

# Intranasal Localization of the Lacrimal Sac

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**Objective:** To optimize the approach to the lacrimal sac during intranasal dacryocystorhinostomy.

**Design:** Microscopic measurement of anatomical landmarks in cadaver sagittal head sections.

**Setting:** The anatomy department of a large university hospital.

**Participants:** Twenty adult cadaver sagittal head sections (12 right and 8 left) fixed with 10% formaldehyde solution were evaluated.

**Intervention:** During endoscopic dissections, the maxillary line, lacrimomaxillary suture, nasolacrimal duct, and lacrimal sac were exposed.

**Main Outcome Measures:** Greater knowledge of the relationship among anatomical structures.

**Results:** The entire lacrimal sac was in 2 of 20 sides anterior and in 3 of 20 sides posterior to the axilla of the middle nasal concha. The fornix of the lacrimal sac was situated above the axilla in all sides. We evaluated the localization of the lacrimal sac to the maxillary line, which is of clinical importance in intranasal osteotomy during dacryocystorhinostomy. In 17 of 20 sides it is possible to reveal the axilla of the middle nasal concha during osteotomy.

**Conclusions:** Underexposure or lack of true localization of the sac are the most frequently encountered reasons for dacryocystorhinostomy failure. The maxillary line and adhesion point of the middle nasal concha are the 2 most important landmarks in localization of the sac. A mucosal incision anterior to the maxillary line and dissection up to the point where the middle concha adheres, followed by osteotomy on the lacrimomaxillary suture, nearly always ensure the exposure of the sac.

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**D**ACRYOCYSTORHINOSTOMY is an operation that can be performed externally or endonasally. The endonasal procedure was introduced in 1893, was modified in 1914 with endonasal osteotomy to the lacrimal bone, and was advanced with the introduction of endoscopy in 1989. The numerous advantages of endoscopic dacryocystorhinostomy have resulted in the widespread use of this method. Dacryocystorhinostomy enables improved visualization, does not pose any risk of creating a lesion in the medial palpebral ligament and orbicularis oculi, does not require an external incision and thus presents a cosmetic advantage, prevents angular vein damage, spares the pumping function of the nasolacrimal system, and promotes faster healing.<sup>1,2</sup> The main difficulty of endoscopic dacryocystorhinostomy is the determination of the place of the mucosal incision and lacrimal osteotomy. Endonasal landmarks are set to establish a correct approach. The land-

marks placed on the lateral nasal wall of the nasal cavity are the axilla of the middle turbinate (the most anterior part of the middle turbinate, where it adheres to the lateral nasal wall), the maxillary line (the protrusion that lies as a curved line from the axilla of the middle turbinate to the inferior turbinate), the ethmoidal bulla, and the uncinat process (**Figure 1**). This study focuses on the reliability of these endonasal landmarks and evaluates the variations of the anatomical localization of the lacrimal sac.

## METHODS

Twenty adult cadaver sagittal head sections (12 right and 8 left) fixed with 10% formaldehyde solution were evaluated. Dissection was performed; component parts were examined with a surgical microscope (Spectra; Möller Wedel GmbH, Wedel, Germany). An electronic digital caliper was used to measure the sections, and metric rulers that measure to the millimeter were used for the photographs. During the dissection, the maxillary line was determined

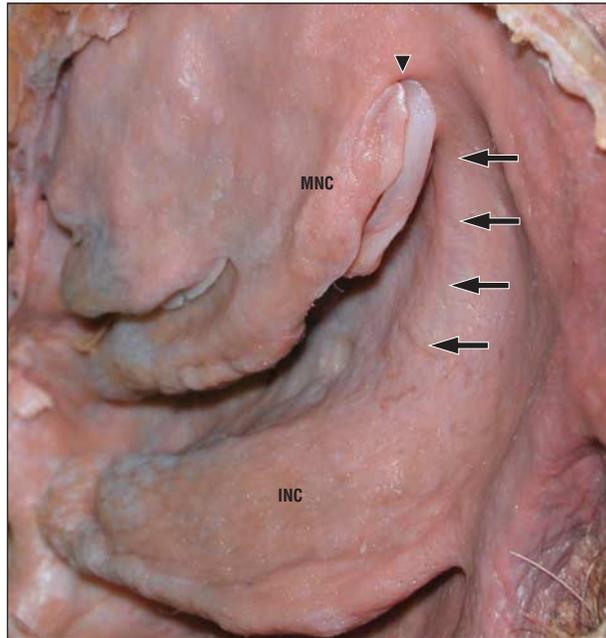
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by the retraction of the middle turbinate superiorly, and, after the retraction, an incision that involved both the mucosa and the periosteum was made through this line. The mucosa and periosteum were elevated, and the lacrimomaxillary suture was exposed. In this way, the relation between the lacrimomaxillary suture and maxillary line was observed. As a next step, the nasolacrimal duct and lacrimal sac were dissected by the removal of the lacrimal bone that lies posterior to the suture and the frontal maxilla that lies anterior to the suture. The relation of the lacrimal bone to the lacrimal sac was observed. The maxillary sinus ostium was then revealed by removing the posterior edge of the uncinate process. The distance and relation of the lacrimal sac to the maxillary sinus ostium, ethmoidal bulla, and axilla of the middle turbinate were assessed (**Figure 2**). The length of the lacrimal bone and the distance from the lacrimal sac to the inferior turbinate, ethmoidal bulla, uncinate process, and anterior nasal spine were measured (**Figure 3**). A paired *t* test was applied to determine whether a significant sta-

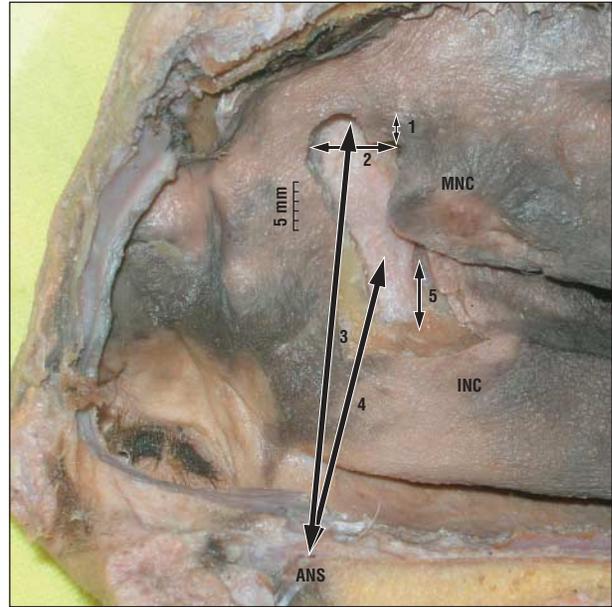
tistical difference existed in the measurements between the parts on the right side and those on the left.

## RESULTS

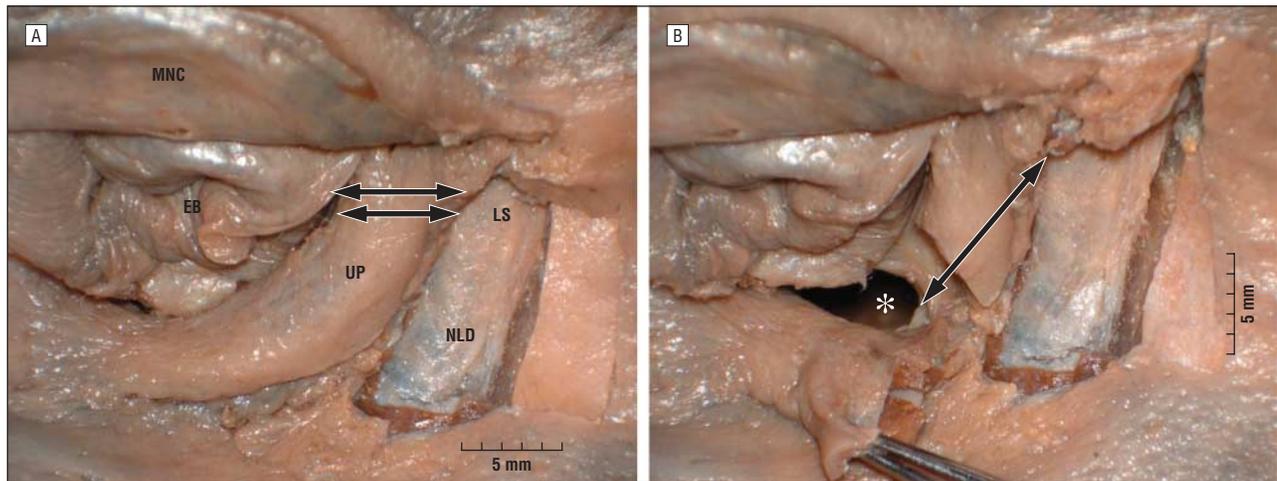
The relations among anatomical structures were evaluated. First, the maxillary line, an important marker in lacrimal sac localization, was identified. The anatomical localization of distances among the maxillary line, lacrimomaxillary suture, and lacrimal sac were evaluated. Within a total of 16 cases, in 11 the maxillary line lay on the same projection as the lacrimomaxillary suture, whereas in 5 the maxillary line was located anteriorly. The maxillary line corresponded with the lacrimal



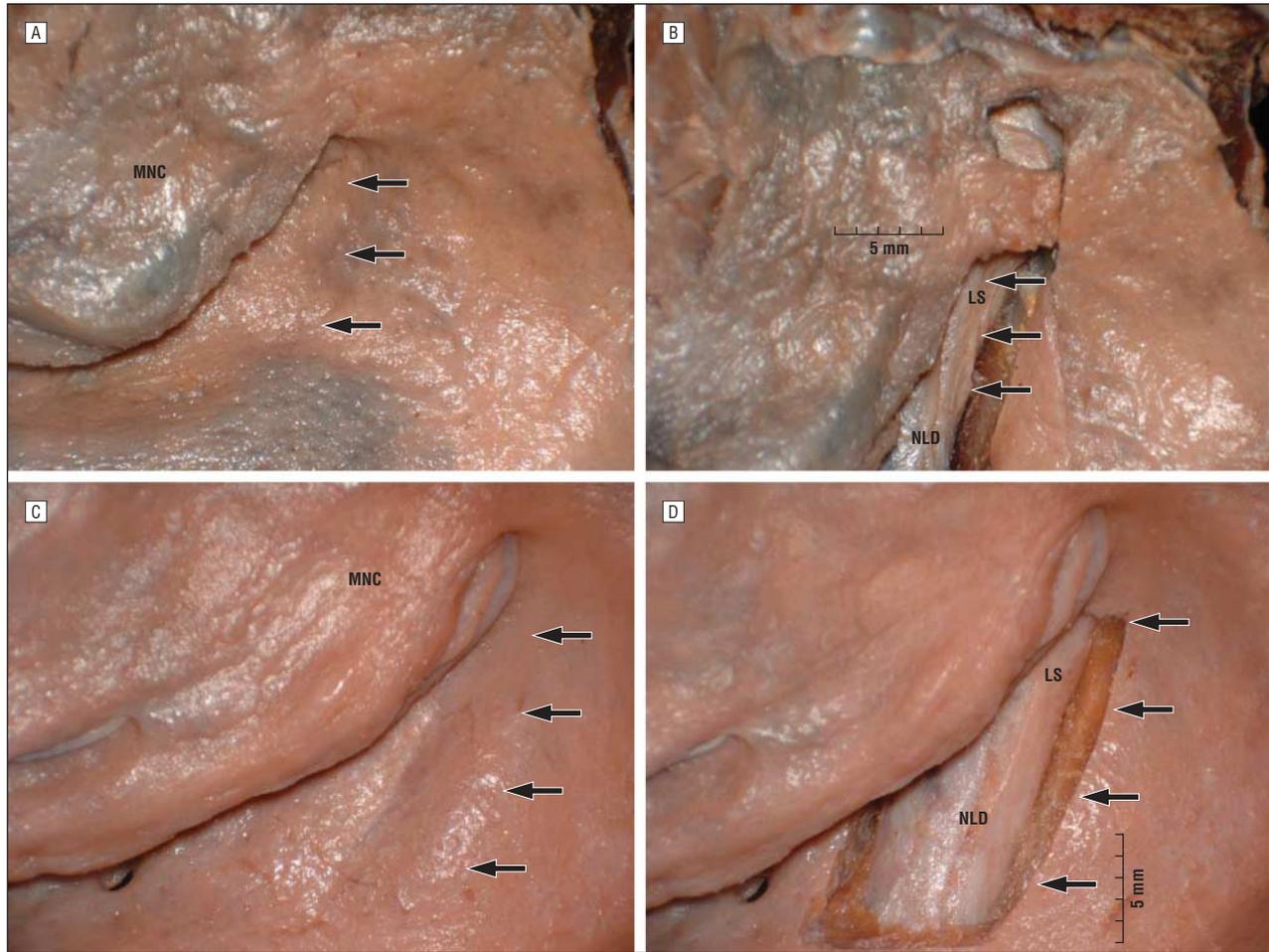
**Figure 1.** Anteromedial view of the lateral wall of the nasal cavity. INC indicates the inferior nasal concha; MNC, middle nasal concha; arrowhead, axilla of the MNC; and arrows, maxillary line.



**Figure 3.** View of the lateral nasal wall. The distances between the axilla of the middle nasal concha (MNC) and the superior border of the lacrimal sac (1), between the axilla of the MNC and the anterior border of the lacrimal sac (2), and between the lacrimal sac and the anterior nasal spine (ANS) (3) are shown. The distances between the nasolacrimal duct and the ANS (4) and between the lacrimal sac and the inferior nasal concha (INC) (5) are also indicated. The scale represents 5 mm.



**Figure 2.** View of the lateral nasal wall. Distance and relationship of the lacrimal sac (LS) to the maxillary sinus ostium, ethmoidal bulla (EB), and uncinate process (UP). A, MNC indicates the middle nasal concha; NLD, nasolacrimal duct; and arrows, distance between the free edge of the UP and the anterior wall of the EB. B, The UP has been removed. View includes the distance between the LS and the maxillary sinus ostium (asterisk). The scales represent 5 mm.



**Figure 4.** Correspondence of the maxillary line (indicated in all parts of the figure by arrows) with the lacrimal sac (LS). A and B, The LS is partially anterior to the maxillary line. C and D, The LS is entirely posterior to the maxillary line. MNC indicates middle nasal concha; NLD, nasolacrimal duct.

sac in 18 of 20 cases (**Figure 4A and B**). Within those cases the lacrimal sac corresponded to the maxillary line; the maxillary line was situated in the middle of the lacrimal sac in 9 of 20 cases, whereas it was on the posterior half of the lacrimal sac in 5 of 20 and on the anterior half in 4 of 20. The maxillary line lay totally anterior to the sac in 2 of 20 cases (**Figure 4C and D and Figure 5**). In 12 of 17 cases the lacrimal bone covered the posterior half of the lacrimal sac, whereas in 3 of 17 more than half the sac and in 2 of 17 less than half the sac was covered by lacrimal bone.

Second, the relation between the lacrimal sac and the axilla of the middle turbinate was observed. In 15 of the 20 cases part of the lacrimal sac was situated on the anterior aspect of the axilla of the middle turbinate, whereas the other part was situated on the posterior aspect (**Figure 6C and D**). On the contrary, in 3 of 20 cases, the lacrimal sac was situated entirely on the posterior aspect of the axilla of the middle turbinate (**Figure 6E and F**), whereas it was situated entirely on the anterior aspect of the axilla of the middle turbinate in 2 of 20 cases (**Figure 6A and B and Figure 7**). In all 20 cases, the fornix of the lacrimal sac was located superiorly on the axilla of the middle turbinate (**Figure 6**).

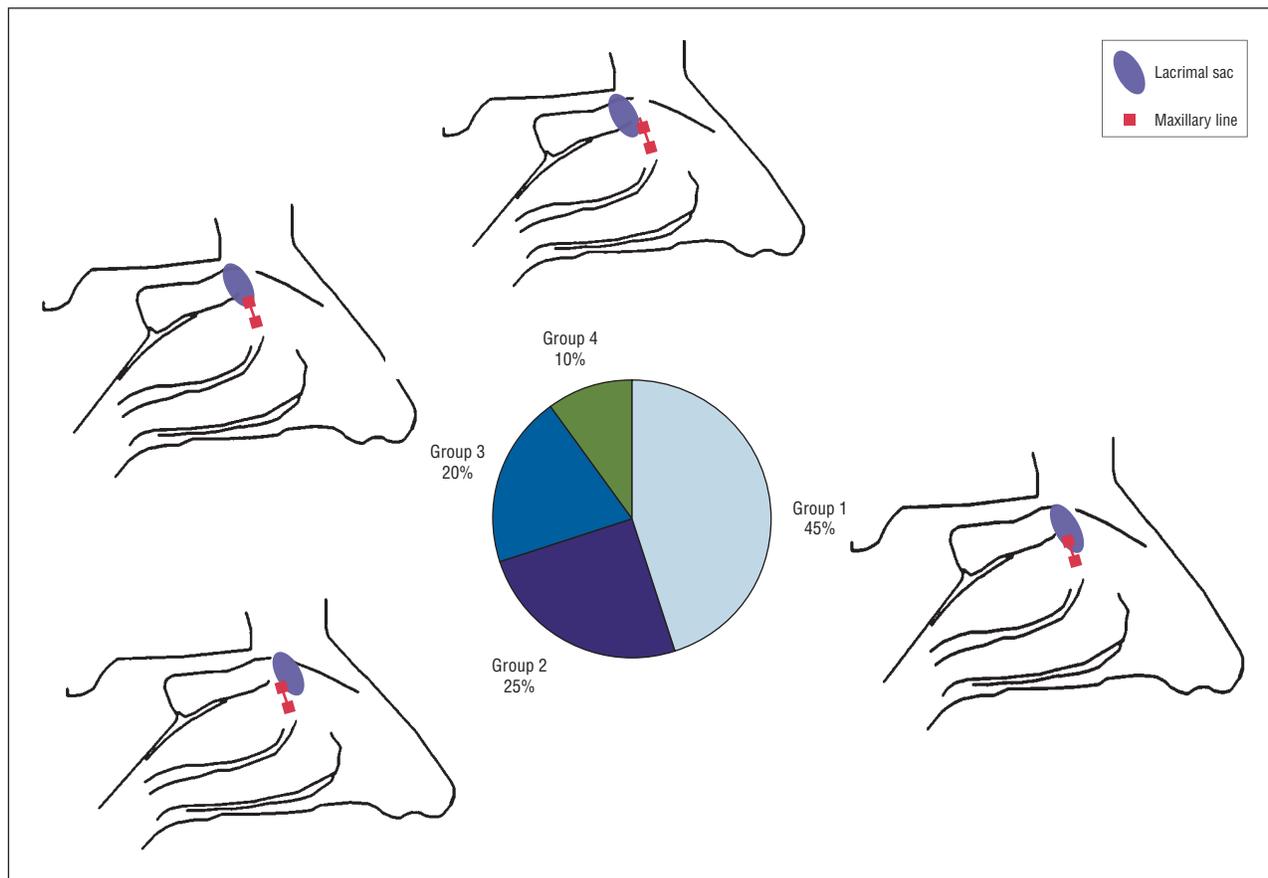
The dimensions of the lacrimal sac were observed. The mean (SD) length of the lacrimal sac was measured as 12.76

(2.25) mm (range, 9.68-17.45 mm) and the anterior posterior width as 7.62 (1.46) mm (range, 5.09-10.23 mm). The distance from the lacrimal sac to the landmarks and its relationship to the adjacent areas were analyzed (**Table**). The application of a paired *t* test to detect whether a statistically significant difference exists in the measurements between the right and left parts of the specimens revealed that no such difference was established.

#### COMMENT

The surgical technique of endonasal dacryocystorhinostomy involves the removal of the frontal process of the maxilla, which is anterior to the middle turbinate, after the elevation of the mucoperiosteum. The success rate of dacryocystorhinostomies performed externally or endonasally is reported to be approximately 80% to 95%.<sup>3-11</sup>

Three important factors are responsible for the failure of the endonasal dacryocystorhinostomy approach: the dimension of the bony ostium, localization of this part, and the size of the lacrimal sac, which may differ from patient to patient.<sup>12,13</sup> Welham and Wulc<sup>14</sup> revealed that the size of the ostium and its localization were responsible for 208 dacryocystorhinostomy failures. To obtain the best result, current studies suggest the necessity of



**Figure 5.** The relation between the lacrimal sac and the maxillary line.

opening the ostium as wide as possible in surgical procedures. The surface anatomy of the lacrimal sac in the nasal cavity is also an important factor.

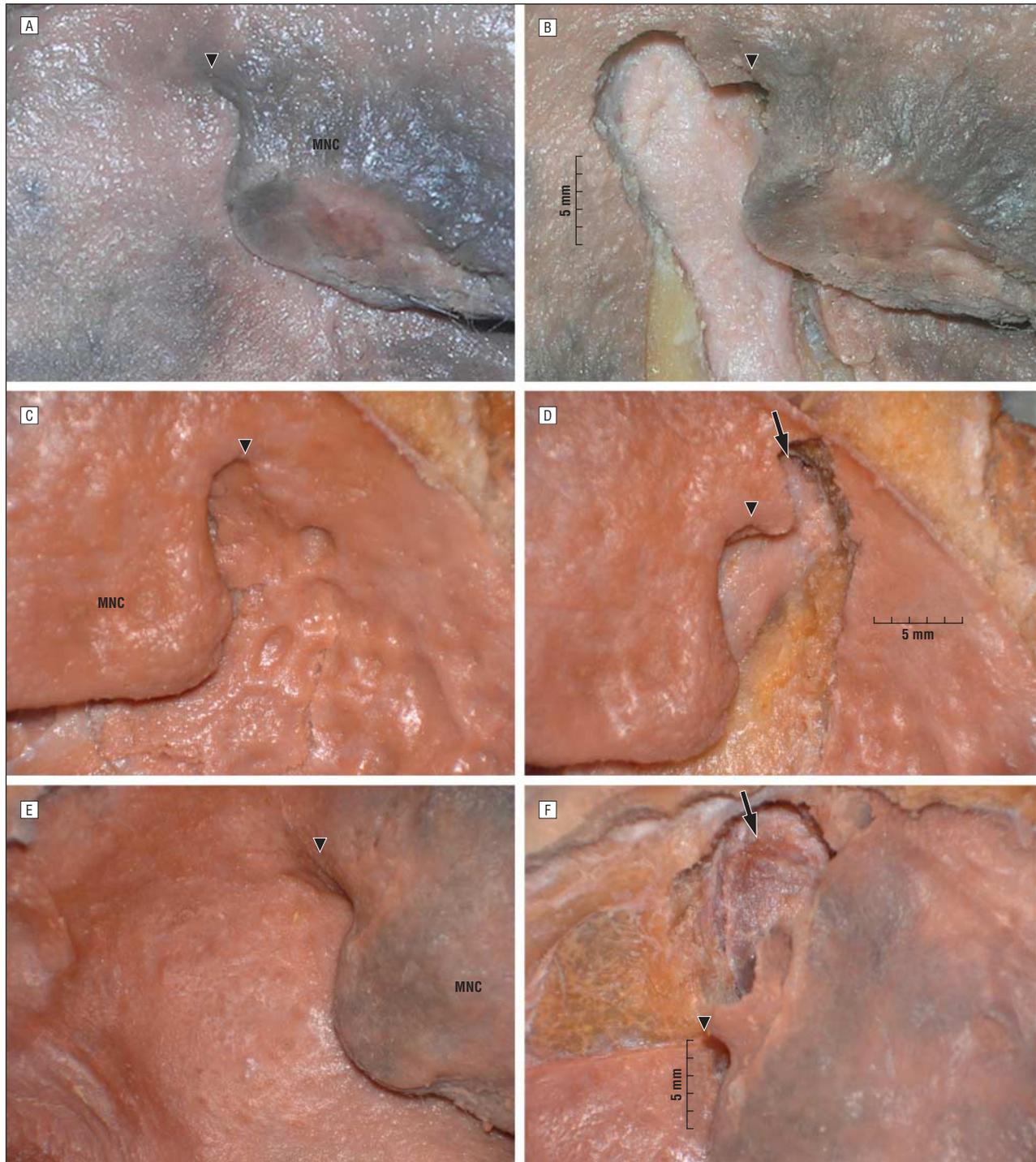
The comprehensive knowledge of surgeons in regard to topographic anatomy and the lateral wall is fundamental to the successful performance of dacryocystorhinostomy. The recognition of the anatomical relationship between the lacrimal sac and other parts nearby enables an easier operation and helps to obtain more reliable results. Relevant landmarks are required to better localize the lacrimal sac on the lateral wall. The maxillary line and axilla of the middle turbinate are the most frequently used anatomical landmarks.<sup>15</sup> However, not many cadaver studies have been performed on these landmarks and their relationship to and variations from the lacrimal sac. When one takes the anatomical variations into consideration, the performance of a mucosal incision and osteotomy in a safer area is essential for more reliable and functional results. Although surgeons perform identical incisions, osteotomies, and operations, these procedures may prove to be unsuccessful because of anatomical differences in patients.

The initial variation to recognize is the maxillary line and the bony structure beneath it. Chastain et al<sup>15</sup> obtained 25 cadaveric nasal specimens, examined the maxillary line and the bony structure beneath the maxillary line, and alleged that the point where the uncinat process adhered to the maxilla intranasally formed the maxillary line, which was on the same axis as the lacrimo-

maxillary suture. Although the maxillary line is a remarkable landmark on the anterior extension of the uncinat process, in our study, in only 11 of 16 cases did the maxillary line overlap the lacrimomaxillary suture. No overlapping was seen in the remaining 5 cases, in which the lacrimomaxillary suture was located posterior to the maxillary line but never on the anterior aspect. Therefore, an incision performed anterior to the maxillary line should be followed by a careful mucosal elevation, which will almost always reveal the lacrimomaxillary suture.

In our study, the relationship of the maxillary line to the lacrimal sac after the removal of the bony structure was observed: the maxillary line overlapped the lacrimal sac at a ratio of 18:20. In 2 cases where it did not overlap the lacrimal sac, it was situated entirely posterior to the maxillary line. Therefore, the rate of reaching the lacrimal sac is 90% through an incision performed anterior to the maxillary line, whereas, in 10% of cases in which the lacrimal sac wall is not visible, the conducting of mucosal elevation and osteotomy more posteriorly is sufficient to reveal the lacrimal sac wall. When the lacrimal sac was examined from different perspectives, it was found to be situated in a lateral and superior relative to the maxillary line.

Unless the middle turbinate is hypertrophic or polypoid, the lacrimal sac commonly lies anterior to the axilla of the middle turbinate.<sup>16,17</sup> Some authors defined the axilla of the middle turbinate as the upper border of the



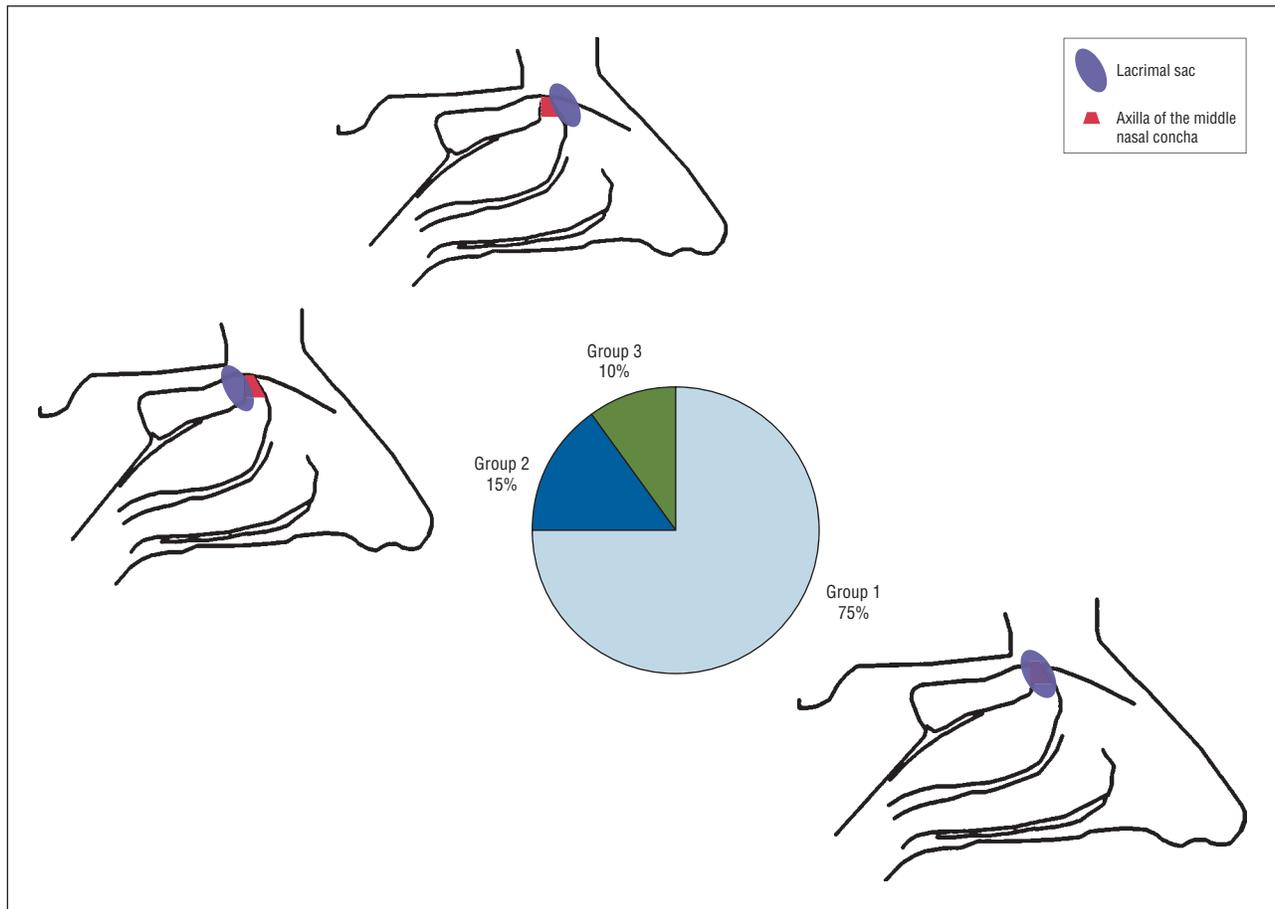
**Figure 6.** Various positions of the lacrimal sac. MNC indicates the middle nasal concha; each arrowhead, the axilla of MNC; and each arrow, the fornix of the lacrimal sac. A and B, The lacrimal sac is located anterior to the axilla of the MNC. C and D, The lacrimal sac overlaps the axilla of the MNC. E and F, The lacrimal sac is located posterior to the axilla of the MNC.

lacrimal sac. However, other authors have proposed that the bone superior to the middle turbinate needs to be removed also to reveal the lacrimal sac in its entirety. In most anatomical drawings and definitions, 0% to 20% of the lacrimal sac is found to be situated superior to the axilla of the middle turbinate.<sup>18,19</sup> Wormald et al<sup>18</sup> analyzed 47 computed tomographic dacryocystograms of patients and determined that the major portion of the lac-

rimal sac was situated superior to the axilla of the middle turbinate.

Neglecting a few variations in the literature, the anterior half of the lacrimal sac is covered with the frontal part of the maxilla, and the posterior half is concealed with the lacrimal bone.<sup>18</sup> Our study confirms these results.

In contrast to data in the literature, our study gives the impression that the lacrimal sac is located superi-



**Figure 7.** The relationship between the lacrimal sac and the axilla of the middle nasal concha.

or to the axilla of the middle turbinate (Table and Figure 1). As the current literature points out, most of the lacrimal sac is localized anterior to the axilla of the middle turbinate in the nasal cavity. However, in our study, the lacrimal sac is shown to be situated in a more superior position than it had been described previously. Therefore, incisions and osteotomies that were performed inferior to the axilla of the middle turbinate may fail to identify the lacrimal sac. Looking for it to be in a more superior position than the localization described may yield better results. Thus, a limited approach that allows one to reach only to the inferior edge of the lacrimal sac can be replaced by the approach from our study, which enables one to reach the entire medial wall of the lacrimal sac. Limited osteotomies, which are performed to reveal just the inferior part of the lacrimal sac, may be one of the reasons for the failure rate of up to 15% for the endonasal approach; this factor may also explain why the success rates of the endonasal approach are lower than those of the external approach.

Fayet et al<sup>20</sup> analyzed 59 patients with nasolacrimal duct obstruction by the injection of contrast agent into the lacrimal sac and the subsequent performance of high-resolution computed tomography. These investigators projected that the axilla of the middle turbinate lies on the lacrimal sac in 53.2% of cases. This situation contradicts the traditional idea that the axilla of the middle turbinate is located posterior to the fossa of the lacrimal sac.

**Table. Distance From the Lacrimal Sac to Landmarks**

Measurements	Mean (SD) [Range], mm
Distance between posterior edge of lacrimal sac and axilla of middle turbinate	4.06 (2.51) [0-9.68]
Distance between anterior edge of lacrimal sac and axilla of middle turbinate	3.67 (2.20) [0-7.51]
Distance between posterior edge of lacrimal sac and most superior part of free edge of uncinat process	5.02 (2.47) [0-8.88]
Distance between posterior edge of lacrimal sac and maxillary sinus ostium	7.21 (1.82) [4.53-10.90]
Distance between posterior edge of lacrimal sac and ethmoidal bullae	7.93 (3.18) [1.70-17.00]
Distance between inferior edge of lacrimal sac and inferior turbinate	8.25 (2.12) [4.91-13.15]
Anterior-posterior diameter of lacrimal sac	7.62 (1.46) [5.09-10.23]
Length of lacrimal sac	12.76 (2.25) [9.68-17.45]
Distance between fornix of lacrimal sac and axilla of middle turbinate	4.73 (2.86) [1.61-12.25]
Distance between anterior nasal spine and fornix of lacrimal sac	41.20 (3.96) [33.79-48.33]
Distance between anterior nasal spine and inferior edge of lacrimal sac	31.36 (3.20) [25.58-36.5]

The results of this study suggest that most of the lacrimal sac is located superior to the axilla of the middle turbinate. However, the axilla of the middle turbinate in axial sections always lies anterior to the lacrimomaxillary suture and is never attached to the lacrimal bone. Hence, the axilla of the middle turbinate may be the most reliable landmark in the localization of the suture line, which is the main target line of the osteotomy for the endonasal and external approaches.

Currently, there is still a 10% to 15% failure rate in endoscopic dacryocystorhinostomy procedures. In review of cadaver studies together with data from the literature, the foremost reason for failure is owing to the anatomical differences described as follows.

First, the lacrimal sac is not located in a standard place. Topographic localization of the lacrimal sac should be presumed with the help of landmarks, such as the axilla of the middle turbinate (primarily), the maxillary line, and the uncinat process. Mucosal incision and elevation should be performed afterward. The most appropriate mucosal incision is that which is placed 8 to 9 mm anterior and reaches 8 to 9 mm superior to the axilla of the middle turbinate.

Second, the lacrimomaxillary suture should be recognized and its relationship to the lacrimal sac should be noted well. This, however, may not always be possible because of bleeding.

Third, after removing the suture, the revealed mucosa does not necessarily point one to the lacrimal sac; the lacrimal sac may tend to be located on a posterior layout. In such cases, there may be a need to further continue dissection posteriorly.

Fourth, an area of mucosal swelling is often assumed to be the lacrimal sac. This assumption can be clarified by entrance through the lacrimal punctum and the ridging of the medial wall to the nasal cavity.

Fifth, it is generally easier for the surgeon to reach the inferior edge of the sac. Therefore, the sac wall should be dissected further superiorly as much as possible.

Sixth, the stoma of the lacrimal sac wall should be noted. The stoma should not be narrow.

In conclusion, apart from anatomical differences and divergences among surgical approaches, the evaluation of the functions of the lacrimal sac is essential in order to avoid surgical failure. Preoperative negligence of the assessment of fibrotic lacrimal sacs with dysfunction will result in failure postoperatively.

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**Author Contributions:** Dr Saylam had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

**Study concept and design:** Orhan, Saylam, and Midilli. **Acquisition of data:** Orhan, Saylam, and Midilli. **Analysis and interpretation of data:** Orhan, Saylam, and Midilli. **Drafting of the manuscript:** Orhan, Saylam, and Midilli. **Critical revision of the manuscript for important intellectual content:** Orhan and Midilli. **Statistical analysis:** Orhan. **Obtained funding:** Orhan. **Administrative, technical, and material support:** Orhan and Saylam. **Study supervision:** Saylam.

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