MORPHOLOGICAL STUDY OF FOSSA FOR LACRIMAL SAC: CONTRIBUTIONS BY LACRIMAL AND MAXILLA

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ABSTRACT

Fossa fc lacrimal sac, houses lacrimal sac and its lower end (orbital opening) continues through nasolacrimal canal to open into the inferior meatus of nose. Surgical procedures like dacryocystostomy and dacryocystorhinostomy are performed extranasally and endoscopic endonasal dacryocystostomy is done intranasally.

Lacrimal bone and frontal process of maxilla, contributing to the formation of fossa, were observed for their morphological features. (based on examination of 734 orbits from 528 skulls)

Shapes of maximum number of fossae observed were found to be oval, and contribution by maxilla and lacrimal bone was in variable proportions. The two extremes were also observed where the fossae were entirely formed by maxilla or lacrimal bone and remaining fossae have been contributed in variable proportions.

Anterior boundary was observed to be formed by maxilla in 99% of cases and by lacrimal in 0.81% cases. Posterior boundary was observed to be formed by lacrimal in 98% of cases and by maxilla in 0.01% fossae, in which the lacrimal bone was either present behind the boundary of the fossa or absent.

From this study it is concluded that one should scan the contribution of the fossa for lacrimal sac by maxilla and lacrimal, as it is essential for endoscopic endonasal dacryocystorhinostomy. Presence of perilacrimal ossicles which are perhaps the detached segments of lacrimal bone and lacrimal bone being rudimentary and absent in some of the cases, are suggestive of the frontal process of maxilla increasing in size and the lacrimal bone gradually vanishing in the process of evolution.]

KEYWORD: Fossa for lacrimal sac, lacrimal crest fromtal process of maxilla, dacryocystituis.

INTRODUCTION

The fossa for lacrimal sac, present on the medial margin of the orbit, is an important part of bony components of lacrimal apparatus. It houses the lacrimal sac and its lower end (orbital opening of nasolacrimal canal) continues through bony nasolacrimal canal to open into the inferior meatus in the lateral wall of nasal cavity.

The descriptions about the fossa are variable in the literature. Many authors described it as being formed by frontal process of maxilla in front and lacrimal bone behind in variable proportions, the two bones being separated by a vertical suture. The medial orbital margin, unlike the superior, lateral and inferior, is not sharp and splits to give place for lacrimal sac. The medial orbital margin, when traced from above, runs downwards and passes slightly backwards into the sharp posterior lacrimal crest of lacrimal bone which ends in a hook shaped process of variable form directed anteriorly, the lacrimal hamulus. Traced from below the infraorbital margin continues more anteriorly as anterior lacrimal crest of frontal process of maxilla.

The junction between infraorbital margin and anterior lacrimal crest is being marked by a small bony tubercle, the lacrimal tubercle, to which the lacrimal hamulus approaches frequently from behind.

The two crests thus enclose, between them, the fossa for lacrimal sac. The vertical suture separating the lacrimal and frontal process of maxilla lies in the deepest part of the fossa but sometimes more anteriorly or more posteriorly as a result of unequal contributions from the two bones.

There is some controversy whether the anterior or posterior lacrimal crest should be considered as the actual orbital margin, and whether the fossa should be considered within[1] or outside the orbit[2]. In most mammals it is definitely outside but in primates (except lemurs) it is probably to speak of the fossa as being on the margin itself since the structures attached thereto, the medial palpebral ligament and orbicularis muscle divide and are attached to both the crests. The margin may thus be spoken of as dividing to accommodate the fossa[3]. The lacrimal part of orbicularis oculi (an extraorbital muscle) is attached to posterior lacrimal crest behind the lacrimal sac in

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human beings.

In India, due to environmental conditions and poor personal hygiene in large population, the dacryocystitis is fairly common amongst inflammatory orbital manifestations leading to epiphora. To get rid of the agony, the surgical procedures like dacryocystostomy and dacryocystorhinostomy are performed extranasally and endoscopic endonasal dacryocystostomy is done intranasally. Zhang et al (2003)[4] suggested that before endoscopic, endonasal dacryocystorhino stomy, one should scan the anterior portion of medial orbital wall so as to understand the anatomy of the fossa and improve the affect of surgery. He found out that in the lacrimal sac fossa, proportion of frontal portion of maxillary bone is bigger than the lacrimal bone. There is about 20 degrees between the rear wall of fossa and coronal plane[4].

In view of the above, it is necessary to have the correct and adequate knowledge about the variations in the shape, size and location of the fossa for lacrimal sac and also about variable contributions made by lacrimal bone and frontal process of maxilla. The orbital opening of the nasolacrimal canal also presents variable shapes and dimensions. The present study, therefore, has been designed to study the morphometry of the fossa for lacrimal sac in a large specimen sample.

MATERIAL AND METHOD

Lacrimal bone, frontal process of maxilla, and fossa for lacrimal sac were observed and various measurements were taken with the help of standardized metrical instruments in 734 orbits (378 right and 356 left) from 528 human skulls. The fossa was examined for its contributions and boundaries.

OBSERVATIONS

The fossae were located in the anterior most part of the medial wall of the orbit.

FOSSA FOR LACRIMAL SAC

The morphological and metrical observations of the fossa for the lacrimal sac were made under the following categories: -

1. Bony contributions of the Fossa (Table-1)

Most of the fossae fell into a category, in which anterior half had been contributed by the maxilla and the posterior half by the lacrimal bone on both the

TABLE 1: CONTRIBUTIONS BY LACRIMAL AND MAXILLA IN FORMATION OF FOSSA FOR LACRIMAL SAC

Contribution		Right		Left	
Lacrimal	Maxilla	No.	%	No.	%
0	1	8	2.17	6	1.69
1/5	4/5	26	6.88	18	5.06
¼	3/4	12	3.17	18	5.06
1/3	2/3	60	15.88	58	16.29
2/5	3/5	18	4.76	20	5.62
½	1/2	176	46.56	164	46.06
3/5	2/5	18	4.76	12	3.37
2/3	1/3	50	13.23	44	12.36
¾	1/4	4	1.06	6	1.69
4/5	1/5	2	0.53	8	2.25
1	0	4	1.06	2	0.56

TABLE 2: BOUNDARIES OF FOSSA FOR LACRIMAL SAC

2 A: Anterior Boundary

S.No.	Observations	Right		Left	
		No	%	No.	%
1.	Crest formed by maxilla	374	98.94	354	99.43
a)	Well defined	338	89.42	322	90.45
b)	Well defined in lower half	30	7.94	30	8.43
c)	Well defined with lower notch	2	0.53	2	0.56
	Flat	4	1.06	0	0
2.	Crest formed by lacrimal	4	1.06	2	0.56

2B: Posterior Boundary

S.No.	Observations	Right		Left	
		No	%	No.	%
1.	Crest formed by lacrimal	370	97.88	350	98.31
a)	Sharp	300	79.37	280	78.66
b)	Sharp in lower half	24	6.35	24	6.74
c)	Sharp in upper half	0	0	4	1.12
d)	Sharp with projection in the middle	2	0.53	2	0.56
e)	Blunt	42	11.11	40	11.24
f)	Flattened	2	0.53	0	0
2.	Crest formed by maxilla	8	2.12	6	1.69

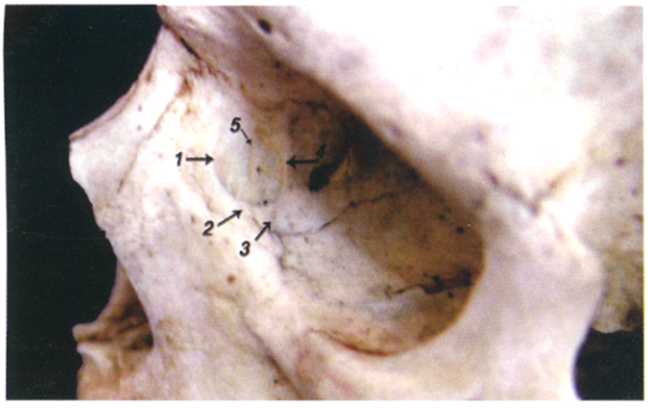

Figure 1: Photograph showing a classical fossa for lacrimal sac of the left side, oval in shape. The fossa is contributed equally by maxilla and lacrimal with well defined anterior (1) and posterior lacrimal crest (4). The lacrimomaxillary suture (5) is seen in the floor of the fossa, midway between anterior and posterior lacrimal crest. The hamulus (3) is well developed and is articulating anteriorly with the lacrimal tubercle (2) on the frontal process of maxilla.

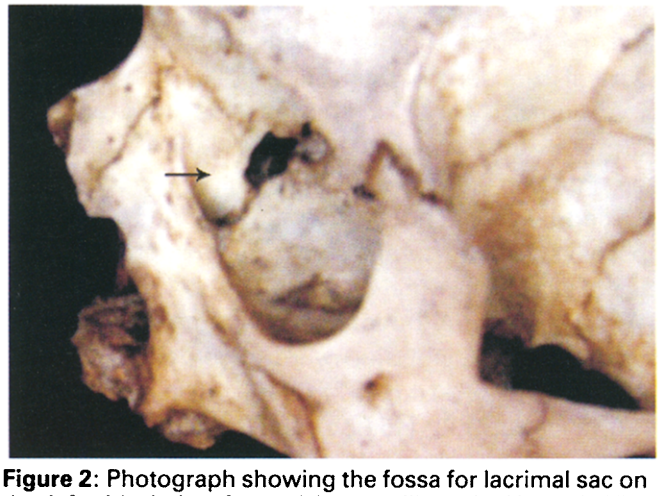

Figure 2: Photograph showing the fossa for lacrimal sac on the left side being formed by maxilla only (Arrow). The space appearing black behind the fossa marks the place for rudimentary lacrimal bone.

Figure 3: Photograph showing the fossa for lacrimal sac on the right side being formed completely by the lacrimal bone which in turn forms both the anterior and posterior lacrimal crest. The lacrimomaxillary suture is on the face (Arrow) and lacrimal hamulus is absent.

Figure 4: Photograph showing the fossa for lacrimal sac of the right side being contributed by lacrimal and maxilla as 1:4. The lacrimal bone is rudimentary (Arrow) with absence of hamulus. In the upper part the frontal process of maxilla is directly articulating with ethmoid.

Figure 5: Photograph showing the fossa for lacrimal sac of right side, contributed by maxilla and lacrimal as 2:3.Lacrimal hamulus is absent. Lacrimal tubercle (Arrow) is well developed.

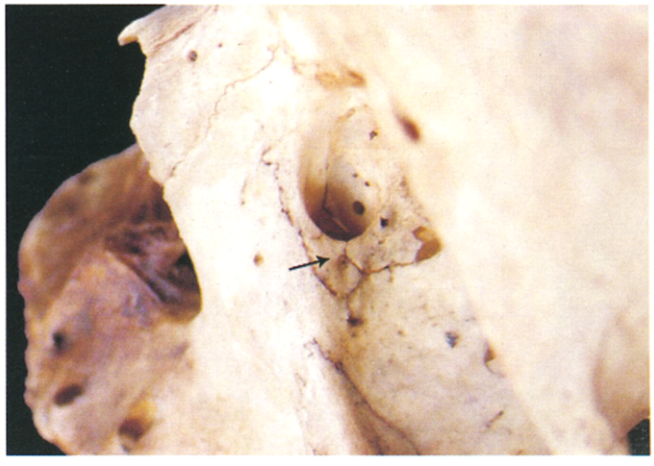

Figure 6: Photograph showing the fossa for lacrimal sac of left side, bony contribution by maxilla and lacrimal being 1: 3. The broad and incomplete hamulus is separated from frontal process of maxilla by a perilacrimal ossicle (Arrow).

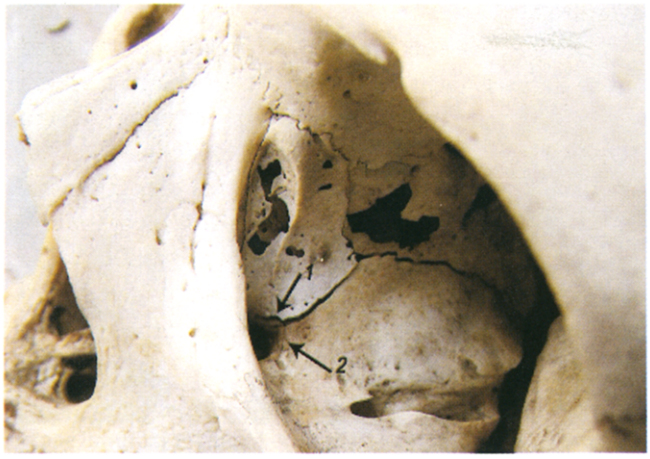

Figure 7: Photograph showing the fossa for lacrimal sac of left side, bony contribution by maxilla and lacrimal being 1:4. The lacrimal hamulus is absent. The posterior boundary of the nasolacrimal opening is contributed both by the lacrimal bone (1) and the lacrimal notch of maxilla (2).

Figure 8: Photograph showing fossa for lacrimal sac of right side contributed by maxilla and lacrimal as 1:1.The hamulus is incomplete with a free anterior end. A dumbbell shaped perilacrimal ossicle (Arrow) is seen at the anterior part of lacrimal notch, extending onto the frontal process of maxilla.

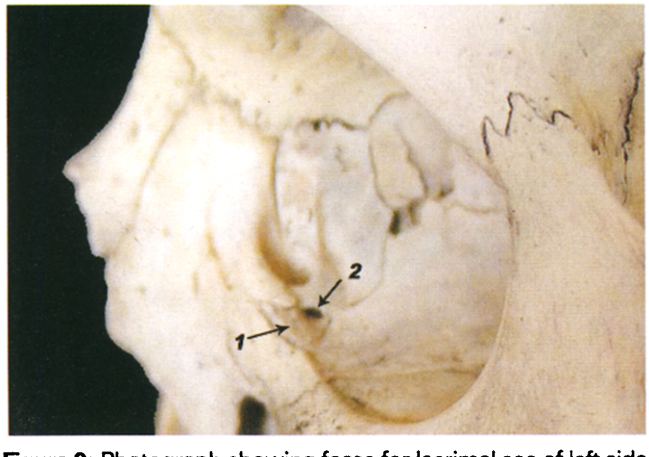

Figure 9: Photograph showing fossa for lacrimal sac of left side with superior boundary below the frontolacrimal and frontomaxillary sutures. The lacrimomaxillary suture is straight with partial synostosis in lower half and bony contributions by maxilla and lacrimal being 1:3. The hamulus is well developed, broad and articulates anteriorly with lacrimal tubercle enclosing a foramen (2) laterally between itself and a perilacrimal.

Figure 10: Photograph showing fossa for lacrimal sac of left side with synostosed lacrimomaxillary suture, absence of hamulus and bipartite lacrimal bone (Arrow) with blunt posterior lacrimal crest.

sides (fig.-1). These were 176 (46.56%) on the right and 164 (46.06%) on the left side. The two extremes were also observed where 8 (2.17%) fossae on the right and 6 (1.69%) on the left side were entirely formed by the maxilla (fig.-2), and 4 (1.06%) fossae on the right and 2 (0.56%) on the left side were entirely formed by the lacrimal bone (fig.-3). The remaining fossae have been contributed in variable proportions by maxilla and lacrimal bone.

The contributions by lacrimal bone and maxilla on the right side were observed as 1/5th : 4/5th in 26 (6.88%) (fig.-4), 1/4th : 3/4th in 12 (3.17%), 1/3rd : 2/3rd in 60 (15.88%) and 2/5th : 3/5th in 18 (4.76%). On the left side, contribution by lacrimal: maxilla were observed as 1/5th: 4/5th in 18 (5.06%), 1/4th: 3/4th in 18 (5.06%), 1/3rd: 2/3rd in 58(16.29%) and 2/5th: 3/5th in 20 (5.62%).

The contributions by maxilla : lacrimal on the right side were observed as 2/5th : 3/5th in 18 (4.76%) (fig.-5), 1/3rd : 2/3rd in 50 (13.23%), 1/4th : 3/4th in 4 (1.06%) and 1/5th : 4/5th in 2 (0.53%). On the left side contributions by maxilla : lacrimal were observed as 2/5th : 3/5th in 12 (3.37%), 1/3rd: 2/3rd in 44 (12.36%), 1/4th : 3/4th in 6 (1.69%) (fig.-6) and 1/5th : 4/5th in 8 (2.25%) (fig.-7).

2. Boundaries of the fossa (Table-2)

(a) Anterior boundary (Table-2A) :-

The anterior boundary was observed to be mostly formed by maxilla as anterior lacrimal crest, having a lacrimal tubercle at its lower end in 374 (98.94%) on the right side (fig.-5) and 354 (99.43 %) cases on the left side. On the right side the anterior lacrimal crest in 338 (89.42%) cases were well defined (fig.-5), 30 (7.94%) well defined in lower half (fig.-8), 2 (0.53%)

well defined with a notch in the lower part (fig.- 4) and flat in 4 (1.06%). On the left side 322 (90.45%) cases had well defined (fig.-7), 30 (8.43%) well defined in lower half (fig.-9) and 2 (0.56%) well defined with lower notch anterior boundary.

The anterior boundary was observed to be formed by only lacrimal in 6 (0.81%) cases, of which 4 (1.06%) were on the right side (fig.-3) and 2 (0.56%) were on the left side.

(b) Posterior Boundary (Table-2B):-

The posterior boundary was observed to be mostly formed by lacrimal as the posterior lacrimal crest in 370 (97.88%) cases on the right side (fig.-5) and 350 (98.31%) cases on the left (fig.-1). On the right side, 300 (79.37%) were sharp, 24 (6.35%) sharp in lower half (fig.-6), 2 (0.53%) sharp with projection in the middle, 42 (11.11%) blunt and 2 (0.53%) flattened. On the left side, 280 (78.66%) were sharp, 24 (6.74%) sharp in lower half (fig.-1), 4 (1.12%) sharp in upper half (fig.-4), 2 (0.56%) sharp with projection in the middle and 40 (11.24%) blunt (fig.-10). The posterior boundary was observed to be formed by only maxilla in 8 (2.12%) cases on the right and 6 (1.09%) on the left side (fig.-2). In these 14 (0.01%) fossae the lacrimal bone was either present behind the boundary of the fossa or absent.

DISCUSSION

The bony fossa which houses the lacrimal sac is located near the medial margin of orbit contributed by frontal process of maxilla and lacrimal bone.

Whitnall (1921) perhaps was the first to describe the anatomy of fossa in great detail in his book 'The Anatomy of Human Orbit and Accessory Organs of Vision', which is still the best exposition of his work[3]. He described the medial margin of the orbit as, splitting to accommodate the fossa for lacrimal sac because, in primates (except lemurs) the structures attached there to, the medial palpebral ligament and the orbicularis muscle, divide and are attached to both the crests. Hence, it is probably best to speak of the fossa as being on the margin itself.

The findings of the present study on 734 orbits were similar to those of Whitnall (1921)[3], Jones (1957)[5] and Bron (1977)[6], suggesting that the medial margin splitted to accommodate the fossa for the lacrimal sac. The inferior orbital margin was observed to be continuous with the anterior lacrimal crest and superior orbital margin when traced down was continuous with posterior lacrimal crest, the space between the two crests was thus, the fossa for lacrimal sac.

The two researchers, Merkel (1901)[2] and Flower (1907)[1] presented the extreme views which are neither compatible with the findings of the present study nor with the work of Whitnall[3]. The former has described the fossa being outside the medial margin while the latter has mentioned it within the medial margin of the orbit. Pick et al (1901)[7] has described the bony components of the medial wall of orbit beginning anteriorly from the nasal process of superior maxillary (frontal process of maxilla). The central idea behind the thought of Pick et.al[7] coincides with Merkel[2] that since the maxilla anteriorly is forming the medial wall of the orbit, the fossa for lacrimal sac contributed by the maxilla should lie within the orbit. The theory proposed by the above three research workers is erroneous and completely baseless since it is not supported by any proof unlike Whitnall (1932)[8] and the findings of the present study. Though Rontal et al (1979)[9] considered the anterior lacrimal crest as medial margin of the orbit for different surgical measurements, but it was only for practical purposes because the anterior lacrimal crest was the anterior most, palpable landmark on the medial orbital margin.

In the present study the bony contributions by maxilla and lacrimal in the formation of fossa were found to be very variable on both the sides, unlike a casual description of 1:1 contribution by the two bones described in most of the standard textbooks of anatomy, and a few research workers like Roper (1980)[10] & Chastain (2005)[11].In the present study a very large sample of 734 orbits revealed that 1:1 contribution was observed in 46.56% on the right and 46.06 % on the left side only, while about 54% of the fossae deviated from the rule of 1:1. According to Duke-Elder (1961)[12] and Bron (1977)[6], the lacrimal bone and maxillary frontal process vary in formation of the fossa, and hence the vertical suture between them also varies. The two extremes were also observed, where, 14 (1.91%) fossae were observed to be entirely formed by maxilla and 6 (0.82%) were by lacrimal. In 1950, Jones et.al [5]has reported a very occasional extent of the lacrimal bone beyond the margin of the orbit on the face. The maximum number of fossae of the remaining showed that the maxillary contribution was more than the lacrimal, which is in agreement with the observation of Zhang T. (2003)[4]. James (1951)[13] and Breathnach (1958)[14] also observed that the lacrimal bone may be absent and entire fossa is formed by the maxilla.

reported "In 1 (0.4%) orbit the entire fossa was formed by maxilla, a finding not previously reported". The aforesaid observation by him does not seem to be correct as, while writing the discussion he was unaware of the information given by James (1951)[13] in Cunningham's textbook of anatomy and Breathnach (1958)[14] in Frazer's anatomy of human skeleton. In the present study, 14 fossae were exclusively found to be formed by maxilla.

The status of lacrimal bone was found to be very inconstant in the present study and very few lacrimal bones corresponded to the normal text description. The lacrimal bone was either absent, rudimentary, in the form of ossicles or bipartite. Our observations were very much similar to those of Flecker (1913)[16] who has described the lacrimal bone as being so delicate that a complete specimen is an anatomical curiosity. He also observed the lacrimal to be variable, frequently incomplete, sometimes absent, bipartite or associated with many types of perilacrimal ossicles. The observations of James (1951)[13], Breathnach (1958)[14] and Bron (1977)[6] were also almost similar to Flecker[16]. The observations of the present work and the aforesaid workers showed that the frontal process of maxilla is increasing in size and the lacrimal bone is gradually vanishing in the process of evolution.

The anterior boundary of the fossa was observed to be formed by maxilla as anterior lacrimal crest. Fazakas (1928)[17] has observed that the anterior lacrimal crest is sometimes duplicated; the feature neither was observed in the present study nor was reported by any other worker in the past. There is a general agreement amongst the authors, research workers and the findings of the present work that the posterior boundary of the fossa is formed by sharp posterior lacrimal crest mostly contributed by lacrimal bone except in a few cases where the lacrimal bone is replaced by maxilla.

CONCLUSION

From the present study on fossa for lacrimal sac in 734 orbits it was concluded that, the medial margin of the orbit splitted to accommodate the fossa for lacrimal sac, the fossa thus being on the margin itself. The contribution by lacrimal and maxilla was 1:1 in approx. 46% of the fossae, while, approx. 54% of the fossae deviated from the rule of 1:1, with the maximum number of fossae showing that maxillary contribution was more than the lacrimal. The anterior boundary of the fossa was formed by maxilla in more than 99% of cases. The posterior boundary was contributed by lacrimal bone in approx. 98% of the fossae. The absence of lacrimomaxillary suture within the confinements of the fossa has been observed in 20 orbits, where the fossa was either completely formed by maxilla or lacrimal bone.

Thus, ultimately it is concluded from the observations of the present work that one should scan the contribution of the fossa for lacrimal sac by maxilla and lacrimal, as it is essential for endoscopic endonasal dacryocystorhinostomy. Presence of the perilacrimal ossicles which are perhaps the detached segments of lacrimal bone, and the lacrimal bone being rudimentary and absent in some of the cases are suggestive of the frontal process of maxilla increasing in size and the lacrimal bone gradually vanishing in the process of evolution.

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