FROM THE PRINTER TO THE THEATRE –
3D PRINTING TECHNIQUE: A STRONGER BASE FOR SKULL BASE

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DISCLOSURE SLIDE

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INTRODUCTION

- Three-dimensional (3D) printing has revolutionized the practice of rapid prototyping.

- This technique has enabled the fabrication of physical 3D models from computer-aided designs in which successive layers of material are deposited onto underlying layers to construct 3D objects to make models, devices, and implants that can potentially improve patient care.

- The field of neurosurgery, in particular, has experienced substantial progress as a result of the usage of 3D printing because most of the surgical procedures and corresponding pathology that neurosurgeons encounter involve intricate, minute anatomical structures.

- 3D printing in neurosurgery have focused upon three main areas; the creation of patient-specific anatomical models for surgical planning and simulation, training and education, the design of neurosurgical devices for assessment and treatment of neurosurgical diseases and the development of biological tissue-engineered implants.
METHODS

• A total of 56 patients were included in our study for last 3 years at S.M.S Medical College, Jaipur, India.

• 3D printed models were prepared for cranioplasty in 22 cases, Craniovertebral junction anomalies in 18 cases, skull base tumors in 4 cases.

• Preoperative data- included indication of operation, positional relationships and preoperative simulation.

• Intraoperative data- included operating time, blood loss and anatomical localization.

• Postoperative data- included clinical and radiological outcome and complications.

• Evaluation - with multi slice helical CT Scan with Slice thickness of 0.8mm, MRI Brain and CT Angiography for relevant blood vessels.

DICOM data were processed and converted to 3D images with MIMICS 13.1 Software (Interactive Medical Image Control System; Materialise Inc., Leuven, Belgium)

Three dimensional (3D) CT reconstructed image of a 26 year old male patient with left FTP craniectomy defect
RESULTS – Making of the 3D implant

STEP 1 - PMMA resin even spread over inner half of the mould.

STEP 2 - PMMA implant shown in the centre with the inner and outer half of the mould.

STEP 3 - PMMA customized prosthesis assembled over cranial defect printout to ensure exact margin apposition

STEP 4 - Placement of PMMA customized prosthesis over the cranial defect Intraoperatively
RESULTS

CRANIOPLASTY

• Post-operative CT scans showed excellent restoration of the bony contour and margins.
CRANIOVERTEBRAL JUNCTION ANOMALIES

- Bony abnormalities such as occipitalized atlas, odontoideum, bifid arch, block vertebrae and most importantly, the Vertebral artery course could be exactly delineated.
- The surgical procedure was rehearsed on the model prior to the surgery.
- The preoperative clinical features and improvement in symptoms were assessed using the Japanese Orthopedic Association score (JOA score).
- Radiological improvement was assessed by comparing the preoperative and postoperative craniometric indices: the atlantodental interval, Chamberlain’s line, and Wackenheim’s clivus canal line.
- We obtained desirable results for all but one patient who developed vertebral artery injury.

(A) A three-dimensional-printed model of a patient with occipitalized atlas. (B) Lateral view of the model. (C) Practice using the model. (D) Model with occiput–C2 screws.
We made each 3D–model data written in the binary STL format with **Different color code** for tumor tissue and related structures.

The model provides a realistic characteristic of the underlying tumor like its multiple lobulations and a **better preoperative planning and intraoperative understanding of different possible relationships and size of the tumor**

This model helped in better delineation of vessels and optic nerve surrounding the tumor. Intraoperatively vessel injury was avoided and optic nerve could be preserved by **prior understanding of the model**
DISCUSSION

• The use of this technology helped us improve the surgical outcome of the patients in the complicated neurosurgical pathologies.

• Since 2016, we have been using 3-D Models for patient's medical Images for a better clinical use, training, and planning of the operative strategy.

• 3D-Printing technologies in Neurosurgery provide a practical and anatomically accurate means to produce patient-specific and disease-specific models for the assessment and treatment of neurosurgical disease.
SUMMARY POINTS

3D printing in neurosurgery have focused upon three main areas -
1. The creation of patient-specific anatomical models for surgical planning, training and education
2. The design of neurosurgical devices for assessment and treatment of neurosurgical diseases.
3. Simulations providing a realistic representation of the surgical procedure without the risk of potential harm to a patient.

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   - Craniovertebral junction anomalies in 18 cases,
   - Skull base tumours in 4 cases

• Preoperative data included indication of operation, positional relationships and preoperative simulation.
• Intraoperative data included operating time, blood loss and anatomical localisation.
• Postoperative data included clinical and radiological outcome and complications.

Expansion of this technology in neurosurgery will help serve patients, practitioners and trainees better.