

## 3D cinematic rendering of fetal skeletal dysplasias using postmortem computed tomography

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As parental consent for invasive perinatal autopsy is declining, post-mortem cross-sectional imaging techniques have gained popularity, as tools for confirming antenatal findings and to highlight new abnormalities. One of the major benefits of imaging, in addition to being a non-invasive method, is that it also allows for the acquisition of a 3-dimensional (3D) volumetric datasets which can be post-processed to produce a variety of imaging reconstructions, such as the traditional 'volume-rendering' technique (VR). Recently, a novel software termed "cinematic rendering" (CR) (Syngo.via, Siemens Healthineers, Forchheim, Germany) has been developed and FDA approved for clinical use, allowing for a more photorealistic and detailed imaging reconstruction.

Whilst CR technology bears several similarities to VR, it utilises a more complex light modelling algorithm incorporating information from multiple light paths and predicted photon scattering patterns<sup>1, 2</sup>. Several recent publications have demonstrated the superior 'realism' and 'expressiveness' of CR over VR techniques in musculoskeletal<sup>3, 4, 5</sup> and vascular diseases (including a pregnant patient with Loeys-Dietz Syndrome)<sup>6</sup>. Given that this technique has been shown to work best where greatest contrast differences between tissues exist, we applied the software to two post-mortem CT datasets, acquired in fetuses with lethal skeletal dysplasias as part of their perinatal death investigation.

The first example was a 22-week gestational aged female fetus, who underwent termination of pregnancy due to a prenatal diagnosis of suspected skeletal dysplasia (Figure 1). Radiographically, the diagnosis was in keeping with thanatophoric dysplasia. Both the VR and CR reconstructions demonstrated key characteristics of shortened, curved long bones, curved femora with trident acetabula and narrow thoracic cavity, however the bone reconstruction with the CR appeared less pixelated, and the paler soft tissue CR overlay (Figure 1c) appeared more realistic and comparable to fetal skin than the red VR overlay (Figure 1a).

The second example was a stillborn 39-week gestational aged male fetus with osteogenesis imperfecta (OI), type 2 (Figure 2). The mother had not attended any antenatal appointments, and the diagnosis was made at post-mortem imaging. Both CR and VR demonstrate the classical features of OI with numerous fractured bones with callus formation leading to bowed, shortened limbs and 'beaded' rib appearances. The fetus was also noted to have a left inguinal hernia containing small bowel loops. Again the CR images provided a more "photorealistic" detail of the internal organs and skeletal findings, with less pixelation than those of the VR reconstructions.

In conclusion, CR appears to represent a promising method for providing more realistic 3D reconstructions of fetal post-mortem imaging for skeletal dysplasias over traditional VR techniques,

without any loss of detail relating to the underlying pathology. It can produce “sanitised” images of the fetus, which could be helpful in the communication of results with parents, or as an educational tool for training healthcare professionals<sup>7</sup>. Further work formally comparing the acceptability and benefit of these techniques against those of standard 2D images and 3D printed models is now required.

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**Conflicts of Interest:**

The authors have no conflicts of interest to declare.

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## Figure Legends

**Figure 1:** Post-mortem CT imaging of a 22 week gestation fetus. The parents opted for a termination of pregnancy due to antenatal suspicion for underlying skeletal dysplasia, which was later diagnosed radiographically as thanatophoric dysplasia. (a, b) Volume rendered reconstructions are provided next to (c, d) cinematic rendered reconstructions of the same fetus showing the underlying skeletal appearances both with and without soft tissue overlay respectively.

Classical features of thanatophoric dysplasia are demonstrated well with both techniques, including slightly curved femora, shortened long bones and trident acetabula. The cinematic rendered images, particularly with the soft tissue overlay (c), provide a more realistic bony appearance of the skeleton (particularly of the skull), compared to the more pixelated outline in the traditional volume rendering technique (a). The umbilical clip (measuring approximately 6cm in length), still attached to the fetus during the CT imaging provides a measure of the size of the fetus.

**Figure 2:** Post-mortem CT imaging of a stillborn 39 week gestation fetus with osteogenesis imperfecta Type 2. The mother had not attended antenatal appointments prior to delivery. (a, b) Volume rendered reconstructions are provided next to (c, d) cinematic rendered reconstructions of the same fetus showing the underlying skeletal appearances both with and without soft tissue overlay respectively.

Classical features of osteogenesis imperfecta are demonstrated with both techniques which include foreshortened, fractured long bones, 'beaded' fractured rib appearances and poor ossification of the skull. The soft tissue overlay images (a, c) demonstrate a left sided inguinal hernia with indwelling bowel loops (white arrow). The internal organs and bones are better differentiated using the cinematic rendered technique, which also provides a more 'smooth' and photorealistic appearance to the skeleton in image (d) compared to (b).

Figure 1





Figure 2

