Medical Illustration: Current Uses and Process

MeCo Visuals

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www.ChicagoMedicalGraphics.com

My Background

© Sam Bond

- Two Companies:
  - MeCo Visuals
  - Chicago Medical Graphics
- BS, Biology: The University of Texas at Austin
  - Neurobiology focus
- Clinical Assistant at Dell Children's Medical Center
  - Pre- and post-surgical
- MS, Biomedical Visualization: The University of Illinois at Chicago
  - 3D Animation in medical education

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The Association of Medical Illustrators

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Asking the Right Questions

- Understanding patient needs

MeCo Visuals

Asking the Right Questions

- Understanding patient needs
    - Physical

MeCo Visuals

Asking the Right Questions

- Understanding patient needs
  - Physical
  - Psychological

MeCo Visuals

Asking the Right Questions

- Understanding patient needs
  - Physical
  - Psychological
  - Learning Needs!

Asking the Right Questions

- Understanding patient needs
    - Physical
    - Psychological
    - Learning Needs!

- Engagement leads to better outcomes, better understanding

Asking the Right Questions

- Understanding patient needs
  - Physical
  - Psychological
  - Learning Needs!
- Engagement leads to better outcomes, better understanding
- Moving away from fee-for-service
  - Accountable Care Organizations
  - Bundled payments

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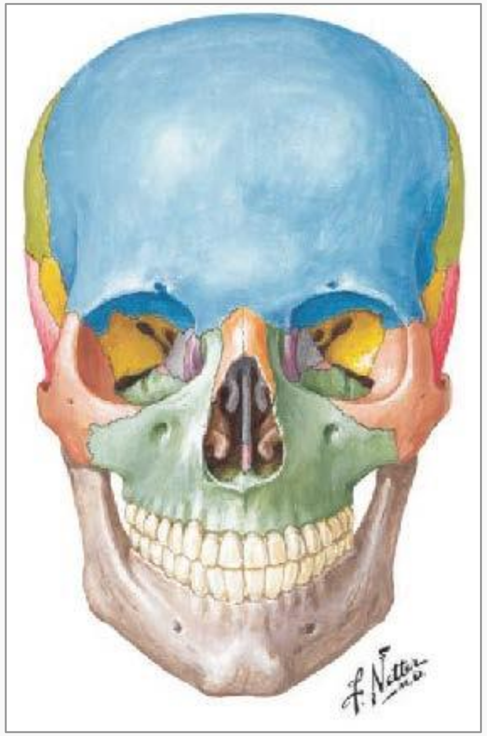
The Healthcare Ecosystem is Changing!

So, What Does a Medical Illustrator Do?

Most people think:
Frank Netter & anatomy books



Frank Netter

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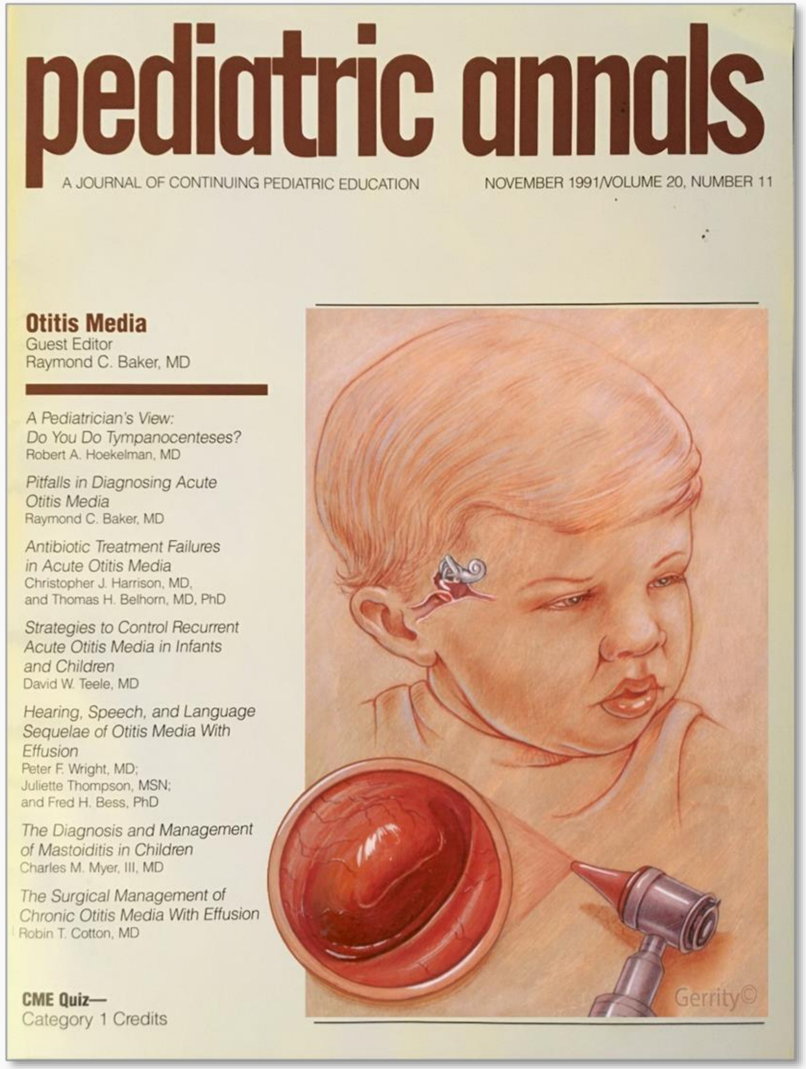
Research Journals



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Websites and Apps

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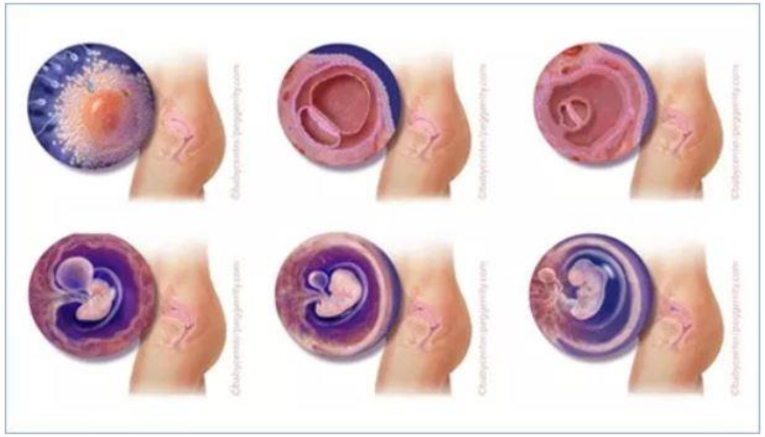
Patient Handouts



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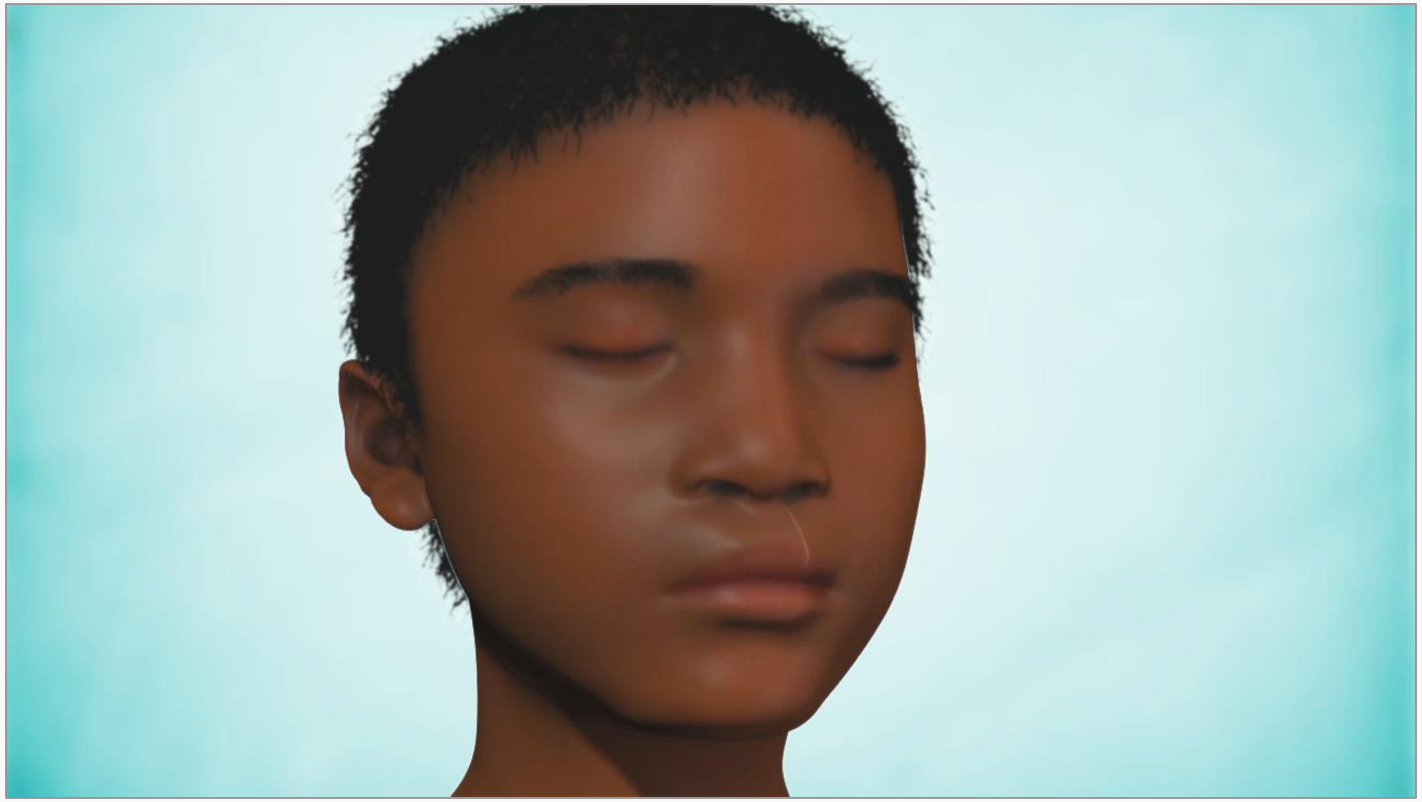
Patient Education



- Patient engagement
- Better-informed consent
- Treating pediatric patients like “little scientists”

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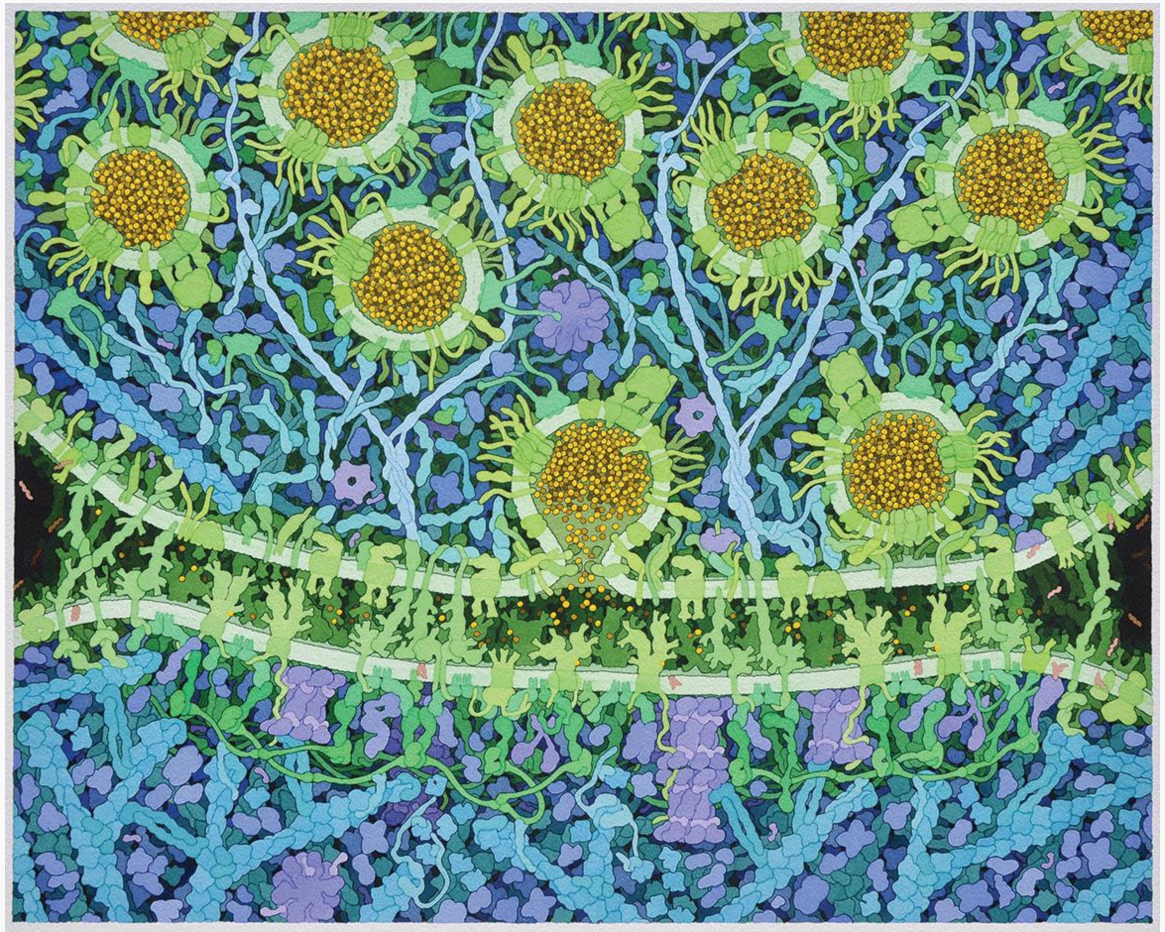
Molecular Visualization



- Mesoscale illustration of a nerve synapse by David Goodsell, PhD (citation #)
- Hand-painted in watercolor

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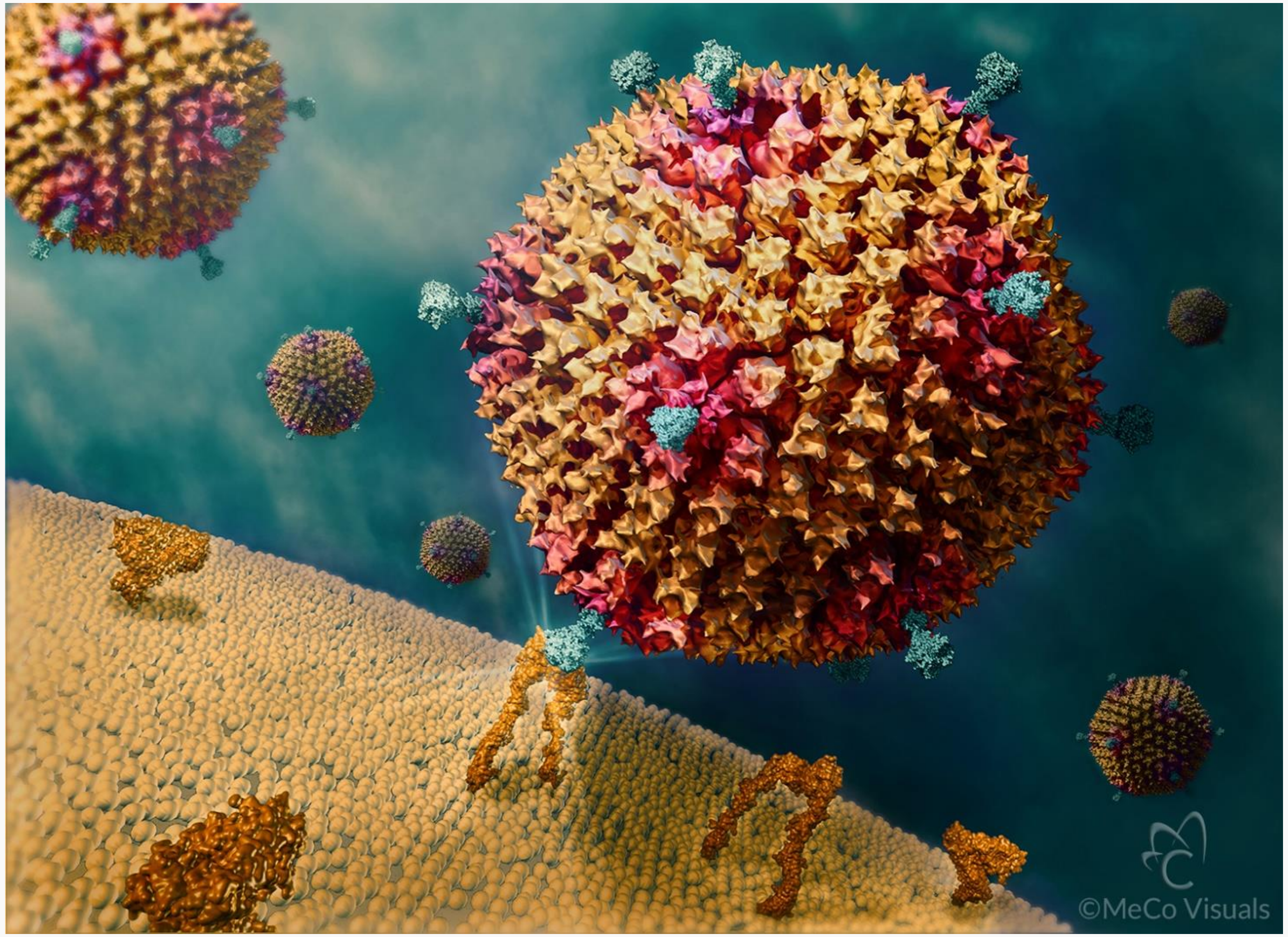
B. D. Campbell and S. Francesca, "Using Art to Visualize Cellular Environments: An Interview with David Goodsell," in *IEEE Computer Graphics and Applications*, vol. 36, no. 6, pp. 6-10, 2016. doi:10.1109/MCG.2016.116

Pharmacological Visualization



- Pharmaceutical Mechanism of Action
- Modified adenovirus, attacking glioblastoma cells

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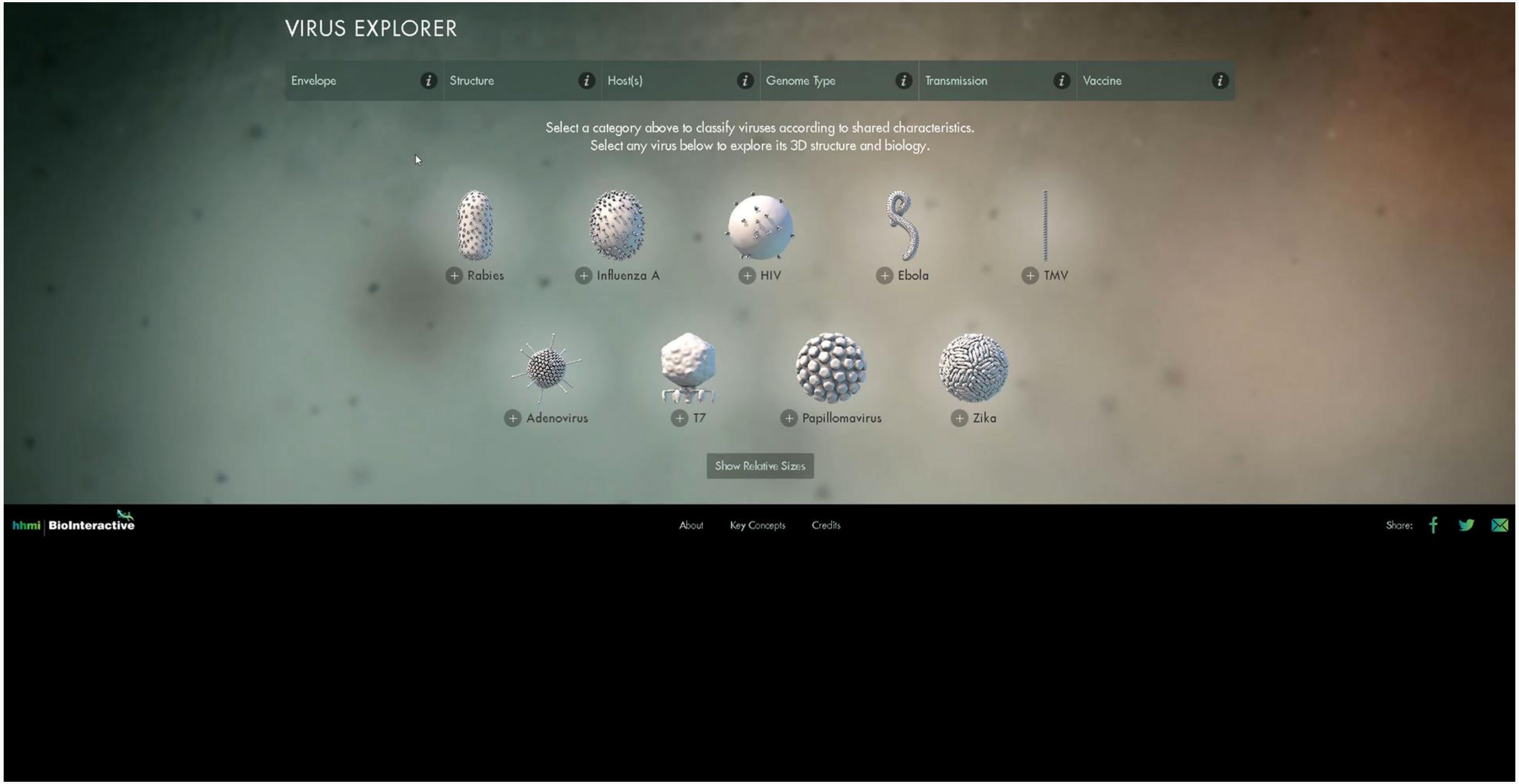

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- Virus Explorer: directed and modeled by Fabian de Kok-Mercado, MA-CMI
- From Howard Hughes Medical Institute (HHMI) BioInteractive

Medical Device

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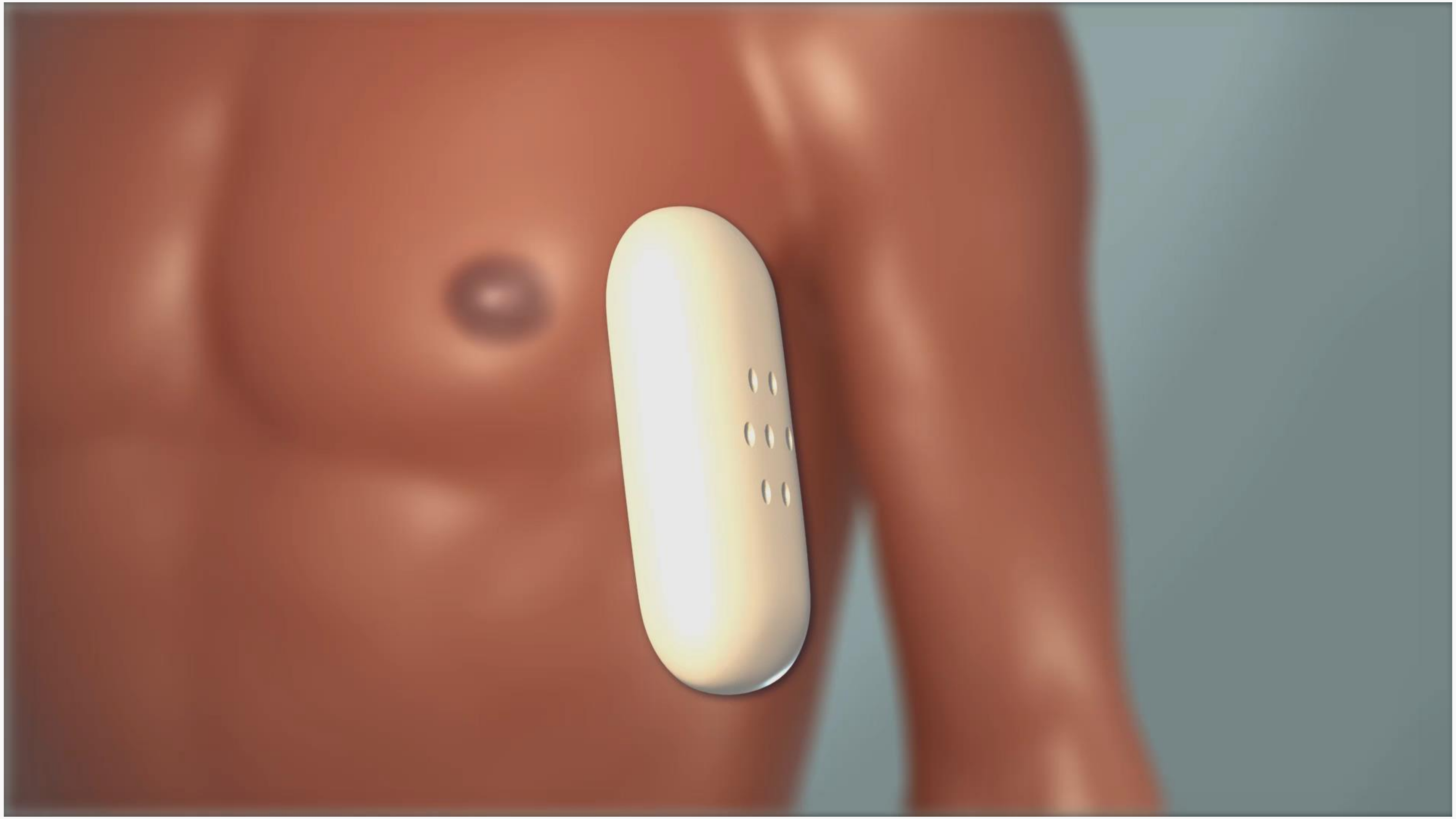
Medical Device



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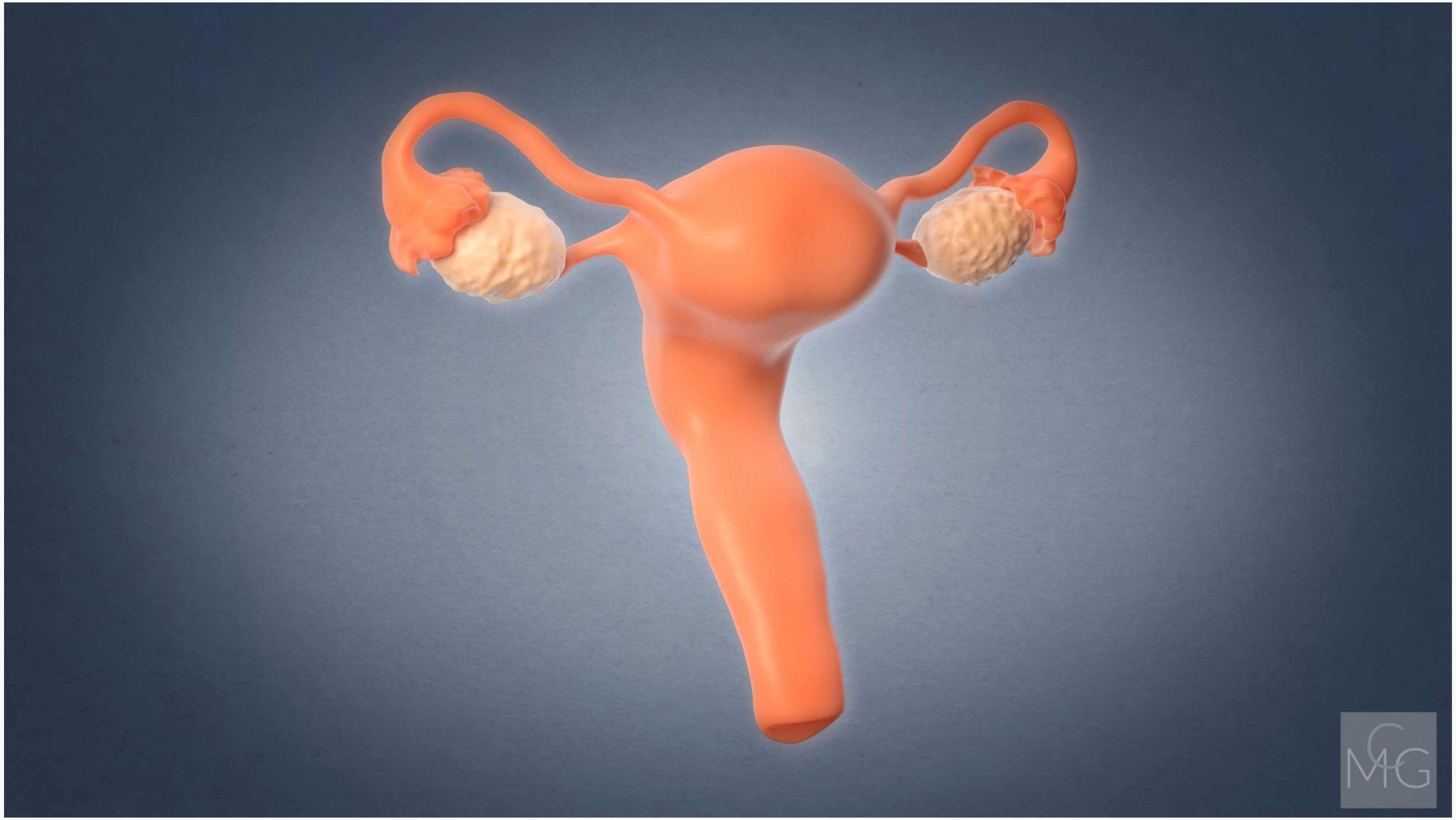
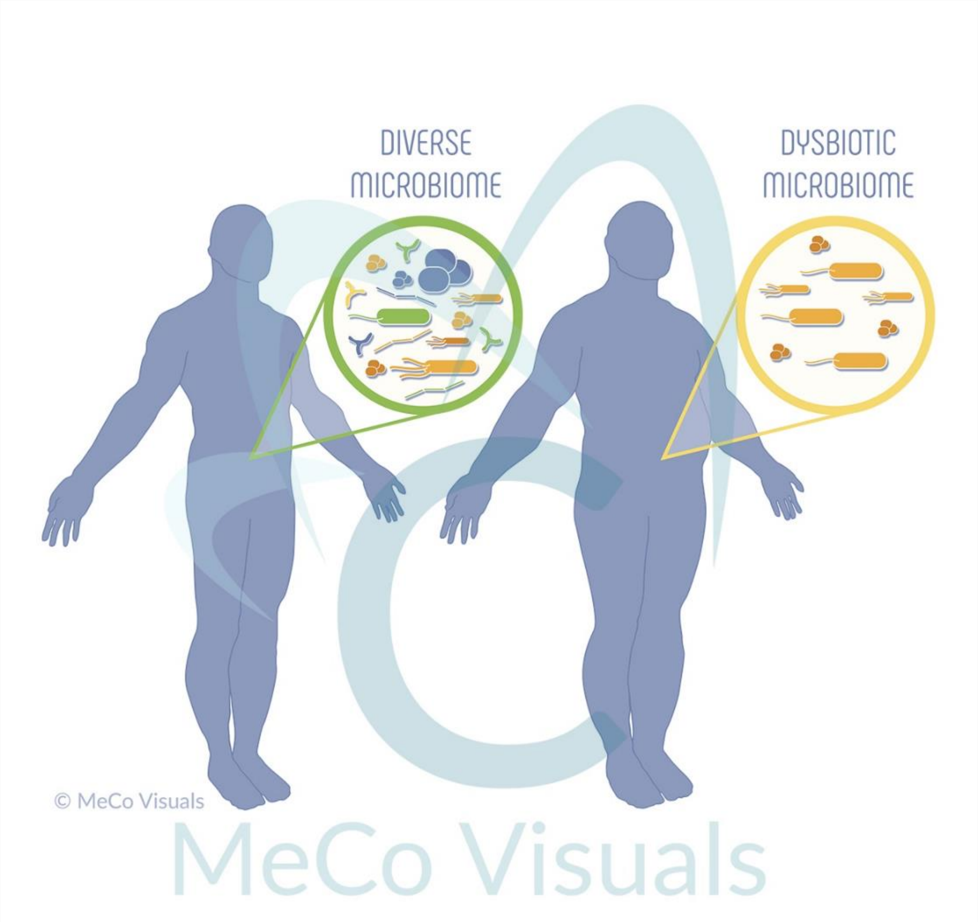
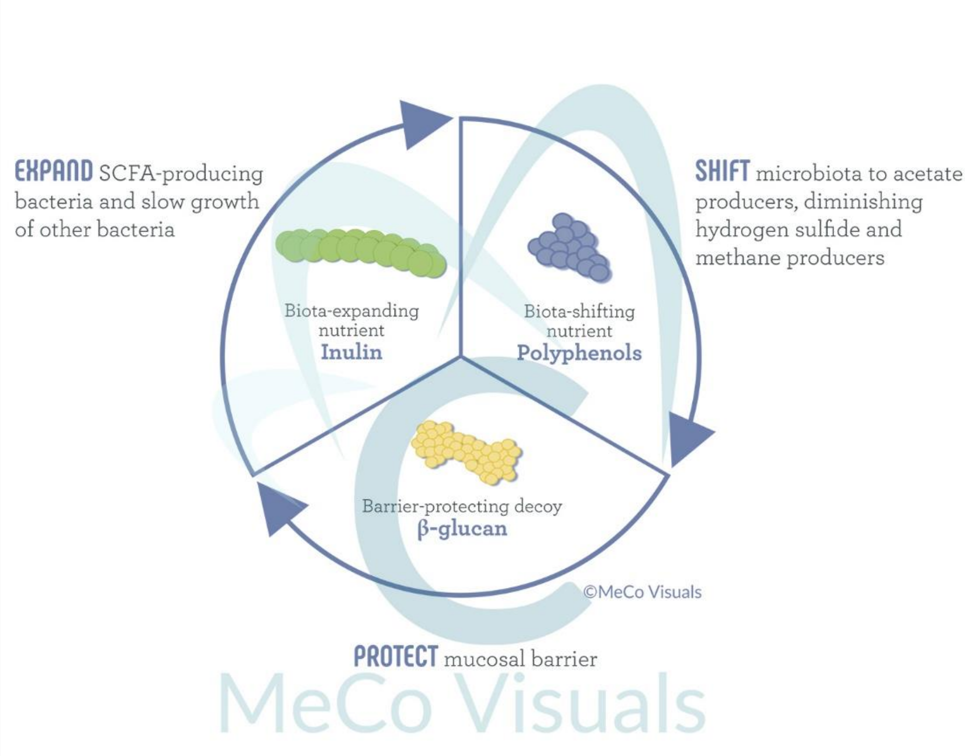
Patient and Investor Education



CME Courses, Webinars





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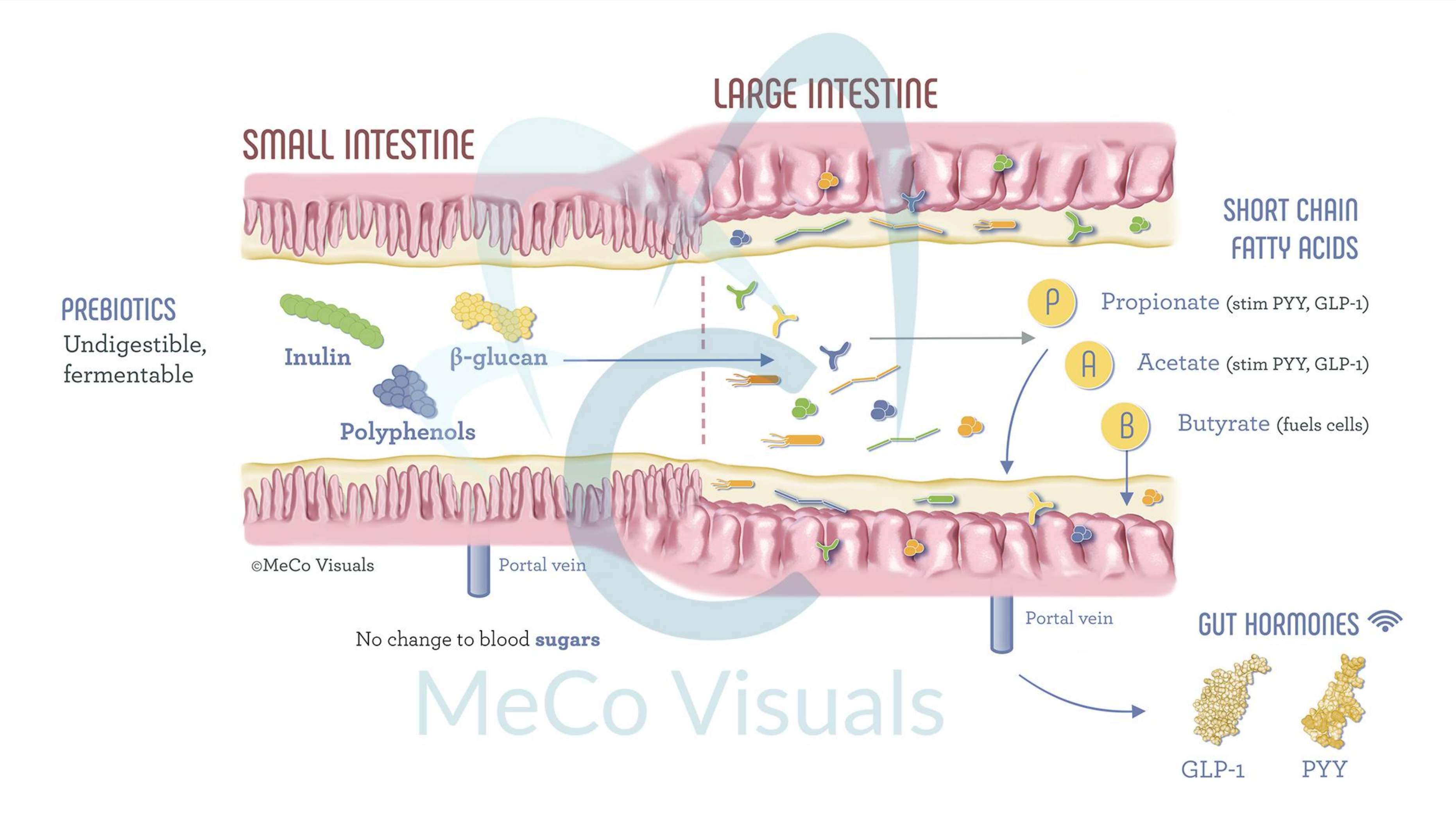
Research Presentations



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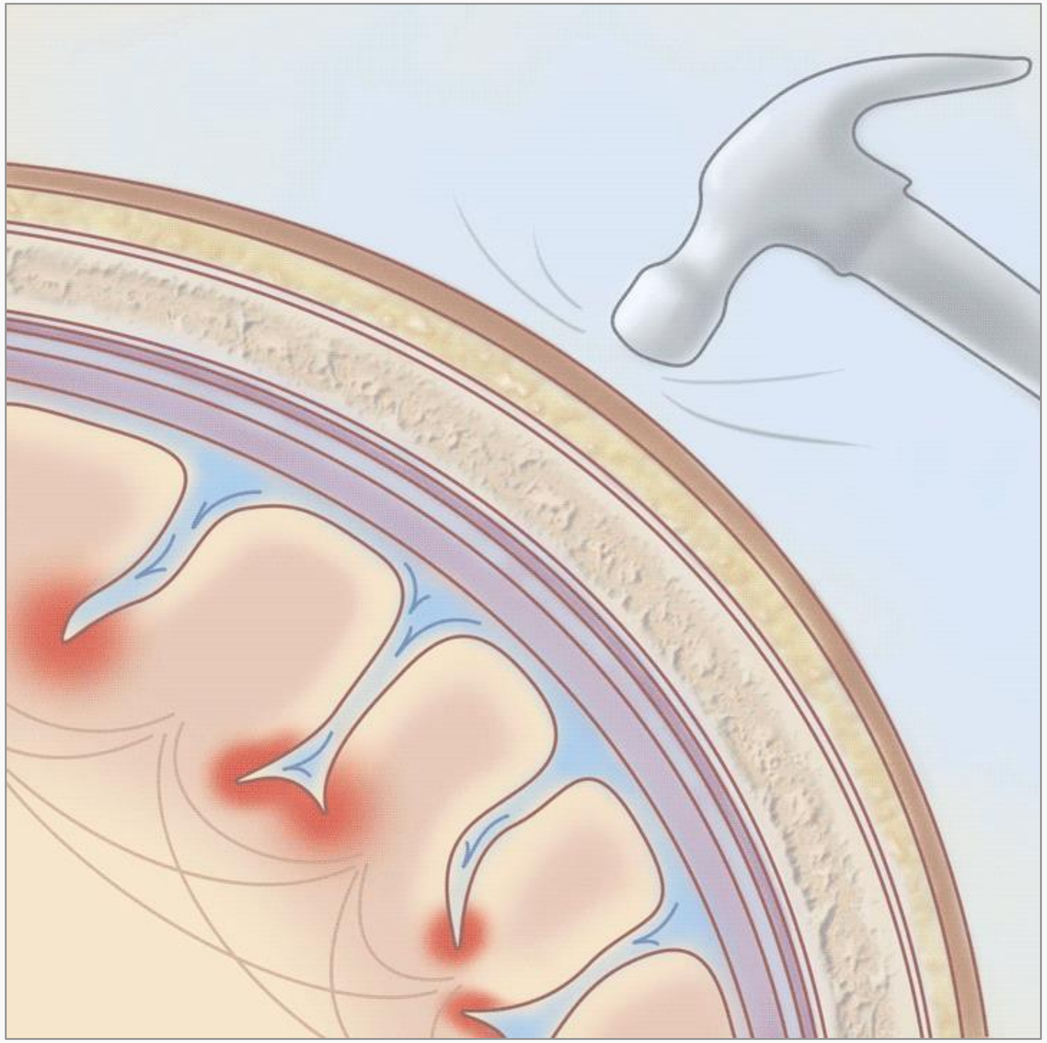
Representational



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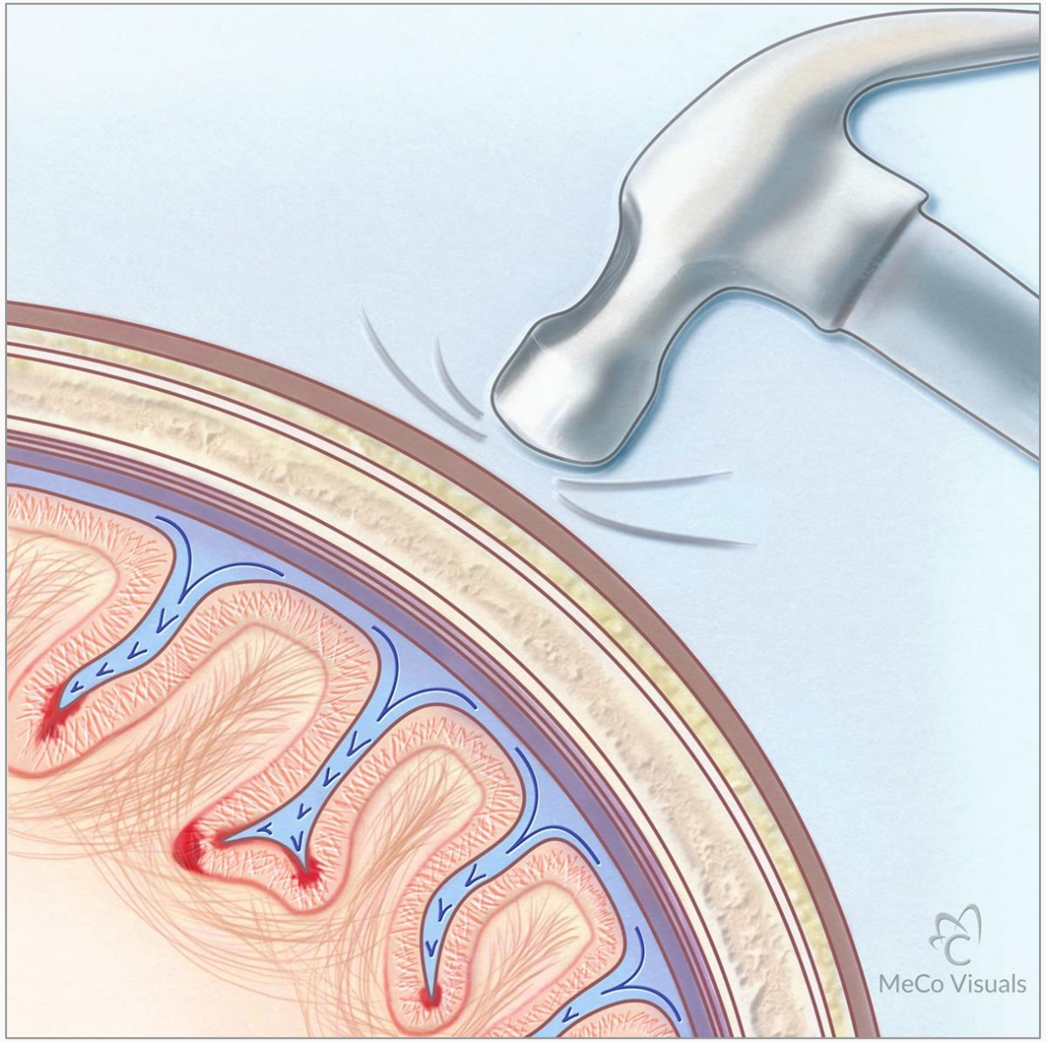
Representational



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Anaplastology

AURICULAR | EAR

ORBITAL | EYE

NASAL | NOSE

LIMBS + DIGITS

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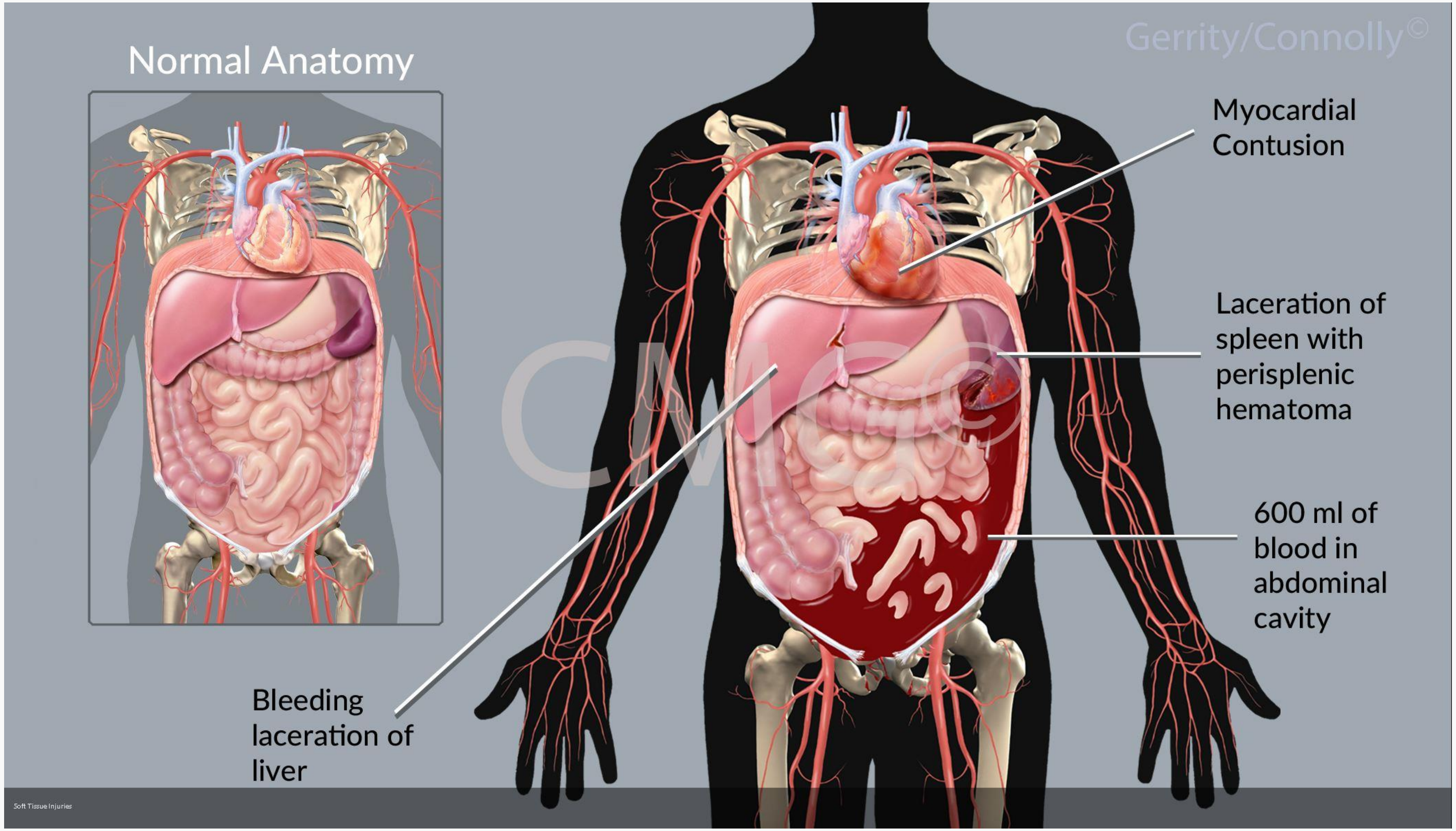
Legal Cases



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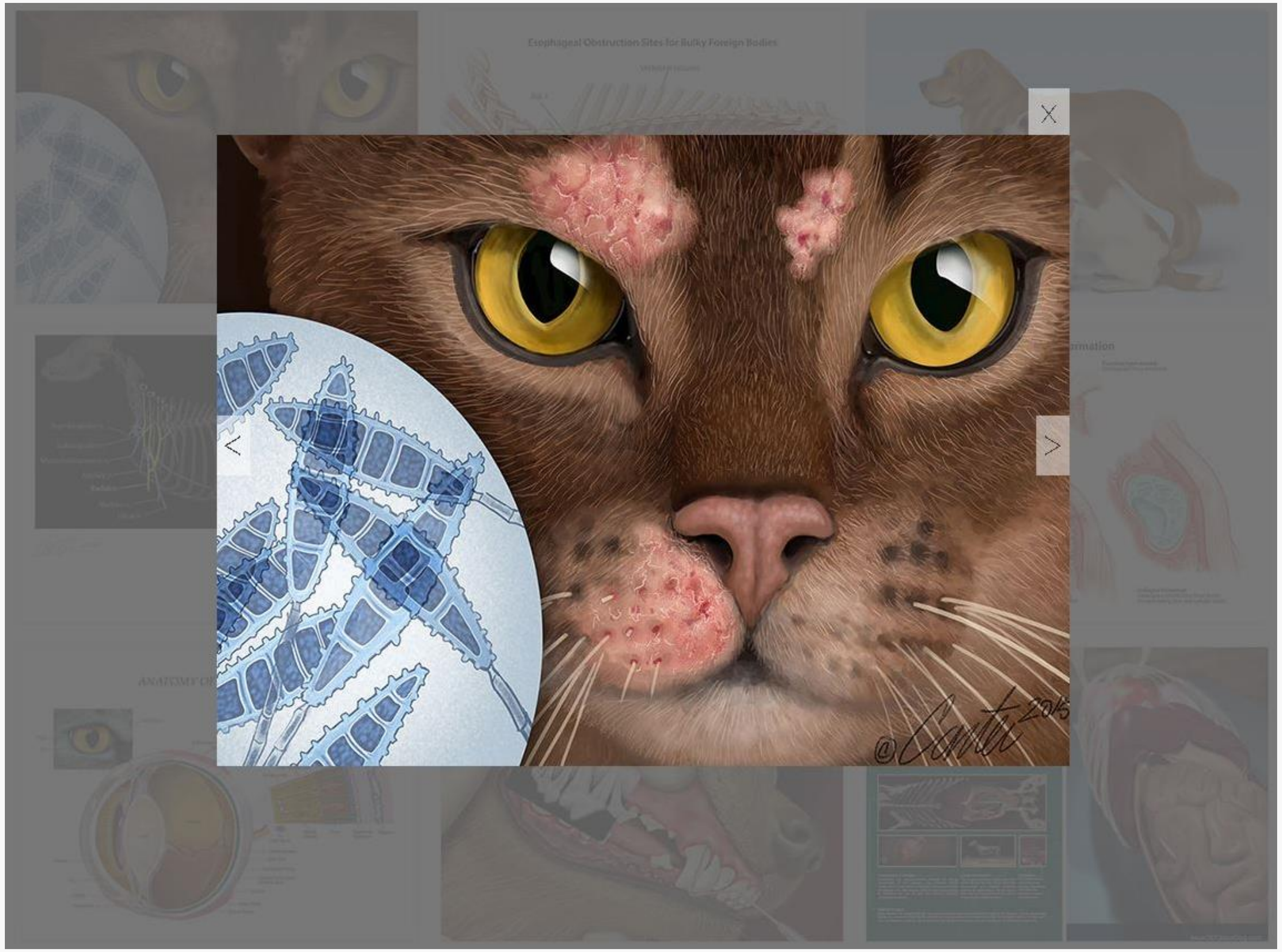
Veterinary



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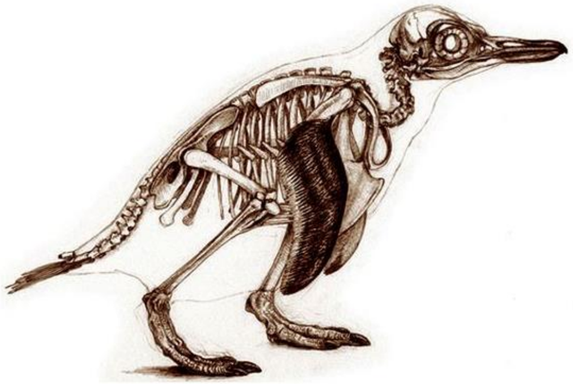
Sciart



Little Penguin

Secretary Bird

Trumpet Manucode

Marabou

© Katrina van Grouw

Mesozoic Art

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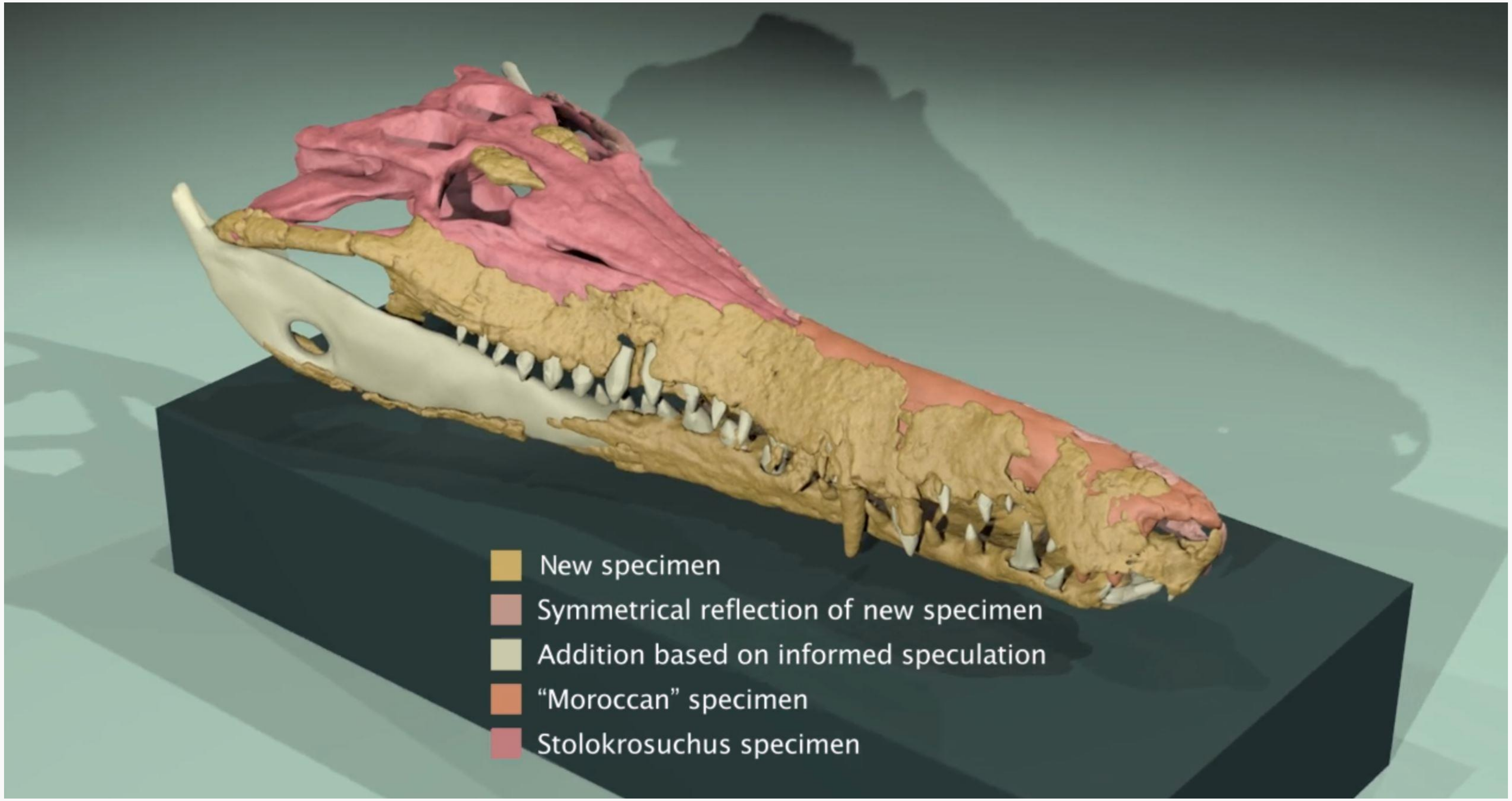
Paleoart



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Interactivity: Augmented Reality (AR)

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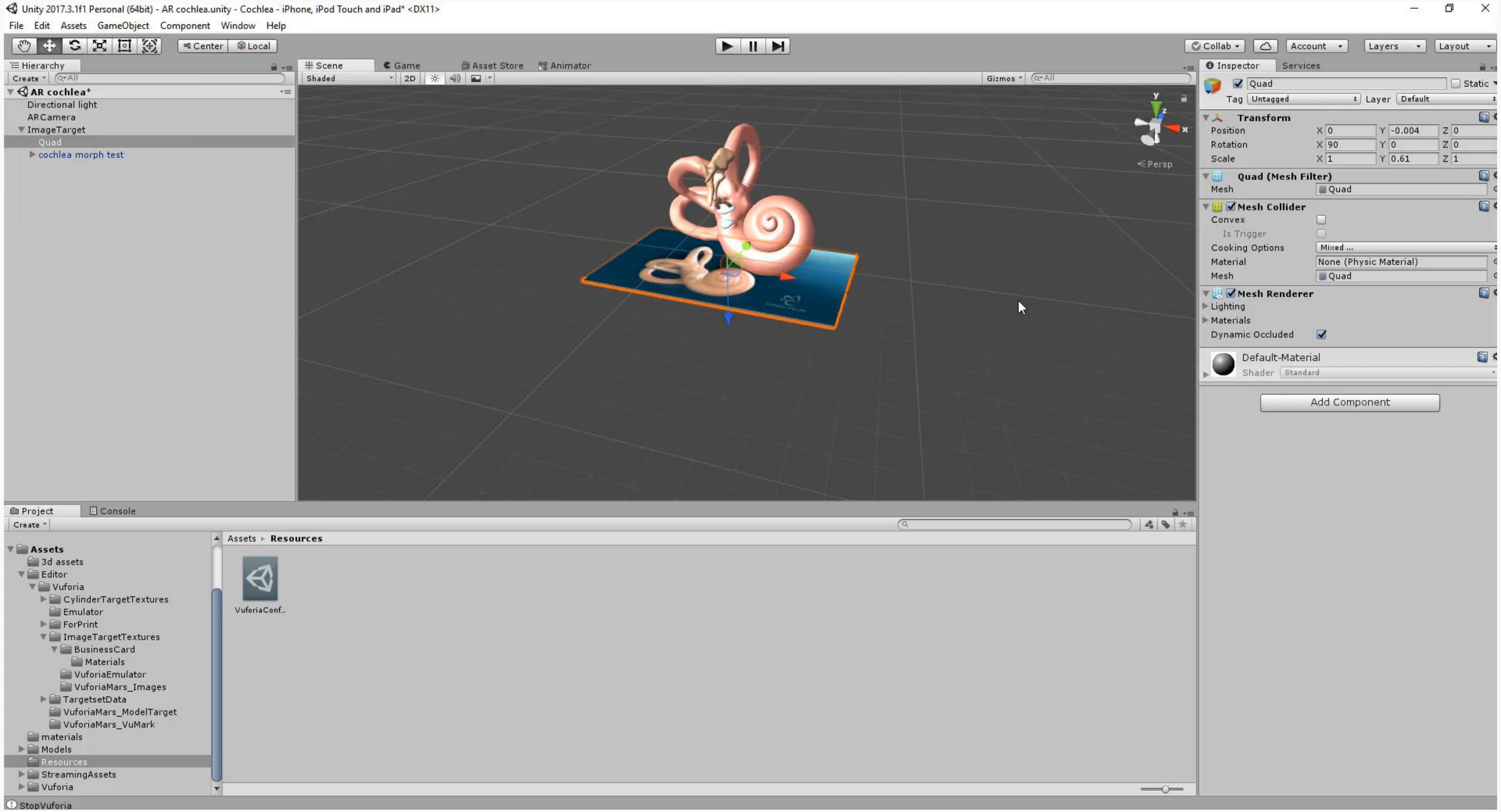
Interactivity: Augmented Reality (AR)



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Interactivity: Virtual Reality (VR)

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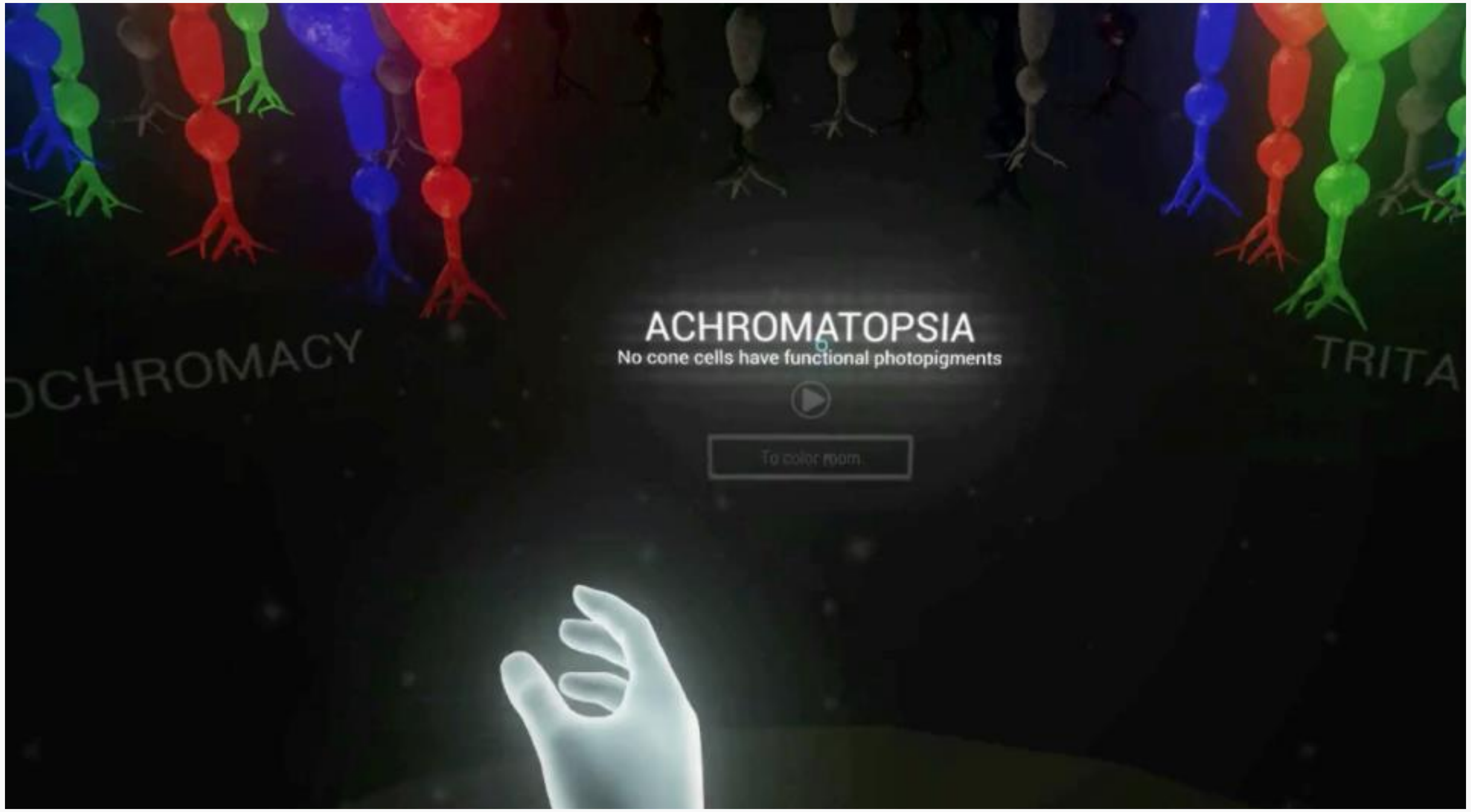
Interactivity: Virtual Reality (VR)

Photo Credit: Ted Kucklick



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Immersive Experiences (Virtual Reality)

- We Are Alfred: Embodied Labs, CEO Carrie Shaw
- For patient families & medical professionals

Immersive Experiences (Virtual Reality)

- We Are Alfred: Embodied Labs, CEO Carrie Shaw
- For patient families & medical professionals

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Interactivity: Mixed Reality (MR)

© Marvel Studios

© Microsoft

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Interactivity: Haptics

© James Vincent, The Verge

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Interactivity: Gaming!

https://www.youtube.com/watch?v=BjnMX-1reus#action=share

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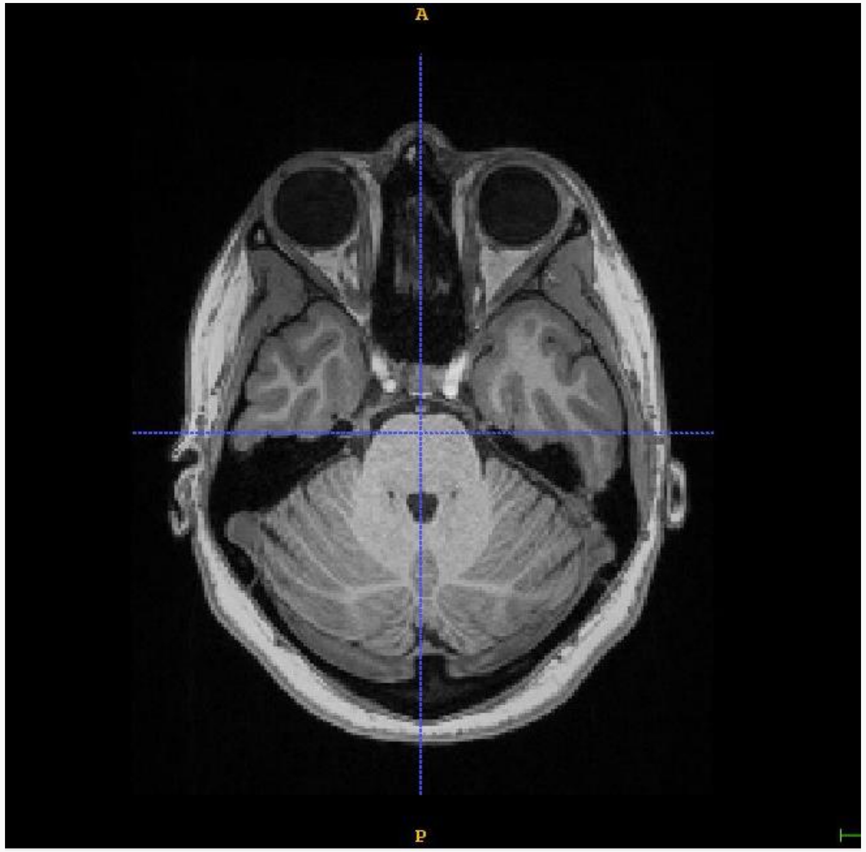
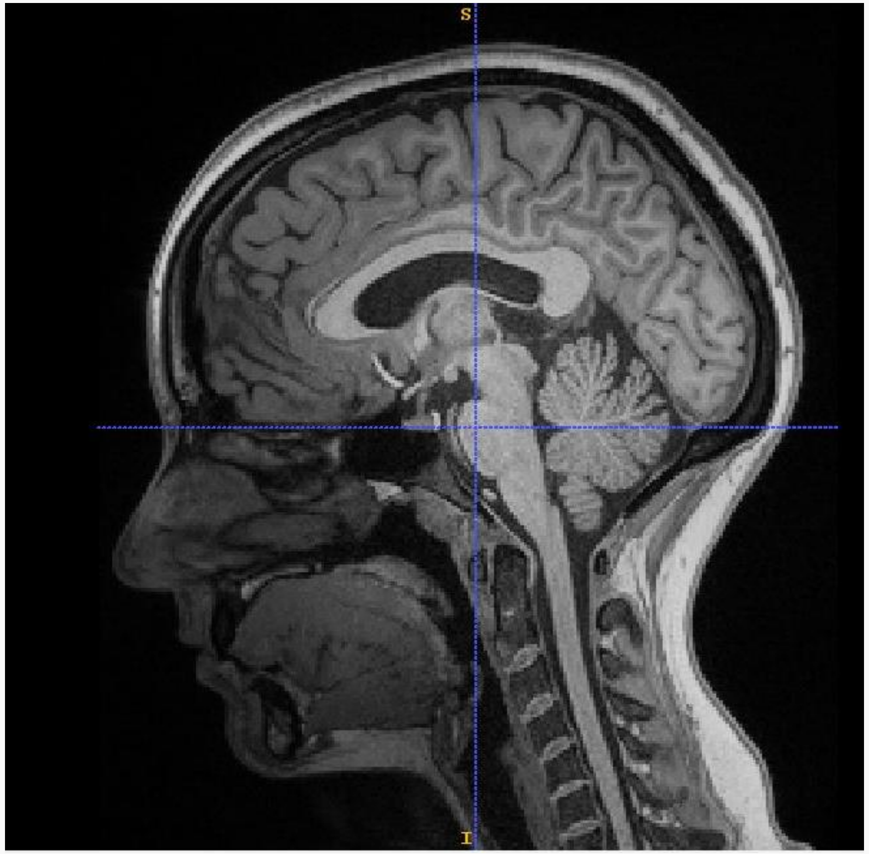
Stretch Break!

So how do we even make models?





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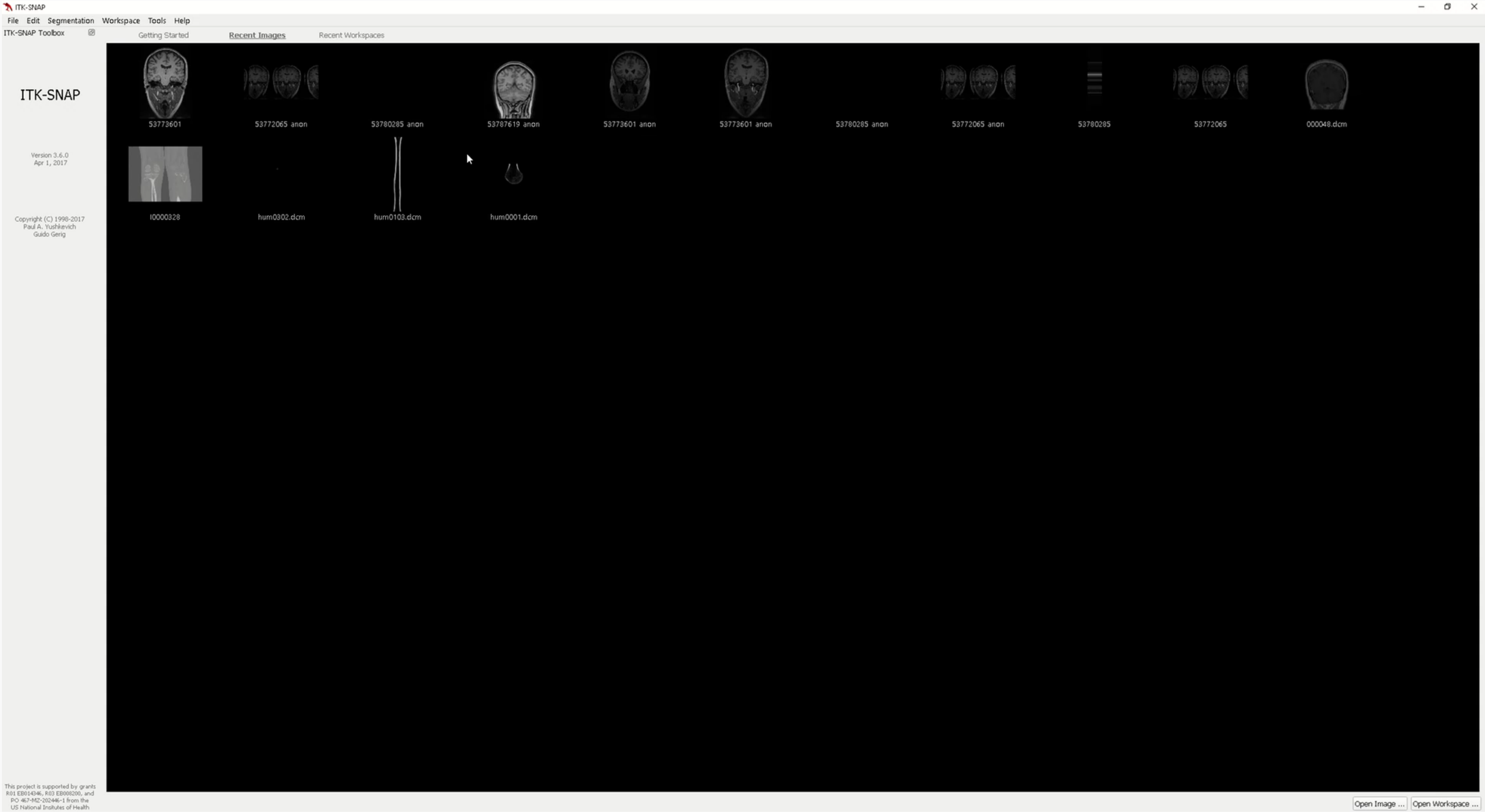

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Segmenting the White Matter of a Brain

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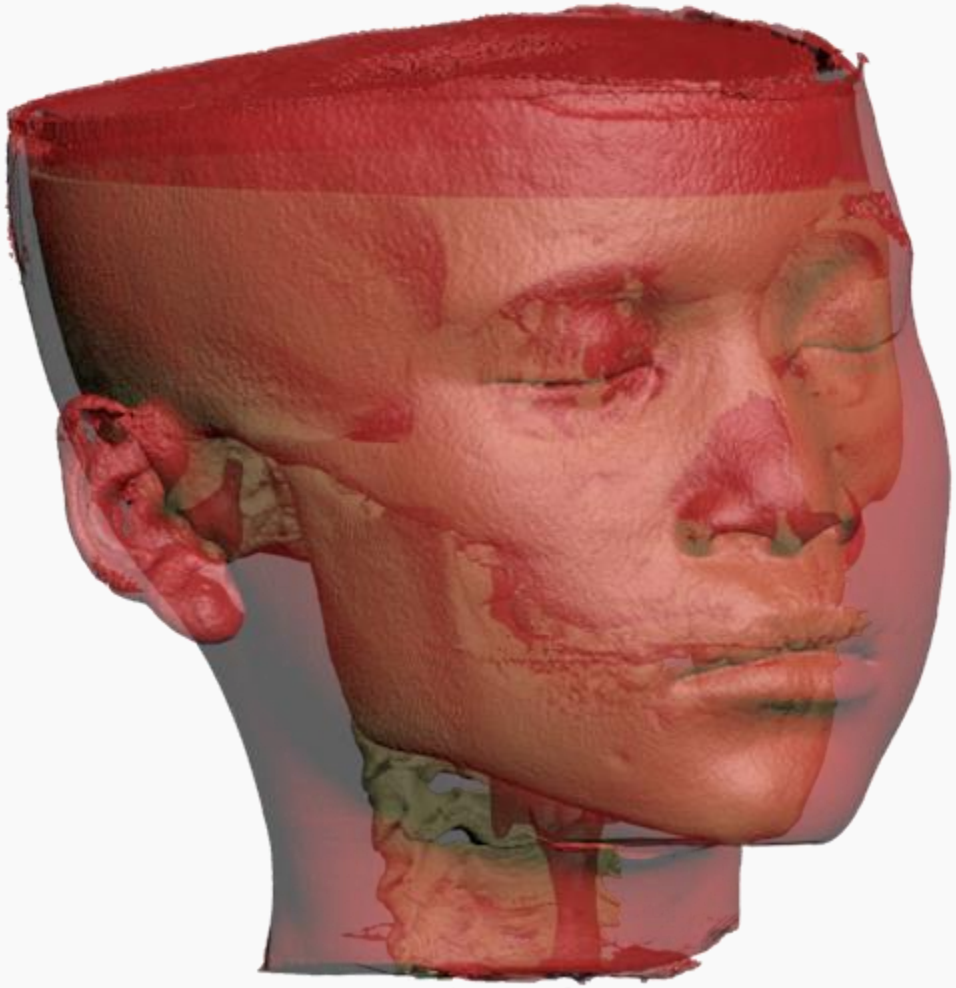
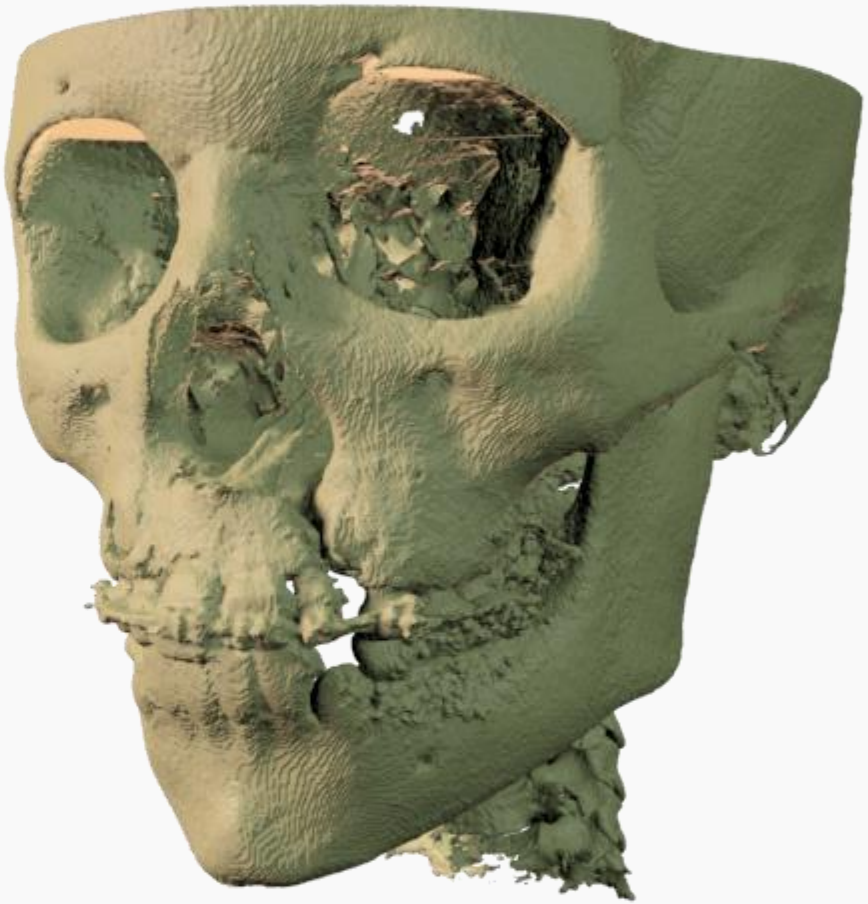
Raw Models from CT Data





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Final Still Image

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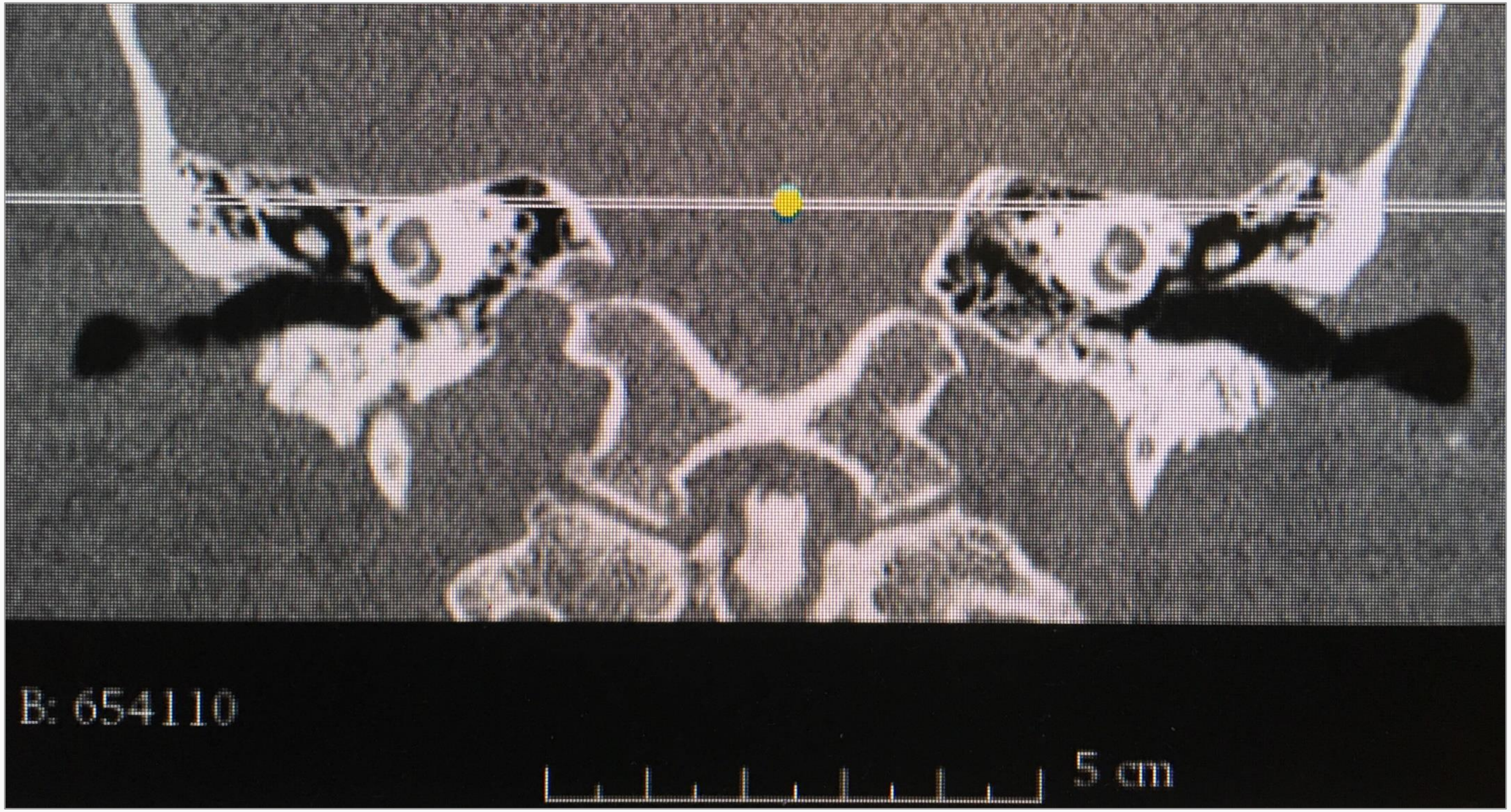
Imaging (DICOM) Data



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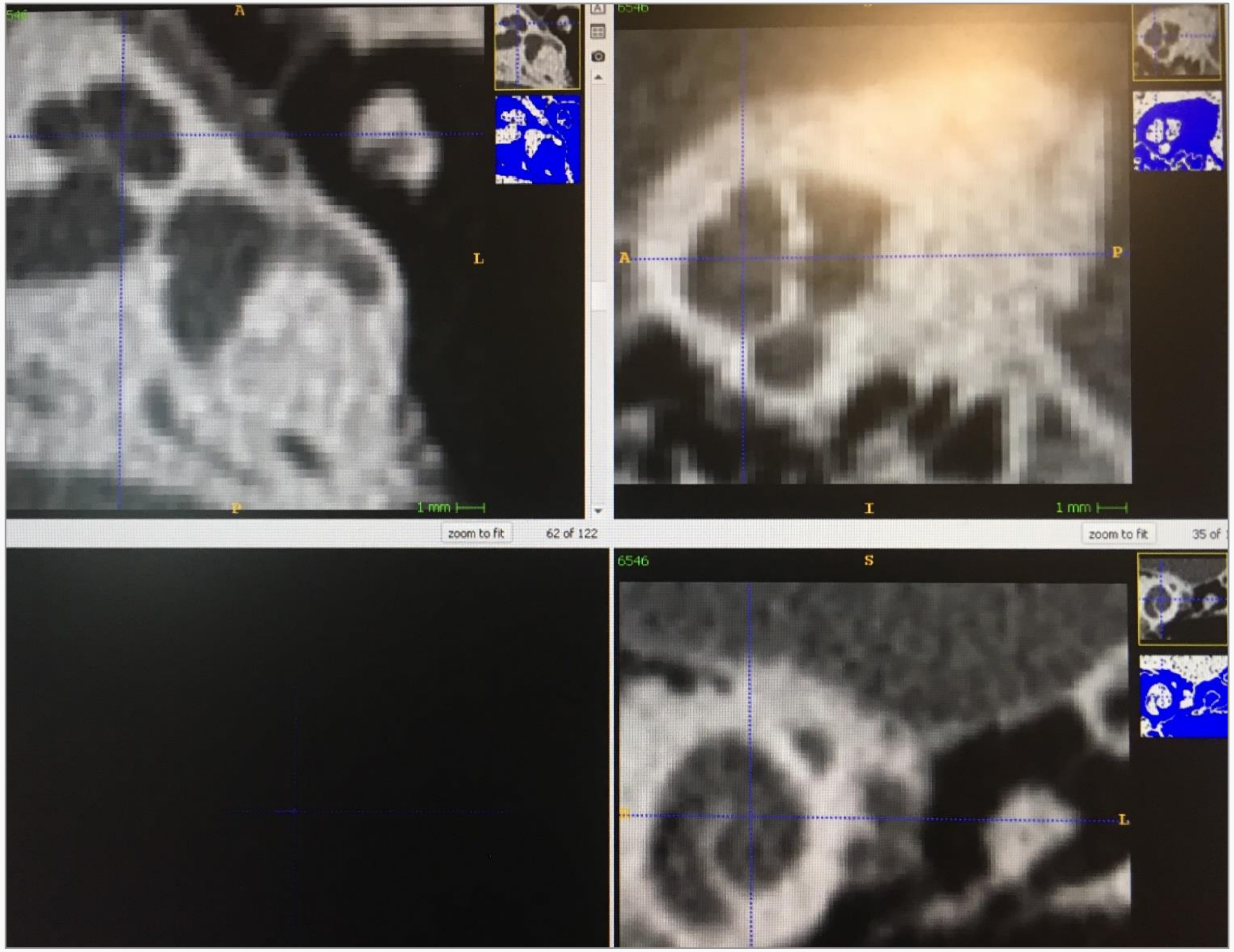
Segmentation



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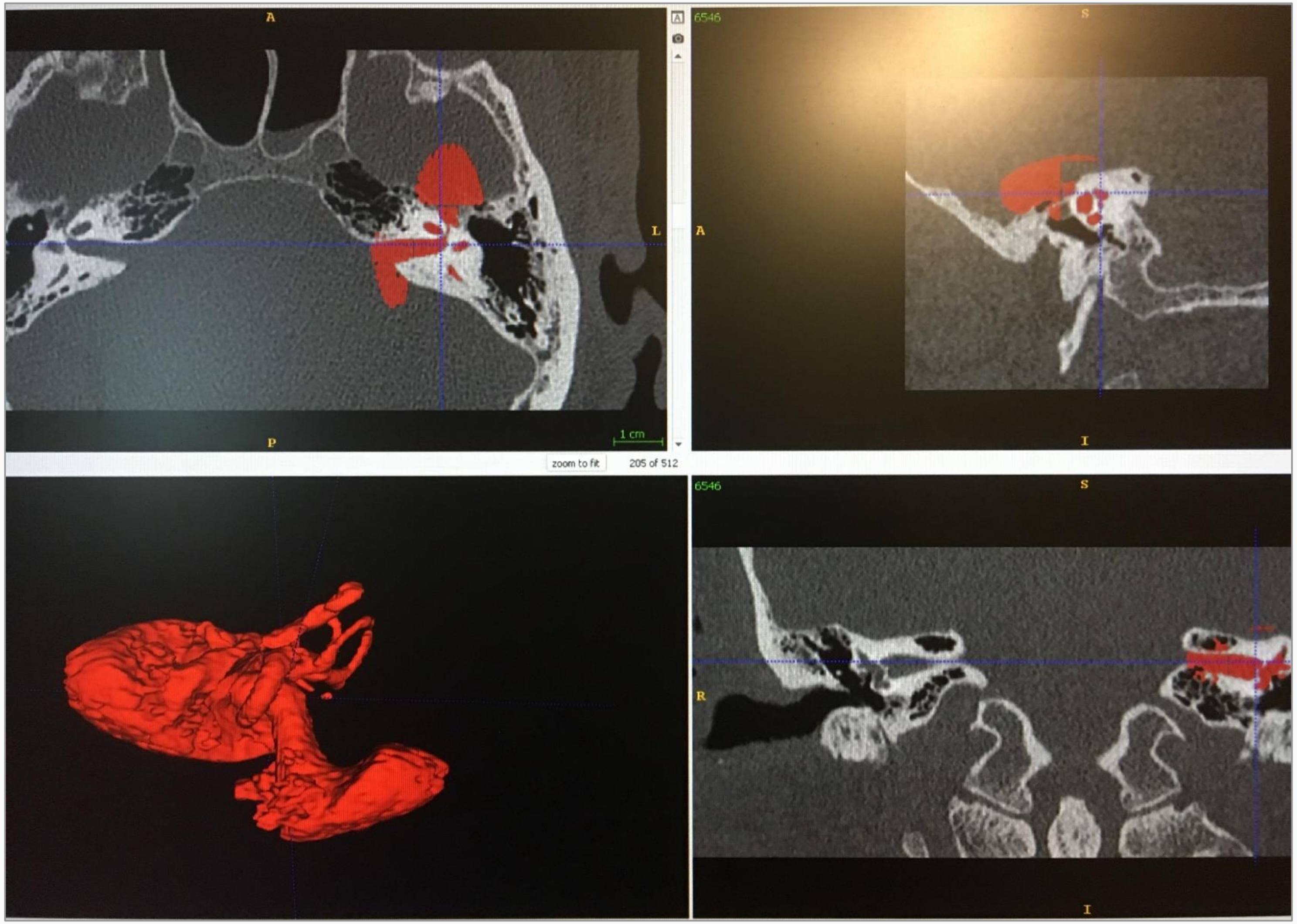
Segmentation Model



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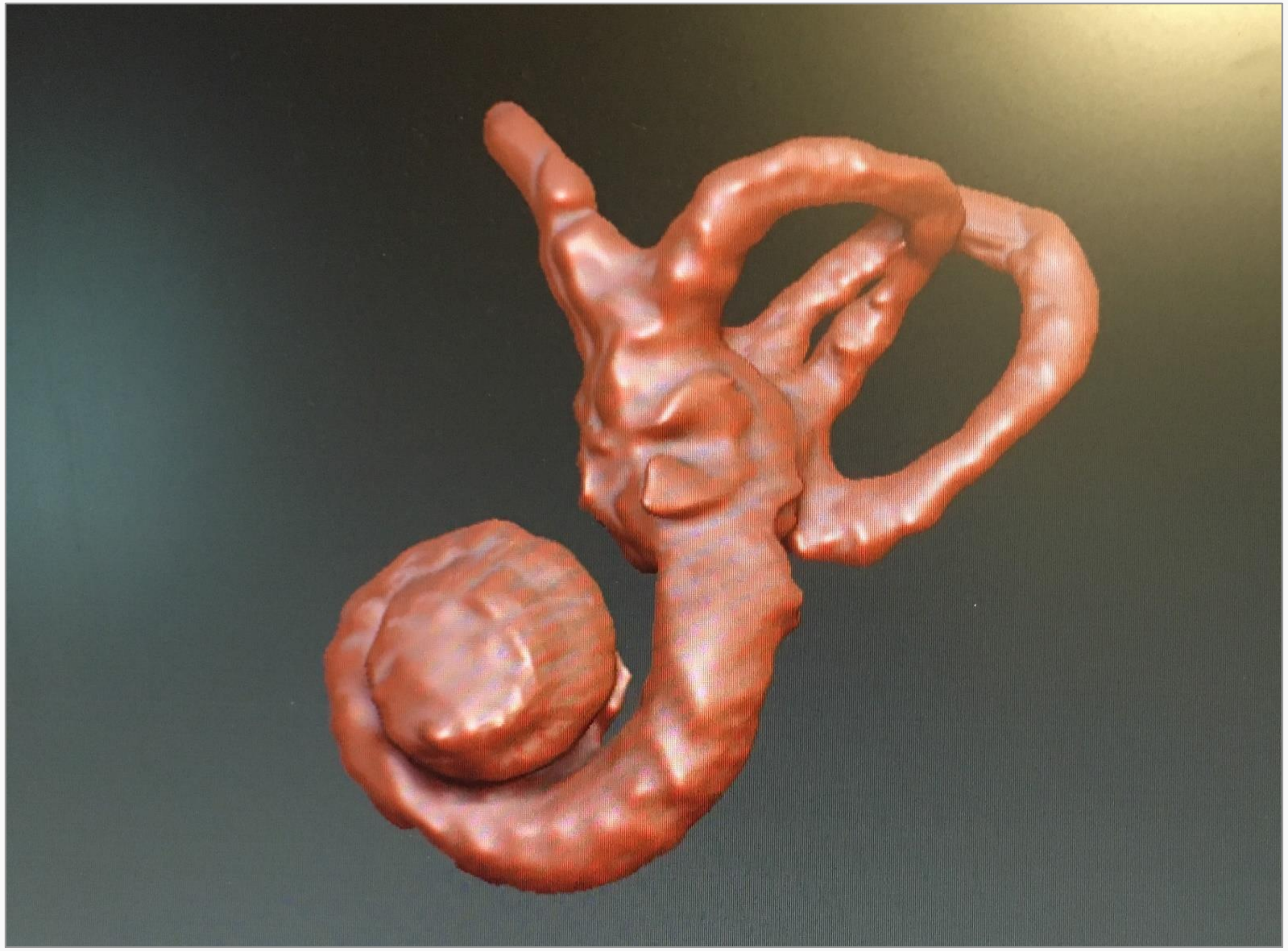
Raw Model from DICOM Data



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Research

THE ANATOMICAL RECORD 296:1083–1088 (2013)

Quantitative Analysis of the Cochlea Using Three-Dimensional Reconstruction Based on Microcomputed Tomographic Images

KANG-JAE SHIN,[1] JU-YOUNG LEE,[1] JEONG-NAM KIM,[1] JA-YOUNG YOO,[1] CHUOG SHIN,[2] WU-CHUL SONG,[1] AND KI-SEOK KOH[1]*

[1]Department of Anatomy, Research Institute of Medical Science, Konkuk University School of Medicine, Seoul, Republic of Korea

[2]Department of Biological Science and Technology, College of Science and Technology, Yonsei University, Wonju, Republic of Korea

ABSTRACT

The aim of this study was to provide data on various dimensions of the normal cochlea using three-dimensional reconstruction based on high-resolution micro-CT images. The petrous parts of 39 temporal bones were scanned by micro-computed tomography (CT) with a slice thickness of 35 μm. The micro-CT images were used in reconstructing three-dimensional volumes of the bony labyrinth using computer software. The volumes were used to measure 12 dimensions of the cochlea, and statistical analysis was carried out. The dimensions of cochleae varied widely between different specimens. The mean height and length of the cochlea were 3.8 and 9.7 mm, respectively. The angle between the basal and middle turns was slightly larger in males than in females, while none of the other 11 dimensions differed significantly between males and females. The cochlear accessory canals were observed in about half of the cases (51.3%). Correlation analysis among measured items revealed positive correlations among several of the measured dimensions. The present study could investigate the detailed anatomy of the normal cochlea using high-resolution imaging technologies. The results of the present study could be helpful for the precise diagnosis of congenital cochlear malformations and for producing optimized cochlear implants. Anat Rec, 296:1083–1088, 2013. © 2013 Wiley Periodicals, Inc.

Key words: the cochlea; micro-CT; 3D reconstruction; diagnosis of cochlear malformation

INTRODUCTION

The inner ear is a complex structure within the petrous part of the temporal bone that is involved in the hearing and balance senses. It includes the cochlea, vestibule, semicircular canals, and membranous labyrinth that is organized into membranous sacs and ducts interconnected within the bony labyrinth (Kirk and Gosselin-Ildari,

Grant sponsor: Ministry of Education, Science, and Technology (Basic Science Research Program of the National Research Foundation (NRF), Korea); Grant number: 2009–0087097.

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Published online 14 May 2013 in Wiley Online Library (wileyonlinelibrary.com).

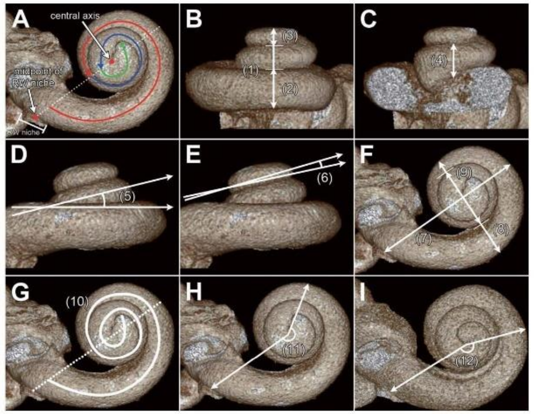


Fig. '. Measurement items of the cochlea. Landmarks and three turns: basal turn (red line), middle turn (blue line), and apical turn (green line) (**A**). (1) Height of the cochlea (HC), (2) height of basal turn (HBT), (3) height of apical turn (HAT) (**B**). (4) Height of middle turn (HMT) (**C**). (5) Angle between basal turn and middle turn (ABM) (**D**). (6) Angle between middle turn and apical turn (AMA) (**E**). (7) Length of the cochlea (LC), (8) width of basal turn (WBT), (9) width of middle turn (WMT) (**F**). (10) Length of cochlear coiling (LCC) (**G**). (11) Number of cochlear turn (NCT) (**H**). (12) Angle of accessory canal coiling (ACC) (**I**). RW niche, round window niche.

TABLE 1. Height, width, length of the cochlea, and length of cochlear coiling (mm)

	Total (N = 39)		Male (N = 22)		Female (N = 17)	
	Mean	SD	Mean	SD	Mean	SD
HC	3.8	0.2	3.9	0.2	3.8	0.1
HBT	1.9	0.1	1.9	0.1	1.9	0.1
HMT	1.8	0.2	1.8	0.2	1.9	0.2
HAT	0.7	0.1	0.7	0.1	0.8	0.1
LC	9.7	0.3	9.8	0.3	9.7	0.3
WBT	7.0	0.3	7.0	0.3	7.0	0.3
WMT	3.9	0.2	3.9	0.2	3.8	0.2
LCC	30.0	1.6	30.1	1.3	29.9	1.9

HC, height of the cochlea; HBT, height of basal turn; HMT, height of middle turn; HAT, height of apical turn; LC, length of the cochlea; WBT, width of basal turn; WMT, width of middle turn; LCC, length of cochlear coiling.

TABLE 2. The ratio among several dimensions of the cochlea (%: a/b × 100)

	Total (N = 39)		Male (N = 22)		Female (N = 17)	
	Mean	SD	Mean	SD	Mean	SD
HC/LC	39.6	2.1	39.6	2.4	39.6	1.6
HBT/HC	49.5	2.5	49.9	2.7	49.0	2.1
HMT/HC	47.9	4.2	47.4	4.4	48.5	3.9
HAT/HC	19.4	2.4	19.0	2.5	20.0	2.3
HMT/HBT	96.6	8.3	94.7	7.4	99.1	9.1
HAT/HBT	39.6	6.5	38.4	6.8	41.1	5.8
HAT/HMT	41.3	7.1	41.0	8.3	41.8	5.4

HC, height of the cochlea; LC, length of the cochlea; HBT, height of basal turn; HMT, height of middle turn; HAT, height of apical turn.

and all dimensions except for ABM were not different between both genders. ABM was slightly larger for males than for females ($P < 0.05$) (Table 3).

The cochlear accessory canal was observed in 20 of the 39 specimens (51.3%). The mean ACC was 114.7 degrees, and ranged from 71.4 to 137.7 degrees (Table 4). Additionally, the structure was observed in seven of the 12 males (58.3%) and in seven of the 11 females (63.6%), and occurred bilaterally in two of the males (28.6%) and four of the females (57.1%).

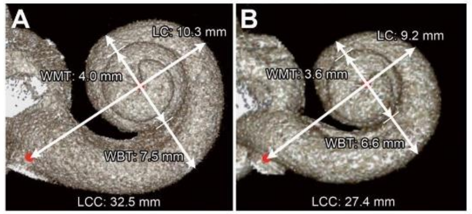


Fig. 2. The coiling patterns of the cochlea. LC, length of the cochlea; WBT, width of basal turn; WMT, width of middle turn; LCC, length of cochlear coiling. The cochlea with relatively longer LC represented less compact coiling by the distal coiling of basal turn (**A**), but shorter LC showed more compact coiling form by the proximal coiling of basal turn (**B**).

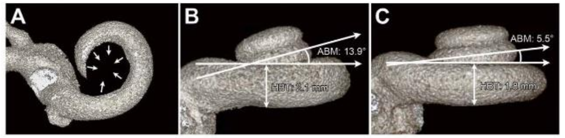


Fig. 3. Two types of ABM. HBT, height of basal turn; ABM, angle between basal turn and middle turn. As HBT increase the thickness of basal turn is thickened, and the donut-like space which is formed by basal turn will be narrowed (**A**). It is thought that the cochlea with relatively larger HBT had larger ABM (**B**) than in the cochlea with relatively lesser HBT (**C**) due to spatial limitation where middle turn will be placed.

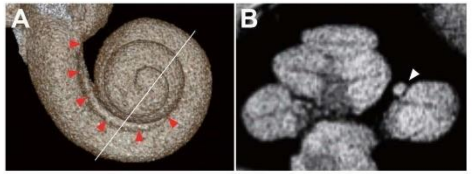
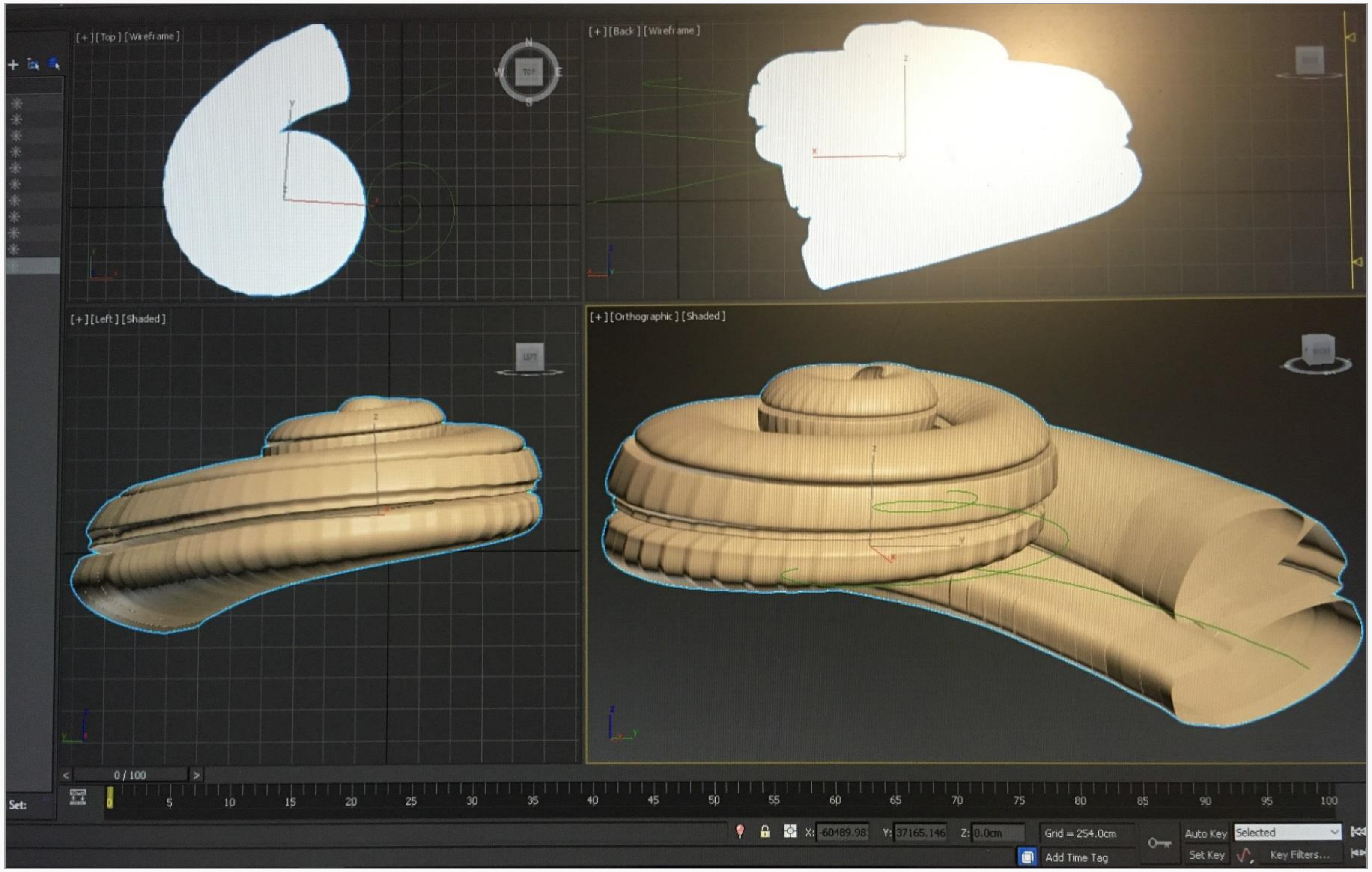


Fig. 4. The detection of the cochlear accessory canal. The accessory canal which could be both observed in three-dimensional volume (**A**) and micro-CT image (**B**) of the cochlea. The traveling course of the accessory canal is shown (red arrows). The accessory canal is an anatomical structure obviously distinct from basal turn (white arrow).

Problem-Solving



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Sculpting, Lighting, & Texturing

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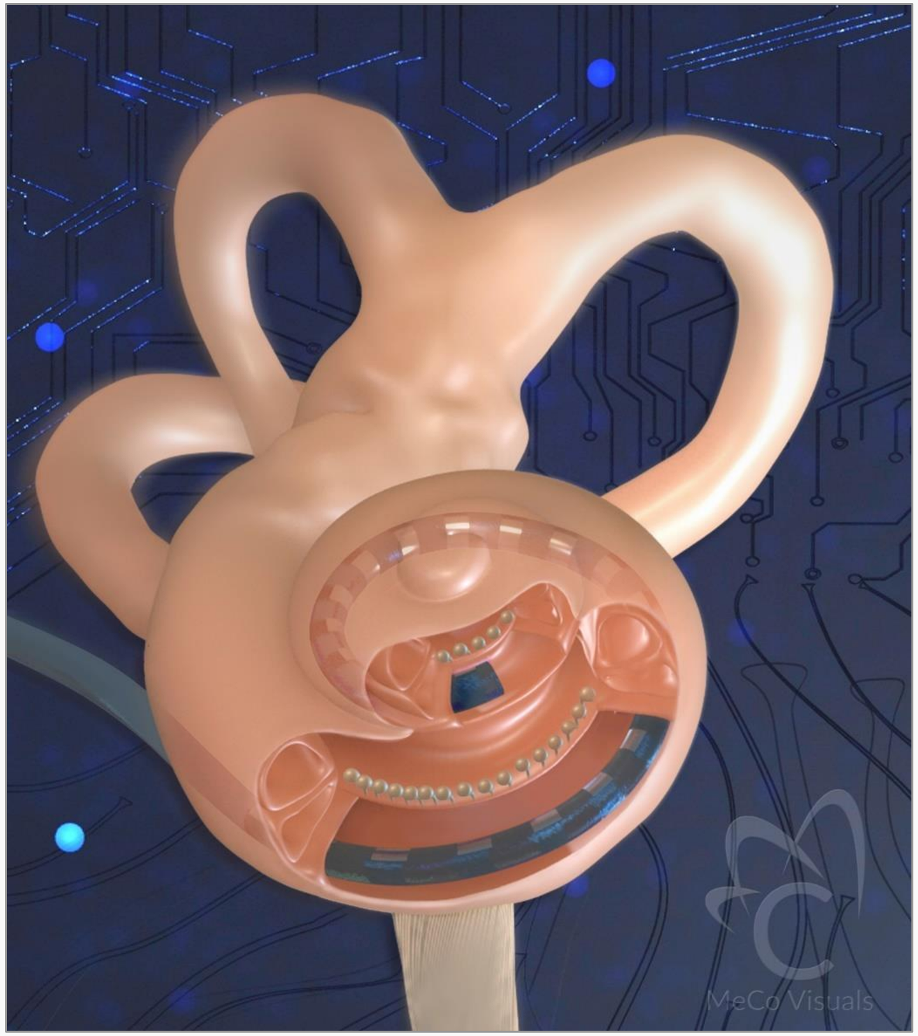
Final Results

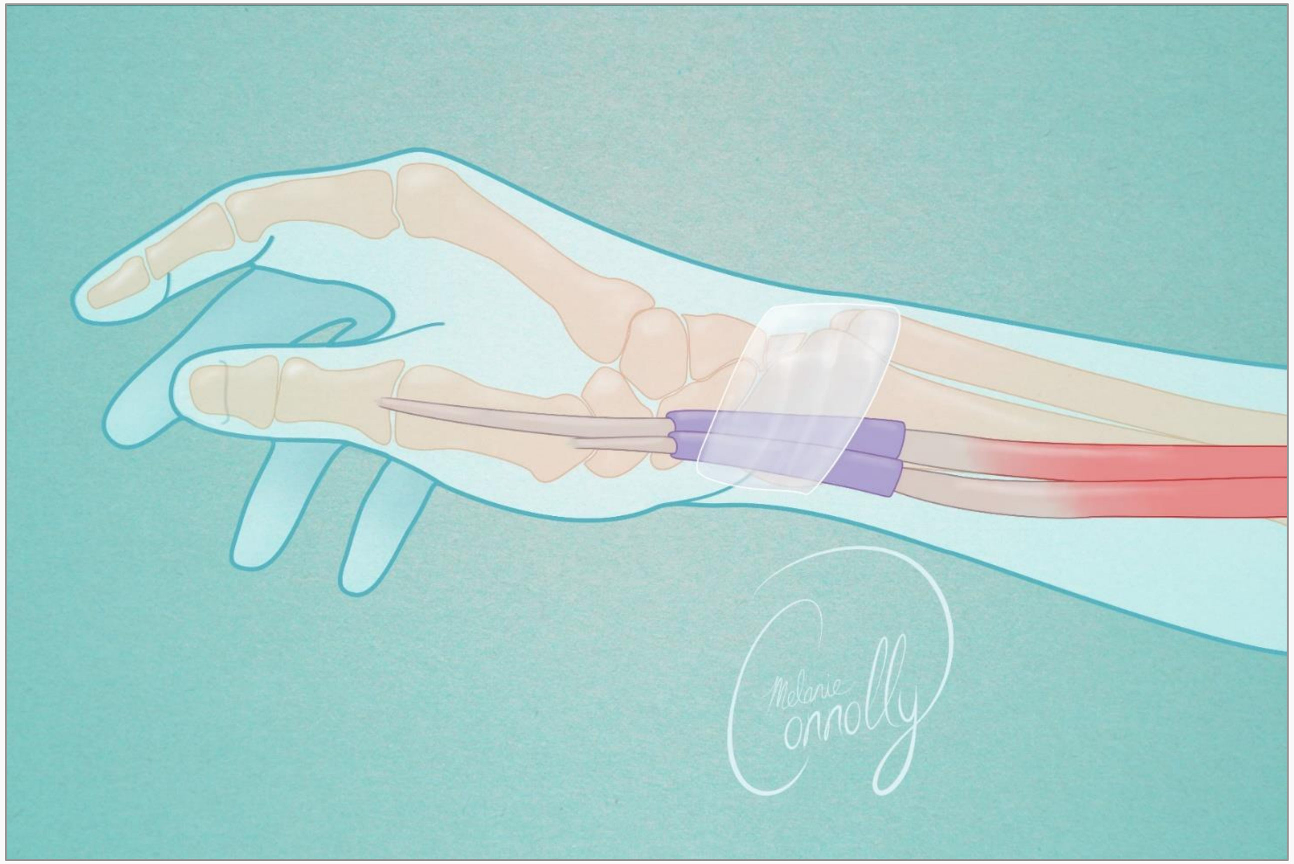


Used in patent applications

Software

Programs used:

ITK-SNAP
Materialise Mimics
Osirix
3D slicer
*Zbrush
*3Ds Max
Mudbox
Vray
Arnold
Red Giant Suite
Molecular Maya
PyMol
Jmol
ePMV
AutoPack/CellPack
ChimeraX
Adobe Illustrator, Photoshop, *After Effects, Premiere, Audition



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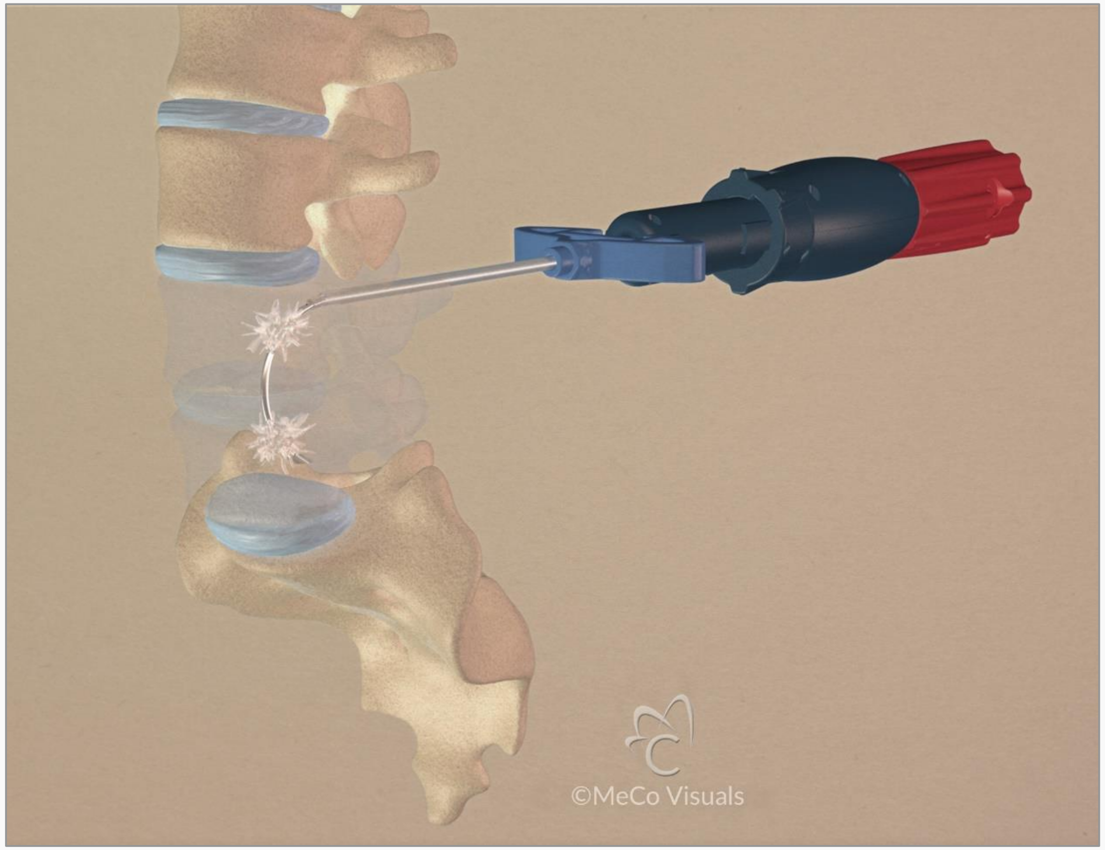
Our Process

How do you work with a Medical Illustrator?

Contact with an idea: **earlier is better**



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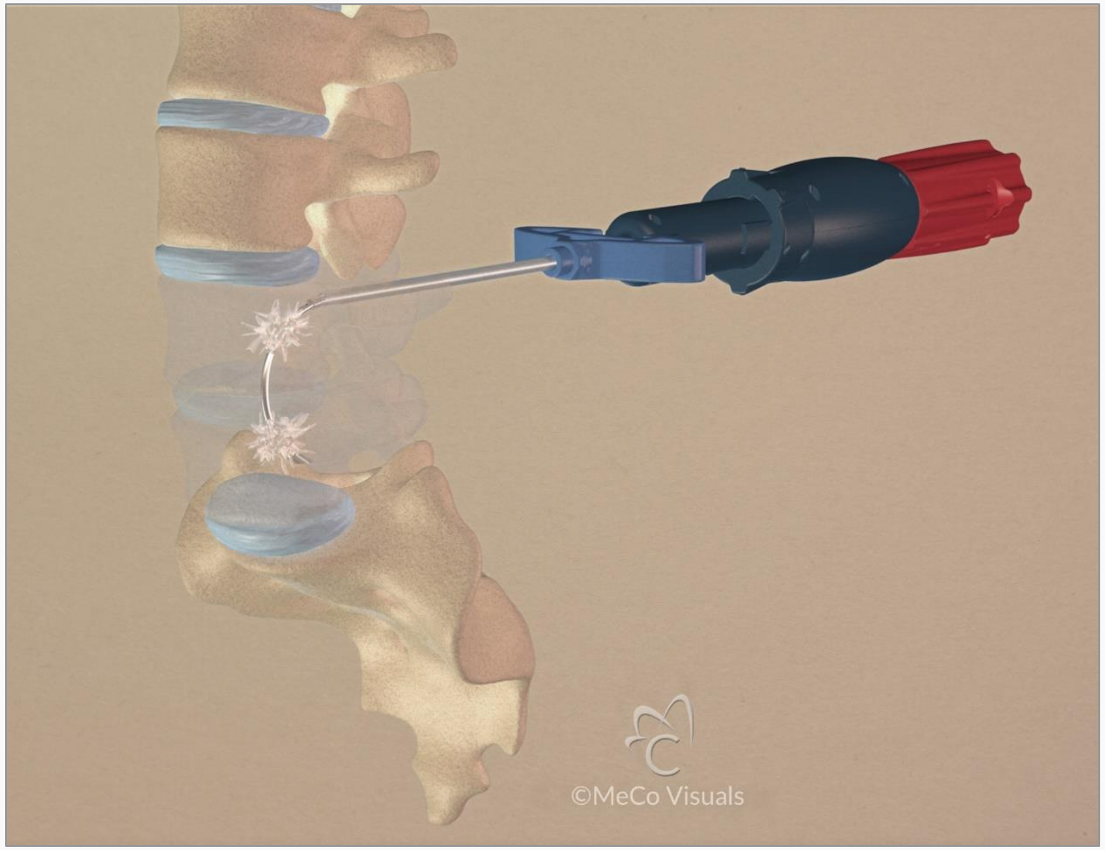
Our Process

We will chat about:

Your audience



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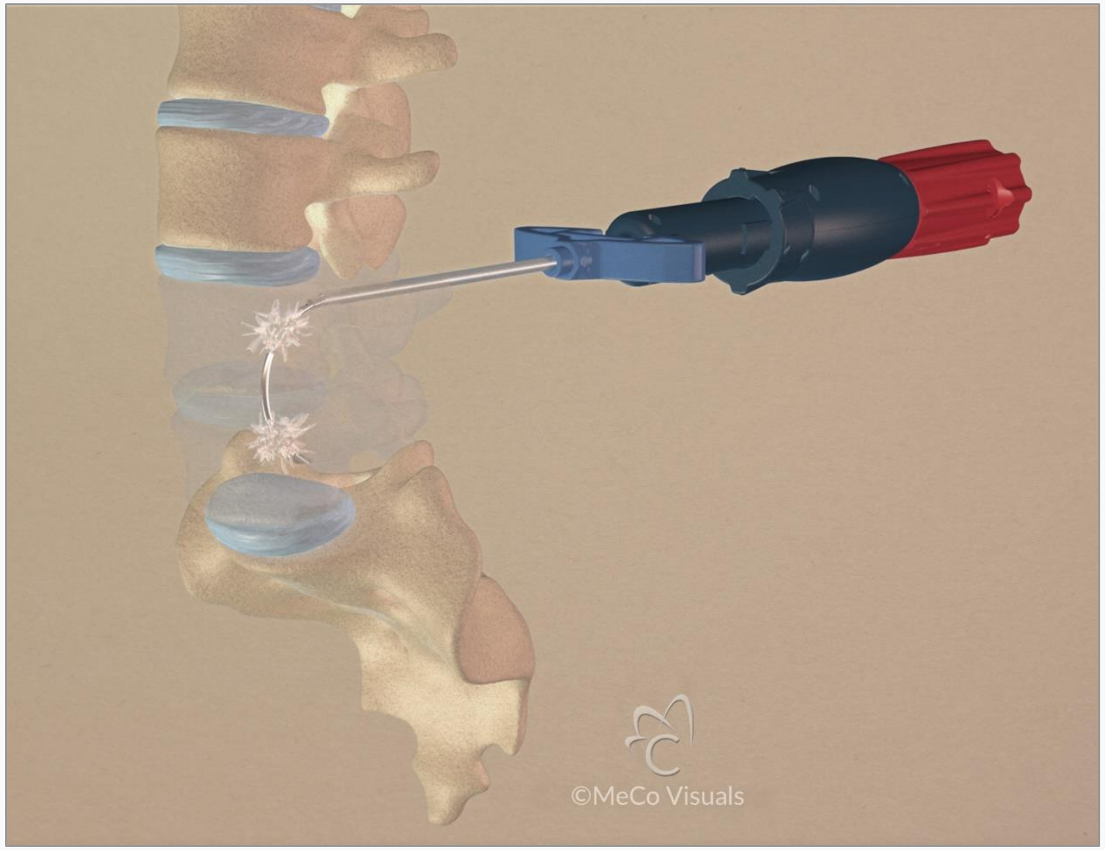
Our Process

We will chat about:

Your audience

The visual problem

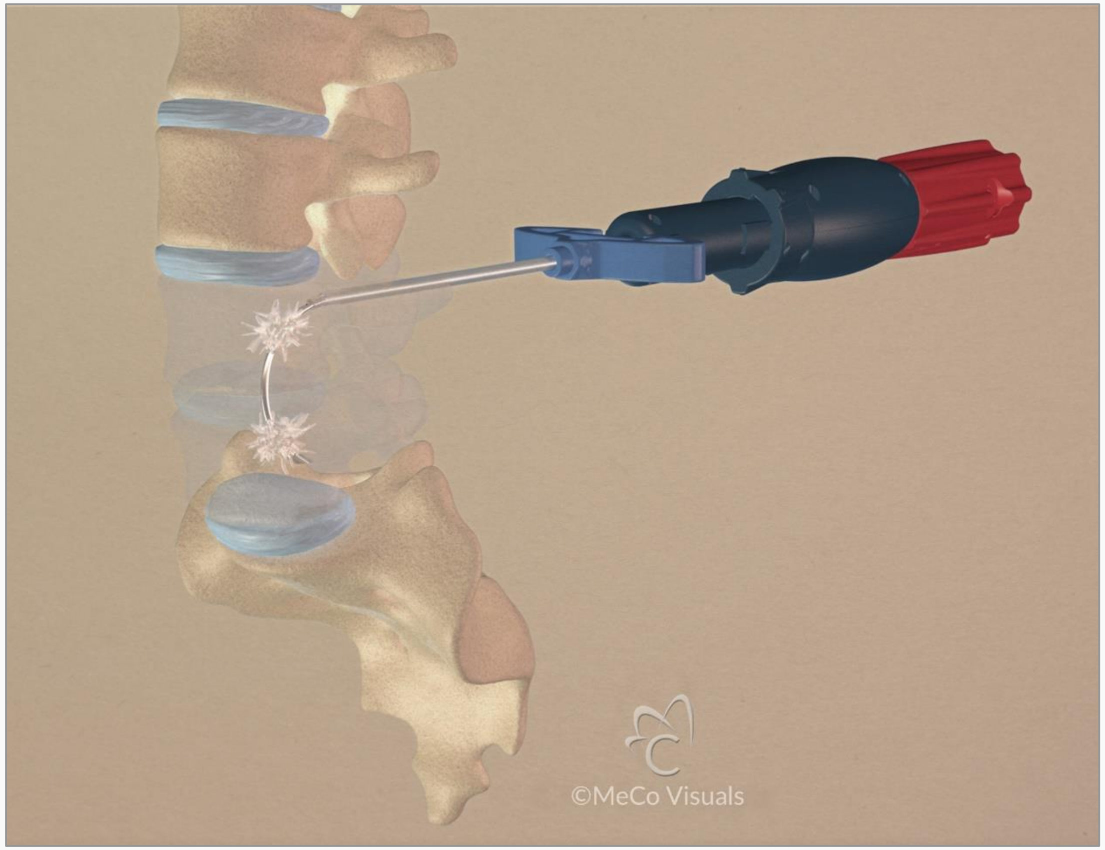


MeCo Visuals

Our Process

We will chat about:

Your audience
The visual problem
Potential solution options



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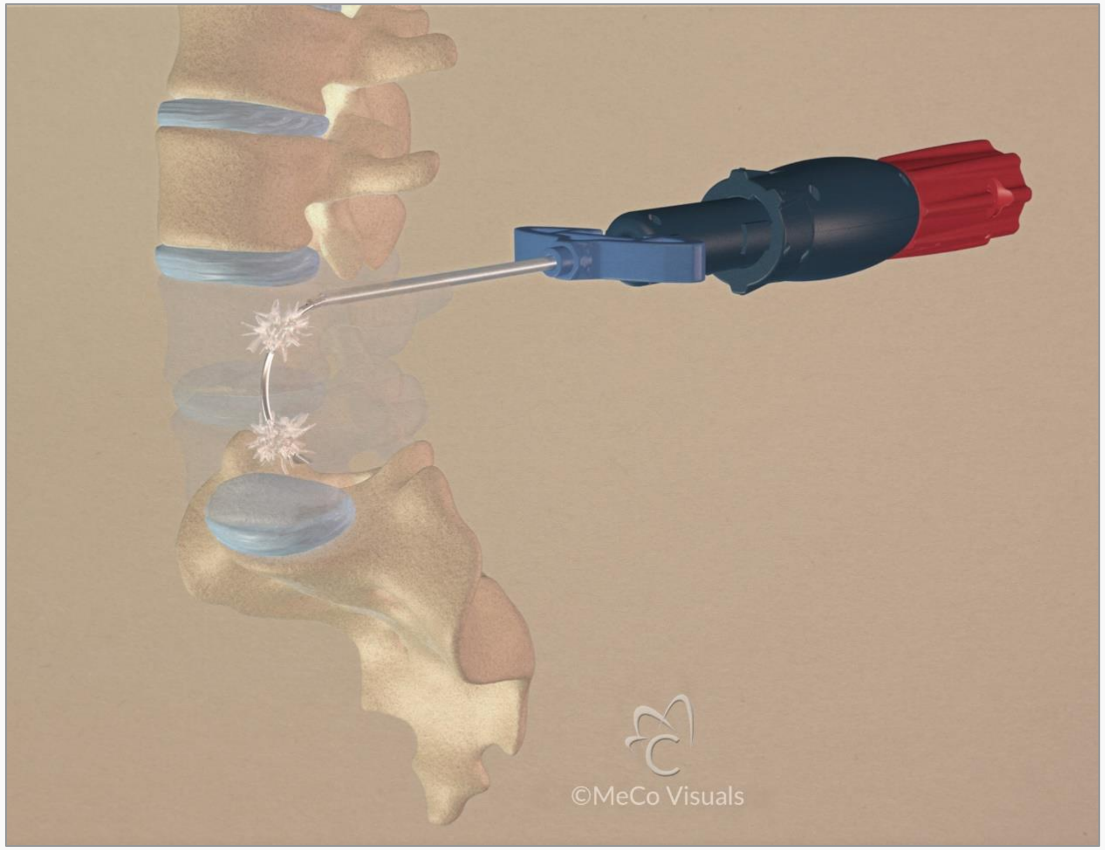
Our Process

We will chat about:

Your audience
The visual problem
Potential solution options
Timeline



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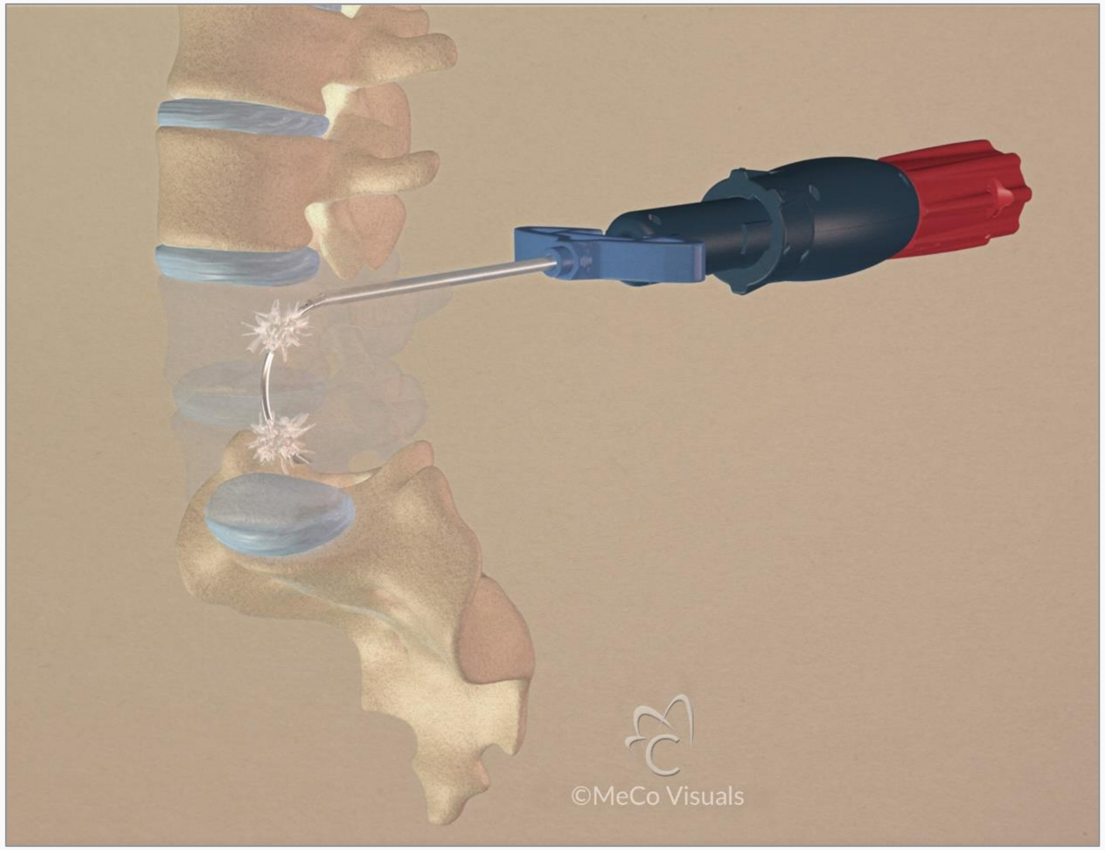
Our Process

We will chat about:

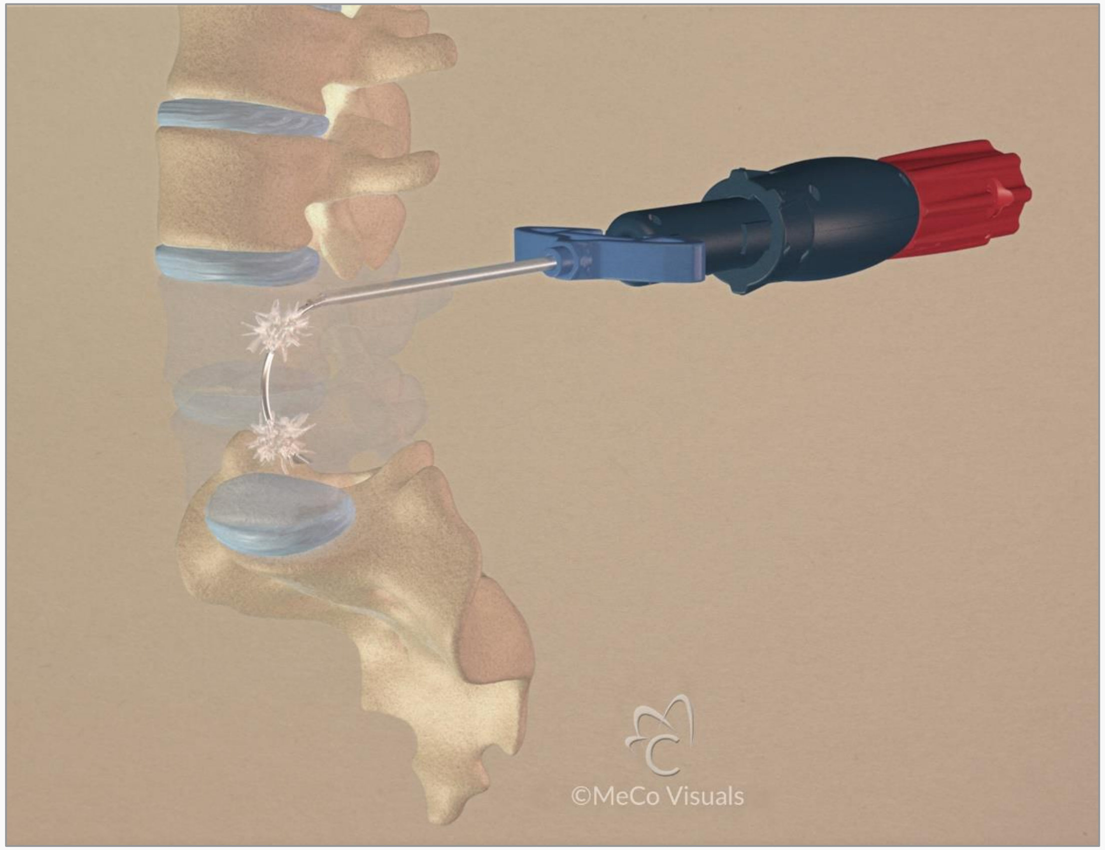
Your audience
The visual problem
Potential solution options
Timeline
Grants



Our Process

We will chat about:

Your audience
The visual problem
Potential solution options
Timeline
Grants
Usage rights



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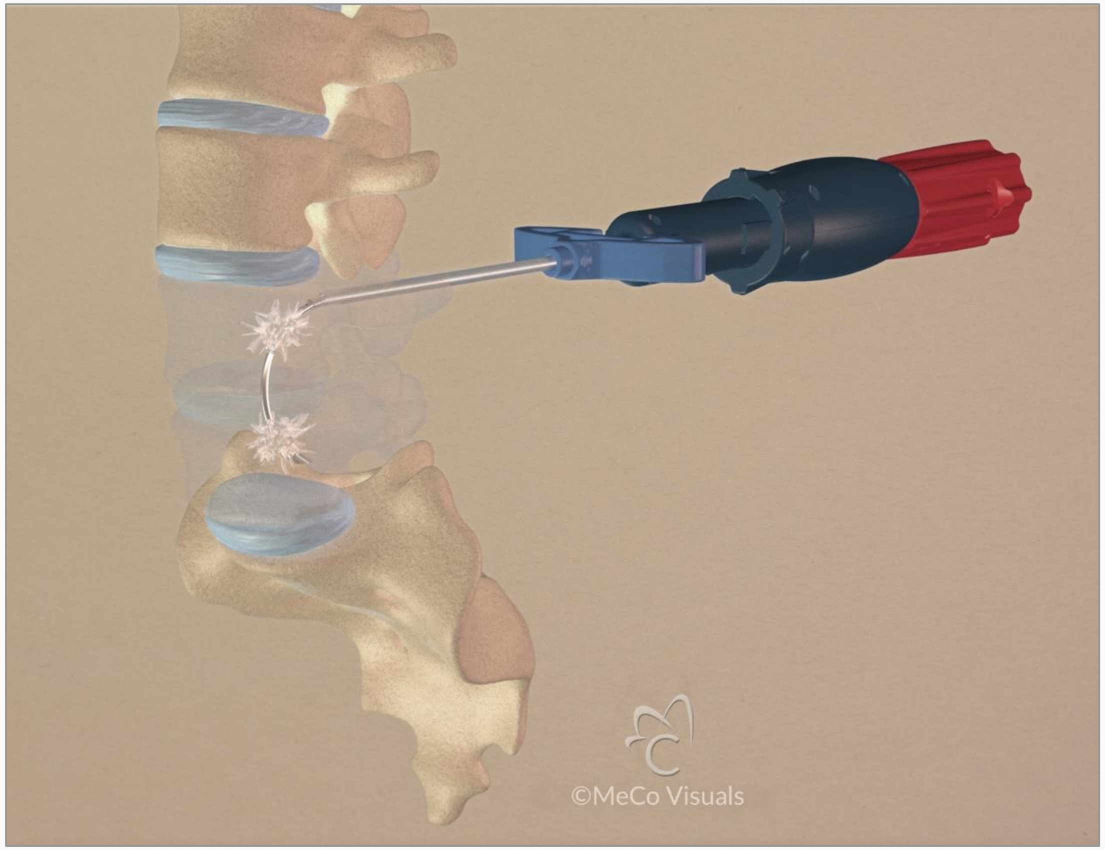
Our Process

We will chat about:

Your audience
The visual problem
Potential solution options
Timeline
Grants
Usage rights
Budget

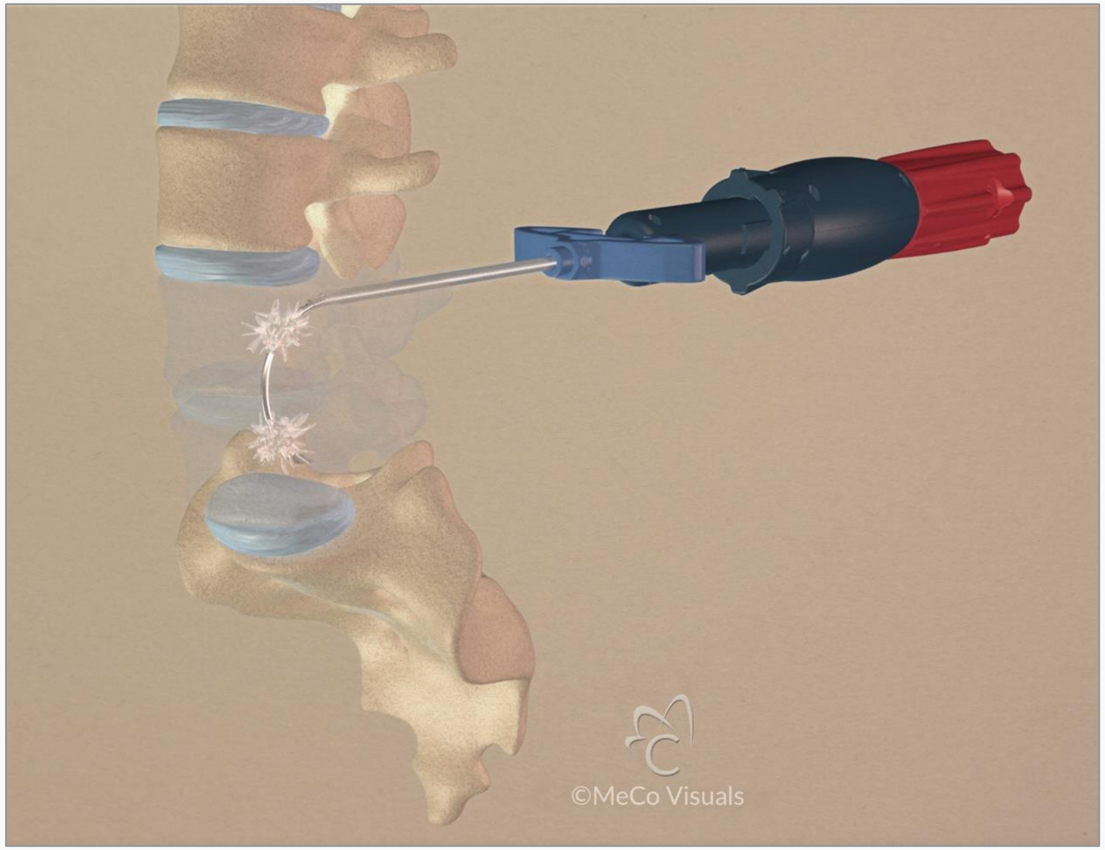


MeCo Visuals

Our Process

I will ask for:

Primary literature



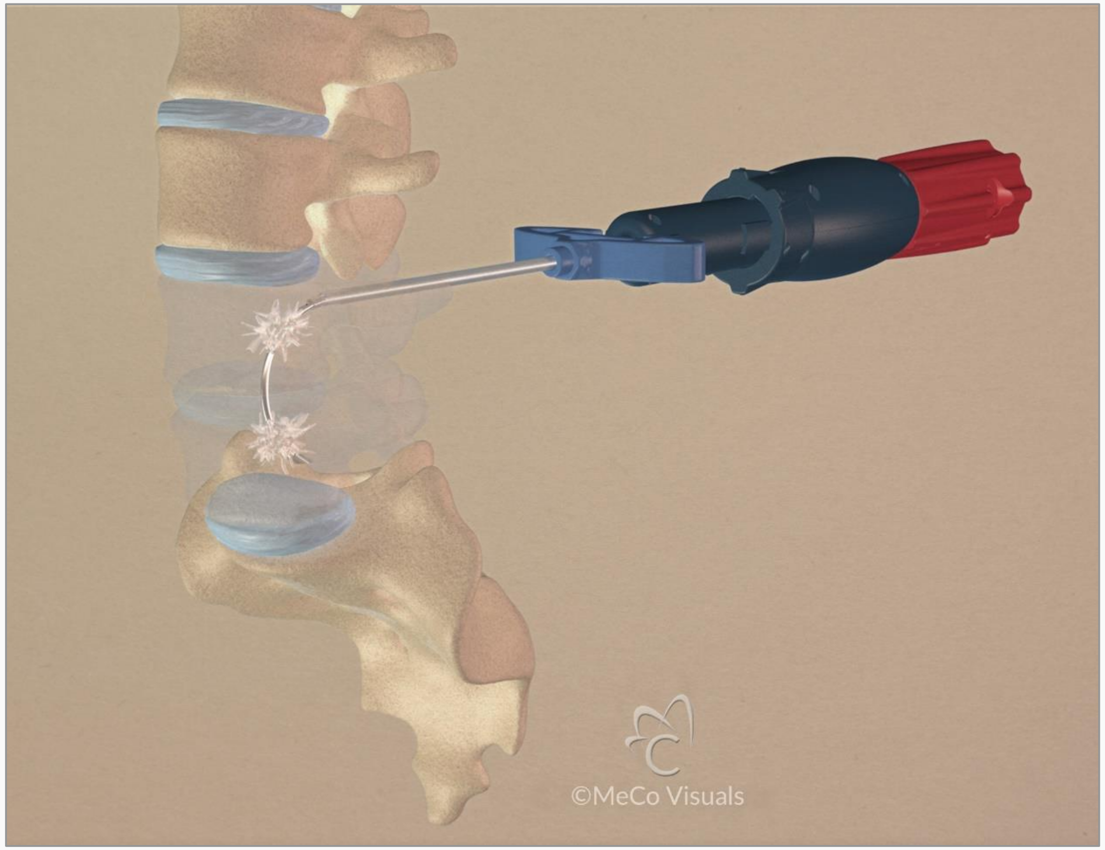
MeCo Visuals

Our Process

I will ask for:

Primary literature

Images (DICOM, device, your sketches)



MeCo Visuals

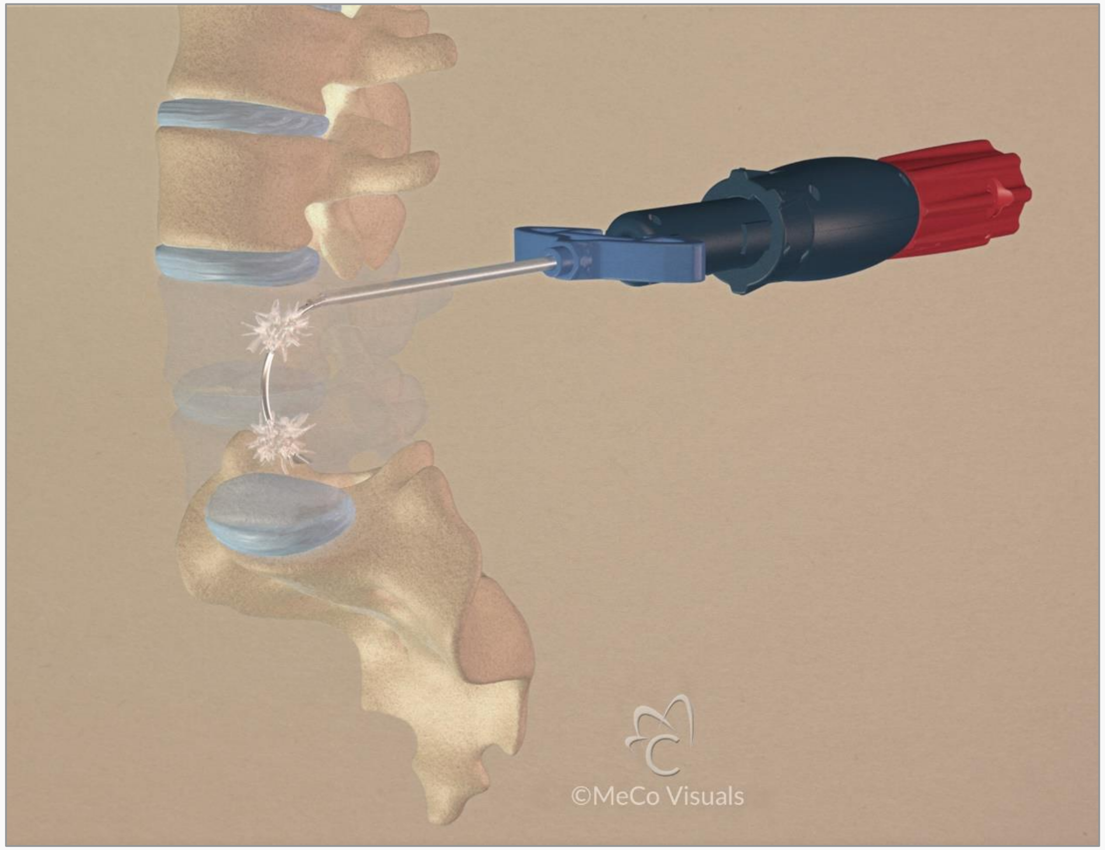
Our Process

I will ask for:

Primary literature

Images (DICOM, device, your sketches)

Responses to checkpoints within 48 hours

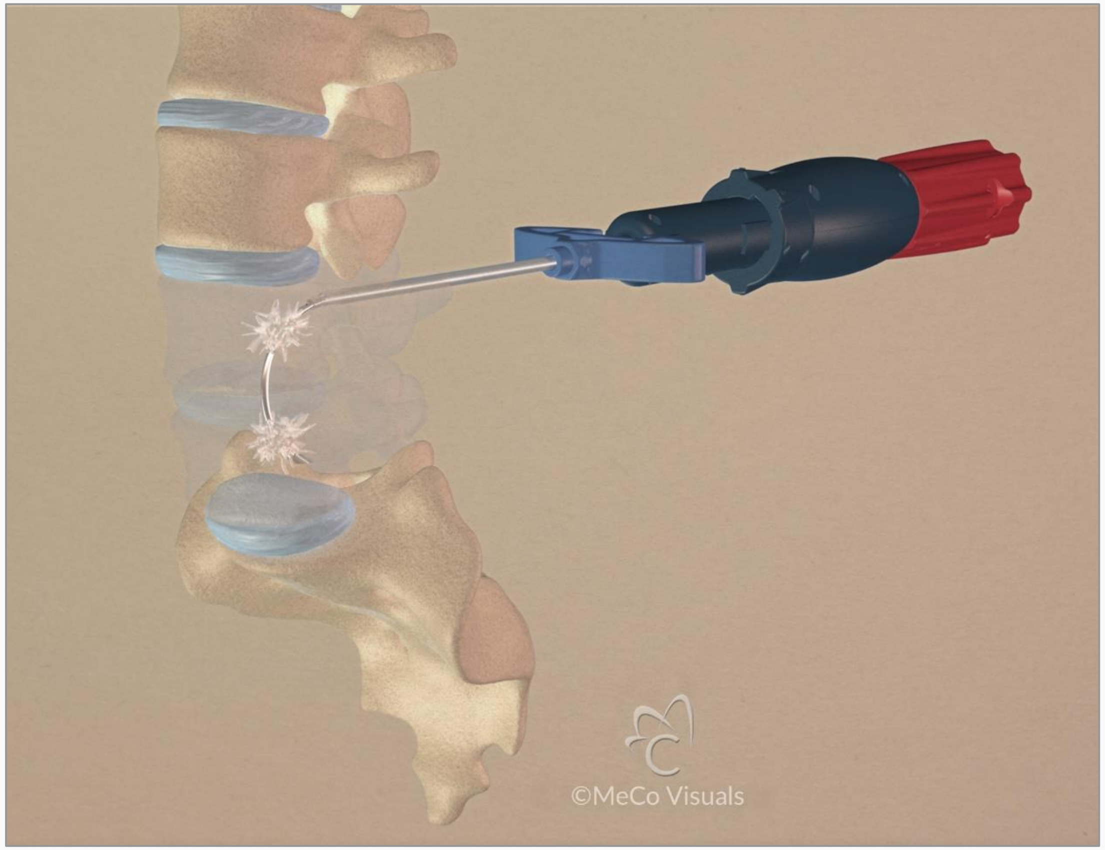


MeCo Visuals

Our Process

I will ask for:

Primary literature
Images (DICOM, device, your sketches)
Responses to checkpoints within 48 hours
Potential observation



MeCo Visuals

In Conclusion

MeCo Visuals

Thank you!

MeCo Visuals

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