The Anatomy of the Lacrimal Portion of the Orbicularis Oculi Muscle (Tensor Tarsi or Horner's Muscle)

By

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Summary: Horner's muscle (the palpebral part of the orbicularis oculi muscle) has a fan-shaped origin in the lacrimal bone. Its muscle fibers are oriented from 160 to 210 degrees relative to the ear-eye plane and converge towards the medial palpebral commissure. Then the muscle divides into superior and inferior bundles of fibers. Some of the lower fibers participate in the formation of the superior bundle and some of the higher fibers participate in the formation of the inferior bundle and, thus, some of Horner's muscle is twisted. Each bundle courses laterally to the lateral palpebral commissure and has three insertions. The first insertion is located at the medial margin of the tarsi. The second insertion is into the subcutaneous tissue along the palpebral margins. Minute fascicles of Horner's muscle are fastened to the palpebral margins. The third insertions are into the lateral palpebral ligament and subcutaneous connective tissue of the lateral commissure. Serial histological sections of a fetus at 14 to 16 weeks gestation revealed that the extent of the envelope formed by Horner's muscle around the lacrimal canaliculus decreases gradually from the lacrimal papilla to the lacrimal sac. The various observations suggest the following roles for Horner's muscle: (1) it closes the medial canthus of the eye and closes the lacrimal punctum; (2) it pulls the tarsus medially; (3) it tautens the palpebral margins and presses against the eyeball; and (4) it squeezes the lacrimal canaliculus with a decreasing gradient of pressure from the lacrimal papilla to the lacrimal sac. These actions are likely to be important for the flow of lacrimal fluid in the lateral to medial direction on the eyeball, for maintenance of the thickness of tear film over the cornea, for opening and closing of the lacrimal punctum, and for passage of the lacrimal fluid from the canaliculus to the sac. Horner's muscle appears, thus, to be a muscle of prime importance in all phases of the flow of lacrimal fluid.

The lacrimal part of the orbicularis oculi muscle was first revealed by Duverney in 1730 and was precisely described by Horner in the 1820’s (Reifler, 1996). From his observations that the lacrimal canaliculi penetrated and passed through the muscle, Horner postulated that the muscle should assist the passage of tears to the lacrimal sac (Horner, 1824). The muscle, which has become known as Horner’s muscle, has been the focus of some controversy for more than a century with respect to its possible role in drainage of tears. Jones proposed the theory of the lacrimal pump (1958, 1961), according to which there are two forces involved in the passage of lacrimal fluid. One force is generated by the temporal and nasal movements of the tarsus and causes inflation and deflation of the ampulla of the canaliculus to push the lacrimal fluid through the lacrimal punctum. The other force is generated by both negative and positive pressure on the lacrimal sac that pushes the lacrimal fluid from the canaliculus into the sac. Jones postulated that both these forces are generated by contractions of Horner’s muscle. Ahl and Hill (1982) and Ritleng et al. (1983) expressed support for the lacrimal pump theory. By contrast, Brienen and Snell (1967, 1969) postulated that the passage of lacrimal fluid from the lacrimal lake to the lacrimal punctum might simply be a response to the pressure gradient generated by closure of the eye. Indeed, the pressure in the conjunctival sac of the rabbit rises by 5 cm of water each time the eye closes reflexively and this increases in pressure results in the flow of fluid from the conjunctival sac to the lacrimal canaliculus. Brienen and Snell also reported their failure to identify strands of Horner's muscle whose contractions might cause inflation of the lacrimal canaliculus.

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naliculus or lacrimal sac. Fernandez-Valencia and Pellico (1990) confirmed the absence of any attachment to the lacrimal sac of Horner's muscle, and their findings also provided evidence against the lacrimal pump theory.

The purpose of the present study was to clarify the origin, course and sites of insertion of Horner's muscle. We found that Horner's muscle twists at its origin, and that it surrounds the lacrimal canaliculi and runs obliquely to an anatomical horizontal plane. We also found that fascicles of the muscle are inserted in the tarsus, palpebral margins and lateral palpebral tendons. The anatomical complexity of Horner's muscle suggests that the muscle might be multifunctional, with effects on the palpebrae, tarsi, lacrimal canaliculi and eye ball.

Materials and Methods

Thirteen orbital cavities with bony walls and palpebrae were obtained from Japanese cadavers that had been donated to Kanazawa Medical University under the Human Body Donation Act (Japan, 1983). The ages of individuals ranged from 48 to 92 years; eight were male and five female.

The superior orbital wall was widely opened and the major contents, namely, the eyeball with the extraocular muscles plus their nerves and the optic nerve, were removed. The periorbital and palpebral skin was removed. The orbicularis oculi muscle, medial and lateral palpebral ligaments and Horner's muscle were exposed and examined under a dissecting microscope (SZH10; Olympus) at magnifications of 7 x to 70 x. In four cases, the head was sawed along a plane parallel to the ear-eye plane that included the bilateral upper margins of the external auditory meati and the lower margin of the right orbital cavity (Figs. 1 and 2). Then the orbital cavity was cut into medial and lateral halves on a sagittal plane that passed through the orbit perpendicularly to the ear-eye plane. Photographs of the medial aspect of these specimens were taken (Fig. 2B) and the orientation of the palpebral aperture relative to the ear-eye plane was determined at the medial canthus (Fig. 3). The orientations of muscle fibers that formed Horner's muscle were also determined (Fig. 3 and Table 1).

Serial sections of the lacrimal canaliculi and sac were obtained from a human fetus that had a crown-rump length of 140 mm (estimated gestational age, 14 to 16 weeks) to confirm the gross-anatomical relationship between Horner's muscle and the lacrimal organs. The left side of Horner's muscle and the lacrimal organs were removed as a mass, cut along sagittal planes and processed for embedding in paraffin and staining with hematoxylin and eosin.

Results

Medial Palpebral Ligament

The medial palpebral ligament originated in the maxillary bone near the border with the nasal and frontal bones. The ligament consisted of thick fibrous bundles that extended from the periosteum. The ligament ran laterally and was firmly attached to the connective tissue of the medial canthus. Several muscle strands extended from the superficial connective-tissue fibers of the ligament. They became muscle bundles within Horner's muscle and some of them were inserted into the subcutaneous

Table 1. Angles made by the palpebral fissure (A), the lower margin of Horner's muscle (B) and the upper margin of Horner's muscle (C) relative to the ear-eye plane (see also Fig. 1)

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<th>A</th>
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<tr>
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<td>30 ± 1</td>
<td>159 ± 21</td>
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Value are means ± S.D.
Number of specimens = 4
tissue of the superior and inferior palpebral margins near the medial canthus. Deep connective-tissue fibers of the ligament were interwoven with fibers of the lacrimal fascia and extended to the common canaliculus and to the bifurcation of Horner's muscle. Thus, the medial palpebral ligament, acting synergistically with the lacrimal fascia, acts as a hawser to fasten the medial canthus and Horner's muscle to the medial margin of the orbit.

**Lacrimal Fascia**

The lacrimal fascia had two surfaces: a frontal and a sagittal surface. The frontal surface was a crescent-shaped expansion of the periosteum from the medial margin of the orbit and the anterior lacrimal crest. The sagittal surface was a continuous fibrous sheet that turned posteriorly to become attached to the posterior lacrimal crest. Thus, the lacrimal fascia separated the orbital fossa into one large region that contained the eyeball and another smaller region that contained the lacrimal sac and nasolacrimal duct. The common lacrimal canaliculus penetrated the sagittal surface of the lacrimal fascia and extended to the lacrimal sac.

**Horner's Muscle**

Horner's muscle originated partly from the posterior margin of the lacrimal bone and partly from the lacrimal fascia, having an oval base of $6 \times 4 \text{ mm}^2$ (Figs. 4a and 4b). At a distance of about 6 mm in the anterior direction, the muscle column of Horner's muscle bifurcated to generate superior and inferior bundles, each of which was about 3 mm in diameter, at the medial palpebral commissure. Many fibers of the muscle were twisted at the origin. Thus, muscle fibers that started from the inferior region of the site of origin participated in formation of the superior bundle while muscle fibers that started from the superior region of the site of origin participated in formation of the inferior bundle (Figs. 4b and 7). The common canaliculus passed through the internal angle of bifurcation that had been formed by the superior and inferior bundles, and then it split into the superior and inferior lacrimal canaliculi. Thus, the horizontal portions of the superior and inferior canaliculi were half-buried in the corresponding bundles of Horner's muscle (Fig. 4a, dotted lines). Thick connective-tissue fibers, some of which were reinforced by the medial palpebral ligament, enveloped the bifurcations of Horner's muscle and common canaliculus, fastening them to the medial orbital wall. Some muscle fibers within the bundles encircled the vertical part of the lacrimal canaliculus and were attached to the medial margin of the tarsus. Most of the muscle fibers of the bundles ran laterally within a groove that was formed on the tarsi along the palpebral margins and they extended minute muscular fascicles to the subcutaneous tissue of the palpebral margins (Fig. 5). Connective tissue of the orbital septum formed a bank beside the groove that prevented the muscle bundle from slipping out of the groove. The muscle bundle was linked loosely to the superior tarsus by loose connective tissue such that the bundle could slide mediolaterally on the tarsus. Muscle fibers of the superior and inferior bundles met at the lateral palpebral commissure, became interwoven with one another and terminated in the lateral palpebral ligament or in subcutaneous connective tissue at the lateral commissure (Figs. 4a and 6).

When the eye was closed, the angle between the ear-eye plane and the palpebral fissure was about 30 degrees; that between the plane and the inferior

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**Fig. 4.** The anterior surface (Fig. 4A) and posterior surface (Fig. 4B) of the right palpebra of an adult. The superior and inferior bundles (SB and IB) of Horner's muscle surround the palpebral aperture and terminate in the lateral palpebral commissure. The muscle is supplied by branches of the facial nerve (arrowheads). The approximate position of the lacrimal canaliculus is indicated by dotted lines. The cleft indicated by small arrows is the lacrimal sac. Note that the superior lacrimal papilla (SP) is located more medially than the inferior lacrimal papilla (IP) in Fig. 4B. This relationship between the two papillae also holds for the fetus (see Fig. 8). CC, common canaliculus; HP, horizontal part of the lacrimal canaliculus; IT, inferior tarsus; ST, superior tarsus; VP, vertical part of the lacrimal canaliculus. The squares numbered 5, 6, and 7 correspond to Figures 5, 6 and 7, respectively. Bar = 5 mm.

**Fig. 5.** Minute fascicles of Horner's muscle are inserted into the subcutaneous tissue of the palpebral margin (arrows) and pull the palpebral margin medially.

**Fig. 6.** In the lateral commissure, Horner's muscle terminates in the subepithelial connective tissue (asterisk) and lateral palpebral ligament (LPL). Occasionally, the superior and inferior muscle fibers are joined together (arrowheads).

**Fig. 7.** The origin of Horner's muscle. At the origin, some muscle fibers cross; the muscle fibers that originate from a low position participate in the formation of the superior bundle and those that originate in a high position participate in the formation of the inferior bundle (arrows).
margin of Horner's muscle was about 160 degrees; and that between the plane and the superior margin of Horner’s muscle was about 210 degrees (Table 1). Judging from these angles, we can assume that the muscle fibers in the bundle of fibers that form Horner’s muscle do not all have the same effect on the palpebra. For example, muscle fibers with the lowest origin in the inferior bundle might depress the inferior palpebra, while those with the highest origin might elevate it.

**Horner’s Muscle in the Fetus**

In the fetus (14–16 weeks gestation), the superior and inferior palpebrae were fused together and the superior and inferior lacrimal papillae were situated side by side. The superior papilla was located medially to the inferior papilla and the puncta were occluded by the edges of the respective papillae (Fig. 8). Occlusion of the lacrimal puncta in the adult can be assumed to occur similarly since the anatomical positions of the lacrimal puncta were the same in the adult (Figs. 4a and 4b) and in the fetus (Fig. 8). In the papillary area, cross sections of Horner’s muscle completely surrounded the entire circumference of the horizontal portion of the canaliculus (Figs. 9a and 9b). Bundles of fibers of Horner’s muscle ran horizontally and perpendicularly to the vertical portion of the canaliculus. The area of cross sections of Horner’s muscle decreased gradually from the connective tissue between the superior and inferior lacrimal canaliculi and finally surrounded less than half the canicular circumference (Figs. 9c, 9d and 9e). In the region of the lacrimal sac, cross sections of Horner’s muscle were visible only posterior to the lacrimal sac, with thick connective tissue interposed between muscle and the sac (Fig. 9f). Judging from the extent of the envelope formed by Horner’s muscle, we can postulate that the effect of contraction of the muscle is greatest in the vertical portion of the lacrimal canaliculi and decreases gradually in the direction of the lacrimal sac.

**Discussion**

The high-speed cinematographic studies reported by Doane (1980, 1981) clarified the key phenomena involved in lacrimal drainage in a normal cycle of blinking. At the closing stage of the cycle, lacrimal fluid excreted from the suprolateral region of the eye moves medially toward the superior lacrimal punctum, in parallel with the medial movement of the superior tarsus and in a part as a result of a capillary phenomenon that involves the palpebral margin and the eyeball. As the palpebrae close, a uniform tear film of fluid of about 10 µm in thickness is formed over the cornea. When the palpebrae are one-third closed, the superior and inferior puncta are occluded. Further closure of the eye squeezes the lacrimal canaliculi and complete closure empties the canaliculi, expelling lacrimal fluid toward the lacrimal sac. During the opening stage of the cycle, the pressure on the canaliculi is released. When the palpebrae are one-third open, the lacrimal puncta “pop” open and lacrimal fluid enters the lacrimal canaliculi through the lacrimal puncta. Then, the cycle continues again to the closing stage. From our observations, it appears that Horner’s muscle is the only muscle whose actions can be related to all the key phenomena of the cycle described by Doane. First, Horner’s muscle can pull the tarsi medially and can squeeze the vertical portion of the lacrimal canaliculi since some fibers of Horner’s muscle surround the vertical portion of the lacrimal canaliculi and terminated at the medial margin of the tarsi. Contraction of Horner’s muscle has a greater effect on the vertical portion and the effect decreases towards the lacrimal sac, and thus contraction can move the lacrimal fluid toward the lacrimal sac. Second, contraction of the twisted fibers of Horner’s muscle brings the superior and inferior papillae closer together and makes the lacrimal puncta close. Relaxation of Horner’s muscle might pop open the lacrimal puncta in parallel with release of pressure in the canaliculi. Third, Horner’s muscle can exert delicate control over the pressure exerted by the palpebral margins on the surface of the cornea by

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Fig. 8. Posterior aspect of the left Horner’s muscle and lacrimal papillae in a fetus. Note that the inferior and superior papillae are side by side, with the latter situated medially. The lacrimal puncta (arrows) are occluded, albeit not completely, by the margin of the papillae. The vertical lines A through F approximate the section planes shown in Figures 9A through 9F.

Fig. 9. Serial sections from the lacrimal papilla to the lacrimal sac. The orientation and bar in Figure 9A applies to all the panels. Arrows indicate the lacrimal puncta. Note that Horner’s muscle (H) surrounds the entire circumference of the canaliculus (Figs. 9A and 9B). Horner’s muscle retreats gradually (asterisks) from the circumference of the canaliculus and is finally situated behind the lacrimal sac with a thick band of connective tissue between the muscle and the sac. IC, inferior canaliculus; S, lacrimal sac; SC, superior canaliculus.
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medial traction of the palpebral margins via the minute fascicles. In this way, it can control the thickness of tear film over the cornea. Horner’s muscle is, thus, multifunctional and all of its functions are related to the movement of lacrimal fluid, from the flow of fluid on to the eyeball to the draining into the lacrimal sac.

The minute skeletal muscles in the palpebral margins at the foot of the cilia are known as Riolan’s muscles or ciliary muscles (Adler, 1950; Ahl and Hill, 1982). Brienen and Snell (1967) and Snell and Lemp (1989) considered that Riolan’s muscles might be ciliary insertions of Horner’s muscle and we confirmed this supposition. Ciliary insertions of Horner’s muscle, namely, Riolan’s muscles, maintain the tautness of the palpebral margin and, when the eye closes, they allow the palpebral margins to sweep over the surface of the cornea at a constant pressure and bring the margins of the superior and inferior lids together. The wide angles of origin of Horner’s muscle fibers suggest that the fibers do not necessarily contract with equal strength but contract differently, depending on the distance from the palpebral aperture. This difference in strength of contraction might be reinforced by the deviation of the palpebral aperture from the ear-eye plane by 30 degrees. Thus, a relatively strong tension in the ciliary insertions, as compared with the tension of muscle fibers in a more peripheral region might cause an inward rolling of the lower palpebral margin (= entropion). Jones et al. (1976) reported that surgical removal of a redundant portion of the preseptal orbital oculi muscle and orbital septum restored the lower lid to normal position. According to Nowinski (1991), the procedure described by Jones et al. is a possible choice for repair of entropion. However, entropion often recurs after such surgery. Various factors are considered to be related to the occurrence of involutional entropion, namely, dehiscence; attenuation or disinsertion of the retractors of the lower eyelid; laxity of the horizontal canthal tendon; upward migration and overriding of the preseptal orbicularis oculi muscle; and, possibly, enophthalmos secondary to aging. These are phenomena that occur at a distance from the palpebral aperture. In addition, the role of the ciliary fascicles of Horner’s muscle should not be ignored when both the cause and the surgical repair of involutional entropion are considered.

References