POSTNATAL DEVELOPMENT OF THE SUBMAXILLARY SALIVARY AND EXTERNAL ORBITAL LACRIMAL GLANDS OF WHITE RATS

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It has been shown that the dimensions of the terminal portions in regenerated salivary and lacrimal glands of rats do not differ from the size of the terminal portions of the same glands of control animals [1-3]. The absence of an appreciable increase in the size of the structural units in regenerated glands gives us grounds to assume that during their regeneration new acini are formed in the entire remaining portion of the gland.

The question arose whether the development of the gland is always accompanied by a formative reaction with the development of new structural units or whether this is characteristic only for regeneration of the gland, i.e., its secondary development. We were especially interested in how long the capacity to form new terminal portions in the indicated glands was retained during the postnatal period of animal development. We could not find any definite information in this regard in the literature. Gabe [4] noted the formation of new terminal portions in the submaxillary gland of mice only during seven days after birth. In the external orbital gland of rats the development of new acini, according to the data of Walker [8], is completed by three weeks of age.

However, the data of other authors [5, 6] permit the assumption that the structural units in the salivary glands are formed even at later periods of life of the animals. According to their observations, the submaxillary gland of rats and mice at birth consists of a system of terminal tubules which is gradually replaced by an acinal structure. This reorganization of the submaxillary gland ends in mice 4-5 weeks and in rats 6-7 weeks after birth. Consequently, new acini can be formed during this entire time. How further growth of the gland occurs cannot be judged from the indicated works since cessation of the formation of new acini is not accompanied by an increase of the dimensions of those present (the latter remain the same from 6 weeks up to 6 months after birth).

This induced us to again investigate how the structure of the salivary and lacrimal glands and mainly the formative processes in them change with age. For this purpose we traced the change of rate, size of the lobes, acini, ducts, nuclei, and mitotic activity of the glands of rats of various ages.

EXPERIMENTAL METHODS

We investigated the submaxillary and external orbital lacrimal glands of 3-, 7-, 14-, 22-, 40-, 75-, and 180-day-old white rats (a total of 30 animals). At each period of the investigation we killed from 3 to 6 rats of the same litter between 10 and 11 AM. The glands were isolated, weighed on a torsion balance, fixed in Zenker's fluid with formalin, and embedded in paraffin. Sections 6 μ thick were stained with hematoxylin-eosin and impregnated with silver after Gomori to elicit the boundaries of the acini. The experiments were carried out during spring-summer.

The mitotic activity of the epithelial cells was determined under a MBI-3 binocular microscope (objective 90×, ocular 7×, aperture in the diaphram of the ocular 7 × 7 mm). We counted 3000 epithelial cells of the 3- and 7-day rats and 12,000-18,000 cells of the animals of the other age groups. The mitotic index reflected the number of mitoses per 1000 cells (per mills).

TABLE 1. Change of the Indices Characterizing the State of the Submaxillary Gland of Rat during Growth

Age of animals (in days)	No. of animals	Average weight			Mitotic index	Area (in μ^2)			No. of acini in lobe
		rat (in g)	gland			lobe ($\times 10^3$)	terminal divisions	nuclei	
			mg	% of body wt.					
3	3	5,3	10,0	0,18	10,2	—	340	—	—
7	3	7,6	12,8	0,16	4,76	18	312	12,1	37
14	3	15,0	22,0	0,14	3,46	101	306	—	60
22	4	47,0	83,0	0,18	3,77	144	477	12,2	109
40	5	71,0	83,0	0,12	0,65	150	409	15,3	174
75	6	270,0	249,0	0,09	0,04	325	613	—	227
180	6	330,0	280,0	0,02	0,013	470	670	18,3	240

TABLE 2. Change of the Indices Characterizing the State of the Orbital Part of the Lacrimal Gland of Rat during Growth

Age of animals (in days)	Av. wt. of gland		Mitotic index (in %)	Area of acini (in μ^2)
	mg	% of body wt.		
3	1,0	0,02	—	—
7	2,4	0,03	16,2	500
22	25,0	0,05	3,8	615
40	38,0	0,05	0,14	852
75	95,0	0,04	0,03	1 068
180	101,0	0,03	0,04	1 579

The area of the lobe of the gland, in acini, and ducts was determined by using Edinger's drawing apparatus (50 and 350 ×) and the area of the nuclei by using the "Abbe" drawing apparatus (objective 90 ×, ocular 20 ×, extended tube 160 mm). The paper drawings of the lobe, acini, ducts, and nuclei were cut out and weighed on a torsion balance. Their area was expressed in square microns by means of an object-micrometer. In each case we measured 100-150 acini, 100 nuclei, 50 ducts, and 25 lobes.

The data were statistically analyzed by the Student-Fisher method.

RESULTS

The data obtained are shown in Tables 1 and 2. The entire submaxillary and orbital part of the lacrimal gland increase with age. Both glands grow most intensely between the 7th and 22nd day after birth. Then an appreciable increment of weight of the glands is noted between the 40th and 75th day of postnatal development.

The weight increase of the submaxillary gland is accompanied by an increase of the size of its lobules. The latter up to the 40th day of age is due to an appreciable formation of new terminal divisions. This is indicated by the results of counting the acini per one lobule, the number of which significantly increases from period to period. Furthermore, indirect proof of the formation of new terminal divisions in the submaxillary gland at this period of life of the animals is the fact that the size of the acini change negligibly during the appreciable weight increase of the gland. We can assume that the formation of new terminal divisions is provided by the high mitotic activity of the epithelial cells. According to our observations the gland acquires an acinar structure between the 14th and 22nd day of life. The duct portion of the gland differentiates into an intercalated portion and salivary tubules beginning with the 7th day of age.

The second weight gain of the submaxillary gland between the 40th and 75th day after birth, from our point of view, is due to several processes. By this time the size of the acini increases with statistical significance. The latter is accompanied by a corresponding increase of the area of the cells and nuclei. The formation of new terminal divisions apparently occurs also at this period, but it is less evidenced than in preceding periods. The difference in the number of acini per one lobe of the gland in 40- and 75-day rats just approaches statistical significance ($P = 0.08$). Furthermore, an increase in the weight of the gland at this period is due, to a considerable extent, to the appearance of a new large portion of its duct part, the convoluted ducts. This division of the gland, absent in the 40-day immature rats, is a characteristic structure of the submaxillary glands of certain rodents. Its appearance at the time of sexual maturation has been noted by other authors [4-6]. In rats, unlike in mice [7], the diameter of the convoluted ducts is identical regardless of sex. The appearance of convoluted ducts leads to approximately a doubling of the relationship of the ductal and acinar parts of the gland. The growth of the gland between the 75th and 180th day after birth is due exclusively to an increase in the size of the cells, nuclei, acini, and convoluted ducts. The mitotic activity of the epithelial cells at this period is extremely low.

The growth of the orbital part of the lacrimal gland occurs somewhat differently. Its weight gain is due mainly to changes in the acinar part. The area of the acini of the gland progressively increases in the animals as they grow (Table 2), which is caused by an increase of cell size since their number in the field of view markedly decrease with age. A characteristic feature of the orbital part of the lacrimal gland is the pronounced polymorphism of the nuclei which is distinctly manifested even in 40-day-old rats. However, despite the progressive increase of the terminal divisions, their number increases. Between the 7th and 22nd day after birth the formation of new acini is beyond doubt and is due to the rather high mitotic activity of the secretory epithelium, which was also pointed out by Walker [8]. A ten-fold weight gain of the gland is accompanied only by an insignificant increase of the acini.

Later, at the period of the second marked increase of weight of the gland between the 40th and 75th day after birth, the formation of new acini is apparently possible. This is indicated by indirect data – by comparing the rate of growth of the gland and the increase in the area of the acini.

Thus, the results obtained permit the conclusion that the capacity to form new terminal divisions in the submaxillary gland and the orbital part of the lacrimal gland during the postnatal period of development is retained for a rather long time. This is in accord with the data of Jacoby and Leeson [6]. However, glands whose acinar part acquired the appearance characteristic for glands of mature animals, also have this capacity. New acini are formed with particular intensity in glands up to 40 days of age, which is due to high mitotic activity of the epithelium of the terminal divisions. After 40 days of life new terminal divisions are formed less intensely in the glands; this is apparently due to the still continuing proliferation of the acinar cells. After 75 days after birth the mitotic index in the acinar cells is extremely low and the glands grow exclusively by an increase of the structural components of the organ.

SUMMARY

The object of study was the character of the growth of the submaxillary salivary and the external orbital glands. The weight of the glands, the size of their lobules, acini, nuclei, and the mitotic activity of the secretory cells were determined. It was found that up to the age of 40 days the increase in the gland weight is due mainly to the formation of new acini; the latter takes place by proliferation of the cells of the terminal portions. After 40 days, the formation of new terminal portions occurs in a slight degree. The growth of the gland by the age of 75 days and later is due exclusively to an increase in the size of all structural components of the organ, and in the submaxillary gland also to the appearance and growth of convoluted ducts.

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