The use of 3-D printing for operative planning in a tertiary referral hip centre

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Introduction

As better technologies have been developed it has become easier to perform segmentation of bone from (CT) scans[1]. Combined with improved printing technologies, there has been a rapid increase in the use of 3-D printing in orthopaedic surgery[2].

As a tertiary referral centre for hip surgery our patients can have significant bony deformity and bone loss resulting in challenging primary and revision surgery. Our unit has partnered with 3D LifePrints (3DLP) Ltd. (Liverpool, U.K) to provide in-house 3-D printing for complex cases.

Aims

1. To review our indications for producing 3-D models for hip surgery
2. Assess the surgeons perception of how useful the model was prior to surgery

Methods and Materials

A retrospective review of all patient records was performed to identify patient demographics, relevant case history and the indication for 3-D modelling at Wrightington Hospital.

All surgeons were requested to complete a feedback form which included two 10-point response scales assessing :

1.Did the model improve your understanding of the patient's anatomy?

2.Do you feel the model assisted your ability to plan the operation more effectively?

Results

83 models printed for planning

58 Females: **24** Males
Mean age **51** (14-88)

Primary Arthroplasty N=26	Revision Arthroplasty N=24	Hip Arthroscopy N=28	Extra-articular deformity N=5
Severe AVN with bone loss (2)	**18 models**:	**13 models**:	Femoral de-rotation osteotomy (2)
Complex dysplasia (9)	Assess bone stock	psoas impingement post THR	Excision of HO post ECMO (1)
Previous paediatric Sx (3)	Surgical simulation	**15 models**:	Multiple Hereditary Exostoses (1)
Sequelae paediatric conditions (3)	**6 Models**:	Simulate FAI Surgery	Excision of Ramus post # (1)
Previous hip fracture (3)	Custom cement guides	Revision CAM	
Previous Septic Hip (2)			
PFFD (1)			
Non union PAO (1)			
Custom hip/neck cut guide (2)			

Surgeon feedback was available for **41** models:

- The mean **'improved understanding'** of anatomy was **8.86** (5-10)
- The mean '**improved operative planning**' was **8.7** (5-10)

Case example – Surgical simulation

Possible discontinuity → 3D Model to allow surgical simulation → contained- suitable for augment → impaction grafting

Discussion

Given the tactile nature of surgery 3-D models provide a multiplanar understanding of complex deformity that may not be appreciated through scans alone[3].

In our series surgical simulation allowed the surgeon to confirm that 'off the shelf' components could be used for reconstruction in certain cases, rather than expensive custom implants. Surgeons felt that they had a better understanding of both the anatomical variants and pre-operative plan when using the models.

Several studies have suggested that the use of 3-D models may reduce operative time, intraoperative blood loss and intra-operative fluoroscopy[4]. 3-D printing of these complicated cases may also provide a valuable teaching resource allowing trainees to practice complex surgical techniques.

In our series we found that 3-D modelling had 4 main purposes:

1. Pre-operative planning
2. Pre-operative surgical simulation
3. Intra-operative reference
4. Patient education

Conclusion

3-D printing is a valuable tool in planning complex hip surgery.

Further work is required to assess its cost-effectiveness and how it effects blood loss and operative time.

References

1. D'Urso PS, Askin G, Earwaker JS, Merry GS, Thompson RG, Barker TM, Effeney DJ. Spinal biomodeling. Spine (Phila Pa 1976) 1999;24:1247–1251
2. Woo SH, Sung MJ, Park KS, Yoon TR. Three-dimensional-printing Technology in Hip and Pelvic Surgery: Current Landscape. Hip Pelvis. 2020;32(1):1-10.
3. Boudissa M, Courvoisier A, Chabanas M, Tonetti J. Computer assisted surgery in preoperative planning of acetabular fracture surgery: state of the art. Expert Rev Med Devices, 2018, 15: 81–89
4. Morgan, C., Khatri, C., Hanna, S. A., Ashrafian, H., & Sarraf, K. M. (2020). Use of three-dimensional printing in preoperative planning in orthopaedic trauma surgery: A systematic review and meta-analysis. World journal of orthopedics, 11(1), 57–67.

Continue to the second slide for further case examples

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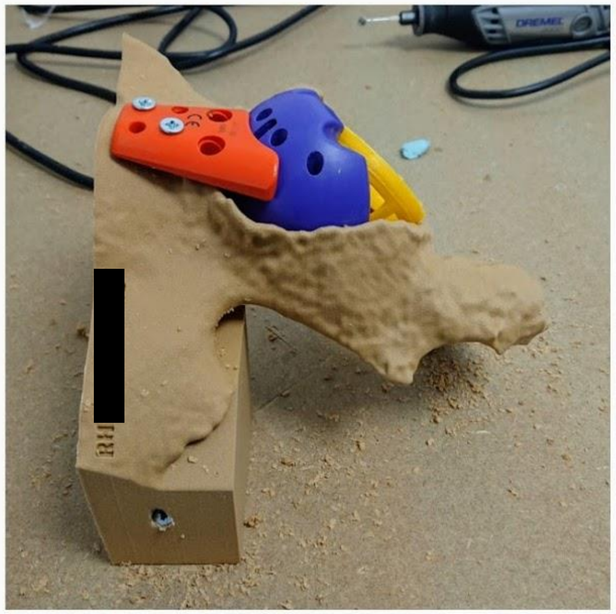
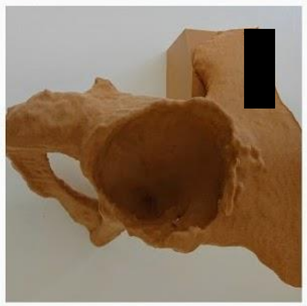
Case 2- Surgical Simulation





A previously revised hip presented as a new referral with deep infection. Significant bone loss from both femur and acetabulum was noted at the time of the first stage revision.

Following a prolonged course of antibiotics and pre-operative optimisation a second stage reconstruction was planned.
A 3-D model was produced to allow assessment of bone loss and surgical simulation of the reconstruction. Accurate model sizing allowed the surgeon to identify the correct implant sizes

The final acetabular reconstruction and proximal femoral replacement. At the time of surgery it was felt that a buttress augment was not required due to stability of the construct.

Continue to the next slide for further examples

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Case 3 - Custom Cement guides for femoral cement

In 6 cases 3-D models were printed to assess the shape and orientation of cement mantles of stems that were to be explanted.

In this case the stem had been implanted in varus. 3DLP were able to manufacture a 3-D printed drill guide that would fit into the proximal canal to guide the drill into the central portion of the mantle.

This has the potential to save time during cement removal and reduces the risk of iatrogenic perforation.

Case 4 – Pre-operative patient and patient education

This model was produced for a patient with femoroacetabular impingement symptoms. The sphericised head allows assessment of the exact point of impingement.

Having a model available in the clinic provides an excellent visual aid for the patients- resulting in a greater understanding of the condition as well as any proposed surgical intervention.

Many thanks for viewing our virtual poster! For any questions please contact the corresponding author:

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