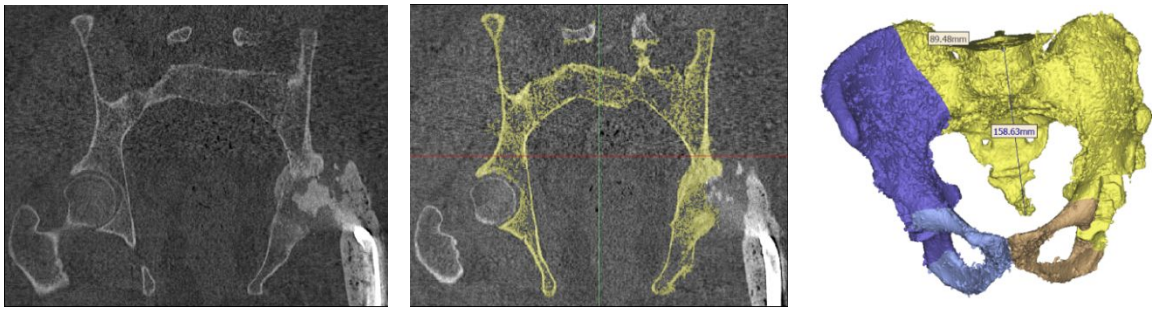
The OrthoCAD Lab, IIT Bombay is using an Aha3D machine for various biomedical cases. The Following information is kindly shared by them, detailing applications and case studies for the relevant audience. All the cases are performed by OrthoCAD lab / BETiC in association with various Doctors, Surgeons and medical practitioners as cited. An Aha 3D machine is used to produce the necessary medical models and jigs.

Surgery Planning Models

High resolution medical imaging-Computed Tomography (CT) and Magnetic Resonance Imaging (MRI), coupled with low-cost 3D Printing has enabled the engineering and medical fraternity to work closely towards better medical services. One of the leading outcomes of this amalgamation is highly customised and accurate surgery planning and the tools for the same. The need for such a tool arises from assistance required for planning convoluted and non-conventional cases and achieving perfection in various elements of surgery - taking incisions, precise placement of implants, excisions, avoiding obstructions, etc. During such cases, the surgeon has to make critical decisions with regards to the complexity involved. Medical modeling allows surgery planning to a high level of detail and precision to avoid critical decision-making during surgery. This ensures better outcome (quality) and shorter OT time (less cost and chance of infection). Its application can be further extended to patient education, simulating surgeries and student training.

On recommendation of clinicians, the data of required cases is received from radiology labs in form of DICOM files, these files can be segmented using available software for segmentation, which can be used to generate 3D models of anatomical parts and design jigs/fixtures if required. The generated 3D models can be further 3D printed, verified and finished. All three BETiC Labs (IITB, VNIT, COEP) are equipped with medical modeling software and 3D Printers. Once received, the researchers segment (defining thresholds, region growing, masking and generating 3D model) the files and generate a 3D virtual image/model which is shared with the clinician for approval. The approved file is 3D printed (in ABS, PLA or ABS M30i) and after post processing (removing support material – HIPS/SR30 using chemical methods assisted with heat and ultrasonic cavitation), it is cleansed, rinsed and dried and delivered to the surgeon.

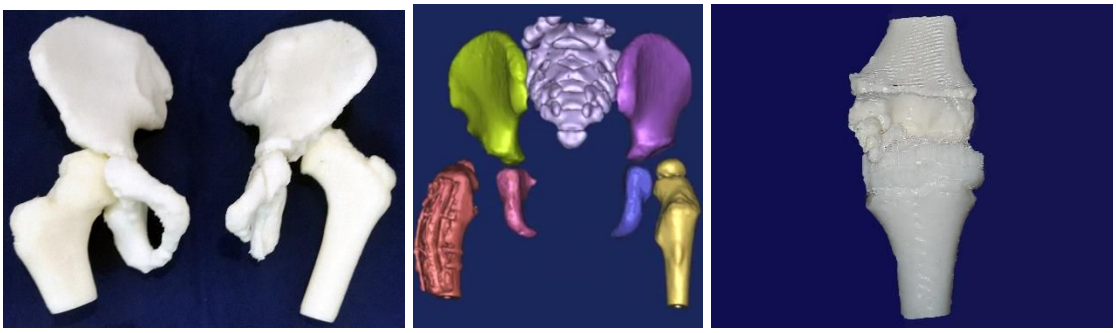


CT scan of pelvis with dysplastic hip, bone thresholding, 3D CAD model

BETiC has catered to more than 20 medical modeling requirements. The process was established by BETiC-IITB team of Lopaa Bagaria, Dr Trimbak Kawdikar, Lata Chawla and Sritam Rout. Currently, Dr Trimbak has taken over all the aspects of the process.

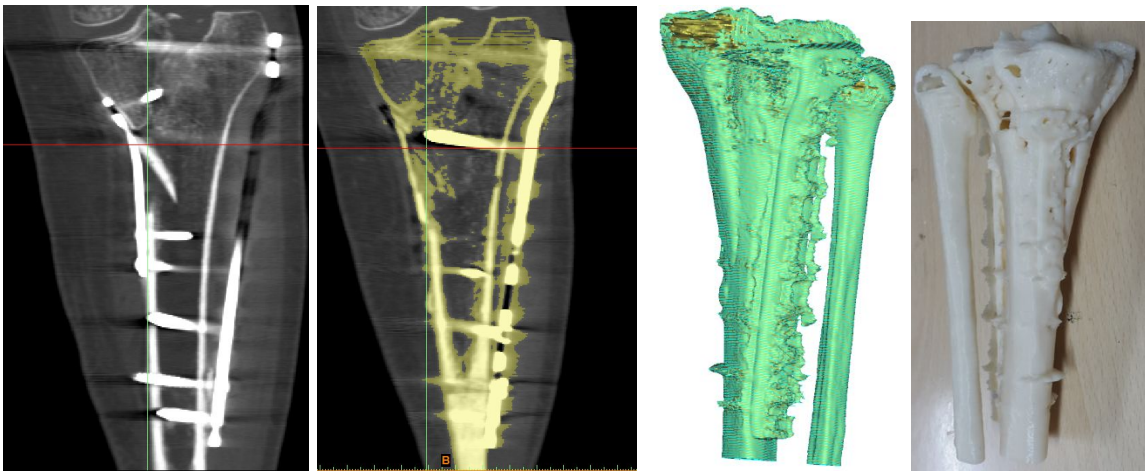
3D printed plastic model, surgery planning with 3D model, implant size decision

Time of print becomes a constraint if the job is bigger and is required urgently. A time frame in such case is discussed with the surgeons beforehand. Volume of the prints if bigger than bed size of the printer, it is made possible by printing multiple small parts and joining. One such case was brought forth by Dr Manish Agarwal from P. D. Hinduja Hospital. The case of dysplastic hip had the pelvis model larger than the build-space of the 3D Printer available at BETiC IITB. The model was split into three parts, printed separately and then joined together as the clinician preferred life-sized model for surgery planning.



Figures: Hip Dislocation, Acetabular dysplasia leading to hip dislocation and tumour growth on Lateral Femoral Condyle

Another complicated case of a 12 Years old girl was brought forth by Dr. Mandar Agashe, which was a post-operative case for Open Reduction of fracture tibia, by Dynamic Compression Plate and screws. Generally, the recovery in such cases takes several weeks; the doctors are compelled to go for another investigation to check the healing fractured site. 3D printed model proves to be a great tool to actually study the crack geometry and propagation root. There being an implant, the slices were full of artefacts due to reflections from the metal, thus introducing a lot of noise in the calculated 3D model. The processing was made easy by tools like edit masks and selective grey value selection to get a clean and healed 3D image of the affected part. It was extremely helpful for the surgeons to find the lines of mal-union of tibia and the propagation of cracks which were not followed by callus formation.



The process of uploading slices, generating mask, calculating 3D and 3D printed medical model.

Medical modeling has improved the success rate of surgeries by helping reducing the time required during the surgery, and as well induce more efficiency into the procedures. More than 20 cases have been successfully completed at BETiC-IITB in collaboration with surgeons from different hospitals in Mumbai. This include cases like multiple complex fractures, dysplastic hip, pre and post-surgical fracture cases, joint dislocation, etc. The process can be scaled up to help clinicians and patients with maximum efficiency. For reference purpose, a few notable cases are tabulated below for their uniqueness of the complexity involved.

Title	Surgeon	Challenges
Lateral Listhesis		grade 3 lateral listhesis (displacement of vertebra) of the C1 vertebra over the C2
Heel bone dislocation	Dr Chasnal Rathod, Jupitar Hospital, Thane	bilateral dislocation of the talocalcaneo-navicular joint with inferior dislocation of tibia
hip dysplasia	Dr Manish Agarwal, Hinduja Hospital, Mumbai	The loss of bone tissue on the affected hip as a result of continuous non-weight bearing on the operated side. The Iliac crest and the Acetabulum being specifically malformed.
post-operative case for Open Reduction of fracture tibia	Dr Mandar Agashe, Agashe Clinic	Noise in the calculated 3D model
malformed flattened acetabulum with superior dislocation of femoral head	Dr Taral Nagda, Jupitar Hospital, Thane	The bones being non-ossified and connected by cartilages are not visualized completely in the CT scans. The Cartilages being invisible in the CT scans, it was not possible to get them in a grey value differentiation.
Varus Deformity	Dr Mander Agashe from Agashe Clinic	that the injury had resulted in a non-union of the lateral condyle in addition to a medial dislocation of the elbow which was resulting into an apparent varus deformity
Complex fracture behind Acetabullum Wall	Dr Ashish Phadnis from Jupiter Hospital	we could plan, bend the plates , pre empt the sizes of the screws cross check at all stages, the fracture was a very complex one , one of the worst we have come across,
Axial Spine Dislocation	Dr Shirish Deshpande from CIIMS Nagpur	Replication of exact pathology.
Tibial Fracture in Multi part print	Dr Viaksh Agashe from Agashe Surgical Nursing home	Rotational malalignment was difficult to analyse on CT scan. Genu varus present. The model for helpful to analyse rotational malalignment of condyle and plan osteotomy.

Malunited proximal tibial condyle right knee joint Multiple Prints	Dr Vikas M Agashe from Agashe Surgical Nursing Home	Depressed and split medial condyle. Malunited lateral condyle. Intra articular deformity present.Genu varus seen Widened medial condyle with diastasis with new bone formation between the 2 pieces which was visualised in the bone model which 3D printed.

Background

Why medical modelling?

To avoid neglected trauma. To pre-plan a surgery with precision so as to avoid decision making during the surgery (for e.g. Deciding the Implant Size required) for surgeries which would be extremely complex and non-conventional (like paediatric cases or patients with bone cancers (which would require a better planned approach)) and patient education and can be used for simulating surgeries and student training.

What are medical jigs and fixtures?

Assistive devices for surgeries which can help for perfect procedures required during a surgery, like taking Incisions, precise placement of implants, excisions, avoiding obstructing parts without any extra human intervention,

Difference in file handling

The medical models of anatomical models can be segmented out via software and the generated 3D models can be used for 3D printing of the desired parts. Jigs and Fixtures on the other hand, cannot be generated via segmentation but have to be produced as the customised matching parts for the segmented 3D model of the desired parts.
Limitation

The virtual fitment and FEA of jigs, fixtures, spacers, etc. is not done, thereby leaving a void in accuracy of models and feasibility in actual surgical use where the parameters of incision or availability of space might be constraints for placing the same. The same has to be verified with the surgeon before designing.

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