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Early development of the human palate in stages 16 and 17

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A study was performed on 12 human embryos at developmental stages 16 and 17 (6th week). In the investigated embryos the primary palate is formed from medial nasal, lateral nasal, and maxillary processes. The medial and lateral nasal processes merge and form the nasal fin at stage 16. This fin regresses and at stage 17 and persists as the oronasal membrane. The primordia of the secondary palate appear at stage 17. (Folia Morphol 2011; 70, 1: 29–32)

Key words: human embryonic period, early palatogenesis, premaxillary bone

INTRODUCTION

Despite extensive research on the development of the face and palate, there remains much controversy in the literature concerning the formation of these regions [1, 3, 5, 6, 20, 23, 26]. Much attention has been paid to the development of these structures because of the high incidence of facial malformations, especially clefts of the upper lip and palate, and the desire by both embryologists and clinicians to identify and fully explain the underlying causes of such clefts [6]. Anomalies of the face are frequently combined with those of the skull [19]. The face and palate develop from a series of growth centres termed processes and the fronto-nasal prominence. The maxillary and mandibular processes are derived from the 1st pharyngeal arch.

Various conflicting opinions have been presented about the morphogenesis of the upper lip and palate of man and animals [7, 9, 10, 11, 21–23]. The palate, which separates the oral and nasal cavities, develops in two stages as primary and secondary different embryological entities.

Some authors ignore the existence of a separate premaxillary bone (os incisivum) and the contribution of the maxillary process in the development of the upper lip [7, 14, 24, 25].

The aim of the present study is to trace the early formation of the primary and secondary palate in staged human embryos during the 6th week.

MATERIAL AND METHODS

The early development of the primary and secondary palate was examined in 12 embryos of developmental stages 16 and 17 (Table 1). The embryos were from the Collection of the Department of Anatomy, University of Medical Sciences, Poznań. Staging of embryos was expressed on the basis of 23 Carnegie stages of O'Rahilly and Müller [18]. All embryos were embedded in toto in paraffin or Paraplast, and serial sections of 5 and 10 μm were made. The sections were in sagittal, horizontal, and frontal planes. Histological sections were stained with various methods and were also impregnated with silver.

RESULTS

During stages 16 and 17, important developmental events take place. These events include:
- beginning of the development of the nasal cavity;
- development of the primary palate;
- appearance of the primordia of the secondary palate.

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Table 1. Crown-rump (CR) length, developmental stage, and age of investigated embryos

Catalogue number	CR length [mm]	Developmental stage	Age (days)	Plane of section
PJK 8	10.0	16	37	Horizontal
B 181	10.0	16	37	Horizontal
IV	10.0	16	37	Sagittal
B 176	11.0	16	37	Horizontal
B 216	11.0	16	37	Frontal
PJK 2	12.0	17	41	Horizontal
B 70	12.0	17	41	Frontal
A 12	12.5	17	41	Horizontal
B 67	12.5	17	41	Sagittal
B 64	13.5	17	41	Frontal
B 180	13.5	17	41	Sagittal
B 68	14.0	17	41	Horizontal

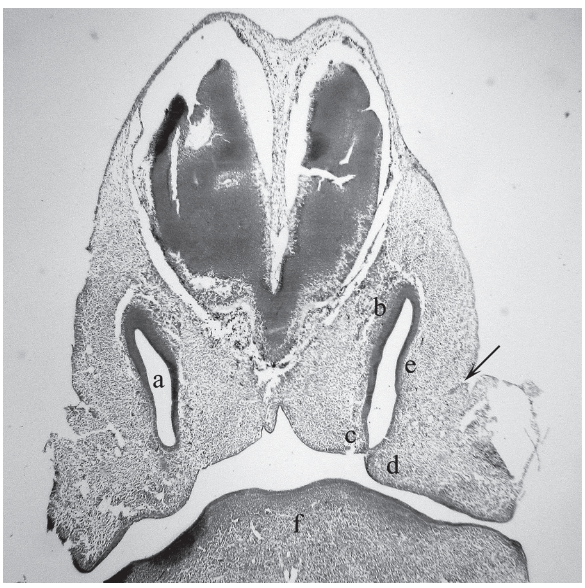

Figure 1. Frontal section of embryo at stage 16; H+E, ×40; a — nasal sac, b — cells of olfactory crest migrating to olfactory bulb, c — medial nasal process, d — maxillary process, e — lateral nasal process, f — mandible, arrow points nasomaxillary groove.

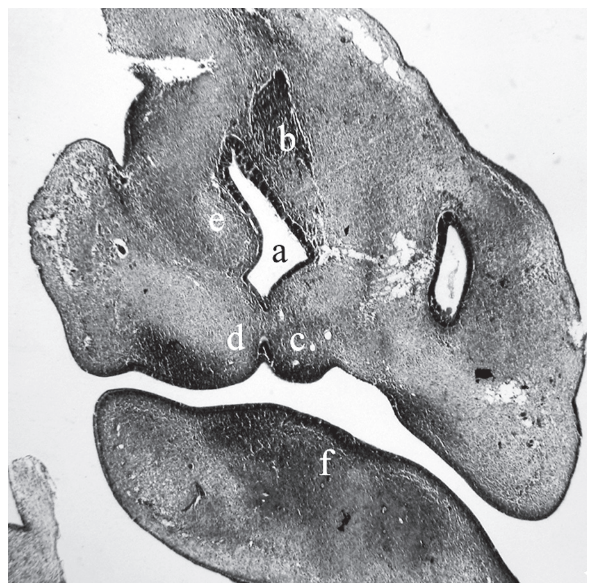

Figure 2. Frontal section of embryo at stage 17; Bodian's protargol; ×40; a — nasal sac, b — nerve cells from olfactory crest to olfactory bulb, c — medial nasal process, d — maxillary process, e — lateral nasal process, f — mandible.

In embryos at stage 16 (39 postovulatory days) the globular process, which is the termination of the medial nasal process and the mesenchymal continuity, is established. At the caudal end of the nasal sac there is a boundary groove between the medial nasal process and the maxillary process (Fig. 1). Deepening of the nasal pits converts them into nasal sacs (Fig. 2). The sacs open on the surface at the nostrils and they form the future nasal cavities. The medial and lateral nasal processes merge and form the epithelial plate or nasal fin, which regresses and in the caudal end persists as the oronasal membrane (Fig. 3), which is composed of two layers derived from the surface ectoderm. This membrane separates the nasal and oral cavities. The primary palate is formed by the premaxillary and maxillary mesenchyme, and it forms the premaxillary portion of the hard palate. This mesenchyme is formed by the

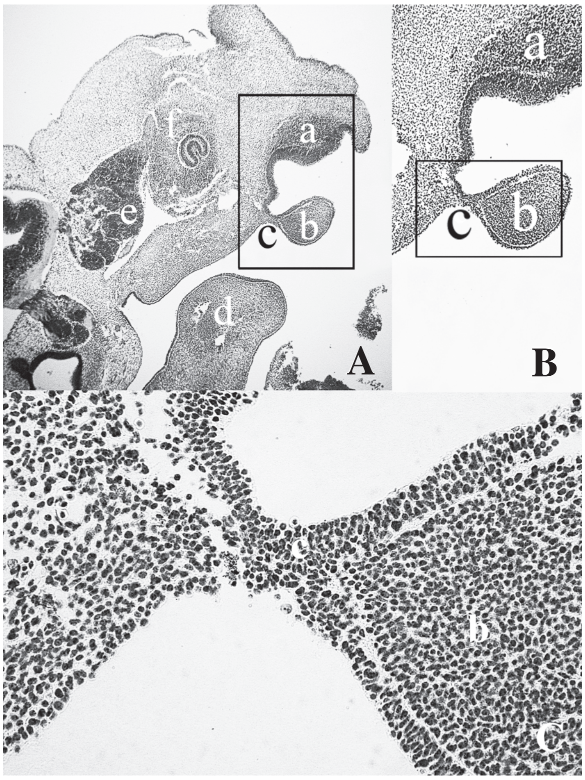

Figure 3. Sagittal section of embryo at stage 17; Bodian's protargol; **A.** ×40; **B.** ×100; **C.** ×400; a — neural crest, b — primary palate, c — oronasal membrane, d — mandible, e — trigeminal ganglion, f — eyeball.

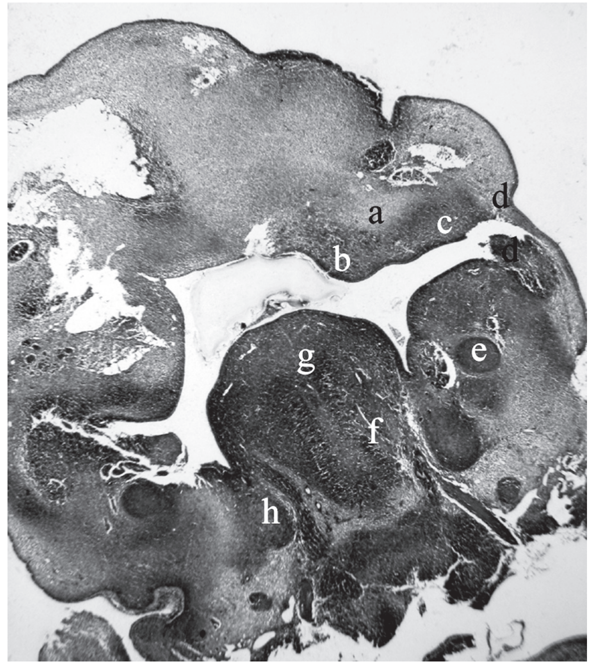

Figure 4. Horizontal section of embryo at stage 17; silver impregnation according to Ogawa; ×40; a — maxilla, b — palatine process of the maxilla, c — dental plate, d — vestibular plate; e — Meckel's cartilage, f — hypoglossal nerve, g — tongue, h — lingual nerve.

merging of the medial and lateral nasal and maxillary processes.

In embryos at stage 17 from the medial aspect of the primary maxilla develop shelf-like out--growths, which are the primordia of the secondary palate (Fig. 4). These short palatal processes are positioned over the tongue. It should be pointed out that fusion of the nasal and maxillary processes is a merging process.

DISCUSSION

According to Johnston et al. [15], facial morphogenesis has been divided into three important phases. First, the epithelial framework of the head is established, within which populations of cells migrate extensively; second, the development of facial processes and their mergence or fusion to form the face and palate; and third, further differentiation of facial process components into specialized tissues and organs.

In the head there are two principal sources of mesenchyme, the paraxial mesoderm and the neural crest [17]. Cranial neural crest is particularly important in the formation of the facial part of the skull [6]. This part of the neural crest is the source of skeletal and connective tissues in the region formed by the frontonasal prominence and pharyngeal arch processes [6, 17].

Palatogenesis is a multi-step process which involves a variety of developmental events such as cell proliferation, tissue movement, cell adhesion, epithelial — mesenchymal interaction, and programmed cell death [4, 8].

The events associated with palatogenesis are controlled by the palatal shelf mesenchyme, under the influence of many homeobox genes, transcription factors, and growth factors [16].

The human palate develops as the primary and secondary palatal regions, which are considered as different embryological entities.

Much confusion and controversy characterize the literature on the development of the primary palate. Numerous problems inherent in the development of this region involve:
- sources of tissues that contribute to formation of the primary palate;
- exact period of formation of the primary palate;
- existence of a separate premaxillary bone.

According to Moxham [16], both the primary palate and the primary nasal septum are derived from the frontonasal prominence. O'Rahilly & Müller [19] and Andersen & Matthiessen [1] conclude that the primary palate develops from the medial nasal processes and receives contributions from the maxillary mesenchyme.

The present study has shown that the primary palate is formed during developmental stage 16 with the merging of the maxillary, medial, and lateral nasal processes. The contributions of the maxillary process and both nasal processes have been confirmed by other investigators [2, 5, 11–13, 21].

Recently, Senders at al. [22] advanced a new hypothesis of lip development, dynamic fusion theory, which combines the mesodermal contributions of merging theory with epithelial fusion of processes.

Diewert and Wang [5] stated that the primordium of the primary palate is established at stage 17, and according to Rude et al. [21] the primary palate develops during the sixth week.

The performed study, similarly to those of O'Rahilly and Müller [19], showed that the primary palate is formed at stage 16.

According to Barteczko and Jacob [2], the discussion about the existence of a separate premaxillary bone (os incisivum) in humans seems to be nearly as old as the history of comparative anatomy. These authors, in their excellent paper, proved that the original premaxilla exists and that it is an important stabilizing element of the facial skull, supporting function in biting and mastication as well as contributing to the closure of the palate.

The performed study showed that the premaxillary bone is a separate structure and that it plays an important role in the morphogenesis of the facial skeleton and palate. This bone forms the primary palate.

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