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The development of Meckel's cartilage in staged human embryos during the 5th week

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The study was conducted on 15 embryos aged 5 weeks. The primordium of Meckel's cartilage appears at stage 13 (32 days) as a rounded structure composed of fusiform and polygonal cells, which blend with other cells of the mandibular process. At stages 14 and 15 (33 and 36 days) Meckel's cartilage forms a well delineated core of small densely packed cells.

Key words: human embryology, Meckel's cartilage

INTRODUCTION

The cartilaginous and skeletal elements of the mandibular arch are formed from the embryonic neural crest [14, 16, 17, 30, 33]. Recent studies indicate that inductive epithelio-mesenchymal interactions mediated by diffusion factors are important during osteogenesis and odontogenesis within the mandible [1, 3–5, 21–23, 31, 32, 34]. Of these factors a crucial role is played by epidermal growth factor (EGF), connective tissue growth factor (CTGF), and bone morphogenetic proteins (BMP). In general, differentiation of the epithelial and mesenchymal tissues of the mandible is mutually dependent [20].

The mandibular cartilage (Meckel's cartilage) is an important skeletal component of the first pharyngeal arch and is involved in the development of the mandible. In birds this cartilage is persistent and has similar histological and molecular markers to limb cartilage [10]. In mammals Meckel's cartilage is replacement cartilage. However, it remains hypothetical as to whether persistent cartilages are actually nascent forms of replacement cartilages [10].

Despite the publication of many papers on the development of the mandible [6–9, 11, 12, 18–20, 25–27, 32] there are still controversies as to the role of Meckel's cartilage in the process of mandibular ossification. Some authors presume that Meckel's cartilage has no relationship to ossification of the mandible [20, 24, 26]. Lee et al. [19] found that the intramembranous ossification and the condensed cellular mesenchyme of the condylar blastema are closely associated with a portion of the perichondral fibrous tissue of Meckel's cartilage. There are also differences in the time of appearance and degradation of Meckel's cartilage during the human intra-uterine period [2, 7, 9, 13, 15, 24, 27–30].

The aim of present study is to trace early formation of Meckel's cartilage in human embryos during the 5th week.

MATERIAL AND METHODS

The study was performed on 15 human embryos between developmental stages 13 and 15 at 32 to 36 days of age (Table 1). All the embryos were from the collection of the Department of Anatomy, Poznań. The embryos were embedded *in toto* in paraffin or paraplast and serial sections were made in the sagittal, horizontal, and frontal planes. The sections were stained according to Mallory's method with haematoxylin and eosin, cresyl violet or toluidine blue according to Nissl's method, and were impregnated with Bodian's protargol. Graphic reconstructions were made of some embryos from each developmental stage.

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Table 1. Developmental stages and ages of the embryos investigated

No.	Catalogue number of embryo	C-R length [mm]	Developmental stage	Age [days]	Section
1	B 194	4	13	32	Horizontal
2	B 202	4	13	32	Horizontal
3	B 213	4	13	32	Frontal
4	B 203	5	13	32	Sagittal
5	B 179	5	13	32	Horizontal
6	B 171	6	13	32	Horizontal
7	A 21	6,5	14	33	Frontal
8	PJK 19	7	14	33	Sagittal
9	A 13	7	14	33	Sagittal
10	B 207	6	14	33	Horizontal
11	WA 32	8,5	15	36	Sagittal
12	PJK 5	8,5	15	36	Sagittal
13	B 69	9	15	36	Sagittal
14	B 175	9	15	36	Horizontal
15	PJK 20	9	15	36	Horizontal

RESULTS

Four pharyngeal arches are well marked in embryos at stage 13 (Fig. 1). The oropharynx and the tubotympanic recess are visible (Fig. 2). The maxillary and mandibular processes of the first pharyngeal arch are also developed (Fig. 3). In both right and left mandibular processes the primordium of Meckel's cartilage is observed (Figs. 3, 4). On the cross-section this primordium presents a rounded structure with fusiform and polygonal cells separated by large intercellular spaces. The primordium is not clearly differentiated from its surroundings. At the periphery the cells of Meckel's cartilage blend with other cells of the mandibular process. In embryos at stages 14 and 15 the mandibular process of the first pharyngeal arch increases in size and other arches are also observed (Fig. 5). Meckel's cartilage forms a clearly delineated round core of small cells (Fig. 6). In the centre of this core the cells are densely packed. This is sign of early differentiation of the cartilage. On the periphery of the core are fusiform cells forming the primordium of the perichondrium. Sagittal sections through the mandibular process in midline do not contain Meckel's cartilage (Fig. 7).

DISCUSSION

Meckel's cartilage plays an important role in craniofacial morphogenesis, viz.:

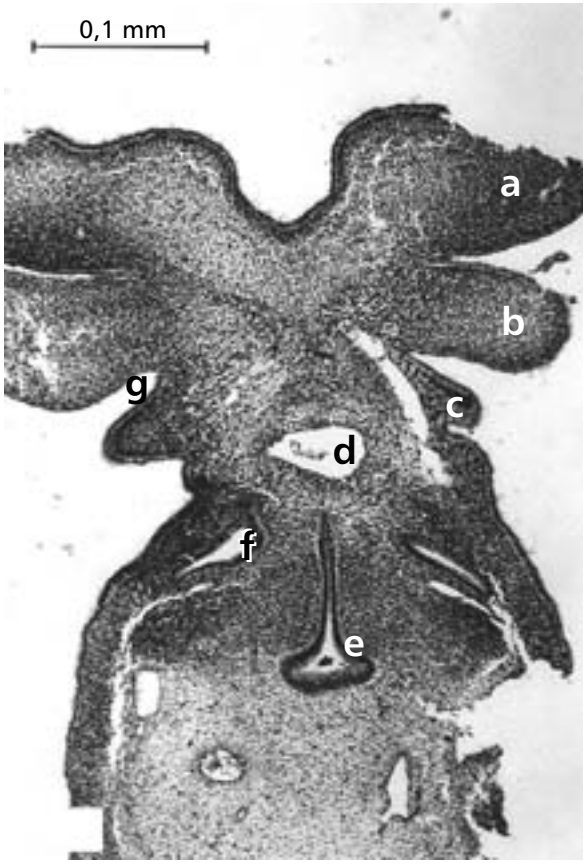

Figure 1. Horizontal section of embryo at stage 13. H+E. a — 1st pharyngeal arch, b — 2nd pharyngeal arch, c — 3rd pharyngeal arch, d — aorta, e — lung bud, f — pharyngeal pouch, g — pharyngeal cleft.

1) it guides development of the mandible, forming a morphogenetic template which exerts tension on the ossification centres [6, 14];
2) it participates in the development of the symphysis menti;
3) it serves as a means of attachment of the muscles of mastication and tongue muscles;
4) it is involved in the development of the middle ear ossicles;
5) it contributes to the formation of the articular disc of the temporomandibular joint;
6) it is important in shaping the palate;
7) it forms, early in the embryonic period, the Meckelian joint, a primary jaw joint homologous with that of reptiles.

Lee et al. [19] observed the first appearance of Meckel's cartilage in human embryos at stage 16. Other authors also found the initial formation of this cartilage in human embryos aged 6 and 7 weeks, which corresponds to developmental stages 16–20 [9, 24, 27].

In the present study we observed the first appearance of Meckel's cartilage in embryos at stage

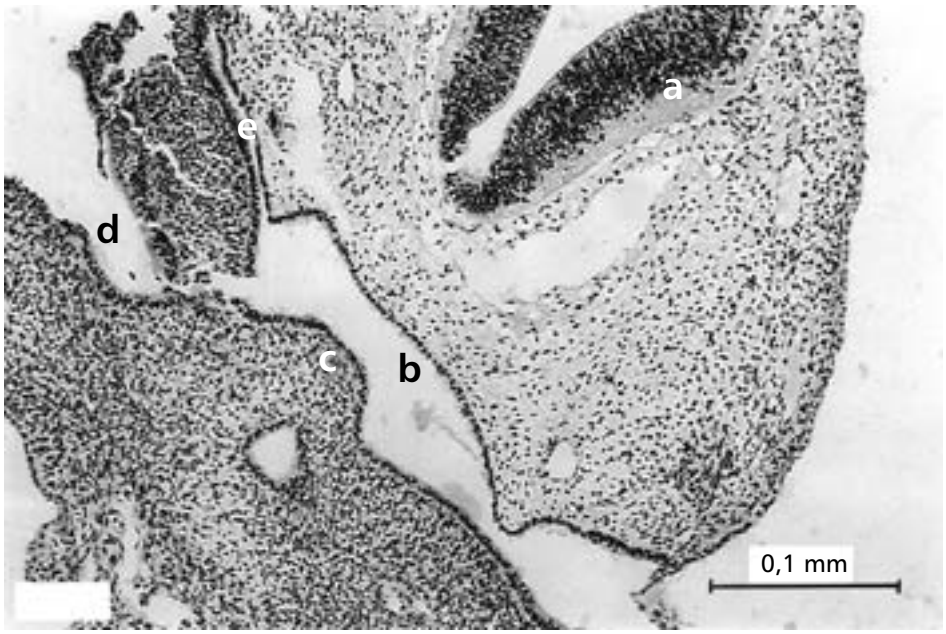

Figure 2. Horizontal section of embryo at stage 13. Toluidine blue. a — medulla oblongata, b — oropharynx, c — copula of tongue, d — 2nd pharyngeal cleft, e — tubotympanic recess.

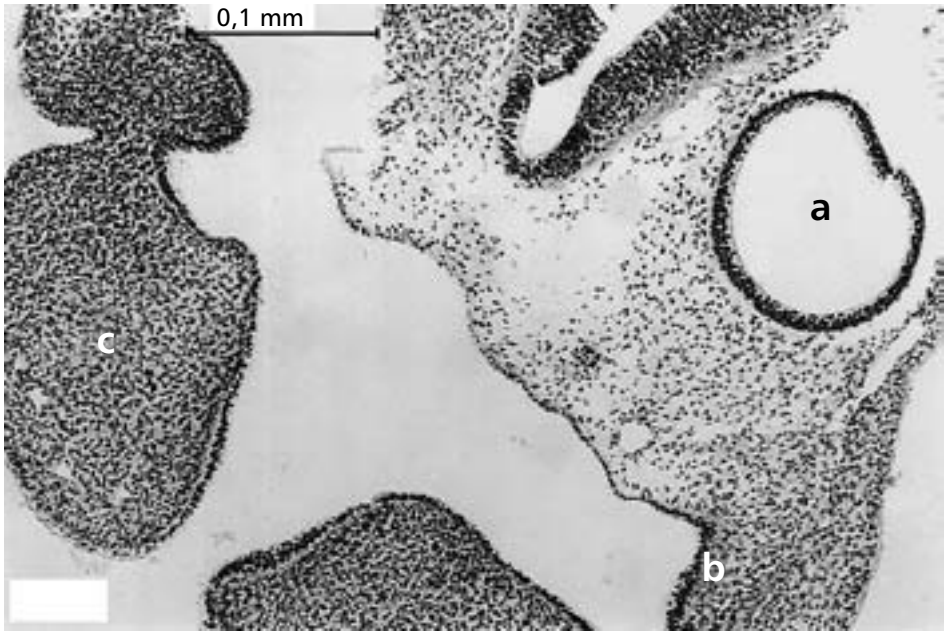

Figure 3. Horizontal section of embryo at stage 13. Bodian's protargol. a — otic vesicle, b — maxillary process, c — Meckel's cartilage in madibular process.

13 (32 postovulatory days). During the 5th week the primordium of Meckel's cartilage differentiates into cartilaginous structure.

We did not find Meckel's cartilage in the future symphysis. The mandibular symphysis (symphysis menti) is a very complex region in the developing mandible. It is evident that Meckel's cartilage participates in the formation of the symphysis [12, 13, 18]. In the later foetal period nodules of cartilage are seen in the fibrous tissue of the mandibular symphysis. The time of disappearance of Meckel's cartilage and its contributions to ossification of the mandible require further studies on human foetuses with detailed staging and precise expression of intra-uterine age.

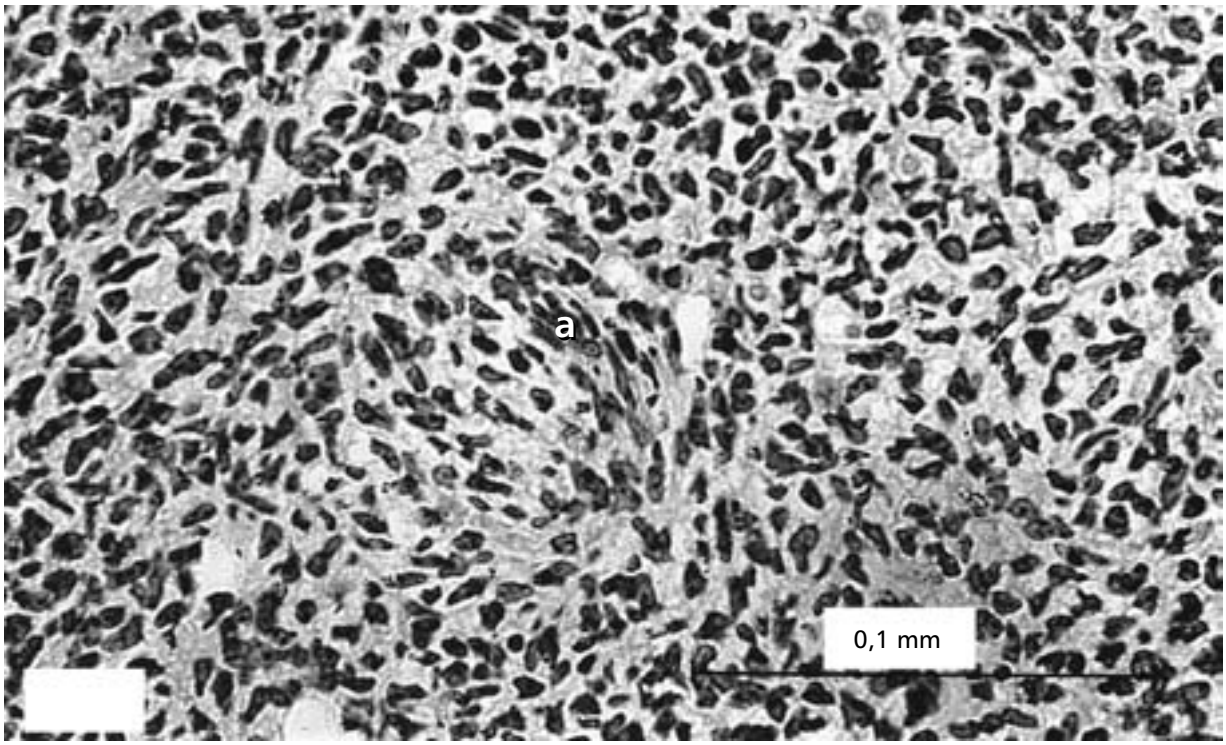

Figure 4. Horizontal section of mandibular process in embryos in embryo at stage 13. Bodian's protargol. a — primordium of Meckel's cartilage.

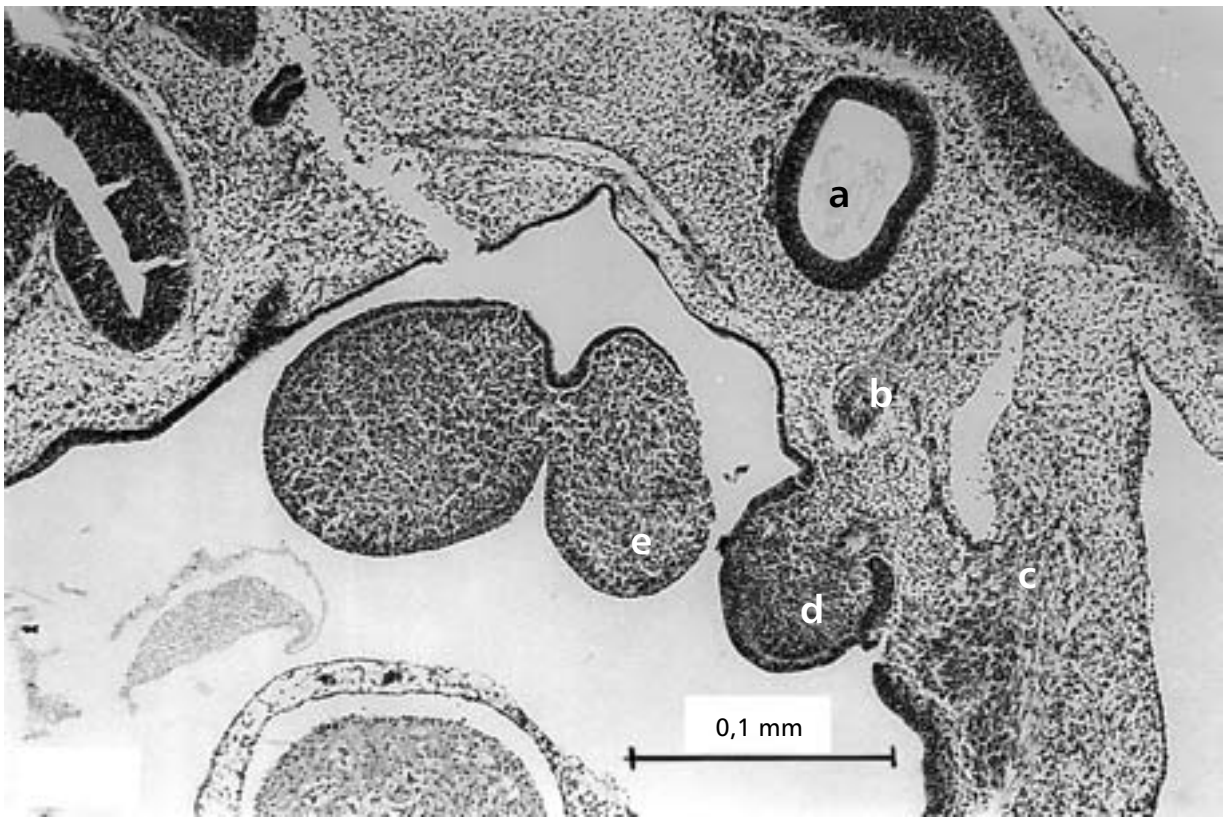

Figure 5. Sagittal section of embryo at stage 14. Toluidine blue. a — otic vesicle, b — glossopharyngeal nerve, c — vagus nerve, d — 3rd pharyngeal arch, e — 2nd pharyngeal arch.

Figure 6. Sagittal section of mandibular process in embryo at stage 14. H+E. a — Meckel's cartilage.

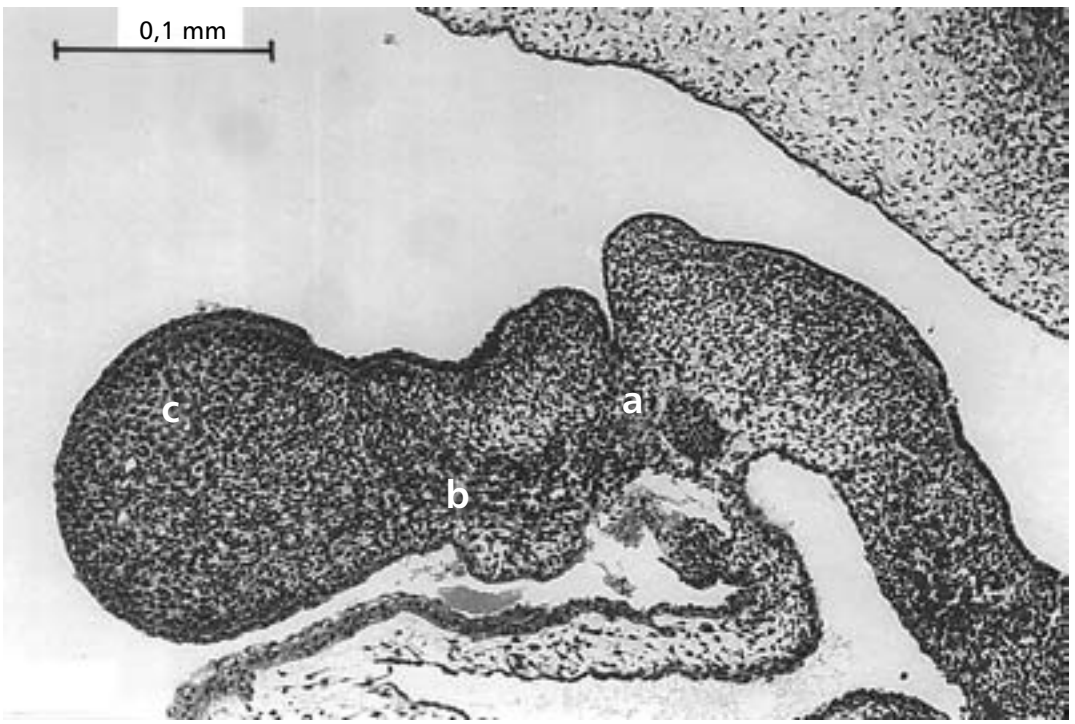

Figure 7. Sagittal section of embryo at stage 14. H+E. a — thyroid primordium, b — hypoglossal cord, c — 1st pharyngeal arch.

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