Three-dimensional printing is a manufacturing procedure in which objects are formed by fusing or depositing materials to create a 3D model. Different printers are used for 3D printing. Medical applications for 3D printing are expanding rapidly and are expected to revolutionize health care. 2D radiographic pictures are converted to computerized 3D prints creating anatomical and clinical structures. There are five steps to technically create a 3D model from image and these steps are image acquisition, segmentation, file optimization, choosing materials and printers and print and post processing of 3D medical model. We report the experience of the radiology service at Marrakech university hospital using a low cost FDM printer. The results of different cases are discussed in this article.

Keywords: 3D Printing, Radiologist, Experience.
We used a Siemens Definition As™ scanner to obtain the images. The slices were 0.63 mm thick and 0.8 pitch value. The acquisitions were exported in Dicom format.

**Materials**

**The printers**
- FDM printer: Ender 3 by Creality™
- Heating plate
- Print size: 220x220x250mm
- Filaments: PLA, ABS

- FDM printer: Volumic stream 20™
- Heating plate
- Print size: 180 x 200 x 240 mm
- Filaments: PLA, ABS

**Softwares**
- **3D Slicer**: Free image analysis and scientific visualization software, Segmentation and modeling from DICOM image
- **Meshmixer**: free computer-aided design (CAD) program based on 3D sculpture
- **Cura**: Free software, which generates a G-code file containing instructions adapted to a specific type of 3D printer

**RESULTS**

**Case 1: Modeling of a learning support for an anatomical structure: The petrous bone**

The specimen has been trimmed to reveal the posterior quadrant of the left side of the skull including the posterior (cerebellar part only) and middle cranial fossa. The model shows the location of the temporal bone and its relationship with the adjoining sphenoid, parietal and occipital bones.

Printing material was gray PLA. The printing time of the model (including support structure) of 63 g was 5h and 43 min and the dimension obtained was 100% of the actual size.

**Case 2: Modeling of a support for surgical planning: scoliosis**

Spine surgeons dealing with scoliosis are familiar with many of the problems of these complex deformities encountered intra-operatively. Vertebral rotation, absent or dysmorphic pedicles and segmentation anomalies are all components of scoliotic spines and distort the anatomical landmarks for pedicle insertion. Current imaging modalities like CT scans or MRI are often found to be inadequate. This 3D printed anatomical model was used to provide the ‘extra’ dimension of tactile feedback to the surgeons which can help them anticipate the technical challenges that may be encountered intra-operatively [15].

In our case, 3D reconstruction of a model was done after implementation of an ROI, thresholding and segmentation on a bone window. The model was used for surgical programming for the neurosurgery team at the Mohammed VI university hospital unit and Lyon university hospital for a joint operation.

The material of the model was Gray PLA with 40%. Magnification and the printing time for 60g model was 8 h 30 min.
Case 3: Modeling of a training support for endovascular techniques: Aorta

The 3D-printed model was extracted and printed from anonymized CT and MRI scans. Printing material for model preparation was transparent PLA. Printing time of 110 g (including support structure) was 12 hrs min with dimension of actual size i.e., 100% and cropped.

Fluoroscopy has been used as an imaging modality for simulation and allowed an opportunity to rehearse procedures using the medical-grade devices and implants in a safe, zero-risk environment.
Case 4: modeling of a support for surgical planning: mandibular trauma

This model was used to plan osteosynthesis and to improve mechanical comprehension of the craniofacial trauma.

The 3D reconstruction of model was performed after implementation of an ROI, thresholding and segmentation on a bone window. Material used was gray PLA. The printing time of model weighing 52g with 100% magnification was 5 h.

Fig-9: CT scan axial view + sagittal MIP of the mandible

Fig-10: 3d model and 3d print

Case 5: Modeling of a support for surgical planning: trauma of the dorsal spine

This model was used to plan surgical treatment and to tactile feedback to the surgeons to help them anticipate the technical challenges for a complex vertebral fracture that was responsible for me.

Printing material was transparent PLA. The printing time of 36 g including support structure was 3h and 34min and the size obtained was actual i.e. 100% magnification.

Fig-11: Sagittal CT view on the thoracic spine

Fig-12: 3D modeling + 3D print
Case 6: Modeling of a support for surgical planning: complex elbow trauma

This model was used to plan osteosynthesis and to tactile feedback to the surgeons to help them anticipate the technical challenges, complicated joint fractures are challenging to treat.

Printing material used was white PLA and the printing weight (including support structure) was 24 g. The printing time was 54 min with reduced size of 25%.

Fig-13: sagittal CT view on the elbow joint

Case 7: modeling of a support for surgical planning and simulation: mandibular malformation

This patient presents a malar deviation of the left mandible that was causing pain and discomfort for the patient.

3D reconstruction after implementation of an ROI, thresholding and segmentation on a bone window was performed. The materials used were gray PLA and the printing time was 5 hours for 90 g weight with 80% magnification.

The model was printed in two parts to simulate mandibular movement and to plan the best possible osteotomy to provide a result with best mechanics.

Fig-14: 3d model + 3d print

Case 8: modeling of a support for surgical planning: Aortic aneurysm

This patient presents an aortic root aneurysm; 3D print of the aneurysm was realized for surgical planning and localization of the coronary arteries.

3D reconstruction after implementation of an ROI, thresholding and segmentation was performed. The materials used were gray PLA and the printing time was 6 hours for 120 g weight with 100% magnification.

Fig-15: direct examination + 3D modeling

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FIG-19: Operative view

DISCUSSION

There are around two dozen 3D printing forms, which utilize 3D printer advances and many materials. These innovations can fabricate 3D objects as characterized in a PC helped structure (CAD) record (Figure 20) [16].

FIG-20: A 3D printer uses instructions in a digital file to create a physical object

In a fundamental arrangement, the 3D printer initially adheres to the guidelines in the CAD document to establish the 3D printed object, moving the printhead along the x–y plane. The printer at that point keeps on adhering to the directions, moving the print head along the z-plane to construct the object vertically layer by layer.

Magnetic resonance imaging (MRI), or computerized tomography (CT) exams can be changed over to computerized 3D files, permitting the making of complex anatomical and clinical structures (Figure 2) [7].

Extraordinary advances have been made in the field of medical 3D printing, including organ models, implants, and 3d printed surgery guides.

Despite the fact that the immediate printing of tissues and organs is still in the underlying stages, specialists have using tissues and organs have started to

FIG-21: Radiographic images can be converted to 3D print files to create complex, customized anatomical and medical structures

Five technical steps required to finalize a printed model

Five specialized steps are required to make a printed model. They begin by choosing the anatomical territory, the segmentation of the 3D geometry by the imaging data originating from a CT/MRI exam, the enhancement and correction of the 3D file for physical printing, and choosing the appropriate 3D printer and materials. "slicing" that computerized structure model into a code readable by the 3D printer. The “sliced” structure is then sent to a 3D printer, which makes the object by beginning at the base layer and building a progression of layers until the item is constructed utilizing the amount of material that is required. An anatomically accurate model made from imaging dataset is finally acquired.

Image acquisition (selecting desired area)

Segmentation (Conversion of DICOM to STL document)

File optimization (making 3D-printable record types for each sectioned part)

Choosing materials and 3D printer

Printing and post processing of 3D medical model
contemplate the printing of vessels. Biomaterials utilized in 3D printing include plastic filaments, metals, polymers and ceramics [3]. Recent research on 3D printing for medical purpose can be grouped into these four applications:

1. Preparing organ models to help for surgical and treatment planning, and diagnosis purpose [4].
2. Research on customized 3d printed nonbioactive implants.
3. Research on manufacturing nearby bioactive and biodegradable moulds and surgical guides;
4. Research on legitimately printing organs and tissues with complete life capacities [5]

3D printing has been applied in medicine since the early 2000s when the innovation was first used to make dental inserts and custom prosthetics. Since, the clinical applications for 3D printing have developed extensively. The current reviews depict the utilization of 3D printing to deliver bones, ears, exoskeletons, eyeglasses, cell cultures, undifferentiated cells, veins, vascular systems, tissues, and organs, just as novel measurement structures and drug delivery devices. The current clinical employments of 3D printing can be sorted out into a few general classifications: tissue as well as organ manufacture; making prosthetics, inserts, and anatomical models; and pharmaceutical examination concerning drug revelation, conveyance, and measurement structure.

Radiologists have witnessed the evolution of medical imaging that allows for 3D printing. Multiplanar imaging with computed tomography (CT) and magnetic resonance imaging gave rise to 3D reconstructions that improved the evaluation of complex anatomy.

In 2016, the Radiological Society of North America (RSNA) endorsed a proposal to make the Special Interest Gathering on 3D Printing (SIG). This report satisfies two of the first SIG objectives: to give proposals towards predictable and safe creation of 3D printed models got from clinical pictures, and to depict a lot of clinical situations for 3D printing is fitting for the expected utilization of patients’ care with those ailments. After the clinical the choice to utilize 3D printing for caring of patients, there are numerous resulting ventures, as investigated in earlier literature.

**CONCLUSION**

3D printing has become a useful and potentially revolutionizing tool in the medical area. goes through a series of processes and use different softwares to develop a model. The results of different models show that printer performance, resolution, and available materials play an important role in model preperation. Radiology can be the clinical specialty to take the lead in co ordinating 3D printing services: processing the imaging data, designing 3D models for preoperative planning, and working with surgeons to optimize 3D-printed prostheses and bioactive implants.

**REFERENCE**