# Applications of 3D Cinematic Rendering in Neuroimaging: Studio Magic Meets Anatomy and Pathology

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# *Disclosures*

The authors have no relevant disclosures.

# *Overview*

- Background
- Cinematic Rendering (CR) Technique
- Applications
- Overall benefits and limitations
- Summary

# *Background*

- Advances in multidetector CT (MDCT) hardware and new post-processing tools has improved ways to visualize complex anatomy.
- Maximum intensity projection (MIP) and volume rendering (VR) techniques are used widely used to:
  - Simulate anatomical model
  - Simplify complex anatomy seen on 2D images
  - Provide global overview of disease process
  - Detail anatomic and pathologic information

# *Background*

**Cinematic Rendering**

- New tool that was inspired by entertainment industry
- Based on various animation programs used in entertainment industry
- Involves random sampling computational algorithms and light maps to generate a lifelike depiction of data.
- Application in various medical imaging subspecialties being studied

# *Background*

## Cinematic Rendering vs. Volume Rendering

- Provides all benefits of volume rendering (VR) with additional benefits:

Traditional volume Rendering  Cinematic Rendering

- Models shadows
- Ambient occlusion
- Multi-scattering and color transmittance

Rowe SP et al. *Journal of Cardiovascular Computed Tomography*.
Dappa E et al. *Insights into Imaging.* 2016;7(6):849-856.

# *Background*

## Cinematic Rendering vs. Volume Rendering

- Provides all benefits of volume rendering (VR) with additional benefits:
  - Enhanced depth and shape perception
  - Modeling of aperture, exposure, shutter speed, and motion blur to create a natural lighting environment

Traditional volume Rendering

Cinematic Rendering

Rowe SP et al. *Journal of Cardiovascular Computed Tomography*.
Dappa E et al. *Insights into Imaging.* 2016;7(6):849-856.

# *Cinematic Rendering: Technique*

Three major steps:

- Classification of each voxel- similar to VR
- Image Projection- different from VR
- Post-processing- different from VR

# *Cinematic Rendering: Technique*

Classification of each voxel- similar to VR

- Determine color and opacity of each voxel via transfer functions.
- Each tissue type in a voxel is determined and represented by a percentage (0 to 100 %) based on a predefined attenuation threshold.
- Weighted sum of each tissue type determines overall color and transparency of each voxel.
- Process is repeated for each voxel in the dataset.

Dappa E et al. *Insights into Imaging.* 2016;7(6):849-856.
Eid M et al. *American Journal of Roentgenology.* 2017;209(2):370-379.

# *Cinematic Rendering: Technique*

Image Projection- different from VR

- Local gradient shading models, in addition to light ray modulation, are used to integrate light scatter.
- Randomized light ray paths are generated by Monte-Carlo simulations using path tracing and global illumination models.
- Progressive averaging of Monte-Carlo samples representing radiance and light scattered to obtain final image
- High dynamic range (HDR) rendering light maps used to provide natural illumination.

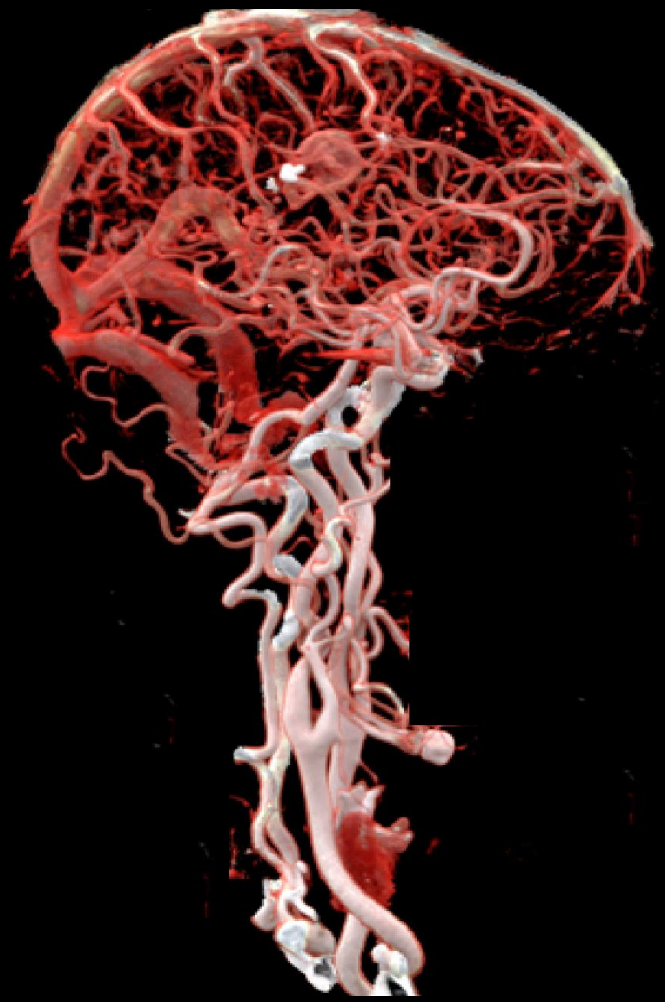
Dappa E et al. *Insights into Imaging.* 2016;7(6):849-856.
Eid M et al. *American Journal of Roentgenology.* 2017;209(2):370-379.

# *Cinematic Rendering: Technique*

Post-processing- different from VR

Multiple post-processing options are available and can be tailored to meet end goal.

- Brightness can be modulated.
- Specular reflection (reflection at one angle) or diffuse reflection can be simulated.
- Sharpness of different image portion can be varied.
- Region/organ of interest can be isolated.

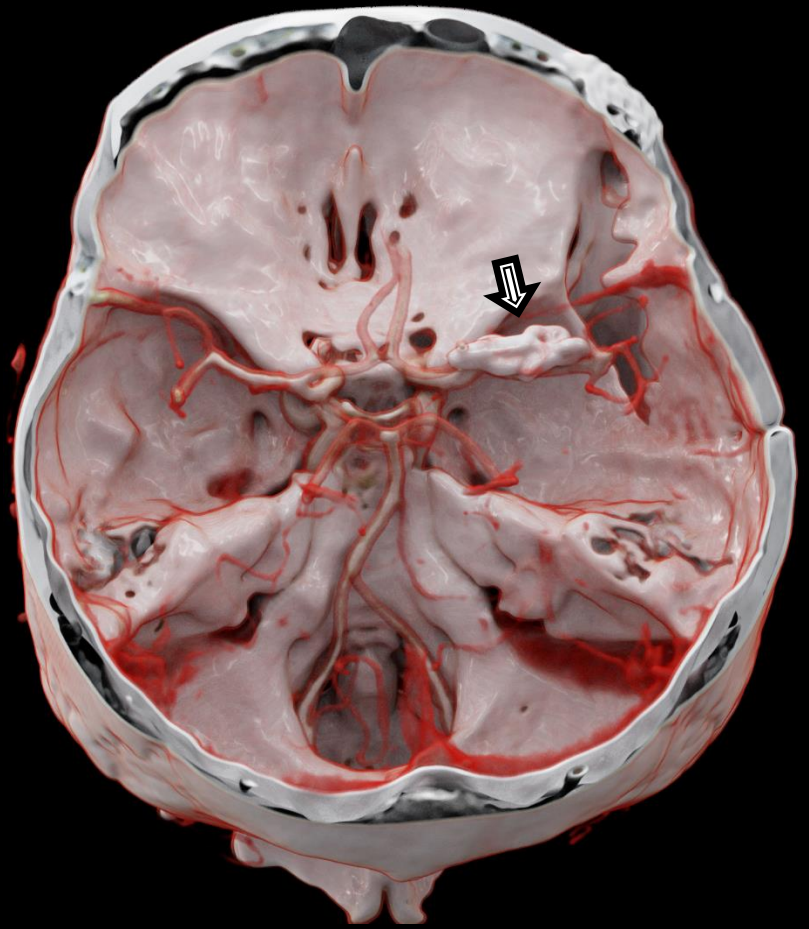


Eid M et al. *American Journal of Roentgenology.* 2017;209(2):370-379.

# *Applications*

Various applications have been proposed including…

- Trainee education
- Patient communication
- Surgical planning



Lifelike cinematic display of skull base and major intracranial arteries. There is an aneurysm clip (arrow) from previously clipped MCA aneurysm.

# *Trainee Education*

- Increasing role of medical imaging in anatomy education
- Positive response by students to inclusion of cross-sectional imaging in their curriculum

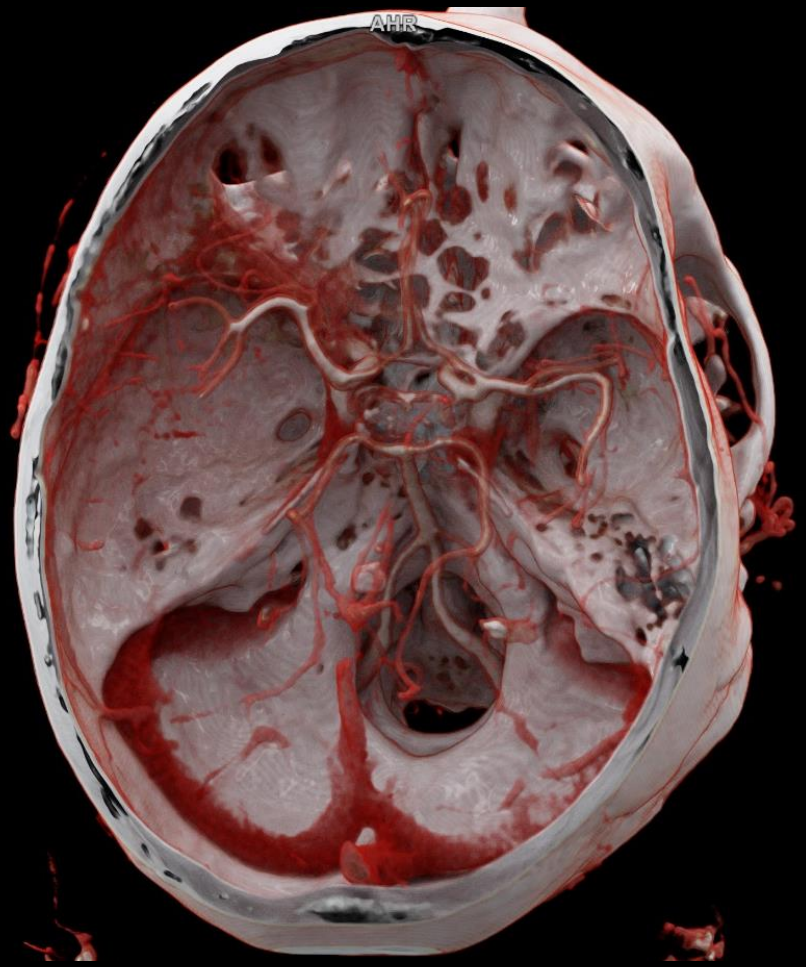
Eid M et al. *American Journal of Roentgenology.* 2017;209(2):370-379.

# *Trainee Education*

- Highly lifelike 3D anatomy simulates real cadaveric anatomy very closely and can complement anatomy teachings.

Cinematic rendering of neck CTA can be used to teach students that fracture of transverse foramina increase the risk of vertebral artery injury due to their close proximity.

# *Trainee Education*



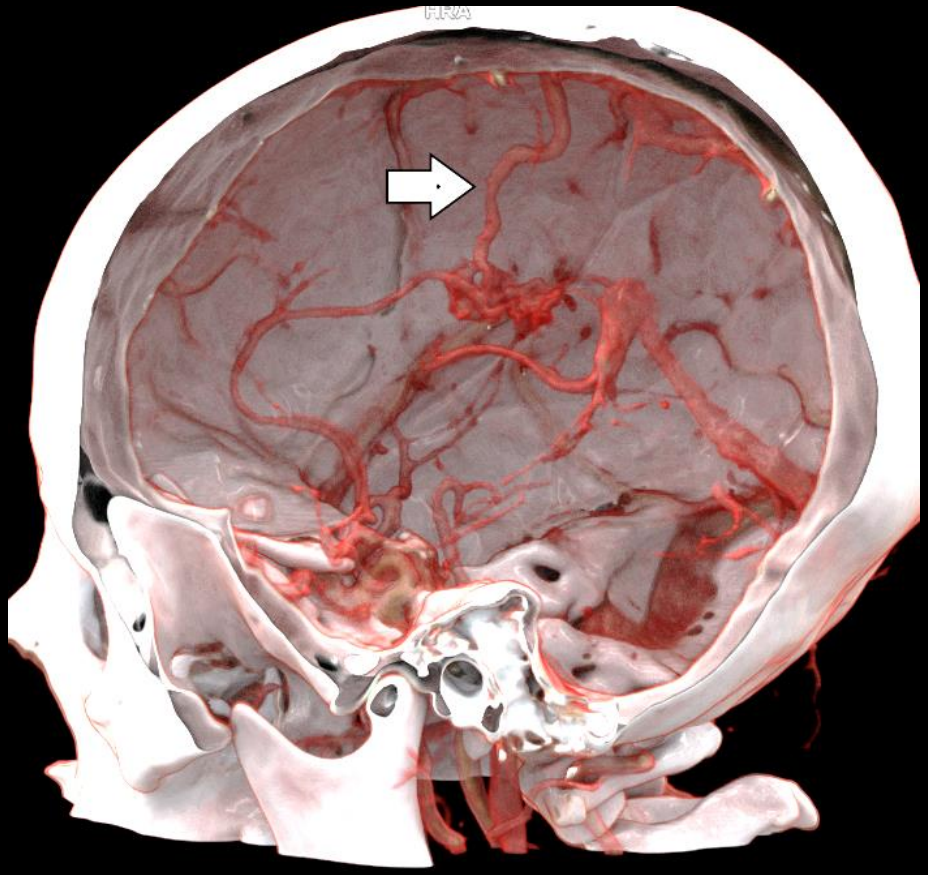
- Coloration help students grasp the anatomic relationship between different structures.

Cinematic display of Circle of Willis arteries and adjacent veins helps students better appreciate their anatomic relationships.

# *Trainee Education*

- Excellent soft tissue visualization
- Ability to step by step removal soft tissue and bones on images obtained through dual energy allowing for virtual dissection that further enhances understanding of human anatomy

# *Trainee Education*



- Helps trainee understand pathology much easily through visualization

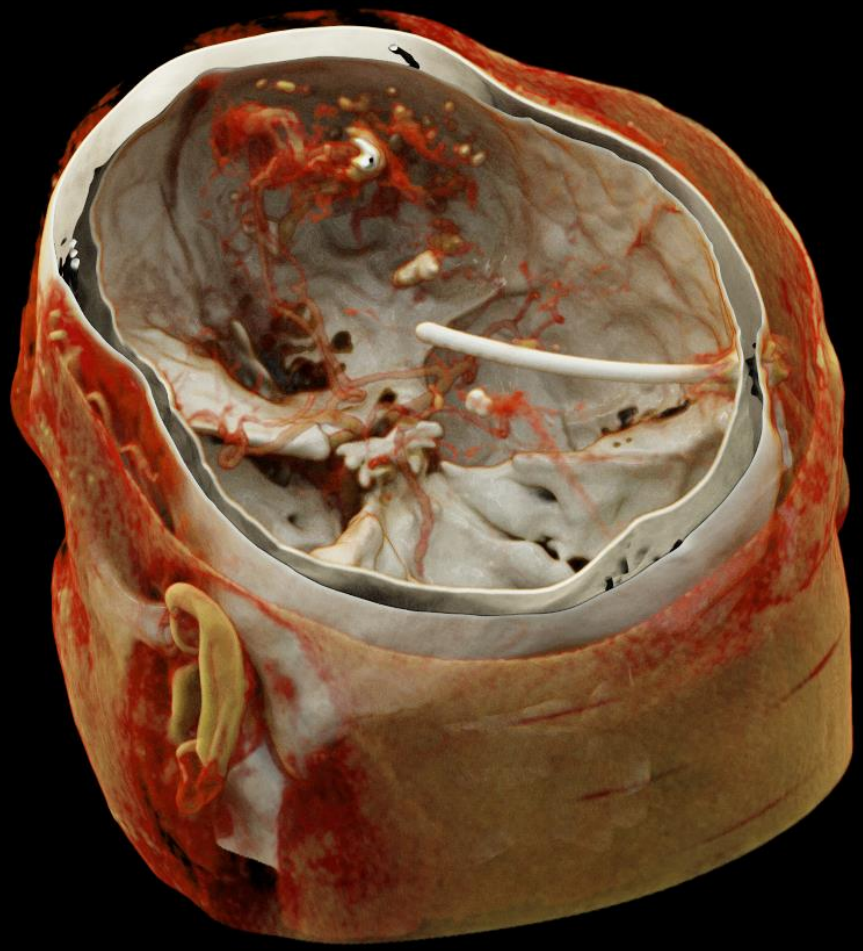
Lifelike 3D image of arteriovenous malformation connecting ACA with superior sagittal sinus (arrow) makes it easier for trainee to understand arteriovenous shunting.

# *Patient Communication*


- Provide more lifelike 3D models that are much easier for patients to grasp

Lifelike 3D image of ventriculoperitoneal shunt makes it easier for patient to understand their extracranial course.

# *Patient Communication*

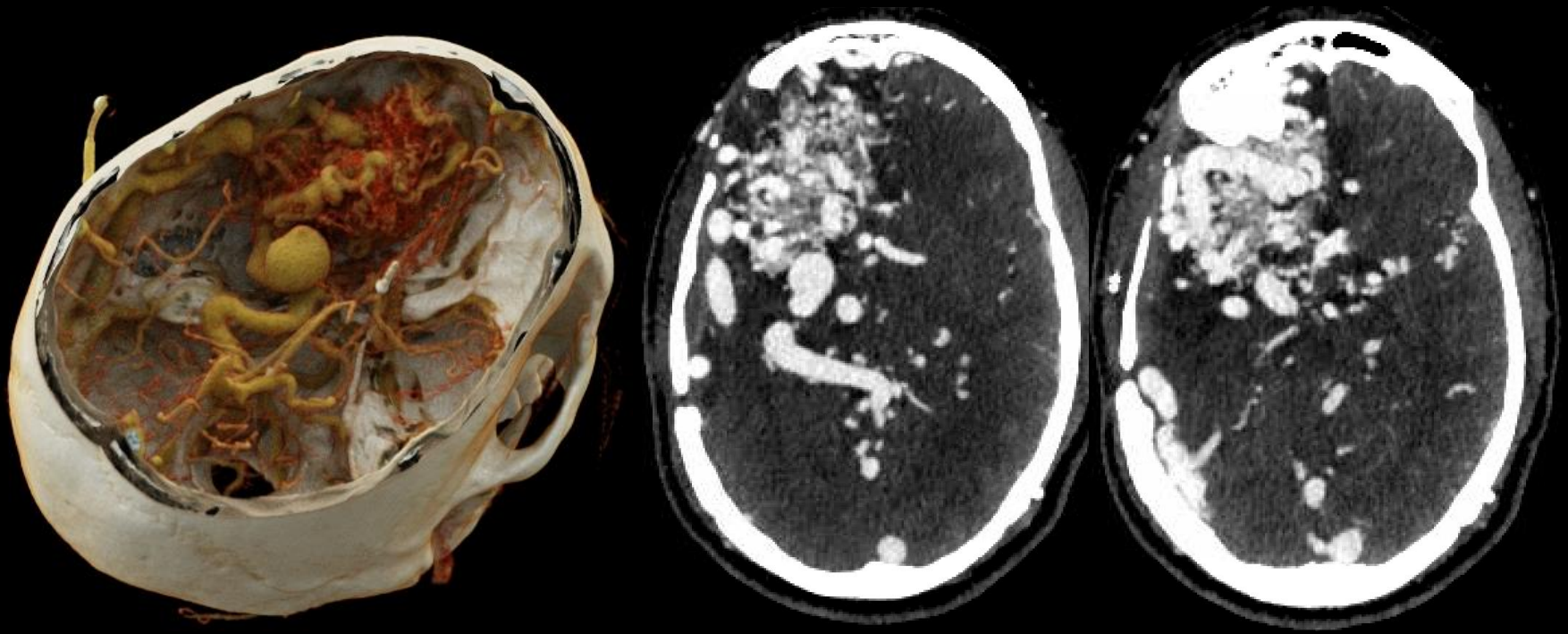


- Excellent soft tissue modeling gives context to patients and makes it easier for them to understand.

Lifelike 3D rendering of head CT demonstrates external context for VP shunt as well as abnormal vessels associated with a vascular malformation.

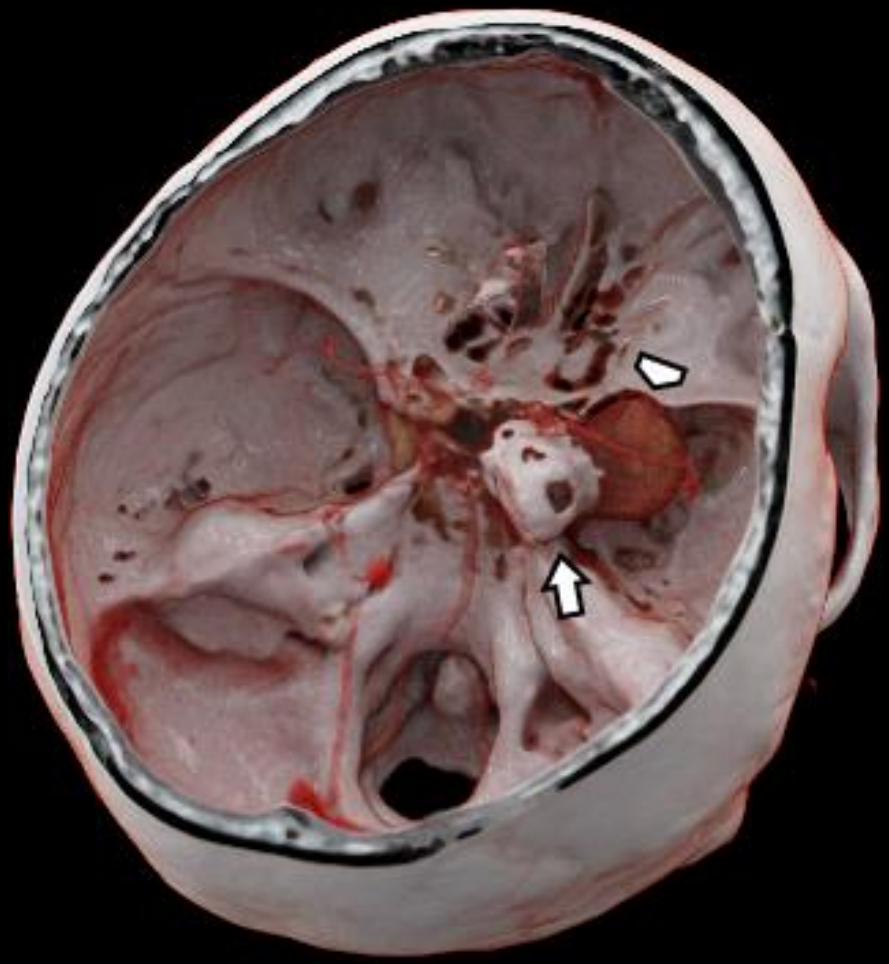
# *Patient Communication*

- 3D model of large Spetzler Martin Grade 5 arteriovenous malformation is much easier for patient to understand than CT images, and helps improve shared decision making process.



*Please note that axial images are flipped right to left to simplify correlation with 3D rendering

# *Surgical Planning*



- Lifelike 3D cinematic reformats with use of different color scheme to highlight different density structures help clinician visualize anatomy and pathology that they will see during surgery.

3D cinematic rendering of complex large right cavernous carotid aneurysm (arrowhead) with calcified portion (arrow) which is easily identified due to differential coloring- important for surgical planning.

# *Surgical Planning*

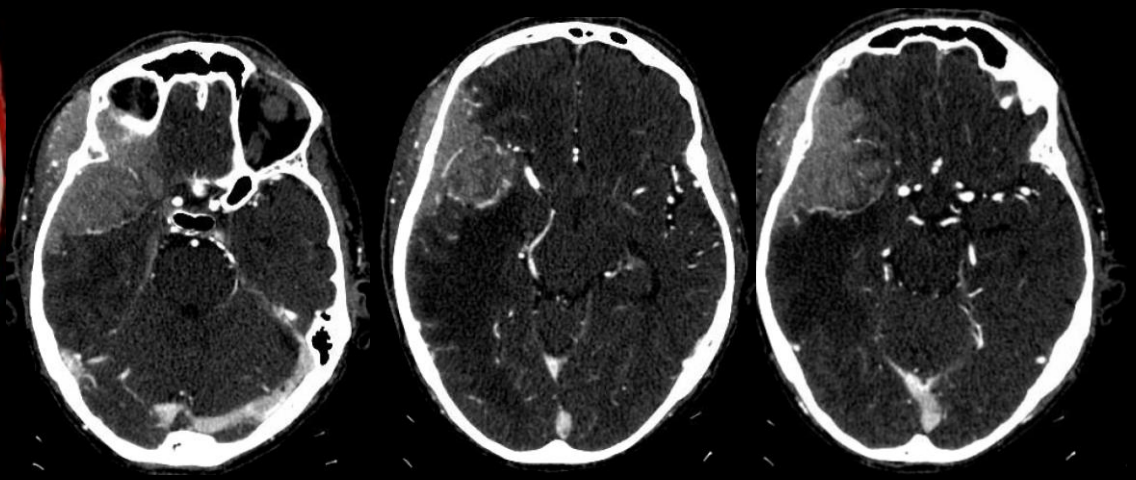
- Imaging is routinely used in surgical planning.
- Ability to appreciate overall picture of complex pathology, which is otherwise difficult to appreciate on 2D images.

3D cinematic rendering of non-contrast head CT helps appreciate complex multiple bilateral skull fractures and bullet fragments within right middle cranial fossa.

Eid M et al. *American Journal of Roentgenology.* 2017;209(2):370-379.
(Figure) Dappa E et al. *Insights into Imaging.* 2016;7(6):849-856.

# *Surgical Planning*

Photorealistic 3D cinematic rendering makes it much easier for surgeons to appreciate and mimics intraoperative pathology better compared to 2D CT images.



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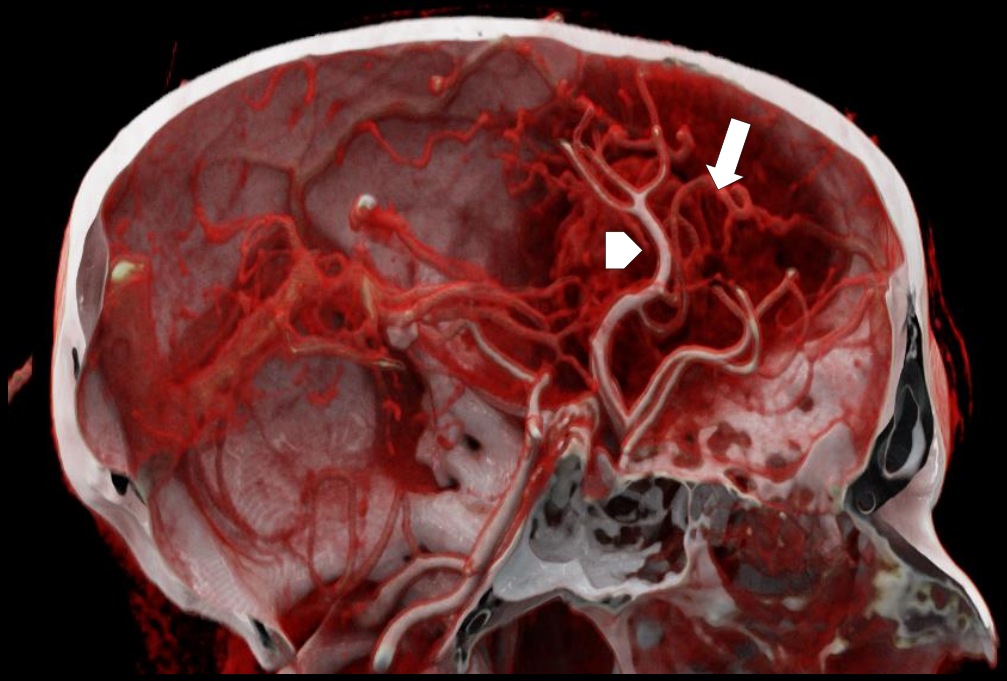
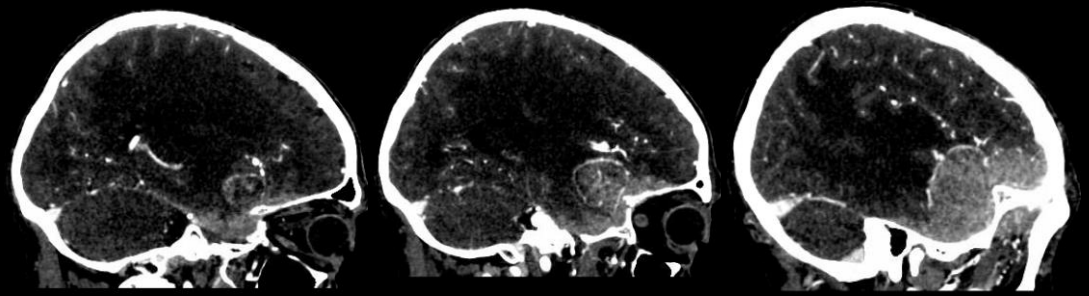
# *Surgical Planning*

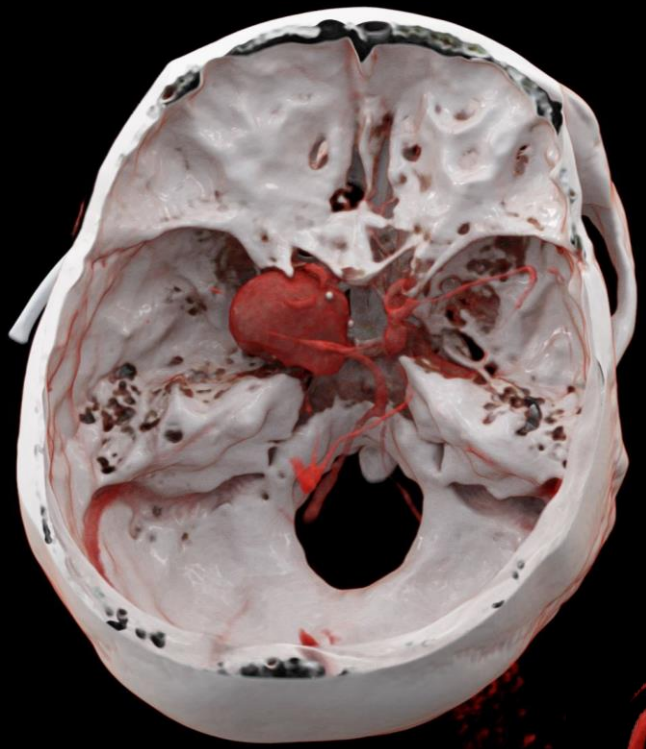




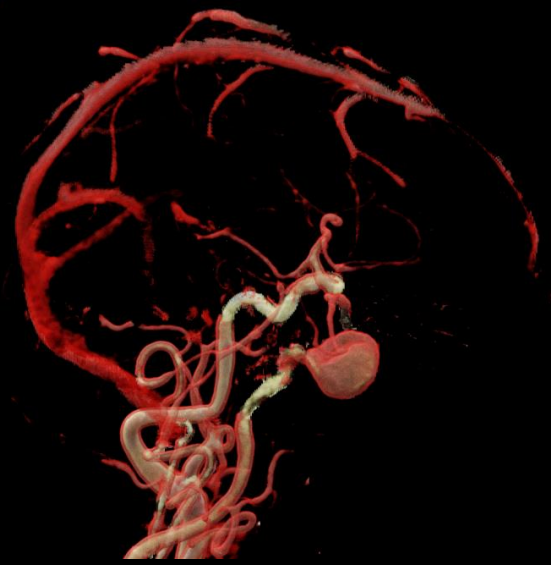
- Improved appreciation of spatial relationship between different structures can help reduce surgical complications.

Photorealistic 3D cinematic rendering demonstrating a vascular mass (meningioma denoted by arrow) displacing adjacent left MCA- crucial for surgeon to appreciate prior to surgery.

# *Surgical Planning*



- Bone subtraction algorithms can be used to isolate vascular pathology that may be partially hidden by the skull base bones.



Bone subtraction helps better appreciate the anatomy and the morphology of the right cavernous carotid aneurysm.

# *Benefits*

- Natural presentation of the medical imaging data
- Photorealistic representation of anatomy
- Improved depth perception and orientation
- High quality 3D reformats of dense structures such as bones and contrast enhanced vessels
- Improved depiction of soft tissue structures and anatomy
- Enhanced evaluation of spatial relationship

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# *Limitations*

- Shadowing effect:
  - Global lightening model used for photorealistic images can potentially obscure critical pathology.
  - It is important to evaluate 3D CR models from multiple angles.
  - Always refer back to source 2D images to correlate the pathology.
- Higher computational processing power needed compared to VR and may result in interruption real time manipulation (e.g. rotation) of 3D image.
- It does not add additional information compared to source data.
- Diagnostic value of CR compared to VR is yet to be evaluated.

Rowe SP et al. *Journal of Cardiovascular Computed Tomography*.
Dappa E et al. *Insights into Imaging.* 2016;7(6):849-856.

# *Conclusions*

- Cinematic rendering is a new and exciting tool that provides lifelike 3D reconstruction of the imaging data.
- Through its various functions, it can help improve trainee education, patient communication and surgical planning.
- However, original source images must be referenced for diagnostic purposes.

# *References*


- Rowe SP, Johnson PT, Fishman EK. Cinematic rendering of cardiac CT volumetric data: Principles and initial observations. *Journal of Cardiovascular Computed Tomography.* Volume 12 , Issue 1 , 56 - 59

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- Eid M, De Cecco CN, Nance JW, et al. Cinematic Rendering in CT: A Novel, Lifelike 3D Visualization Technique. *American Journal of Roentgenology.* 2017;209(2):370-379.

*Thank you very much for your attention!*

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