
- Age between 16-50y
- Male 80%

- EXCLUSION

  - Lack of follow-up data
  - Trauma affecting the operated area

MEDICAL CARE

- No nasal Administration pre- or post-
- Postoperative application of thermoplastic nasal splints and nasal tape

RESULTS

SWELLING RESOLUTION

Based on the data of 8 patients average swelling reduction between follow-up:

1st month 0.14ml (reduction by 0.45%)  
2nd month 0.87ml (reduction by 7.13%)  
Total reduction 1.01ml (reduction by 7.43%)

*Calculation is compared in 1-month value

SHAPING VISUALIZATION

Nasal dorsum: bowing and thinning out
Tip of nose: anterior-caudal drop

Image 2 Example of one patient’s 3D Image. Image on the left shows change of nasal dorsum and Image on the right change of tip of nose.  
- 1 month after surgery
- 6 month after surgery

CONCLUSION

1. Possible swelling resolution beyond 6 months is in conclusion with previous studies on Caucasians (2) but needs long-term follow-up for clarification.

2. 3D imaging showed to be useful for objectifying and visualizing post-operative swelling resolution and possible value for improvement of patient-doctor communication (result exploration etc.)

3. Confounding importance of skin type, daily skin changes, etc. as well as methodological bias (influence of change of photographer/imaging evaluators) using 3D imaging needs further assessment.

REFERENCES


26. ACCURACY OF MAXILLARY POSITIONING WITH CAD/CAM INTERMEDIATE SPLINT AFTER 3D SIMULATION IN BIMAXILLARY SURGERY

Yamauchi, Kensuke *, Yoshihiro Yamaguchi, Hikari Suzuki, Daigo Okamoto, Shinnosuke Nogami, Tetsu Takahashi
Tohoku University
Oral & Maxillofacial Surgery
Sendai, Japan

Keywords: orthognathic surgery, accuracy, CAD/CAM splint

Purpose/Aim: The efficacy of computer-assisted surgical planning in orthognathic surgery has been documented over last decades. The purpose of this study was to compare the location of maxillary position at bimaxillary surgery by using 2 different procedures: the conventional model surgery and a Computer Aided Design / Computer Aided Manufacturing (CAD/CAM) method.

Materials and Methods: A 3D surgical simulation was achieved using a software (ProPlan CMF) by the combination of a 3D skull model acquired from computed tomography (CT) and surface scanning of the upper and lower dental arch respectively and occlusal position by plaster model. With the conventional procedure, surgical wafer was made by plaster model surgery using SAM mechanical articulator. By a CAD/CAM procedure, the wafer was designed using the software and manufactured by 3D printer. Each wafer was used for maxillary repositioning after Le Fort I osteotomy. By evaluating the difference between 3D simulation and postoperative CT scanning at first incisor (U1) and second molars (M2), the results with this procedure were then compared with conventional and CAD/CAM procedures.

Results: 24 patients underwent bimaxillary surgery, 10 patients were applied conventional procedure and 14 patients were used CAD/CAM splint. There was no significant difference between conventional and CAD/CAM group in U1 horizontal (p=0.949), sagittal (p=0.365), M2-right horizontal (P=0.266), vertical (p=0.565), sagittal (p=0.891), M2-left horizontal (p=0.651), vertical (p=0.770). There was significant different in U1 vertical (p=0.008) and M2-left sagittal (p=0.0296).

Conclusions: 3D surgical simulation and CAD/CAM surgical splint are proven to facilitate treatment planning and acquire an accurate result in orthognathic surgery.
Workshops

ADT Pre & Post Conference Elective Workshops

WEDNESDAY, June 19th & SATURDAY, June 22nd:
These workshops come at an additional cost.

The Impact of Virtual Reality (VR) on CranioMaxillofacial Surgery:
The Future is Here

Pravin K Patel MD, Lee Alkureishi MD, Jay Banerjee MBA, Linping Zhao PhD, Rosemary Seelaus MAMS, Christopher Micallef MD
Craniofacial Center, UIC
Industrial Engineering and Design, UIC and Immersive Technologies

Date: Wednesday, June 19th & Saturday, June 22nd
Time: 1:30 PM - 5:30 PM
Room: A1/A2

For nearly half-a-century, reconstructing patients with craniofacial deformities has relied primarily on two-dimensional photographic images and radiographs. It was the surgeon’s eye and experience that integrated the two-dimensional records to generate the virtual three-dimensional image for surgical planning. In the last decade of the twentieth century, multi-dimensional visualization of the skeletal deformity became possible with the emergence of computerized tomography (CT). This allowed the surgeon the ability to visualize the complexity of the deformity but not the ability to simulate surgery.

It is only within the last several years that rapid advances in computational software began to transform the pure visual imagery of CT to allow the surgical simulation to become a reality. Today surgeons and orthodontists are beginning to have the tools to simulate orthodontic movement, various craniofacial skeletal osteotomy patterns and the ability to manipulate each of the bony elements. However, the limitation of true simulation has always been the inability to fully visualize the third dimension on two-dimensional flat screen displays. Thus, surgeons relied on 3D printed models for tactile feedback and to visualize depth. With the recent introduction of immersive virtual reality (VR), augmented reality (AR) and haptic feedback (HF), true three-dimensional surgical simulation becomes a possibility.

This presentation will review currently accessible technology for the practicing surgeon and dentist through a series of cases studies for patients who required various components of craniofacial surgery. This will include pre- and post-processing of diagnostic 3D surface and skeletal records; integrated orthodontic-surgical planning, 3D relevant software for both orthodontic and skeletal manipulation, translation from virtual to physical environment with CAD/CAM 3D printed models and guides. This presentation will also showcase the technology of the future where resident training and patient-specific planning for the surgeon will be done in an immersive VR environment that will closely simulate the operating theater.

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**The Impact of Virtual Reality (VR) on CranioMaxillofacial Surgery: The Future is Here**

**Wednesday, June 19th AND Saturday, June 22nd @ 1:30pm & 5:30pm**

**Instructors:** Pravin K Patel MD, Lee Alkureishi MD, Jay Banerjee MBA, Linping Zhao Ph.D., Rosemary Seilunas MAMS, Christopher Micallef MD

**Accuracy and Reproducibility of Measurements in State-of-Art Virtual Reality (VR) Environment: Validation**

**Thursday, June 20th @ 4:05pm**

**Invited Speaker:** Linping Zhao Ph.D.

**Virtual Reality in Surgical, Dental and Orthodontic Rehabilitation**

**Thursday, June 20th @ 4:25pm**

**Invited Speaker:** Lee Alkureishi MD

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