Ultrasound Obstet Gynecol (2008)
Published online in Wiley InterScience (www.interscience.wiley.com).

Letter to the Editor

The use of rapid prototyping didactic models in the study of fetal malformations

The importance of rapid prototyping (RP) in the biomedical sector has been increasing steadily during the past decade. Different uses of RP models have been reported widely in the medical scientific literature[1,2]. In our eight studied cases, of which the final models of two are presented, RP was performed after magnetic resonance imaging (MRI) (Figure 1) or computed tomography (CT) (Figure 2) of fetuses at gestational ages greater than 26 weeks. The indications for MRI were central nervous system, thoracic, gastrointestinal or genitourinary malformations, and skeletal malformations for CT. All cases were examined first by ultrasound imaging. MRI examinations were performed using a 1.5-T scanner (Siemens, Erlangen, Germany). The protocol consisted of: T2-weighted sequence in the three planes of the fetal body (HASTE; repetition time, shortest; echo time, 140 ms; field of view, 300–200 mm; 256×256 matrix; slice thickness, 4 mm; acquisition time, 17 s; 40 slices). The entire examination time did not exceed 30 min[3]. CT was performed using a multislice 64 scanner (Philips, Solingen, Germany) with the following parameters: 40 mA, 120 kV, 64 slices per rotation, pitch 0.75 and slice thickness 0.75 mm. This corresponds to a mean radiation dose to the fetus of 3.12 mGy (CT dose index weighted). The acquisition lasted around 20 s and was performed during maternal apnea[4].

In order to construct physical models from the medical examinations (MRI and CT) of the cases described, with the aim of didactic use, the first step was the production of three-dimensional (3D) virtual models. These models are made by the use of medical segmentation software (ScanIP version 2.0, Simpleware Ltd., Exeter, UK) to select the contours, allied to design and engineering software (Dassault Systèmes, SolidWorks Corp., and Autodesk Maya) that is used when connections are necessary between parts, and also for surface smoothing and adjustments. When the 3D virtual model is ready, the next step is its physical materialization using RP technology, which works by the principle of overlapping of layers of materials (selected according to the RP technology)[5].

In the first case, to build the model presented (Figure 1), the technology adopted was fused deposition modeling. The material used was thermoplastic acrylonitrile butadiene styrene and the total machine time for the RP construction was 32 h. The model required a supporting water-soluble material, which was removed after the construction process through immersion in an ultrasound bath in a liquid release agent. The final production cost of this model was US$280.

Figure 1 Rapid prototyping model of a fetus created using fused deposition modeling after magnetic resonance imaging at 34 weeks.

The second model presented was made using the 3D Systems Viper Stereolithography process (Figure 2), in which a laser is used to 'draw' successive cross-sectional layers in a photosensitive resin. The building process was followed by a postprocessing stage, in which the support was removed and the piece cleaned by removing polymer residues that did not harden during the building process. The model was then totally hardened under ultraviolet light. The RP machine time was 26 h, with a final production cost of US$240.

Through the associated use of MRI and CT with RP technologies, we believe that physical models will help, in a didactic, tactile and interactive manner, the study of complex malformations by a multidisciplinary staff.

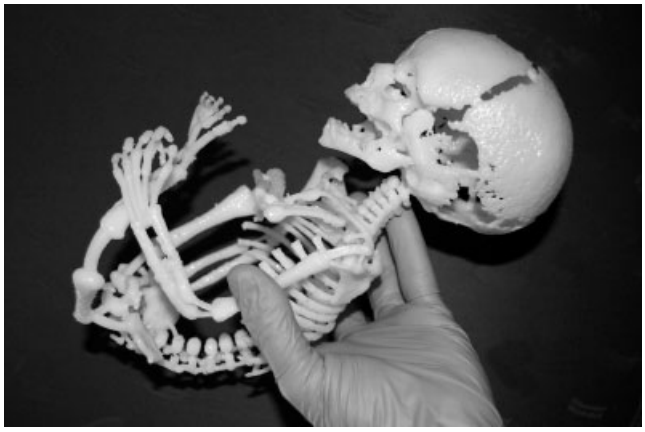

Figure 2 Rapid prototyping model of the skeleton of a fetus created using stereolithography after computed tomography at 35 weeks.

H. Werner*†, J. R. Lopes dos Santos‡§, R. Fontes‡, E. L. Gasparetto†¶, P. A. Daltro†, Y. Kuroki† and R. C. Domingues†
†*Clínica de Diagnóstico por Imagem,*
‡*Instituto Nacional de Tecnologia and*
¶*Department of Radiology,*
Federal University of Rio de Janeiro School of Medicine, Rio de Janeiro, Brazil, and
§*Royal College of Art, London, UK*
**Correspondence.*
(e-mail: heron.werner@gmail.com)
DOI: 10.1002/uog.6253

References

1. Armillotta A, Bonhoeffer P, Dubini G, Ferragina S, Migliavacca F, Sala G, Schievano S. Use of rapid prototyping models in the planning of percutaneous pulmonary valved stent implantation. *Proc Inst Mech Eng* 2007; **221**: 407–416.
2. Robinoy M, Salvo I, Costa F, Zerman N, Bazzocchi M, Toso F, Bandera C, Filippi S, Felice M, Politi M. Virtual reality surgical planning for maxillofacial distraction osteogenesis: the role of reverse engineering rapid prototyping and cooperative work. *J Oral Maxillofac Surg* 2007; **65**: 1198–1208.
3. Prayer D, Brugger PC, Prayer L. Fetal MRI: techniques and protocols. *Pediatr Radiol* 2004; **34**: 685–693.
4. Cassart M, Massez A, Cos T, Tecco L, Thomas D, Van Regemorter N, Avni F. Contribution of three-dimensional computed tomography in the assessment of fetal skeletal dysplasia. *Ultrasound Obstet Gynecol* 2007; **29**: 537–543.
5. Willis A, Speicher J, Cooper DB. Rapid prototyping 3D objects from scanned measurement data. *Image and Vision Computing* 2007; **25**: 1174–1184.