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MORPHOLOGICAL STUDY

Morphology of the lacrimal sac and nasolacrimal duct in adult human cadaver

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Abstract: The lacrimal sac (LS) is a dilated structure that lies in the lacrimal fossa, and the nasolacrimal duct (NLD) is the continuation of LS from its neck up to the inferior meatus of the nose. A study of 50 specimens of formalin-fixed adult cadavers of both sexes of Indian origin was conducted. The morphological features like length and breadth of LS and NLD, along with the histology of LS has been observed. The mean length of LS and NLD on the right side was 10.5 mm (1.04) and 16 mm (2.6) respectively, whereas the mean breadth of the above structures, on the right side was 6 mm (0.63) and 5.66 mm (0.81) respectively. The mean length of LS and NLD on the left side was 10.57 mm (1.13) and 16.42 mm (2.29), whereas, the mean breadth of the same structure on the left side was 6.71 mm (0.95) and 5 mm (0.81) respectively. The sides did not show any significant statistical difference but when the correlation between the length and breadth of LS is considered, significance was observed in the lacrimal sac of the left side. No variations were observed in the gross structure of LS and NLD. Microscopic study showed the presence of elastic fibers in LS. The importance of LS and NLD is that the blockage of this lacrimal passage is the most common cause of epiphora (watering of the eye). The presence of elastic fibers in this study confirms the hypothesis that the sac elasticity may perform a dynamic role, in forceful evacuation of lacrimal fluid in reverse direction *(Tab. 2, Fig. 3, Ref. 10)*. Full Text (Free, PDF) *www.bmj.sk.*
Key words: lacrimal sac, nasolacrimal duct, elastic fiber, epiphora.

The description regarding the anatomy of LS, the NLD and the lacrimal apparatus as a whole is vague in text books and medical literature. Details on the gross morphology of LS and the NLD are very superficially described, even in standard texts. The lacrimal apparatus is a system made of 3 parts: (i) secretory system, consisting of various glands; (ii) the distributional system, consisting of the lids which not only carry the fluid to all parts of the conjunctival sac, but also furnish the motor power for the lacrimal pump; and (iii) the excretory system (1). The excretory system consists of lacrimal puncta, lacrimal canaliculi, LS and NLD and is also known as the lacrimal drainage system.

Until the writings of Leone (Quoted by Del-Castillo, 1982) LS and NLD were thought to be the secretory mechanism. However, his careful anatomic findings were not accepted for at least a century after his work. Further details of the outflow system came to light gradually during the ensuing three centuries (2). Studies by various authors showed the length of NLD to vary from 6–21 mm and the breadth 2–7 mm; whereas the length of LS was between 6–18 mm and the width of LS did not exceed 4 mm (3, 4). The microscopic study done by various authors showed the epithelium of LS to be of two or three nuclear layers on average, occasionally up to five layers, and contained goblet cells besides the mucous gland and observed that the lacrimal ducts were surrounded by a wide ranging cavernous system (5, 6).

The possible assumption that, functionally, the lacrimal apparatus plays a rather minor role in the higher mammal, man, as compared to lower vertebrates has unfortunately relegated the lacrimal to back page and footnotes (7).This study attempts to focus attention on the excretory system with emphasis on LS and NLD anatomy. The aim of the present study is to observe the size, shape, variations in gross structure, and also to delineate the histological features of LS and demonstrate the presence of elastic fibers.

Materials and methods

A total of 50 LS with the NLD (right side, 26; left side, 24) were dissected out from the formalin fixed adult cadavers of both sexes in the anatomy department at the Kasturba Medical College, Mangalore. The nasal septum in saggital sections of the head was removed to expose the lateral wall of the nose, before the inferior concha was excised to show the ostium of the NLD. The muco-periosteum was then striped out to reveal the bony duct canal. The thin lacrimal bone and the thicker lacrimal pro-

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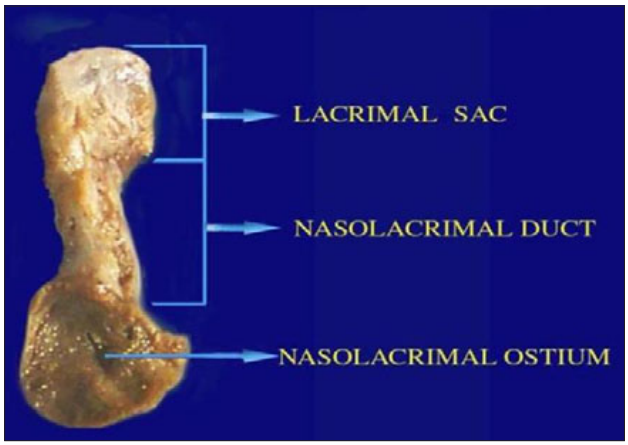

Fig. 1. Showing the lacrimal sac and nasolacrimal duct with its opening.

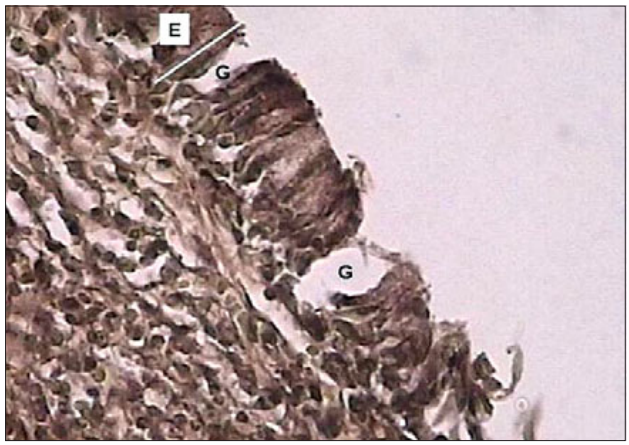

Fig. 2. Verhoeff's stain (40x) showing the lacrimal sac epithelium. Epithelium – E, Goblet cells – G.

cess were chipped off with a bone cutter. The ostium of the duct was next prised out from the adherent mucoperiosteum, facilitating an easy stripping out of the remaining portions of the duct. A skin incision on the face at the naso-orbital region and clearing the lacrimal fascia and a portion of the orbicularis occuli muscle exposed the sac fully and allowed a simple removal (7). The isolated ducts were then washed in the running water and stored in 10% formalin. Naked eye and hand lens magnified observations on sac size; shape, features and variations externally were listed and measured by a caliper. Comparisons were made between the right and left LS and NLD on length and breadth and correlation between length and breadth were studied.

For microscopy, transverse sections of LS were made. To prevent collapse and flattening of LS, and consequent distortions in lumen shape and contour inherent in fixing procedures, the duct-sac was pumped up with molten paraffin before immersion in wax bath. Special stains (i.e, Orcein and Verhoeff) were used for the sections.

Tab. 1. Side comparison and statistical significance (50 Lacrimal sac and duct).

Group	Side	N	Mean	Std. Deviation	Z
Right vs left – Length					
Lacrimal sac	Right	26	10.5	1.048	.07400
	Left	24	10.57	1.133	p=.941 ns
Nasolacrimal duct	Right	26	16	2.607	.36300
	Left	24	16.42	2.299	p=.717 ns
Right vs left – Breadth					
Lacrimal sac	Right	26	6	.632	1.389
	Left	24	6.71	.951	p=.165 ns
Nasolacrimal duct	Right	26	5.66	.816	1.29
	Left	24	5	.816	p=.194 ns

N – Sample size, Z – Mann-Whitney U test, P – Probability <0.05 is significant, p<0.006 highly significant, p<0.001 is very highly significant

Results

The external morphology of LS and NLD did not showed any gross variation (Fig. 1). The mean length of LS and NLD on the right side were 10.5 mm (1.04) and 16 mm (2.6), whereas the mean breadth of LS and NLD on the right side were 6 mm (0.63) and 5.66 mm (0.81) respectively. The mean length of LS and NLD on the left side was 10.57 mm (1.13) and 16.42 mm (2.29) whereas the mean breadth on the left side was 6.71 mm (0.95) and 5 mm (0.81) respectively (Tab. 1). There is no significant difference between the right and left side mean values of LS and the NLD. The variations in the length and breadth between the two sides are not significant (Tab. 1).

When the correlation between the length and breadth of LS is considered, significance was observed in LS of the left side.

Tab. 2. Side comparison and significance of correlation.

Group	Side			Breadth
Lacrimal sac	Correlations			
Lacrimal	Right	Length	R	298
			p	.323
			n	.26
	Left	Length	R	.645
			p	0.024 sig
			n	24
Nasolacrimal duct	Correlations			
Lacrimal	Right	Length	R	-.275
			p	.363
			n	26
	Left	Length	R	-.074
			p	.819
			n	24

r – Karl Pearson's Coefficient of correlation

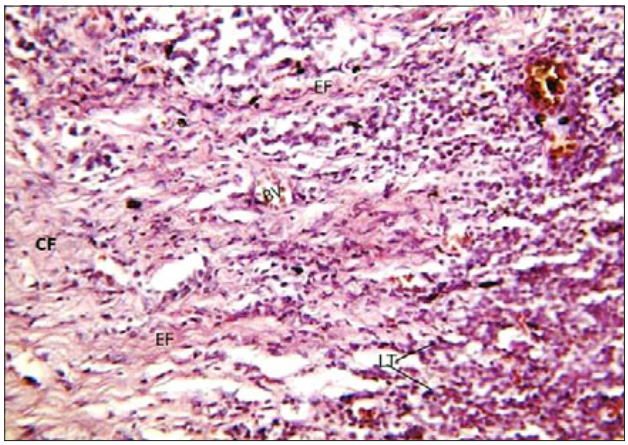

Fig. 3. Orcein stain (40x) of lacrimal sac. Blood vessel – BV, Collagen fibers – CF, Elastic fibers – EF, Lymphoid tissue – LT.

When the length of LS increased, the breadth of the left side sac is also increased. When the correlation between the length and breadth of NLD is considered, no significance was seen. It is obvious that when the length of NLD is increased, the breadth is decreased (Tab. 2). Histological observations reveal that LS mucosa was made up of double-layered epithelium, superficial layer composed of columnar cells, the deeper layer being flatter, with occasional goblet cells (Fig. 2). The lamina propria was infiltrated with lymphocytes and consisted of collagen and elastic fibers. Large cavernous spaces with red blood corpuscles were also seen. The outer coat was rich in elastic fibers with few collagen fibers interspersed in between (Fig. 3).

Discussion

Thorough knowledge of gross anatomy is vital for proper techniques in any surgical field. The anatomy of lacrimal system is important to ophthalmologist for formulation of principles and techniques in the management of lacrimal problems. A very common problem is watering from the eye (epiphora) due to hypersecretion or failure of the lacrimal pump or obstruction of the lacrimal passage. The obstruction of the lacrimal passage is the most common cause of epiphora. With the popularity of endoscopic surgery for dacrocystorhinostomy, knowledge of the lacrimal system has become essential.

Wormald et al (2000) with the help of CT dacryosystogram and CT scans measured LS in 47 individual, in relation to the common canaliculus and 76 in relation to the insertion of the middle turbinate. Measurements taken from the long axis of LS showed that the mean height of the sac above the middle turbinate insertion was 8.8 mm and below it was 4.1 mm. The average measurement of the sac above the common canaliculus was 5.45 mm and below the common canaliculus was 7.7 mm (8).

Gross observation of the dimensions recorded in the present study showed that the length of LS was less, and the breadth of LS was more compared to the data given by Groell et al (4). The breadth of the NLD was also more in the present study when compared with the results given by Nema and Nema (3). A difference was observed in the shape described for the apex of LS, which appeared rounded not triangular as well as in the anterior and posterior borders which appeared smooth and not well defined as stated by an earlier study (7). While LS and NLD are described as circular in transverse section earlier (7), surprisingly we found that in almost all specimens, the structure was flattened from side to side.

No clear cut stricture, the „isthmus“ could be made out, externally between LS and the NLD as mentioned in literature (1). Our study showed only a small narrowing externally while LS opened into the NLD. Schaeffer (1912) observed that the opening of the NLD was into the inferior meatus and it was slit like or rounded and did not open into a raised projection or pass directly through the mucous membrane of the nose (9). Knop and Knop (2001) investigated the lacrimal drainage systems and found the epithelium of LS to be of two or three nuclear layers on average, occasionally can even go up to five layers, and contained goblet cells besides the mucous gland (5), which is conformed in th present study. Paulsen et al (1998) carried out a study on lacrimal systems, where they analyzed the structure of the lacrimal duct epithelium and observed that the lacrimal ducts were surrounded by a wide ranging cavernous system. They also demonstrated LS and the NLD to contain a double-layered epithelium, resting on a broad basement membrane (6).

Histological observations of LS obtained from our study reveal that LS mucosa was made up of double layered epithelium, superficial layer composed of columnar cells, the deeper layer being flatter. The lamina propria was infiltrated with lymphocytes and consisted of collagen and elastic fibers. Large cavernous spaces with red blood corpuscles were also seen. The outer coat was rich in elastic fibers with few collagen fibers interspersed in between.

Earlier clinical trials, coupled with results obtained through the observation on the gross and microscopic structure of LS demonstrates that it’s unique elastic trait, may yet uncover some hitherto unknown functions of this frequently trivialized area in head and neck anatomy. The clinical application of the ‚sneeze maneuver‘ trials should have a bearing on ophthalmic procedures for removing foreign bodies from the eye, and could also aid in effecting a non-invasive ENT clinical procedures in treating epiphora caused by chronic and recurrent stricture of canaliculi [10]. The presence of elastic fibers in LS, which has been demonstrated in the present study, may play a significant role to aid in “sneeze maneuver” theory postulated by Kumar (10).

Conclusion

The presence of elastic fibers in LS, confirms the hypothesis that LS elasticity may perform a dynamic role, in forceful evacuation of lacrimal fluid in a reverse direction. Further ophthalmologist and medical community in general should have a knowledge of the lacrimal system, especially while dealing with patients with one of the common problem of the system i.e watering from the eye (epiphora).

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