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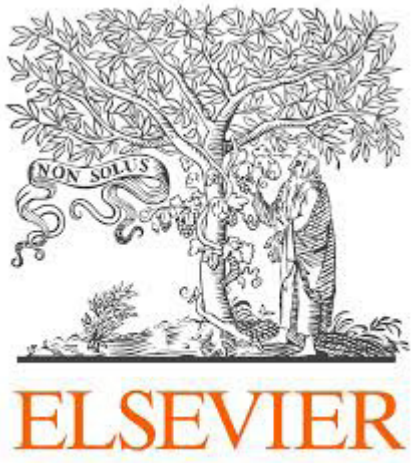

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Humanities & Social Sciences

Kuzniak Nataliya Bogdanivna,
Bukovyna State Medical University, Ukraine,
Professor, Chair of the Children's Dental Surgery Department

Development of the inner nasal cavity in animals in phylo- and ontogenesis: functional anatomic significance in the development period

Abstract: The research deals with the analysis of the nose and mouth cavity functions. We have compared them in phylogenesis of different animals before and after the secondary palate development. We have drown a conclusion about the changes of the lacrimal, salivary glands, and the mucous membrane of the nose and mouth functions connected with the development of the secondary palate in warm-blooded vertebral animals. We have compared the data with the stages of ontogenesis.

Keywords: nasolacrimal canal, paranasal sinuses, mucous membrane of nose and mouth, secondary palate in vertebral animals.

It is well-known that the main functions of the inner nose in humans are respiration and olfaction. To make their work successful and effective a human needs a large surface of the inhalable and exhalable air contact, air warming and moistening. It is known that smells are perceived only with the incoming air and their perception intensifies due to the sufficient moisturizing either of air or of the nose mucous membrane (for example, after rain). For this purpose we need a large surface of the nose mucous membrane supplied by a complicated configuration and numerous nasal sinuses and nasal passages. Among theories about possible functional significance of sinuses there exists an opinion about their role of skull mass reduction, resonance improvement, enlargement of the perceptive membrane, the inner nasal pressure regulation, and nasal cavity moisturizing by mucin. All these opinions are anatomically and physically grounded and complementary [1,2]. Real functional significance of the paranasal sinuses is unknown. We can't clarify the necessity of tear inference through the nasolacrimal canal in the inferior nasal meatus and also vegetative innervations of the nerve vascular plexus of the nose submucous layer, while as a re-

sult of nerve irritation of pterygopalatine canal there is an increased mucous producing in the nasal cavity (Feil Syndrome). The importance of these organs in animals in phylogenesis before and after the secondary palate development can explain their anatomic and functional designation.

The objective of the research is to find out the functional significance of some anatomic formations of the inner nose and their development peculiarities in phylo- and ontogenesis.

Material sand methods. In the research we used a method of comparative anatomy where we compared well-known facts of different animals' development before and after secondary palate formation in phylo- and ontogenesis. Undoubtedly, Haeckel biogenetic law cannot be absolute in such investigations, though morphogenesis with evident signs of recapitulation (concise reiteration of phylogenesis on ontogenesis) cannot be doubted [3]. Searching for the signs with important functional significance for ancestors and preserved in a modern human in a new way explains peculiarities of some pathological processes. And the way of cognition based on facts comparing and logic can be effective.

Results of the investigation. Brain development and walking upright caused changes in the form of brain and facial skull in humans. Changes in the nutrition character and organization caused development of new functional peculiarities of nose and mouth cavity. Thus, the sense of smell in humans is quite decreased, and the ability of secreted chemical factors (pheromones) perception is lost. As a result of the olfactory zone decrease a human loses olfaction with age and because of being a high rung on the evolutionary ladder. Phylogenetically the olfactory organ development can be described this way. Thus, in invertebrates the olfactory organs are olfactory pits in different parts of the body covered by ciliary epithelium. Olfactory pits in the main end of the body first appeared in chordates.

In lower vertebrates an olfactory organ develops in the form of the double-layer thickening of ectoderm on the front end of the head which further form an olfactory pit opening outwards. Many fish have two disclosing openings: front and back. Thus, the olfactory organ develops as a canal with two openings through which as a result of water penetration the olfactory ability increases. Besides, there develop different pits to hold water in the canal.

In selahii (sharks and other cartilaginous fish) olfactory pits through a channel disclose with the mouth cavity; this way the disclosing olfactory pits with the mouth cavity (choana) develop.

To strengthen the olfactory function many vertebrates develop structures increasing the layer of the olfactory epithelium. It is achieved by development of the nasal folds and conchae in the nasal cavity, and also by the way of the supplementary bosom development the mucous membrane of which doesn't have olfactory cells. Thus, having first appeared as olfactory facilities paranasal sinuses lost this ability as a result of the habitat, nutrition and respiration character changes. Paranasal sinuses formation in animals happens after the secondary palate formation, which is proved by the human embryo development. Thus, the secondary palate in embryo develops by the second month of development, and sinuses' development begins on the 3-4 month.

An important condition of preserving effective olfaction is moist olfactory epithelium. Besides, moist mouth and nose cavities are important for effective food propulsion which is especially difficult with the undeveloped secondary palate. Thus, in land animals nose development complicates with the lacrimation, nasolacrimal canals, and mucous producing regulating by the vegetative nervous system.

In many amphibians and reptiles with the undeveloped secondary palate nasolacrimal and pterygopalatine canals (Vidian nerve) open to the nose cavity disclosing with the mouth cavity. Ontogenesis in the nasolacrimal canal in humans is widely investigated. The canal development starts on the early stages of embryogenesis. In the 7mm embryos (5-6 week of the embryonic development) develops a cavity which presents the beginning of the nasal orbital furrow development, which is limited by an external and submandibular nasal outgrowth. In the area of the nasal-orbital fracture develops a thickened epithelial bundle in the upper end of which a tear-bag and lacrimal canals develop. On the 4^{th} month (11 week) of development in the thick nasolacrimo-ectodermal bundle develops an epithelial canal which is closed by a conjunctiva in the upper part, and in the lower part by an epithelium of the lateral side of the nose cavity. By the time of the eyelashes separating on the 5-7 months of the embryo's development happens an upper-membrane canalization, and a bit later a lower-membrane canalization. An abnormal resorption delay of the lower membrane may cause an inborn nasal lacrimal obstruction in newborn babies. Within a normal development the lower section of the canal is ended by the Gasner epicanthic fold. In

the upper-section of the canal there are Rosenmuller and Krauser membranes, which regulate the incoming tear from lacrimal canals into a tear-bag. Physiological significance of these membranes is not investigated yet [3,4]. Nasolacrimal canal opens on the lateral side of the nose cavity in the front third of the inferior nasal meatus.

We may assume that these valves used to regulate the incoming tear in the nose and mouth cavity and used to be a barrier to the food while the secondary palate was absent. Practically, all glands of the jaw-facial area (lacrimal, salivary, nose and mouth mucous membrane glands) in humans and other animals are regulated by facial and trifacial nerves. [6,7]. Such complicated innervations are due to the anastomoses between them and also through vegetative ganglion including sympathetic and parasympathetic fibers (eyelash, pterygopalatine, ear, lower-jaw bundles). The innervations of the lacrimal gland are fulfilled by a lacrimal nerve including the anastomoses and temporal nerve. In the innervations of the lacrimal gland also takes part a facial nerve bundle - n.intermedius (Wrisberg's nerve), in the structure of the Vidian nerve, which perforates the bone external orbital part connecting with the lacrimal gland and zygomatic region skin. When a person feels worried there appears an irritation of the sympathetic nervous system on the skin of zygomatic region (innervations zone n. zygomaticofacialis) appears a white 3 mm ischemia spot and dry sclera of the corresponding eye. Transmission these nerves through the bone of the external orbital side can be explained by peculiarities of the phylogenetic development of the facial skull. Due to Schmalhausen I.I. (1938), in the mammals (platypus, etc.) orbit is not completely developed and in the direction of malar and frontal bone is quite vast space displaced by soft tissues inside of which the nerves are placed. Such a comparison explains peculiarities of the anatomic face built.

The trifacial nerve system as well as the vegetative nervous system (pterygopalatine bundle, Vidian nerve) supply innervations of the nose mucous membrane in the result of which cells and submucous glands produce mucous covering the inner surface of the nose and paranasal sinuses. Daily from 0,5 to 0,7 liters of mucous are produced. Lacrimal glands normally produce 0,5-1,0 ml of tears [8,9]. The exact amount of the tear coming in the mouth cavity is difficult to calculate, though we assume that it is quite big. For instance, many patients admit quick lacrimation while reading in bed which is connected with the change of the tear flow direction along the nasal lacrimal canal.

Disfunction (large increase) of the mucous production happens during the neuralgia of the Vidian nerve (Feil Syndrom). Intersection of this nerve (Golding-Wood surgery, 1961) decreases mucous production in the mouth cavity and causes xerophthalmus.

Of great interest is development of the mouth glands in vertebrates. In fish and water amphibians that live in water habitat there are no complicated mouth glands. They appear when animals go on land and serve for moistening the food and moisturizing the mouth-nasal cavity. Phylogenetically, mucous glands (unpaired paranasal gland in amphibians, sublingual, labial glands and also poison-producing glands of teeth in reptiles) appear first. Birds have glands in the palate and sublingual glands which are especially developed in the granivorous birds [10,11]. Development of the big salivary glands is typical for mammals and connected with the nutrition changes, secondary palate formation, intensive metabolic processes and energetic costs. Besides, glands start producing not only mucous but also serous which is helpful at the primary stage of digestion. Sublingual and submandibular glands are probably a rudiment of the reptiles' sublingual gland and the parotid gland, developed from buccal glands, is a new acquisition of mammals.

First animals with the secondary palate appeared in the middle of the Permian period. This last period of the Paleozoic era (280 million years ago) was characterized by a rapid fall of temperature and need to use new more effective energetic way of nutrition. At the same time giant equisetum and moss disappeared, forests stepped back to equator and many amphibians died (cold-blooded), who could not adapt to cooling down. Secondary palate is a hemogenetical structure, which means it has similarities in different species that do not have common origin. Independently it developed in crocodiles, turtles, mammals and some lizards, which is an example of convergent evolution. Secondary palate turned out to be very necessary to survive and played a crucial role in the development of the warm-blooded. With the development of the secondary palate upper jaws and facial skull became stronger; later masticatory teeth appeared. Importance of mucous and lacrimal glands limited to the nose cavity and serous and mucous glands of mouth received new functions of animal and vegetable food digestion.

Discussion of results

In humans and animals with the secondary palate nasal lacrimal glands lost their initial applicability – the moisturizing agent in amphibians and reptiles. Probably

it's the involution of the nasolacrimal meatus. In many cases meatus lower valve (Gasner membrane) after the child's birth closes the nasal lacrimal canal and may be a cause of the inborn obstruction. Humans phylogenetically and functionally preserved only the moisturizing function of the nose mucous membrane (from 1 to 10 ml tears a day), though if it was the main function the opening of the canal would be in the upper nasal canal.

Glands innervations of the jaw-facial area are possible due to the tri-facial, facial, glossopharyngeal nerves, their anastomosis, and interrelation influencing the vegetative nervous system.

Trifacial nerve evidently has a prominent functional role, though facial nerve also including motor nerve, secretory, sensible fibres and plays role in developing aural sense, taste, mucous membrane secretion and saliva production.

In reticular bridge formation together with the nucleus of the facial nerve there is an upper salivary nucleus (nucleus salivatorius cranialis superior) which is a vegetative innervations center of the submandibular, sublingual and salivary glands. Salivary, submandibular and mucous glands of the nose are phylogenetically more ancient as provide nose and mouth cavity moisturizing within the absent secondary palate in amphibians and some reptiles which helps in food propulsion (insects, reptiles with dry surface). Position of the common nuclei which provide glands' functioning also presents such neuroformations' unity. Thus, in humans salivary and lacrimal glands secret is limited by the nose cavity after the secondary palate formation. This provides olfaction and moisturizing of the nose mucous membrane. Pathological processes development is much connected with the limitation of the nose cavity by a secondary palate. Such anatomic built is caused by inborn obstruction of the nasolacrimal canal, its inflammatory processes and development of rhinitis connected with neuritis and neuralgia.

Human salivary glands daily produce from 1,5 to 2 liters of saliva providing preparation and primary food digestion in the mouth cavity.

Thus, during phylogenesis nose and mouth cavity were anatomically and functionally separated. Though, if take into account common innervations, blood circulations and reaction to external distracters, in our opinion, such group of glands (lacrimal, mucous, salivary) can be a unified system of primary neurosecretory reaction while contacting with the environment.

Conclusions

1. The method of comparing phylo- and ontogenetical data is effective within the functional meaning of the human organs.

2. Phylogenetically the earliest structures of the nose and mouth cavity in coldblooded which have only primary cavity (amphibians and reptiles) is nasolacrimal and Vidian canal, nose and mouth mucous glands, lacrimal and sublingual glands. They serve for moisturizing and swallowing the food (insects, reptiles, etc.).

3. Ontogenetically nasolacrimal canal starts developing on the 1st month of the embryonic development. Big salivary glands develop after the secondary palate development or simultaneously with it, which produce mucous secretion first two years after birth. Development of the perirhinal bosom begins on the 3-4th month of the embryonic life, after the secondary palate development. Such ontogenetic sequence of nose, mouth and palate development is the same as in animals in phylogenesis.

4. Development of the secondary palate in warm-blooded vertebrates changed (limited) functional applicability of the lacrimal gland and nasolacrimal canal, mucous glands of nose and vegetative innervation.

5. Groups of lacrimal, mucous glands of nose and mouth, big salivary glands are a unified system of primary, neurosecretory reaction to an environment.

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