

# Auditory Tube Angle and Mastoid Size: Association Not Endorsed

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## Abstract

**Background:** Some reports have described the midst of the lumen of the bony eustachian tube to meet the lumen of the external ear canal more nearly straight in ears afflicted with otitis media.

**Objectives:** To determine whether the "auditory tube angle" indeed is more nearly straight in ears with evidence of childhood otitis media.

**Methods:** Of 41 bequeathed adult crania without clinical otitis, the five with the largest mastoids, and the five with the smallest mastoids, had computed tomography referencing the Frankfort horizontal plane. Two observers independently assessed the angles, and distances from sigmoid sinus to bony external meatus. Mastoid size was assessed by two independent techniques: area of pneumatization on Law lateral radiographs; distance from sigmoid to bony external meatus.

**Results:** Auditory tube angles did not correlate with mastoid size. Variations in auditory tube angles and distances from sigmoid sinus to bony meatus were found in adjacent CT slices.

**Conclusions:** These data do not support the idea that the eustachian bony lumen and external auditory canal meet more nearly straight in ears with evidence of childhood otitis media.

## Introduction

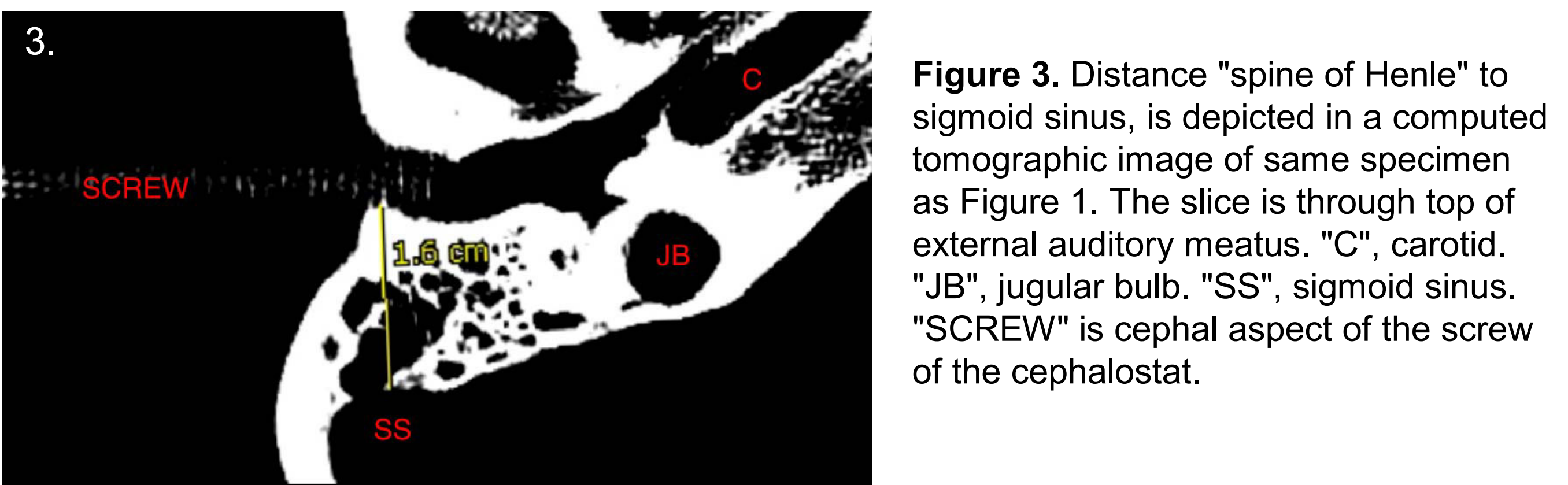
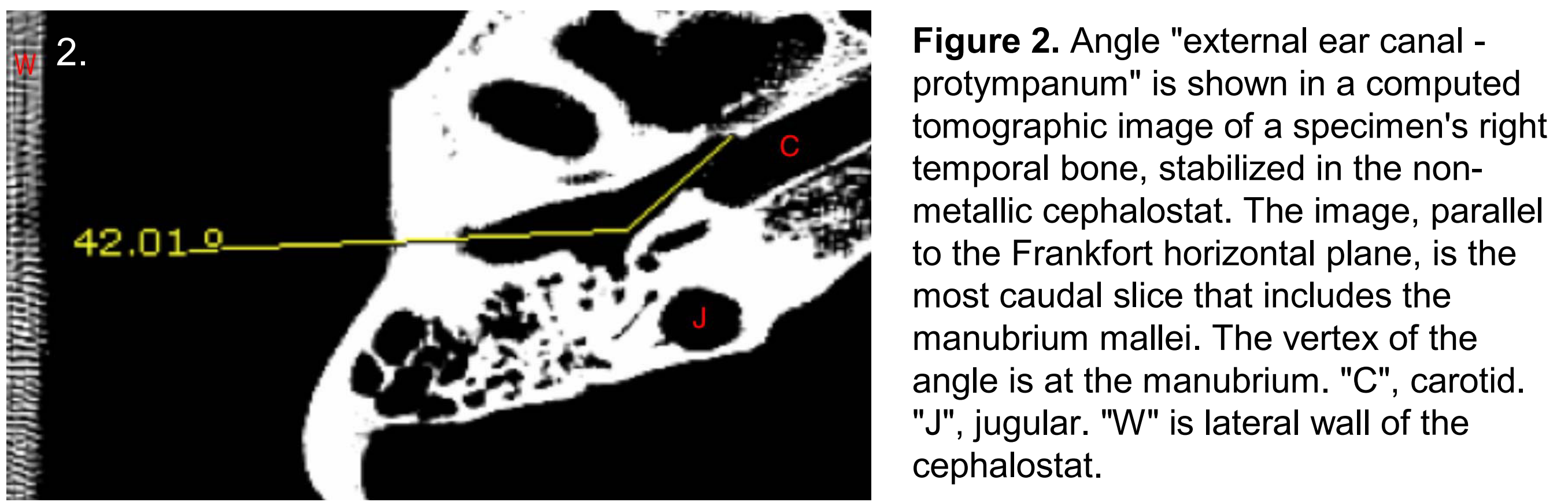
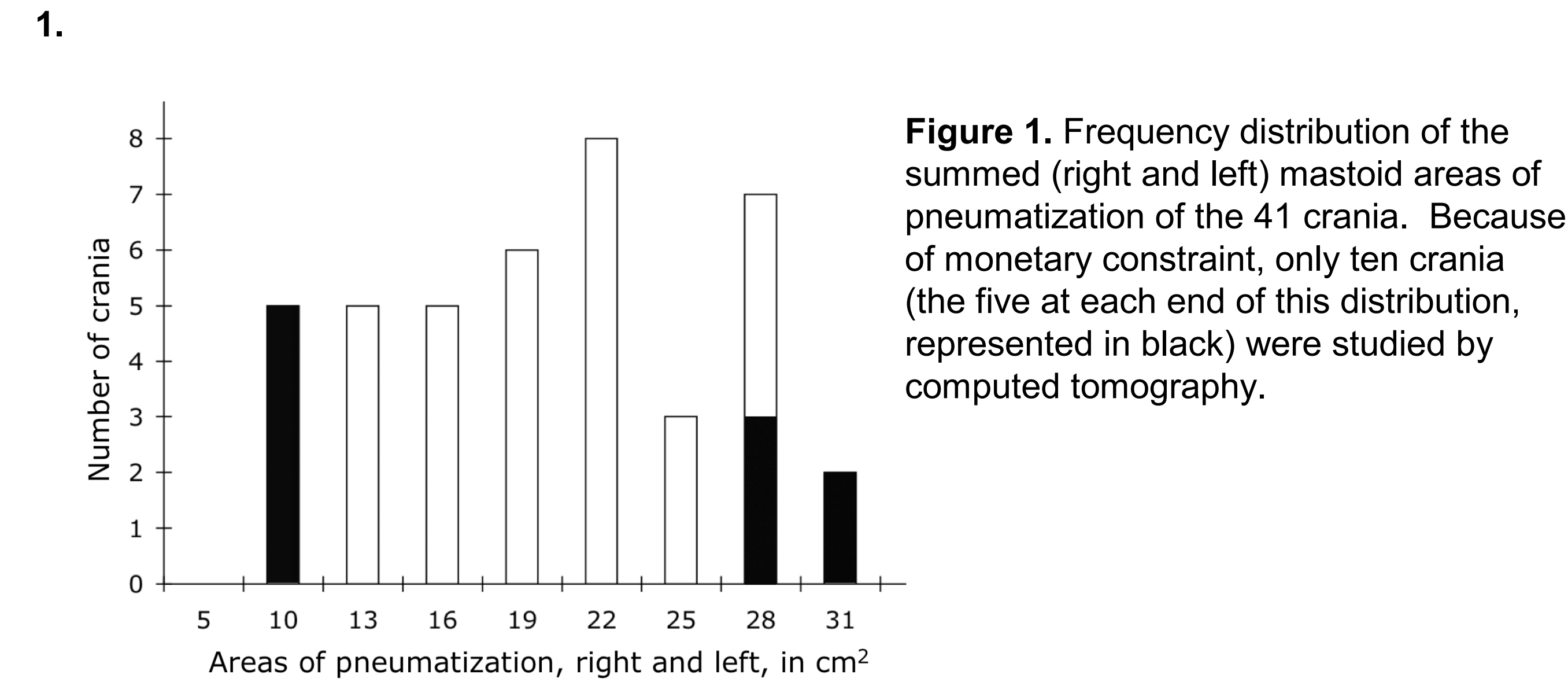
Siricki *et al* (2001) reported that persons with otitis media have a more nearly straight-line relationship of the axis of the external ear canal with the axis of the bony eustachian tube. Other anatomic difference associated with otitis media include short eustachian tubes (Todd 1991), short clivus (Todd 1998), and brachycephaly (Stolovitsky and Todd 1990).

Todd and Muller (1991) found the positions of both the bony and cartilaginous portions of the Eustachian tube unrelated to otitis indicators; the reference plane was Frankfort, similar orientation as the orbitomeatal line used by Siricki et al. (2001). Many clinical observations skepticize the variability of orientation of the bony external ear canal. Nevertheless, the approximate 30° range of "auditory tube angle" is plausible.

Reports applicable to the "auditory tube angle" (Siricki et al.,2001 and 2004) have both limitations and delimitations, as do all reports. Concerns include that neither intra- nor inter-observer agreement of the angles was checked, that each person was indeed positioned in the same "axial" plane, that mastoid volume was assessed only in otitis patients (not in their 20 "independent healthy mastoid ... control subjects", that bilateral symmetry of angles was not checked, and that independent non-biased measurements were not specified.

Our present study addresses three inter-related questions about relationships of the "auditory tube angle", and the question of correlation of two different indicators of mastoid size:

- Are intra- and inter-observer agreements reasonable for the "auditory tube angle"? Specific hypothesis: these agreements are excellent.
- Is the "auditory tube angle" correlated with ipsilateral mastoid size? Specific hypothesis: a more nearly straight "auditory tube angle" (the angle formed by the line of the lumen of the bony eustachian tube, and the line of the external ear canal) is found in ears with small temporal bone pneumatization ipsilaterally.
- Are "auditory tube angle" bilaterally symmetrical? Specific hypothesis: symmetry exists for the "auditory tube angles".
- On an axial computed tomographic image, does the distance from the spine of Henle to the closest wall of the sigmoid sinus, correlate with mastoid size? Specific hypothesis: Henle-sigmoid distance correlates well with area of mastoid pneumatization as shown on lateral mastoid radiograph.



## Methods

### Specimens:

41 adult skulls were provided by the Anatomy Department. Most were white, the remainder black. No specific racial, age, or sex information was available. Though none had died of ear disease, no specific ear historical data were available.

### Mastoid size, computed tomography, and specimen orientation:

As previously described (Todd, 2007), pneumatization was quantitatively assessed by planimetry on Law lateral radiographs.

### Computed tomography and specimen orientation:

Ten crania (the five with the smallest [summed right and left] Law lateral pneumatization areas, and five with the largest [summed right and left] areas) were imaged by high-resolution computed tomography (CT) with a prospective bone algorithm (GE Light Speed Ultra multi-detector scanner, GE Medical Systems, WI): 1.2 mm non-helical images were done with mA 200, 120 kVp, scan FOV 25cm, and edge-enhancing algorithm. (Because of monetary constraint, the other 31 crania were not studied by CT.) Each specimen was placed in a non-metallic cephalostat. Direct axial images, parallel to the Frankfort horizontal plane, were obtained.

### "Auditory tube angle":

Using the "MagicView 300" software program, the angle was determined independently twice by two examiners (EK and NWT). NWT used the most caudal CT image that included the manubrium. This slice is quite similar to that used by Siricki et al.(2001) A straight line was drawn from the most anterior-medial portion of the visualized bony eustachian tube, to the manubrium. More arbitrary was deciding the middle of the external bony canal; for the few cases in which the external auditory meatus was not included in the CT slice, the midst of the visualized canal was used.

Because NWT noted the "auditory tube angle" to be quite different in adjacent CT image slices, EK used the image slice that exhibited the greatest distance of the eustachian lumen. She measured the angle formed by the axis of the eustachian lumen and the posterior wall of the external bony ear canal.

### Distance "spine of Henle" to sigmoid sinus:

Also using the "MagicView 300" software program, the distance was determined independently twice by the two examiners (EK and NWT). NWT used the CT slice depicting the midst of the 5.8mm (outside diameter) nylon screw of the cephalostat. Measurement was directly to the most convex portion of the external auditory bony meatus to the closest point of the wall of the sigmoid sinus.

Because of the realization that NWT found quite-different distances in adjacent CT image slices, EK used the CT slice depicting the (difficult to recognize) spine of Henle, and measured to the closet point on the sigmoid sinus.

### Statistics:

Twice the two examiners did the measures of each ear's "auditory tube angle" and "Henle-sigmoid distance", independently, in the image slices already described. The measure of each mastoid area, of both sides of each specimen, had been twice carried out independently on two separate occasions. The statistical unit was each cranium's right or left ear, as specified. For statistical assessment of a relationship between numeric variables, the non-parametric Spearman rank correlation  $r_s$  was determined at <<http://StatPages.org> >; through the same website, the non-parametric Wilcoxon two sample test was used to compare sizes of angles and distances. The 95% confidence interval around  $r$  was determined at <<http://glass.ed.asu.edu/stats/analysis/rci.html>>.  $P$  values smaller than .05 were considered statistically significant. No Bonferroni correction was applied.

## Results

Table I. Repeatability and 5-number summary of the distribution for each measurement of the 41 crania, and the 10-crania subset studied by computed tomography. Repeatability of measurements was excellent for mastoid areas, and fair-good for the angular and linear determinations. Table I. Ranges of measurements were wide. Intra-observer agreements were at least fair

Measurement	Repeatability $r_s$	Minimum	1st quartile	Median	3rd quartile	Maximum
mastoid area, right, all crania	.89, N=41, $p<.001$	2.4	5.7	9.6	12.4	14.2cm <sup>2</sup>
mastoid area, left, all crania	.92, N=41, $p<.001$	2.0	7.5	10.0	11.6	18.0cm <sup>2</sup>
mastoid area, right, studied crania	.88, N=10, $P<.01$	2.4	4.6	9.2	13.3	13.8cm <sup>2</sup>
mastoid area, left, studied crania	.95, N=10, $P<.001$	2.0	3.9	9.2	14.0	18.0cm <sup>2</sup>
Henle-SS, right, by NWT	.94, N=10, $P<.001$	8.0	11.6	12.2	14.1	20.0mm
Henle-SS, right, by EK	.83, N=10, $P<.01$	14.0	16.2	16.8	19.2	22.5mm
Henle-SS, left, by NWT	.96, N=10, $P<.001$	6.0	12.5	14.5	16.0	19.5mm
Henle-SS, left, by EK	.97, N=10, $P<.0001$	13.0	15.4	17.5	18.9	21.5mm
angle, right, by NWT	.83, N=10, $P<.01$	122.0	131.2	138.2	143.0	145.5°
angle, right, by EK	.90, N=10, $P<.001$	135.6	144.7	147.8	151.9	157.4°
angle, left, by NWT	.49, N=10, $P<.16$	130.5	135.5	139.0	140.5	142.0°
angle, left, by EK	.86, N=10, $P<.01$	131.4	139.9	147.5	149.6	163.4°

Table II. Bilateral symmetry of measurements, right versus left, is apparent only for mastoid areas. Neither protympanum-canal angle nor Henle-sigmoid distance suggested bilateral symmetry, statistically, for each examiner.

MEASUREMENT	$r_s$
mastoid area, on Law lateral radiograph, N=41	.68, $P<.001$
mastoid area, Law lateral (of CT-studied crania), N=10	.66, $P<.05$
angle by NWT, N=10	-.24, $P<.50$
angle by EK, N=10	.74, $P<.02$
Henle-SS by NWT, N=10	.86, $P<.01$
Henle-SS by EK, N=10	.48, $P<.16$

Table III. Relationships of mastoid pneumatization (per Law lateral plain radiograph) with Henle-SS distances, and EAC-protympanum angles. Pneumatization is that of the ipsilateral mastoid. No association of pneumatization and angle "external ear canal - protympanum" is suggested (for  $N = 10$ ,  $r_s >.65$  is statistically significant at  $P < .05$ ).

ASSESSMENT	Spearman rank correlation, $r_s$	
	Right Side	Left Side
Angle EAC-protympanum, by NWT	.38, $P<.28$	-.41, $P<.25$
Angle EAC-protympanum, by EK	.33, $P<.34$	.23, $P<.51$
Henle-SS distance, by NWT	.81, $P<.01$	.66, $P<.05$
Henle-SS distance, by EK	.97, $P<.001$	.99, $P<.001$

Table IV. "Auditory tube angles" were more nearly straight in ears with larger mastoid pneumatization areas, in three of four checks (each time by EK, one with  $P < .04$ ; once by NWT). Henle-sigmoid distances (operationally defined slightly differently by the two observers) were small in ears with small mastoid pneumatization areas, and vice versa: in three of four checks, the size differences were unlikely by chance ( $P < .05$ ).

	Mastoid area, on Law lateral X-ray			
	Right Side		Left Side	
	5 smallest	5 largest	5 smallest	5 largest
Angle EAC-protympanum, by NWT	median 136.5, range 129.5-143.5	median 140, range 122-145.5 $P<=.69$	median 139, range 138.5-140.5	median 134.5, range 130.5-142.0 $P<=.64$
Angle EAC-protympanum, by EK	144.3, 135.6-149.0	152.5, 145.6-157.4 $P<=.04$	142.7, 131.4-149.8	147.8, 138.9-163.4 $p <= 0.42$
Henle-SS distance, by NWT	11.5, 8-12.5 $P<=.03$	14.5, 12-20	12.5, 6-16	16, 14-19.5 $P<=.05$
Henle-SS distance, by EK	16, 14-17 $P<=.04$	20, 16.5-22.5	16.5, 14-19	18.5, 13-21.5 $p <= 0.2937$

## Discussion

Limitations: lack of specific information about the age, sex, race and otologic history of the specimens.

Delimitations: computed tomography was done on only one-fourth of the specimens (because of cost).

### Strengths:

- rigorously set cranial positioning for computed tomography
- checking intra- and inter-observer agreement
- checking bilateral symmetry
- each of our measurements was independently acquired; for "auditory tube angle" and Henle-sigmoid distance measurements
- each observer tried to not be influenced by the extent of temporal bone pneumatization that was obviously present in the CT image slice, and in viewed adjacent slices.

## Conclusion

Auditory tube angle, in this study, does not correlate with the small mastoid indicator of otitis media. Spine of Henle to sigmoid distance correlates well to mastoid size.