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ORIGINAL ARTICLE

Peculiarities in the Development of the Superior Semicircular Canal☆

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KEYWORDS
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Abstract
Objective: Our objective was to study the ontogeny of the superior semicircular canal in order to describe its peculiarities.
Methods: We analysed 76 series of human embryos aged between 32 days (6 mm) and newborns. The samples were cut serially and stained using Martin's trichrome technique.
Results: In semicircular canal development there were a number of peculiarities, such as: a defined chronological sequence of osteogenesis with a variable rate of ossification; the fact that each nucleus of ossification was involved in the formation of one of its covers (the upper in the superficial and the lower in the deep); the appearance of transitory dehiscence; and canal closure by means of bone with laminar pattern, with a minimum thickness of 0.1 mm.
Conclusion: The peculiarities in canal development could explain the origin of pathological dehiscence in the canal, whether congenital or acquired.

PALABRAS CLAVE
Ontogenia;
Canal semicircular superior;

Peculiaridades en el desarrollo del canal semicircular superior

Resumen
Objetivos: Realizar un estudio sobre la ontogénesis del canal semicircular superior con el fin de describir sus peculiaridades.

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Dehiscencia;
Humanos

Métodos: Para ello se han analizado 76 series embriológicas humanas de edades comprendidas entre los 32 días (6 mm) y recién nacidos. Las preparaciones estaban cortadas en serie y teñidas con la técnica de tricrómico de Martins.
Resultados: En el desarrollo del canal semicircular hemos observado una serie de peculiaridades, como: secuencia cronológica definida de su osteogénesis con un ritmo de osificación variable, cada núcleo de osificación interviene en la formación de una de sus cubiertas, el superior de la superficial y el inferior de la profunda; la aparición de una dehiscencia transitoria, y el cierre del canal por hueso de tipo laminar con un grosor mínimo de 0,1 mm.
Conclusión: Las peculiaridades en el desarrollo del canal podrían explicar las causas del origen de la dehiscencia patológica del mismo, ya sean congénitas o adquiridas.

Introduction

Anson,[1] Olaizola and Hotna,[2] and Bergeron[3] give a detailed description of the embryological development of the semicircular canals, showing that the superior semicircular canal forms from the dorsal utricle wall of the otocyst in week six (8–11 mm human embryo) as an outpouching or diverticulum in the form of a common disc for the vertical canals (superior and posterior), and how the mesodermal tissues surrounding it adapt to the morphology and rapid growth of the membranous labyrinth, progressively condensing and transforming into precartilage. This subsequently matures and develops into cartilage, and they showed how around week 18, the ossification process starts from the 2 primary and one accessory ossification centres.[4]

Its size is complete at week 23[5] and computerised tomography[6] shows how at week 19 the canal is surrounded by a partially ossified ring, with ring completion at week 21.

Bach-Peterson and Kjaer[7] observe that, although ossification may occur more rapidly in some foetuses, the pattern follows a well defined chronological sequence and Dzieciolowska-Baran[8] describes how between week 18 and 24 morphological forms are more dynamic and abundant.

Minor et al.'s[9] description of dehiscence of the superior semicircular canal and the existing controversy regarding whether dehiscence is due to congenital or acquired defects[10,11] led us to carry out a study on the ontogeny of the superior semicircular canal in order to describe its peculiarities and provide data to help establish its etiopathogenesis.

Materials and Methods

We studied the development of the superior semicircular canal in embryos and human foetuses. Analysis was performed on a series of human embryos belonging to the collection of the Department of Anatomy and Human Histology in the University of Zaragoza, aged between 9 mm (6 weeks) and newborns. The total number of series studied was 77.

We used the O'Rahilly and Muller tables to date the ages of the foetuses used. These are based on relating different measurements (maximum length, crown to heel length, foot length, biparietal diameter, abdominal circumference and head circumference) and body weights. These measurements were compared with data from the clinical record and ultrasound scan, when available.

In embryos and foetuses of under 12 weeks the whole head was set, whilst in older foetuses detailed and scrupulous dissection of the temporal bones was carried out.

All the samples were fixed in 10% formalin and decalcified with 2% nitric acid, at a temperature of 25 °C. Mean time of decalcification varied between 1 and 4 weeks, depending on specimen size and thickness. After decalcification, the acid was eliminated by washing under running water. The samples were progressively dehydrated in increasing alcohol concentrations, embedded in paraffin, cut with a Leitz microtome in 7–10 μm and stained using Martins' trichrome technique.

All sections were observed under an OLYMPUS (BH-2) dual headed microscope with 2, 4, 10, 20, 40, 60 and 100× 3.3 lenses and photographed with an OLYMPUS PM-CBSP and a LEICA DMD108. The latter has an integrated calibration system for microimaging measurement, with which the morphometric data were obtained or measured with microscopic precision.

Results

The superior semicircular canals develop from the mesenchyme of the future optic capsule which contains the membranous ducts.

At *6 weeks*, the ducts are surrounded by mesenchymal tissue, characterised by looseness, made up of stem cells which are rounded or elongated, with large nuclei and little cytoplasm.

At *7 weeks*, the mesenchyme is differentiated into chondroblastic cells. At this stage, the future canal presents 2 areas. The closest to the duct is precartilaginous (1) in appearance whilst the distal area (2) is cartilaginous (Fig. 1a).

At *8 weeks*, the canal has a cartilaginous structure, its exterior or superficial cover is clearly developed and adopts its shape as a characteristics arch, the convexity of which leans towards the middle cerebral fossa. Its mean thickness is 0.2 mm, tapering as it reaches the apical area.

At *9 weeks* of development we observe the beginning of the formation of the future periosteal and endosteal layers of the canal wall through the mineralisation of the cartilage matrix and cellular differentiation in the future perilymphatic space into 2 strata, the first of which is fibrous and the second loose. At *10 weeks* of development, the mineralisation process of the cartilage matrix increases in the periosteal layer (Fig. 1b).