Rapid Prototyping in Surgery

Dr. Richard Bibb
This presentation will cover three main aspects of the application of Rapid Prototyping in surgery

1. Anatomical models
2. Surgical guides and templates
3. Direct manufacture of implants
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1. Anatomical models

   These applications are becoming routine and have been used clinically for more than 10 years.

   Most laboratories will have use models at some point.

   Hundreds of models per year are being used in the UK alone.
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Typical Applications

• Cranioplasty
• Orbital floor
• Mandible reconstruction
• Osteotomy planning
• Distraction planning
• Extra-oral osseointegrated implant planning
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Cranioplasty

- By far the most frequent application
- Possibly 75%+ of all models made in the UK
- Model use encouraged by recent changes to regulations regarding retaining bone flaps
- Recent research in UK Maxillofacial Laboratories found a consensus view that models should be mandatory for cranioplasty cases
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Orbital Floor Reconstruction

• Easily the second most common application

• Possibly 10%+ of all models made in the UK

• Particularly useful for large orbital floor fractures

• Recent research in UK Maxillofacial Laboratories found strong support for the view that models should be mandatory for large orbital floor fractures
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Mandible Reconstruction

• An acknowledged application

• Particularly useful for pre-bending plates and planning drilling sites

• Recent research in UK Maxillofacial Laboratories found that models were useful for mandible reconstruction
Osteotomy Planning

• An acknowledged application for congenital abnormality, post cancer reconstruction and trauma cases

• Particularly useful for rehearsal of osteotomies and pre-bending plates

• Recent research in UK Maxillofacial Laboratories found that models were useful for osteotomy planning in complex cases
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Distraction Planning

• An acknowledged application for congenital abnormality, post cancer reconstruction and trauma cases

• Particularly useful for calculating vectors and pre-bending distractor plates

• Recent research in UK Maxillofacial Laboratories found that models were useful for distraction planning in complex cases
Extra-oral Osseointegrated Implant Planning

- An acknowledged application for prosthetic retention
- Particularly useful for complex cases or where software is not available
- Recent research in UK Maxillofacial Laboratories found that models are being used for planning extra-oral implant sites
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2. Surgical guides and templates

Some of these applications are becoming routine and have been used clinically for about 5 years.

Some laboratories will have used surgical guides at some point; mostly dental.

Hundreds of surgical guides per year are being used in the UK.

Extra-oral applications are however still uncommon.
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Typical Applications

• Oral implants
• Extra-oral implants
• Osteotomies
• Sinus surgery
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Oral implants

• By far the most frequent application
• Fully commercialised services available
• Dedicated software is required
• Now considered routine in many practices
Extra-oral implants

• Not a common application but increasingly used for complex cases

• At a transitional point, commercial services available but not to the same extent as oral

• Dedicated software may be required depending on service provider

• Not considered routine but being undertaken practices
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Implant Planning

Surgical Guide directly manufactured in 316L Stainless Steel using Selective Laser Melting

Patient name blurred out for confidentiality
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Osteotomies

• Not a common application but a few published case studies

• Promising results so far but still needs more research

• Several software packages may be required to fully plan and design the guides
Osteotomy Cutting Guide Design

Guide designed in FreeForm Supports are generated so that they do not interfere with the fitting surface
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Sinus Surgery

• Not a common application

• Being undertaken in several laboratories using a variety of techniques

• Several software packages may be required to fully plan and design the guides
3. Direct manufacture of implants

This is still very much a research area and only a very small number of cases have been implanted.

However there is massive potential with the recent developments in machines capable of processing Titanium.
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Titanium implant made by Gerrie Booysen
Central University of Technology
Bloemfontein, South Africa
www.cut.ac.za/crpm
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Implant for cranial reconstruction designed using 3Matic and made using Arcam electron beam melting in Titanium

Courtesy of IDEE / Maastricht Instruments; case study from Materialise N.V.

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Consensus from UK research

From interviews with the heads of the five biggest maxillofacial laboratories in the UK…

- Medical models represent good value for money in specific applications
- Models reduce errors and improve accuracy
- Models are being used appropriately
- Cranioplasty plate and orbital floor reconstruction should be conducted with models
- Strength and accuracy are the most important model properties
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Consensus from UK research

• Models were identified as essential for cranioplasty plate manufacture reconstruction by all five respondents
• Models for large orbital floor fractures were identified as essential by two respondents
• Models for nasal septum were identified as essential by one respondent
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Conclusions from UK research

- Medical models are being appropriately used in significant numbers
- Medical models reduce errors and improve results
- Medical models represent good value for money
- Cranioplasty plate manufacture requires a model
- Labs are increasingly interested in purchasing their own machines
- Model cost is not a major impediment
- Models should be stored as a legal medical record
Conclusions from UK research

- More work is needed to develop surgical guides for osteotomies
- More research is needed into direct implant manufacture
- Audits of existing applications are needed to build the evidence base and demonstrate clinical effectiveness and value for money
Most of the research in this presentation was conducted by the Centre for Applied Reconstructive Technologies in Surgery (CARTIS)

CARTIS is a collaborative joint venture between Morriston Hospital and PDR

For more information look up www.cartis.org