Advancements in the Diagnosis and Visualization of Heterotopic Ossification

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INTRODUCTION

Physical models of an anatomical region can help to provide a diagnosis and visualization of an injury. CT scans by themselves, although comprehensive may not give an adequate representation of the injury site. Presently, physicians depend on X-rays and CT scans to interpret the extent of an injury (1).

Heterotopic Ossification (HO) is the abnormal formation of true bone within the extraskeletal soft tissue. This bony formation has become more common following combat related injuries and amputations. Individuals sustaining blast injuries seem to be the most likely to develop HO (2). Large numbers of the amputees from the Iraqi conflict have developed HO primarily around the transection site.

Symptoms of this bony formation are skin breakdown, pain, arterial complications, and prosthetic complications. (1,2)

When trying to visualize the full extent of the problematic region, virtual and physical 3D models can be very beneficial.

Virtual models or surface generation although helpful may not provide the same detailed information as a physical model a physician can hold in their hands. Therefore these virtual models are more frequently being produced as a physical model.

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METHODS

Three-dimensional Reconstruction

- CT sets spanning the area of interest are imported into MIMICS (Materialise, Ann Arbor MI) to create a 3D Stereolithography (STL) file.
- Any artifact is manually removed from the computational file.
- Computational models are then cleaned and supporting features added (if necessary) using Magics (Materialise, Ann Arbor MI)

Anatomical Modeling

- STL Files are processed on a build platform using Light Year (3D Systems, Rock Hill SC).
- Files are rapid prototyped using an SLA 7000, a Stereolithography Apparatus, by local curing resin using an ultraviolet laser layer by layer in the Z-direction at 0.125 mm increments
- Models are drained, washed in Tripropylene Glycol Monomethyl Ether (TPM), rinsed in water, and dried.
- Supports (lattice structure) are stripped from the model, followed by the models being post-cured (Post Curing Apparatus, 3d Systems, Rock Hill SC)

Treatment/Surgical Planning

- Physicians are then given the model to plan the appropriate treatment or surgical plan. Most models are delivered 24-48 hours after the request is made.

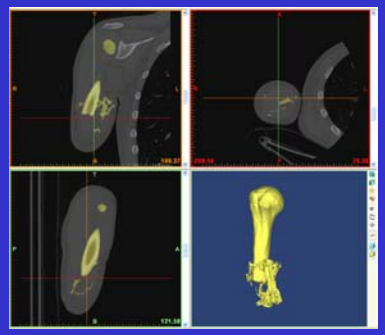
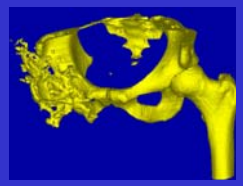
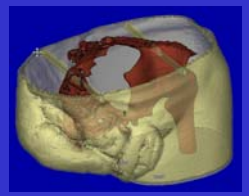


Figure 1: MIMICS (Left)
MIMICS imports standard CT scans, calculates the sagittal and coronal views, and using Hounsfield Units allows the user to threshold the scans and make 3D reconstructions

Figure 3: If a CT is taken with a contrast agent, the path of the artery through the HO may be visualized and modeled. The virtual and physical models help with surgical planning.



Virtual model of HO



HO present in relation to the soft tissue

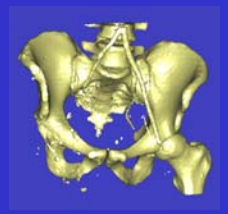


Figure 6: In a hip disarticulation, the patient wears a saddle that straps around the waist, in which his pelvis sits. The prosthesis is attached to the anterior lower side and is activated by swiveling the hip. When the HO exists in such abundance, no saddle can successfully be fitted. Upon removal of the HO, this patient was able to be fitted for a prosthesis and return to his normal lifestyle, including running.

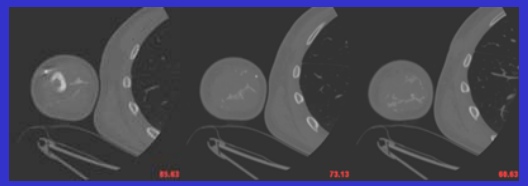


Figure 2: Standard CT (Above)
Three slices of a CT scan spanning the HO Region. Conventional methods may be more difficult to show the extent of the HO.

Figure 4 & 5: Two separate HO Cases
On the left is an extreme case of HO following a gun shot wound. On the right is HO developed after an amputation.

Virtual model processed and "printed" into a three-dimensionally accurate physical model

RESULTS / DISCUSSION

The virtual and physical models can provide information not easily obtained in standard radiographic scans. Physicians can evaluate the full extent of the HO and decide on the appropriate plan of action for each individual patient.

REFERENCES

[1] Gajewski et al. J AAOS. 2006.
[2] Potter et al. J AAOS. 2006