Ontogenetic Growth of the Membranous Labyrinth

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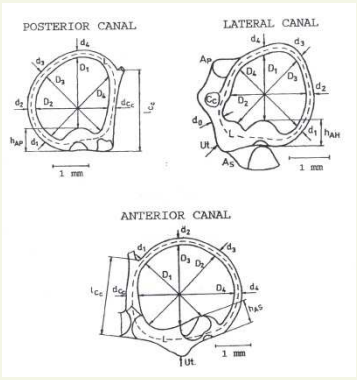
Background: The vestibular labyrinth is the non-auditory part of the inner ear that plays the dominant role in the subjective sensation of motion and spatial orientation of the head. The semicircular canals sense angular accelerations and decelerations of the head and enable coordination of posture and body movement, as well as visual stability. The vestibular labyrinth contains five receptor organs: three semi-circular canals sensing head rotation and the sacculus and utriculus sensing linear motion (Fig.1). The knowledge of the size and the geometry of the vestibular organ is very important to understand its function. Previous studies have provided contradictory findings on the dimension of the vestibular organ. Therefore the present study was designed to contribute the dimension of all three semicircular canals SCC (anterior, posterior, horizontal) during growth.

Fig. 1: The left labyrinth of human embryo

Aim of the study:

- A systematic standardized measurement of the membranous labyrinth
- The analysis and assessment of anatomical measurements during growth
- The calculation of function from the relevant dimensions



The membranous labyrinth of Wistar Rat.

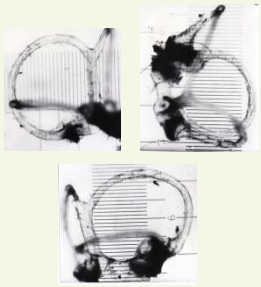


Fig. 2: The standardized measurement of the Wistar Rat membranous labyrinth at selected points.

Materials and methods: We have examined the shape and size of the membranous labyrinth in mammals (Table 1) during ontogenetic growth.

Species	Number	Age
Wistar-Rat	87	19. gestation day - 120. postnatal day
Rabbit	3	newborn, 5. postnatal day, adult
Guinea Pig	5	7., 10., 12. postnatal day, adult
Cat	4	newborn
Human	4	3 to 5 months of gestation

Table 1. Overview of samples

The membranous labyrinths were removed manually by means of a scalpel under a dissection microscope (16 -25 magnification). All three SCC of the labyrinths, along with the ampulla and utriculus were completely removed and placed in the water bath. Two methods were used to measure the dimensions of SCC:

1. The SCC projections were measured with the help of the "two coordinates gauge".
2. To measure the projection from the photo, the Zeiss object measurement plate was photographed under the preparation (Fig. 2).

For the calculation of function from the dimension the following formula used:

$$T_2\_K_2 = \frac{l \bullet r^2}{l_d} \qquad T_1\_K_1 = \frac{R^2}{r^2}$$

Results: All dimensions (length of canal, the thin segment, utriculus, ampulla and crus commune, diameters of the transverse canal, the thin segment) of the three semicircular canals in rat, rabbit, cat and human increased significantly. The dimensions of SCC in guinea pig don't change postnatal. Some parts of labyrinth showed a different growth pattern, the corresponding parts of all three canals revealed a proportional growth. The figures 3-4 show the developmental changes of selected parameters of the SCC.

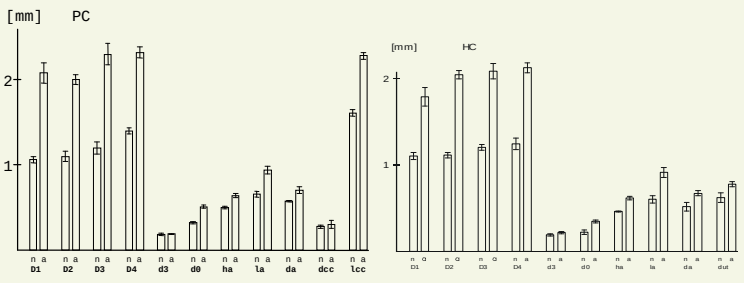


Fig. 3: The parts of the posterior and horizontal SCC increase differently
n - newborn group, a – adult group

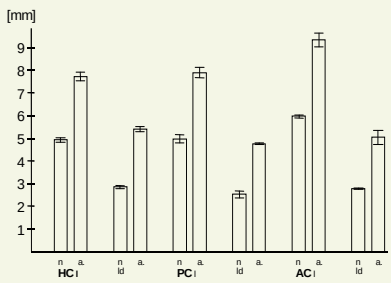


Fig. 4: The same parameters (l - length of canal and ld - length of thin segment) for AC, PC and HC increase proportional
n - newborn group, a – adult group

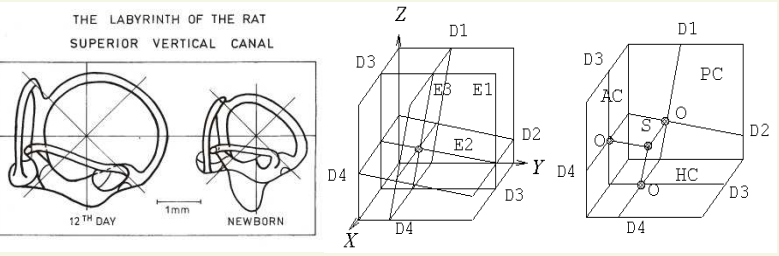


Fig. 5: The spatial orientation of the semicircular labyrinth in all species is stable during growth. The relative place of the anatomical center remains unchanged

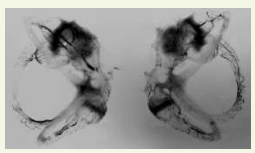
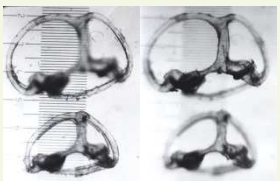
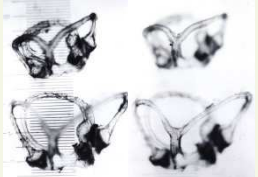


Fig. 6: The left and right labyrinths of newborn cat





	Rat	newborn	2d	4d	6d	8d	10d	14d	adult
K_1	HC	67,1	72,6	88,4	111,6	134,0	149,3	150,3	150,6
	PC	77,9	89,2	103,8	131,3	159,0	152,5	170,5	175,3
	AC	111,4	125,3	145,4	178,2	197,0	212,6	232,2	220,8
K_2	HC	0,015	0,014	0,015	0,013	0,014	0,016	0,014	0,014
	PC	0,017	0,014	0,015	0,015	0,016	0,016	0,014	0,015
	AC	0,015	0,017	0,016	0,018	0,019	0,019	0,019	0,017
	Rabbit	newborn		5d					adult
K_1	HC	137,6		222,3					372,3
	PC	177,5		220,7					403,3
	AC	252,5		345,4					642,3
K_2	HC	0,013		0,019					0,018
	PC	0,013		0,022					0,018
	AC	0,015		0,024					0,023
	Guinea Pig				7 d		10d		ad
K_1	HC				232,5		228,6		206,9
	PC				187,5		-		190,0
	AC				246,7		-		288,2
K_2	HC				0,018		0,019		0,018
	PC				0,021		-		0,022
	AC				0,023		-		0,023
	Human SSL (mm)	63			105		125		145
K_1	HC	100,0			156,1		141,5		208,8
	PC	115,8			224,1		197,4		250,5
	AC	172,5			263,8		248,0		292,8
K_2	HC	0,022			0,053		0,059		0,069
	PC	0,019			0,034		0,057		0,068
	AC	0,024			0,045		0,073		0,081

Table 2: The change of time constants during growth show the functional significance for the development of vestibular labyrinth.