The Movin' Groovin' Outer Ear:
Visualizing Compliance to Help Inform Comfortable Fit

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DIRECTOR OF TRANSLATIONAL RESEARCH
LANTOS TECHNOLOGIES

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Learning Outcomes

- 1) After this course, participants will be able to give a brief explanation of how the Lantos scanning system works
- 2) After this course, participants will be able to describe how jaw motion affects ear canal shape.
- 3) After this course, participants will be able to explain how pressure applied during scanning or impression-taking can affect ear shape.
- 4) After this course, participants will be able to describe the regions of compliance in the outer ear and ear canal.

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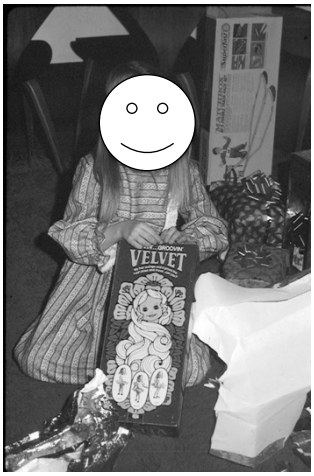
"Scientist. Audiologist. Teacher."

Director of Translational Research at Lantos Technologies
Work across the organization, based in R&D but do some clinical work as well

PhD in Pharmaceutical Chemistry
>10 years in academic science studying the "protein folding problem" using both computational and experimental methods, teaching chemistry and biochemistry

AuD 2013
(Pre-AuD) Stay-at-home parent of deaf child
Volunteer for local organizations related to hearing loss
Two years as a clinician



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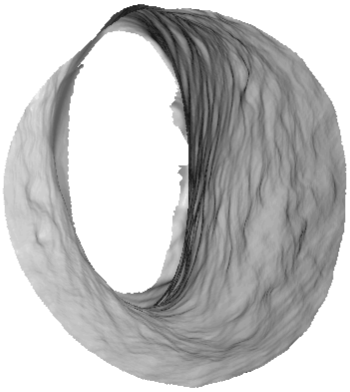
Outline

- How ear scanning works using the Lantos system
- Why should we care about ear dynamics and ear compliance?
- Ear dynamics with jaw motion
- What can we learn about compliance from comparing scans and impressions?
- Ear reaction to applied pressure



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The Lantos 3D Scanning System

The Lantos Ear Scanning Process

Multi-Step Scanning Process

1. Placement under direct visualization
2. Solution fills inside of the membrane (does not touch the ear), inflating peristaltically.
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4. Each still image is stitched into one 3D file.
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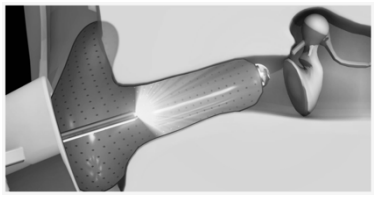

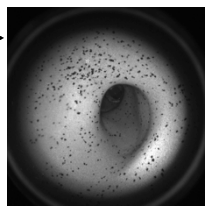

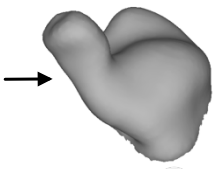

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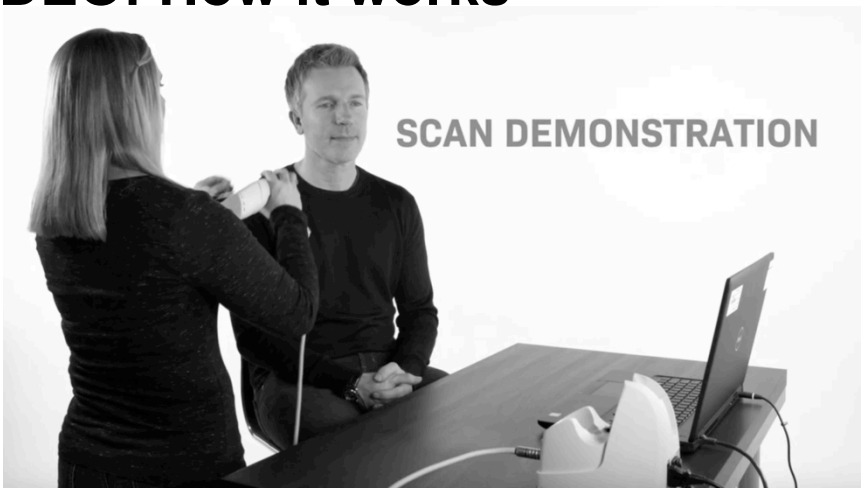
VIDEO: How it works



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Definitions

Ear dynamics: the motion of the pinna and/or ear canal in response to jaw motion, head position, etc.

Ear compliance: the regional, varying flexibility of the pinna and ear canal

Why does understanding ear <u>dynamics</u> matter?

Jaw movement

⇩

Lateral migration of HA

⇩

- Feedback
- Inadequate amplification
- Discomfort

⇩

Frustration and lack of benefit

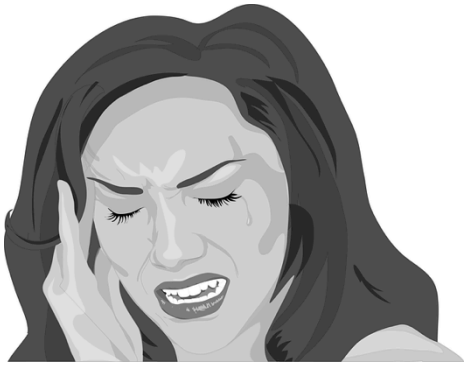

Image by Luisa Munoz at Pixabay.com

Why does understanding ear compliance matter?

Knowing where the ear has "give" helps design ear devices and direct modifications and remakes.

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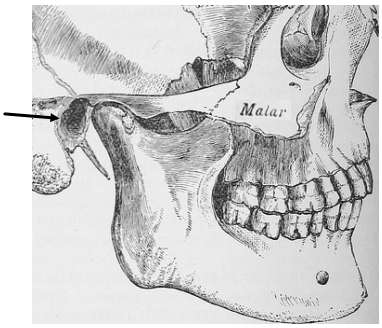
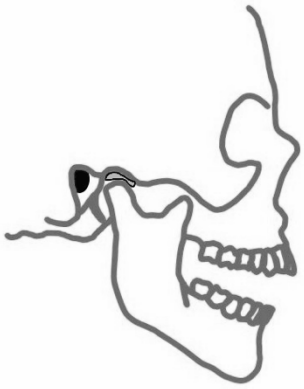
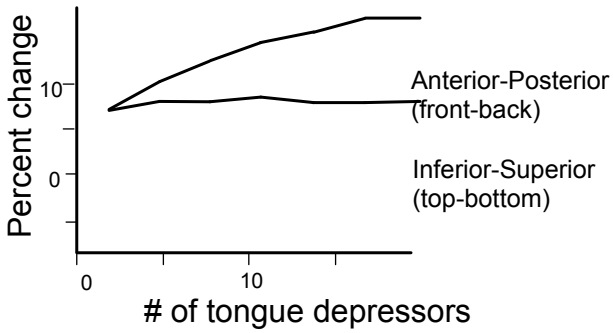
Jaw opening can expand the ear canal

External Auditory Meatus (bony portion)



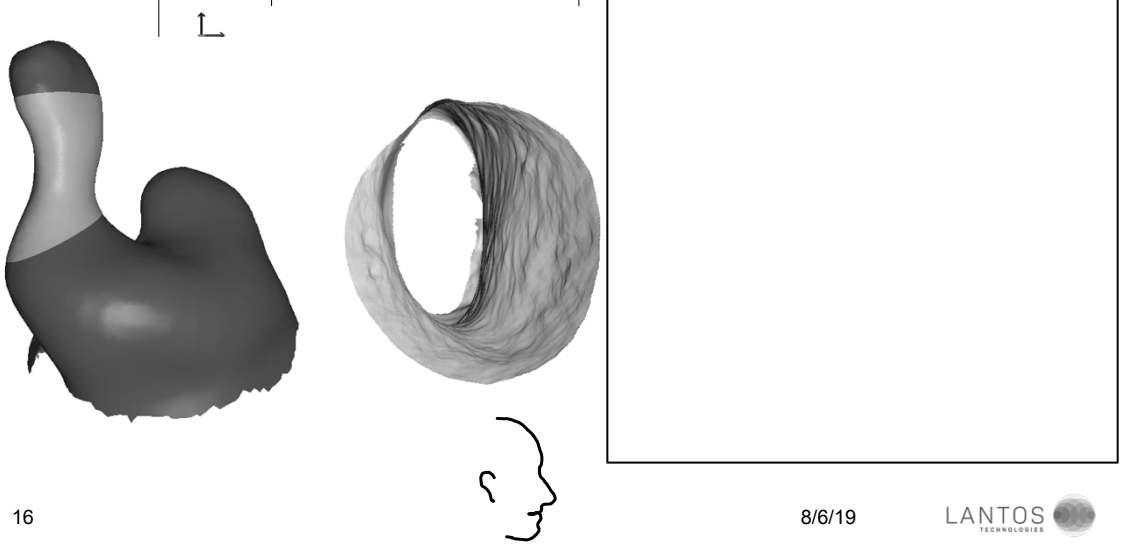


Shape changes with jaw opening from ear impressions

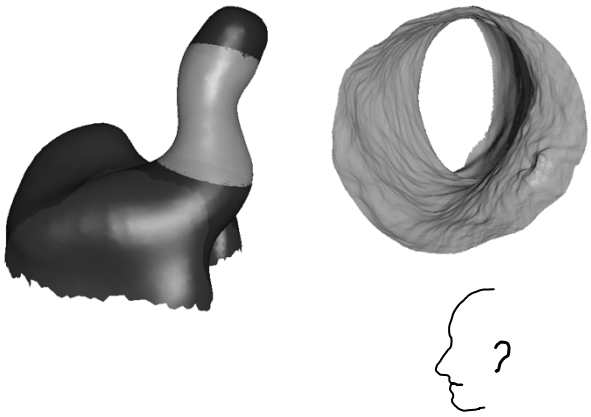


Adapted from Oliveira R. (1995). The dynamic ear canal. In: Ballachanda B, ed. *The Human Ear Canal*. San Diego, CA: Singular Publishing Group, pp. 83–112.

Motion during Jaw opening, BF Right ear



Motion BF Left ear



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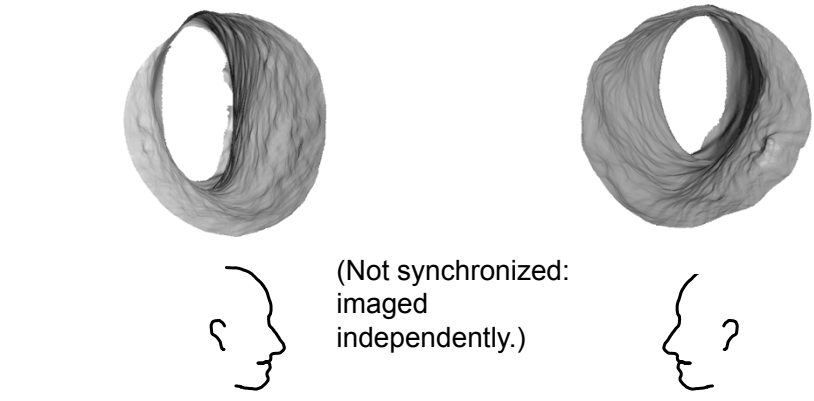
BF Right vs Left



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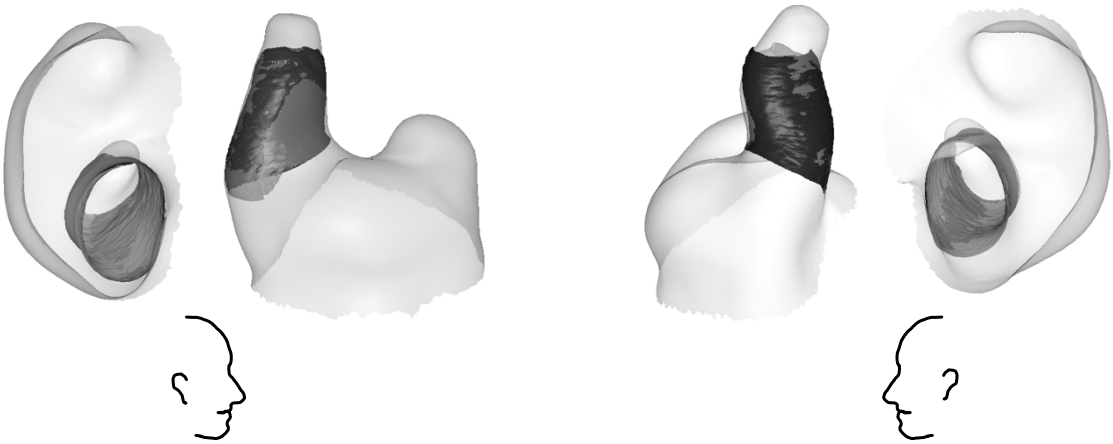
Motion during jaw opening, JG



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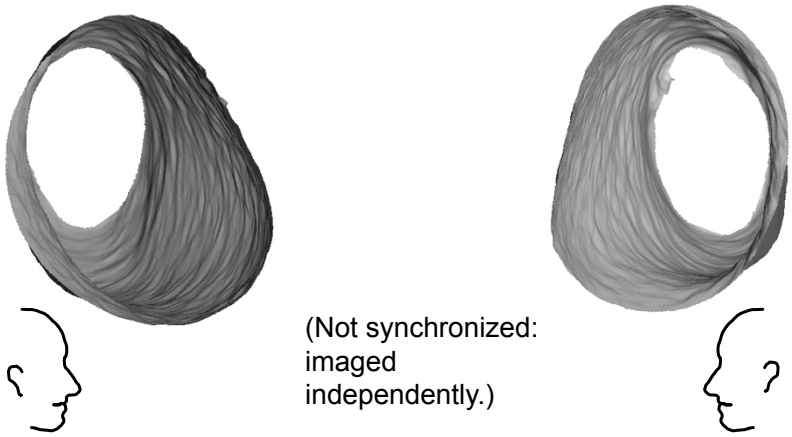
Motion during jaw opening, JG



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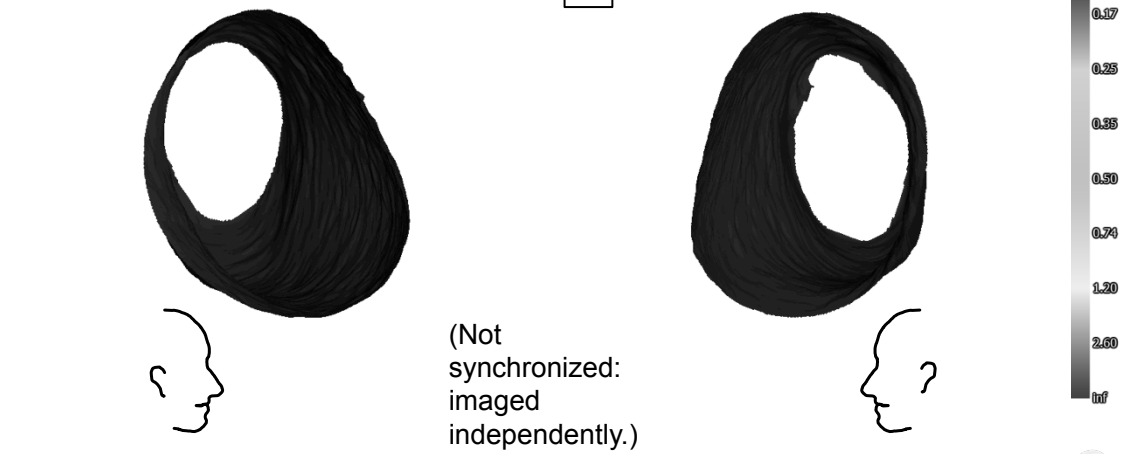

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Jaw Motion-Induced Dynamics Re-cap

- ♫ The ear bone's connected to the jaw bone ♫
- Individual ears can show different amounts of motion, even in the same individual
- The shape change is a process, not definable with a small number of static states
- The magnitude of change is ±1 mm, 10-15% of the ear canal's diameter

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Ear Imaging Timeline

Dental impressions from wax and plaster

First known ear impression, 1890

Powder/ liquid acrylic invented

https://commons.wikimedia.org/wiki/File:HearingAid_ITE.png

First ITE; silicone for impressions introduced

Desktop impression scanning → digital shell modeling

3D printers used for making hearing aids

Lantos and Otometrics demo direct ear scanning at AAA 2018

1850 1900 1950 2000

https://wellcomecollection.org/works/e7g3wmtu

https://commons.wikimedia.org/wiki/File:3d_printer_richards.jpg

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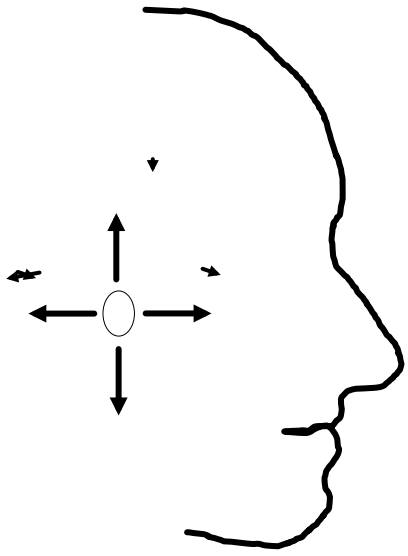
Ear Imaging History

For further reading, see Wayne Staab's series of articles:
https://hearinghealthmatters.org/waynesworld/2016/ear-impression-history-teeth-ear/

Aperture compliance: scans vs impressions

Method:

- Overlay scans and impressions for 68 matched pairs
- Optimize alignment at aperture+canal
- At the aperture, measure difference in four directions



The Lantos Ear Scanning Process

Multi-Step Scanning Process

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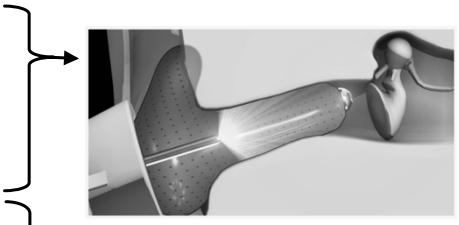

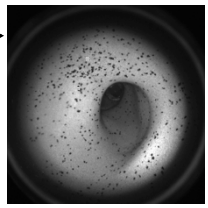

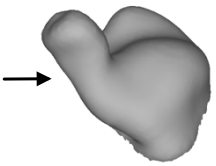

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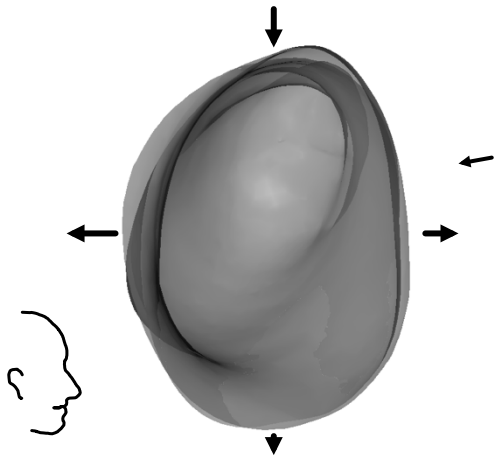
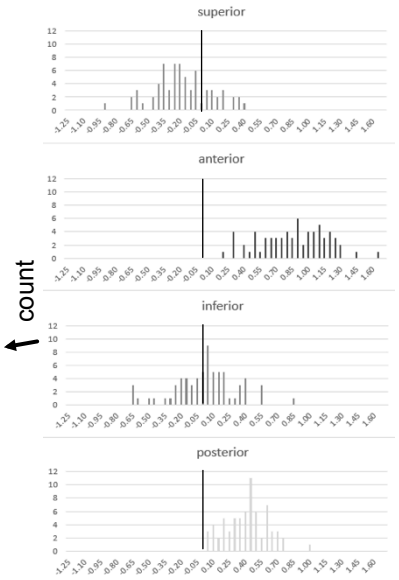
Aperture compliance with inflation



scan in pink, impression in blue



Displacement relative to impression (mm)

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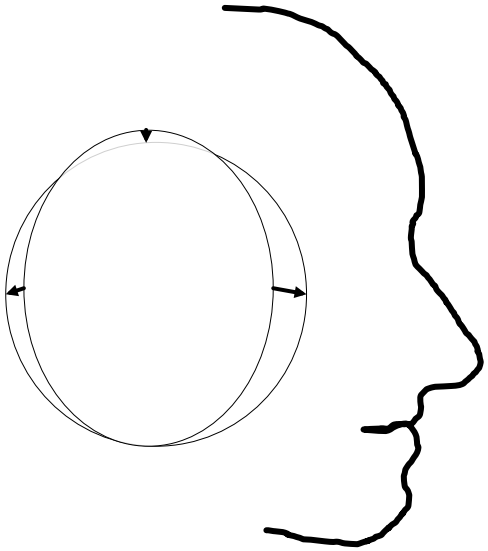
Impression vs Scan Aperture *Summary*

By overlaying 68 scans with impressions, we discovered that with membrane inflation, the aperture expands most to the front of the canal and slightly to the back, with little to no change at the top and bottom.

Similar to what happens with jaw motion, though measurements were made in the aperture, not 1st to 2nd bend region.



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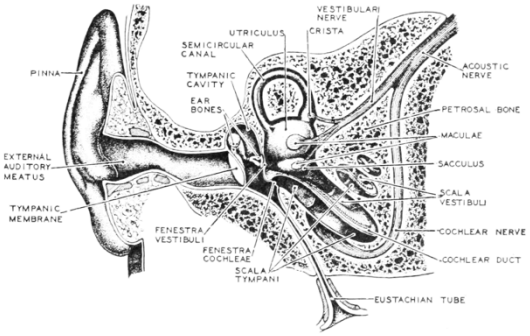
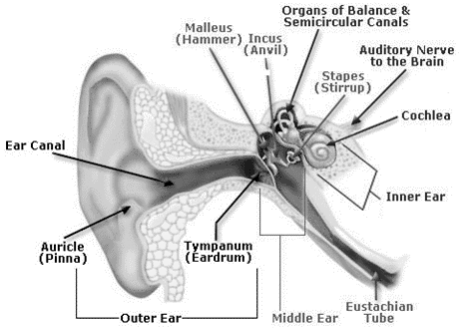
The ear canal pictures we see in class and in books





Neal, HV & Rand HW, Comparative Anatomy. P. Blakiston's Son & Co., Philadelphia, 1936

OSHA, 1999

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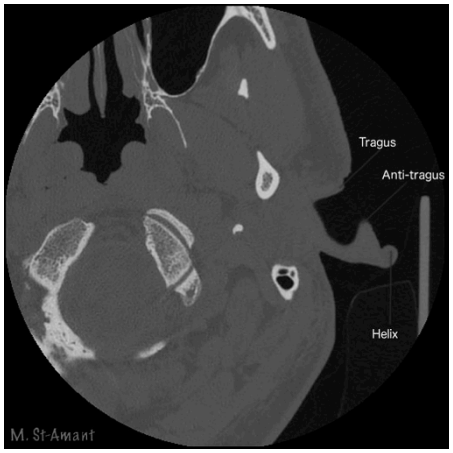
CT scan example 1 (normal)

face



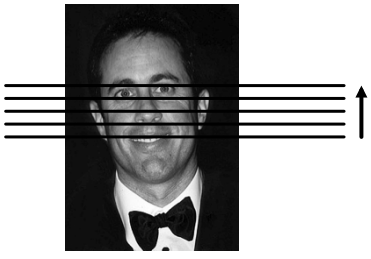


photo by John Matthew Smith

Case courtesy of Dr Maxime St-Amant, Radiopaedia.org, rID: 55612

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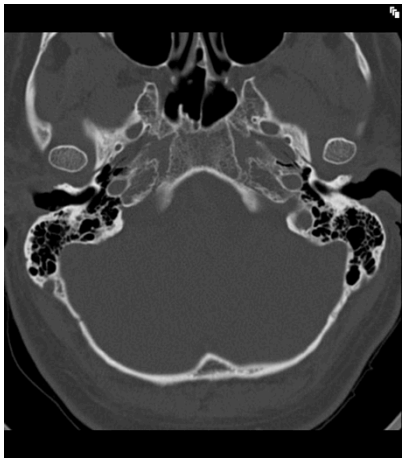
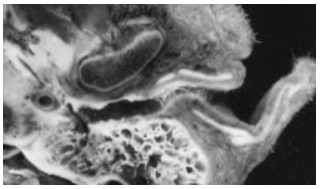
CT scan example 2





http://www.dartmouth.edu/~rswenson/Atlas/AxialHead/AxialHead10B.html

Case courtesy of Dr Bruno Costa Gomes, Radiopaedia.org, rID: 21732

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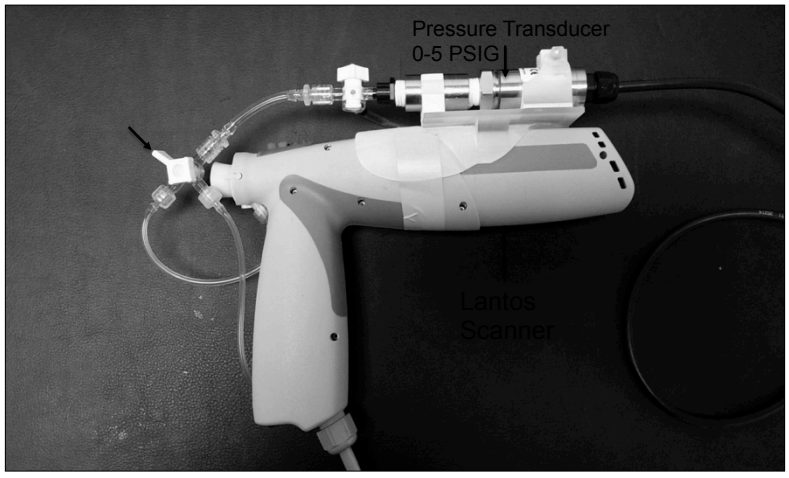
What is effect of pressure on ear canal shape?



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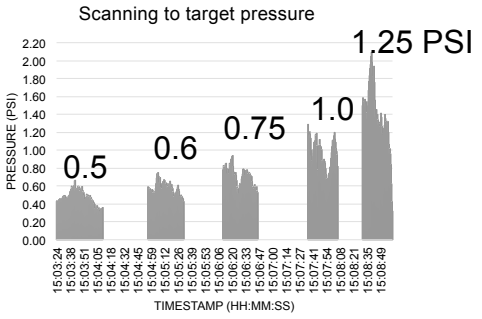
Scanning to target pressure

Operator kept to an average target pressure during a series of 5 scans.



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Old membrane design

Straight membrane

- Scans canal & proximal concha
- Allows creation of canal hearing aids and earpieces

Full ear membrane

- Scans canal, lower, and (most of) upper concha
- Allows creation of full shell products

Outer ear image: Anatomy, Physiology and Hygiene by Charles Henry May, W. Wood & Co., New York, 1890

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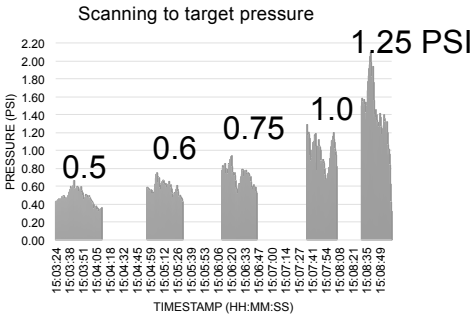

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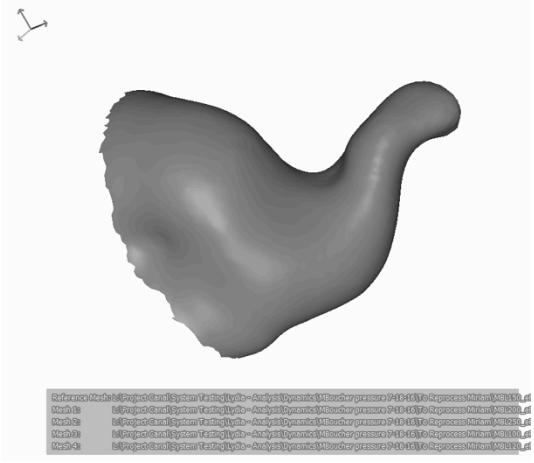
MB left ear



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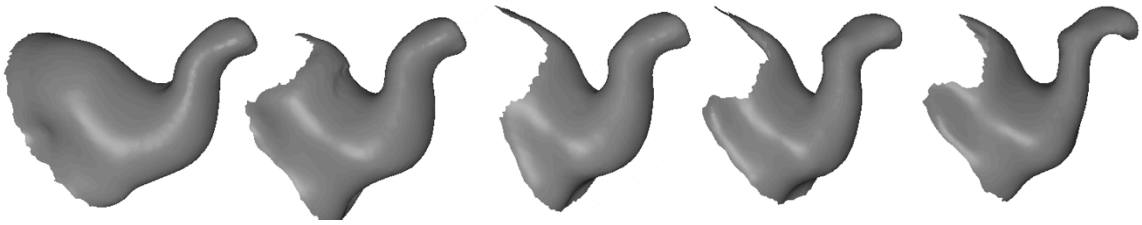
MB left still images of scans



0.50 0.60 0.75 1.00 1.25 PSI

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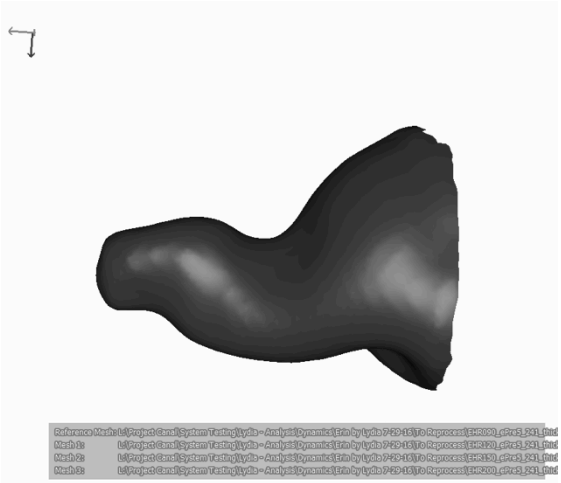
EH right ear



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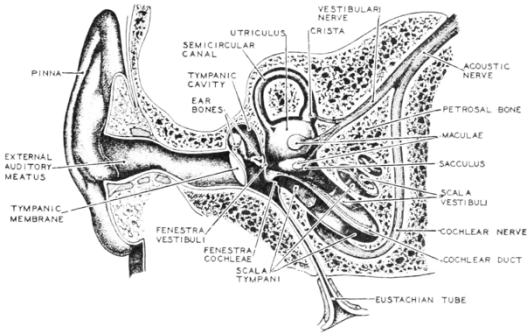
The ear canal pictures we see in class and in books



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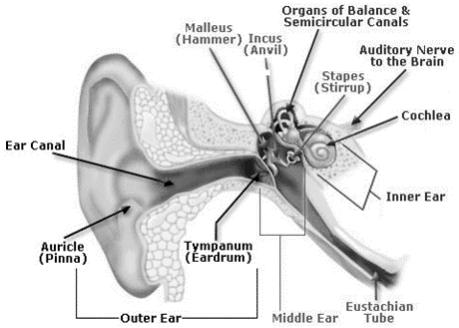

OSHA, 1999

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Contact me

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Questions?