Histological observations of eyelids of the Japanese monkey and the rhesus monkey

(Histological studies of Primates 1)

By

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Introduction

Histological studies on the human eyelid have been reported by many investigators (Virchow, 1904; Eggeling, 1905; Adachi, 1906; Kreiker, 1935; Lauber, 1936; Seto, 1953; Aoki et al., 1953; Rohen, 1964), while the eyelids of monkeys and apes have been studied only by Adachi (1906), Kolmer (1930) and Yamamoto et al. (1959). Further, on the eyelid of Japanese monkey, no histological study has been published. The present authors had a chance to observe those of Japanese monkeys and rhesus monkeys and some new findings will be described.

Materials and Methods

Materials used are eyelids from 4 Japanese monkeys, *Macaca fuscata* Blyth (two males of about 5 years old, a female of about 15 years old and a male of 8 years old) and two rhesus monkeys, *Macaca mulatta* Zimmerman (males of about 5 years old). Materials were fixed in 10% formol solution, and embedded in paraffin, and then were serially cut in sagittal section at 6 to 8 microns. These sections were stained by hematoxylin-eosin stain, Heidenhain's azan stain, Weigert's resorcin-fuchsin stain for elastic fibers and van Gieson's acid fuchsin stain for collagenous fibers.

Observations and Discussion

I. Macaca fuscata

1. Palpebra superior

The cutaneous side of the eyelid of Japanese monkeys is covered

with a three to five layered hornified stratified squamous epithelium and the papillae are more poorly developed than in the human eyelid. At the marginal part of the eyelid, the epithelium becomes gradually thicker and at the posterior lid-margin it represents a 11 to 1 layered one, but the papillae are still ill-developed. At the cutaneous part of the eyelid, melanin granules are scarcely contained only in the basal layer of the epidermis when compared with those in the human (Japanese), and near the anterior margin of the eyelid they show increase in quantity, and then at the lid-margin they are abundantly contained in cells of basal and pickle-cell layers of the epidermis.

In immature animals, the conjunctiva palpebrae are covered with a stratified squamous epithelium near the posterior lid-margin. At the level somewhat lower than the middle height of the tarsus or the level of lower one-third of the conjunctiva palpebrae, the stratified squamous epithelium passes into a stratified columnar epithelium with goblet cells. On the other hand, in adults, the stratified squamous epithelium decreases in thickness after passing over the sulcus subtarsalis. At the upper tarsal region the epithelium is transformed into a columnar epithelium with many goblet cells.

Mode of the transition of epithelium shows a difference by genus and species of animals. Eggeling (1905) stated that, in the Malayan flying lemur, *Cynocephalus variegatus* Audebert (Dermaptera) and the white-fronted lemur, *Lemur fulvus albifrons* E. Geoffroy, the stratified squamous epithelium of the lid-margin turned over the inner surface of the eyelid only in a short distance, while in the Hamadryas baboon *Papio hamadryas* Linnaeus, the transition occurred more closer to the posterior lid-margin than in the above two species. According to Adachi (1906), the transition in the white-handed gibbon, *Hylobates lar* Linnaeus, was gradual, but in the common squirrel monkey, *Saimiri sciurea* Linnaeus and the mongoose lemur, *Lemur mongoz* Linnaeus it was seen in the vicinity of the posterior lid-margin. In the lion marmoset, *Leontocebus rosalia* Linnaeus, all tarsal part of the conjunctiva was covered with a non-hornified squamous epithelium, and a columnar epithelium began to appear beyond the upper border of the tarsus (Adachi, 1906). In the brown macaque, *Macaca speciosa* Cuvier, the transition was completed near the posterior lid-margin on the inner surface of the eyelid (Adachi, 1906). Yamamoto et al. (1959) reported that the transition in a Formosan macaque *Macaca cyclopis* Swinhoe, was suddenly observed passing over the posterior edge of the lid-margin. In the columnar epithelium, melani-

granules are almost not found (Yamamoto et al., 1959).

Adachi (1906), in *speciosa*, described a rather conspicuous transversely-running groove parallel to the posterior lid-margin, which was observed at the level of the lower end of the tarsus on the mucous side of the eyelid. He named it sulcus subtarsalis and assumed the sulcus as to be specific to the monkey. The sulcus subtarsalis is also described in *cyclopis* (Yamamoto et al., 1959). In adults of *fuscata*, the sulcus subtarsalis was observed, but in immature ones obscure.

In the cutaneous side, the subcutaneous tissue does not contain any fatty tissue, while in human eyelids (Japanese) some fatty tissue are common in general. Hairs in this part are thin and short, and are not accompanied with m. arrector pili. Sweat glands are observed fewer than in the human palpebrae. Kolmer (1930) described in the night monkey, *Aotes trivirgatus* Humboldt that the sweat glands were well developed in both palpebrae especially inferior one.

Dense connective tissue area is seen between the lower limit of the tarsus and the lid-margin epithelium. Two or three rows of eyelashes are found near the anterior edge of the lid-margin. Each eyelash is accompanied with a sebaceous gland, Zeis' gland. But the eyelashes of *fuscata* are not accompanied with m. arrector pili as in the other primates (Adachi, 1906; Yamamoto et al., 1959), while in pig, sheep, goat, cattle, horse, cat and dog, Zietzschmann (1904) described the existence of mm. arrectores pilorum attached to the eyelashes. Moll's glands of the monkeys are less in number and more simply formed than in the human eyelid.

The pars palpebralis of m. orbicularis oculi is situated in front of the tarsus, and its lower part which is called m. ciliaris Rioli is divided into an anterior part, pars marginalis s. ciliaris and a posterior one, pars subtarsalis. Pars orbitalis deviates outward at the height of the fornix conjunctivae.

In the tarsal part of the palpebral conjunctiva, the propria mucosae are very thin in thickness, while in the upper portion beyond the tarsus, they become thicker by confluence with pretarsal connective tissue.

On the tarsus, Eggeling (1905) stated that among many species of mammals only the last named monkeys including two primates, *Lemur fulvus albifrons* and *Papio hamadryas*, had tarsi in their eyelids. However, Zietzschmann (1904) reported that the tarsus is provided in the eyelids of pig, sheep, goat, cattle, horse, cat and dog. Adachi (1906) and Yamamoto et al. (1959) reported the presence

of the tarsus in monkeys. The present authors recognized the existence of tarsus in Japanese monkeys. Such disagreement of opinions, as Adachi (1906) pointed out, can be assumed to be due to vagueness of the boundary between tarsal dense connective tissue and the surrounding one. Kolmer (1930) reported in the vervet monkey, *Cercopithecus aethiops griseoviridis* Desmarest, that in the lower palpebra there was contained no conspicuous tarsus but in the middle part of the palpebra fatty body consisting of many acini was observed.

Virchow (1904) described two types of Meibom's glands in the middle part of the upper tarsus of apes; one is stout but short and located in the marginal parts of eyelid, and the other is long and thin and extending upwards to the upper part of the tarsus. He thought that the latter developed secondarily from the former. Also the present authors found two types of Meibom's glands in the middle part of the upper eyelid of *fuscata* and the short ones were well developed. In the other parts of the upper palpebra and lower palpebra, the short type of this gland is not seen. According to Adachi (1906), the long type is not seen in prosimiae, while the glands of both types are equally well developed in the higher primates, man and anthropoid apes.

Between the m. orbicularis oculi and the tarsus, there exists pretarsal connective tissue (prä-tarsal Bindegewebe, zentrale Bindegewebsschicht Schwalbe) which had no fatty tissue.

Between the distal end of m. tarsalis (Müller's tarsal muscle) and the upper end of tarsus superior, the present authors found a thin layer of elastic fibers. This tarsal elastic layer represents a meshwork consisting of sagittal and transverse fibers. In immature monkeys, the tarsal elastic layer is very long comparing with adults because the tarsus in the latter is higher than in the former. This is a hitherto undescribed structure in monkey eyelids. In human however, Lauber (1936) stated that the distal end of m. tarsalis is connected with the upper pole of the tarsus by about 1 mm long connective tissue which is abundant in elastic fibers. Similar structure is called "elastische Sehne" by Rohrer (1964).

2. Palpebra inferior

Although the palpebra inferior is slightly smaller in height than the palpebra superior, its histological details do not essentially differ from those of the latter. Fatty tissue is not included in the corium and pretarsal connective tissue. Between the lower end of the tarsus and the upper end of the m. tarsalis, there is found the elastic layer mentioned above. The Meibom's glands are well developed

oped, but that of short type is almost not seen. In the adult, the sulcus subtarsalis (A d a c h i) is recognizable, while in immature obscure.

II. *Macaca mulatta*

1. Palpebra superior

As a whole, the form in sagittal sections of palpebra is more slender than in *fuscata*. The cutaneous side is covered with a hornified stratified squamous epithelium. At the anterior lid-margin, the epithelium becomes non-hornified and the lid-margin is covered with thick non-hornified epithelium. Passing over the posterior lid-margin, the epithelium becomes gradually thin and is intermingled with goblet cells which disappear at the sulcus subtarsalis (A d a c h i). Melanin granules are almost similar in quantity and distribution to those of *fuscata*. Papillae are less developed and irregular.

The conjunctiva palpebrae in the upper tarsal part is covered with a thin two layered stratified squamous epithelium, and beyond the upper end of the tarsus the epithelium is changed with a stratified columnar epithelium with many goblet cells. This mode of transition is similar to that of *Leontocebus rosalia* (A d a c h i, 1906).

The corium of the cutaneous side is much less developed in thickness than in *fuscata*. The hairs and sweat glands are less in number than in *fuscata*. No fatty tissue is observed in the subcutaneous tissue.

The propria mucosae of the conjunctival side are very thin in thickness. The tarsus is as high as that of the adult *fuscata*. Between the upper pole of the tarsus and the distal end of m. tarsalis, the tarsal elastic layer is observed as well as in *fuscata*. Meibom's glands can not be classified to two types which are seen in the superior palpebra of *fuscata*. Pretarsal connective tissue is less in thickness than in *fuscata* and does not contain any fatty tissue.

The m. orbicularis slightly deviates to the cutaneous side. It is less in thickness than in the *fuscata*.

2. Palpebra inferior

The palpebra inferior is not differ in histological detail from the palpebra superior. The hairs in cutaneous part are somewhat more numerous in number than in the upper palpebra. In the posterior surface, there is a sulcus subtarsalis (A d a c h i). The tarsal elastic layer is also seen in the inferior palpebra. Fatty tissue is not observed in the corium and the pretarsal connective tissue as in palpebra superior.

Summary

Four Japanese monkeys and two rhesus monkeys were used as materials, and the palpebrae obtained from these animals were investigated histologically.

1. *Macaca fuscata* (Japanese monkey)

In the palpebrae of the Japanese monkeys, the cutaneous side is covered with a thin hornified stratified squamous epithelium and papillae are very poorly developed. In the lid-margin the epithelium is thick and at the posterior lid-margin it becomes non-hornified.

On the inner surface of the palpebra in adult animals, sulcus subtarsalis (A d a c h i) is seen, while in immature ones it is obscure. In adults, passing over the sulcus subtarsalis, the epithelium becomes very thin, and at the level of the upper tarsal part the epithelium is replaced with a columnar epithelium with many goblet cells, whereas in immature animals the epithelium is rapidly transformed to a stratified columnar epithelium with abundant goblet cells at the lower tarsal part.

The corium of the cutaneous side contains sweat glands less in number than in the human palpebra (Japanese). Moll's glands are more simple in form and less in number than in the human. No fatty tissue is observed in the subcutaneous tissue and the pretarsal connective tissue.

Between the proximal margin of the tarsus and the distal end of the m. tarsalis, a thin elastic layer is observed representing a meshwork of sagittal and transverse fibers, which is hitherto undescribed in the monkey palpebra.

Meibom's glands in the middle part of superior palpebra are differentiated into two types, one is short and the other long.

2. *Macaca mulatta* (rhesus monkey)

The eyelids of *Macaca mulatta* are thinner and higher than those of *Macaca fuscata*. In the inner side of the palpebra, there exists sulcus subtarsalis (A d a c h i), and beyond the sulcus the stratified squamous epithelium becomes very thin and is mingled with a few goblet cells, and then near the fornix conjunctivae the epithelium is replaced with a columnar epithelium with numerous goblet cells.

Hairs and sweat glands are fewer than in the Japanese monkeys. Fatty tissue does not contain in the subcutaneous tissue and the pretarsal connective tissue. The tarsal elastic layer is seen as the Japanese monkey. Meibom's glands can not be classified to two types.

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Explanation of figures

- Fig. 1. The transitional part of the epithelium in the conjunctiva palpebrae of a male Japanese monkey of about 5 years old. Hematoxylin-eosin stain. $\times 80$.
- Fig. 2. The tarsal elastic layer between the proximal end of the tarsus and the distal end of the m. tarsalis in a male Japanese monkey of 8 years old. Weigert's stain. $\times 120$.
- Fig. 3. The transitional part of the epithelium at the fornix conjunctivae of a male rhesus monkey of about 5 years old. van Gieson's stain. $\times 80$.
- Fig. 4. The tarsal elastic layer between the proximal end of the tarsus and the distal end of the m. tarsalis in a male rhesus monkey of about 5 years old. Weigert's stain. $\times 80$.
- Fig. 5. Sulcus subtarsalis at a male rhesus monkey of about 5 years old. Meibom's gland is seen at the left. van Gieson's stain. $\times 80$.