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Anatomical guidelines for intranasal surgery of the lacrimal drainage system*

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SUMMARY

To facilitate identification of the nasolacrimal duct during intranasal surgery, we have determined the distances between the lacrimal drainage system and certain anatomical structures on the lateral wall of the nasal cavity. A total of 15 adult cadaver skulls were bisected midsagittally and evaluated morphometrically. In our specimens, the average distance from the natural ostium of the maxillary sinus to the nasolacrimal duct (NLD) was only 5.5 mm. This rather small distance should be taken into consideration, in order to prevent trauma of the NLD during surgical enlargement of the ostium of the maxillary sinus. The distances from NLD to the anterior surface of the bulla ethmoidalis, the free edge of the uncinate process and the attachment point of the middle turbinate on the lateral nasal wall were found to be 10.2 mm, 8.8 mm and 5.4 mm, respectively. Taking these distances into account, easy identification of the NLD during endonasal dacryocystorhinostomy surgery will be possible.

Keywords: anatomical data, dacryocystorhinostomy, intranasal surgery, nasolacrimal duct

INTRODUCTION

The lacrimal drainage system (LDS) can be accidentally traumatized in view of its location on the lateral wall of the nasal cavity. This might occur during the treatment of maxillofacial trauma, rhinoplasty, orbital decompression, surgery of the nasal and paranasal sinus tumours, as well as conventional or endoscopic sinus surgery (Serdahl et al., 1990; Bolger et al., 1992; Tjon et al., 1994; Weber and Draf, 1994; Ünlü et al., 1996). Recently, endonasal endoscopic dacryocystorhinostomy (DCR) surgery has been successfully introduced in the treatment of chronic epiphora in many otolaryngological clinics. It is favoured over other practises because its advantages are that external scars are avoided and the pump mechanism of the sac is left intact (Massaro et al., 1990; Metson, 1991; Weidenbecher et al., 1994; Metson et al., 1994).

This study was undertaken in Turkish cadavers to measure the distances between certain anatomical structures on the lateral nasal wall with respect to the LDS. The results provide a set of measurements that enable easy identification of the LDS during intranasal surgery, and reveal a wide range of data, comparable to those reported in the few previously published papers. Probably this variability depends on differences (e.g., gender) in the populations investigated.

MATERIAL AND METHODS

A total of 15 adult Turkish cadavers (4 female and 11 male) were evaluated at the Department of Anatomy of Ege University Medical Faculty in İzmir. Each skull was mid-sagittally bisected and the nasal septum removed (Figure 1). A window-shaped section of the mucosa was taken out of the lateral wall of the each skull, mid-sagittally bisected as is done during DCR. With the help of a chisel the bony wall of the nasolacrimal duct (NLD) was removed, and the anterior and posterior margins of the NLD were exposed (Figure 2).

The anterior attachment of the inferior turbinate to the lateral wall of the nasal cavity (NC) was preserved and after segmentally removing of the anterior one-third of the inferior turbinate, the opening of the NLD into the inferior meatus, known as Hasner's valve, was detected. In incomplete specimen the valve locations were detected via a probe passing through the NLD, and its distance from the anterior nasal spine (ANS) and the angle it made with the floor of the nose was measured (Figures 3-4). Furthermore, the height of Hasner's valve from the floor of the nose was recorded.

The distances between the posterior margin of the NLD and the free edge of the uncinate process as well as the anterior surface of the bulla ethmoidalis were measured with respect to a point

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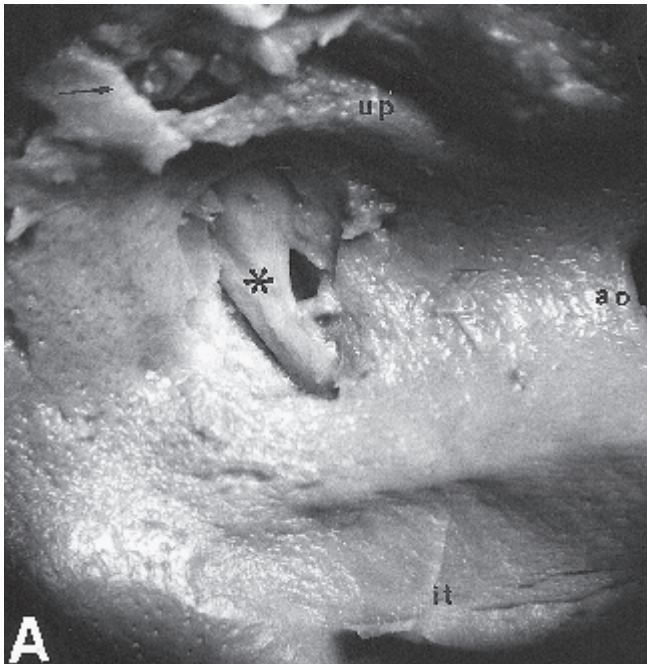
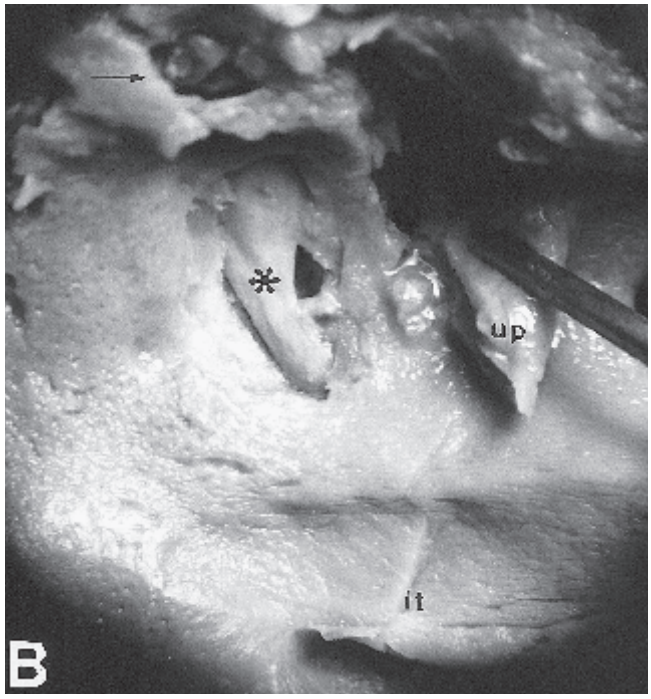
Figure 1. Mid-sagitally bisected skull showing the right lateral nasal wall.

halfway between the attachments of the middle and inferior turbinates to the lateral nasal wall. In addition, the width of the NLD on the midportion was recorded. With the help of a sickle knife an infundibulotomy incision was performed and uncinate process removed, as in functional endoscopic sinus surgery (FESS; Figure 2). Next, the natural ostium of the maxillary sinus was identified and its width anteroposteriorly as well as its distance to the posterior margin of the NLD was measured. The free edge of the bulla ethmoidalis was divided into four equal parts from the top down. The first part located anterosuperiorly was called “first quarter” and the remaining three equal parts were called “second”, “third” and “fourth quarter” on the postero-inferior direction, as previously described by Lang and Sakals (1982). The location of the maxillary sinus ostium with respect to these quarters was then recorded. The distance from the anterior attachment of the middle turbinate to the NLD was also noted (Figure 5).





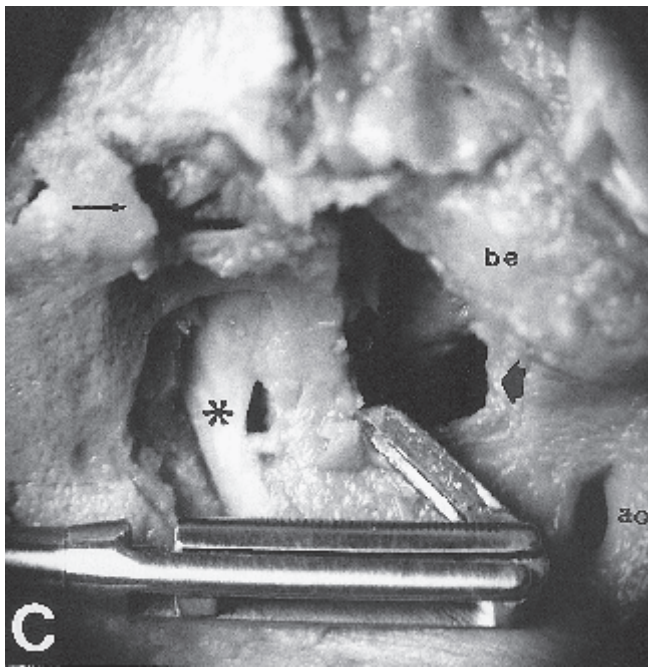


Figure 2. (A) On the right lateral nasal wall the NLD is exposed as a window shape (asterisk). (B) By displacing the uncinate process *(up)* medially with an infundibulotomy incision, the maxillary sinus ostium is demonstrated (*be:* bulla ethmoidalis; *small arrow*: attachment of middle turbinate to the lateral nasal wall). (C) On the right side the distance between the NLD (asterisk) and maxillary sinus ostium (big arrow) is shown, relative to the cutting edge of the back-biting forceps used in FESS (*ao:* accessory ostium on posterior fontanelle; *it:* inferior turbinate).

All measurements were performed with a micrometer. To obtain a more accurate measurement a binocular anatomical dissection microscope, Jena-390822, was used and light micrographs were taken with the microscope (Figures 2-4).

Mean values of the measurements and right and left sides for each skull were statistically compared using the Student’s *t* test.

Figure 3. The opening of the NLD into the inferior meatus (Hasner's valve) is demonstrated (arrow) after removal of the segment of inferior turbinate *(it)* on the left side (*ans:* anterior nasal spine).

Figure 4. On the right side the segment of the inferior turbinate is removed (small arrows), Hasner's valve (large arrow) is identified by passing a probe *(p)* through the NLD (*im:* right inferior meatus)

RESULTS

A total of 26 sides (11 bilateral and 4 unilateral) of 15 mid-sagittally bisected adult cadavers were studied. The obtained mean distances from the LDS to the various anatomical structures on the lateral wall of the NC are shown in Table 1. The comparison of right and left sides of the 11 bilaterally evaluated specimens revealed statistically significant differences only in the cases that had an accessory ostium (p=0.047). Differences between the other measurements were not statistically significant. The location of the maxillary sinus ostium with regard to the anterior surface of the bulla ethmoidalis is seen in Table 2. The accessory ostium was detected in 13 specimens (50%). In 9 cases its location was found on the posterior fontanelle, in 3 cases on the anterior fontanelle, and in 1 case on both the posterior and anterior fontanelles.

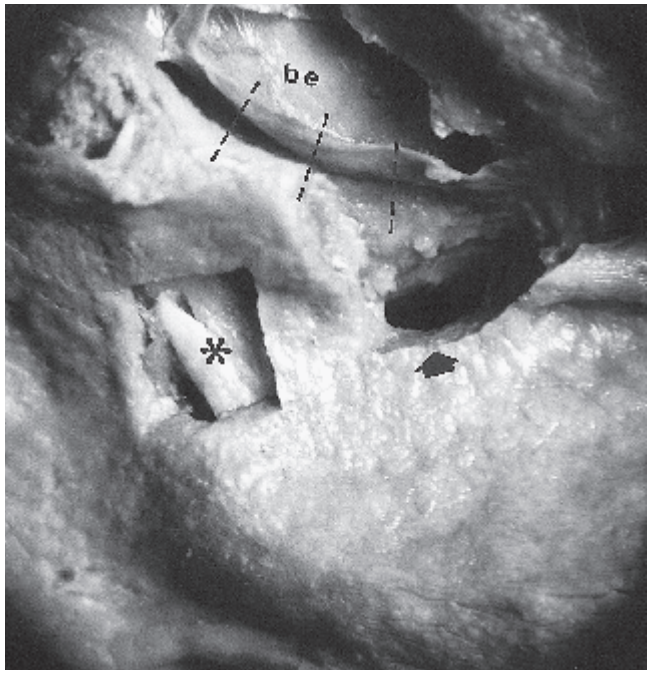


Figure 5. The uncinate process was resected in the right nasal cavity and the NLD (asterisk) and maxillary sinus ostium (large arrow) at the fourth quarter are shown.

Table 1. The distances of the lacrimal drainage system to several anatomical structures on the lateral nasal wall (SD: standard deviation; ANS: anterior nasal spine; NC: nasal cavity; MT: middle turbinate; NLD: nasolacrimal duct).

structures	main distance (±SD; mm)	range (mm)
Hasner's valve-ANS	23.0±3.3	17-30
Hasner's valve-ANS (angle)	35.8±9.3°	20-55°
Hasner's valve-floor of NC	13.2±2.7	9-19
attachment of MT-NLD	5.4±1.4	3-8
uncinate process-NLD	8.8±2.1	7-15
bulla ethmoidalis-NLD	10.2±2.0	7-16
anteroposterior width of NLD (midportion)	4.7±0.7	4-6
maxillary sinus ostium-NLD	5.5±1.9	3-9
width of maxillary sinus ostium (anteroposterior)	5.7±2.9	3-14

Table 2. The location of the maxillary sinus ostium related to the anterior surface of the bulla ethmoidalis.

location of the maxillary sinus ostium	No. (%)
first quarter	0 (0)
second quarter	10 (38.5)
third quarter	12 (46.2)
fourth quarter	1 (3.8)
second and third quarter	2 (7.7)
third and fourth quarter	1 (3.8)

DISCUSSION

The LDS can be damaged during the antrostomies performed in the surgical treatment of chronic sinusitis. The orifice of the NLD at the inferior meatus, known as Hasner's valve, can be traumatized during inferior meatal antrostomy (Serdahl et al., 1990; Bolger et al., 1992; Weber and Draf, 1994). In our study we chose the anterior nasal spine, a more stable structure than the congestible or constructible anterior tip of the inferior turbinate, as a reference point to measure the distance of Hasner's valve. The distance from Hasner's valve to the ANS was determined at 23.0±3.3 mm, and the angle at 35.8±9.3°. The mean height of Hasner's valve from the floor of the nasal cavity was 13.2±2.7 mm (Figures 3-4).

Epiphora, caused by lacrimal duct damage, is an annoying complication of FESS that often can only be corrected by a secondary surgical procedure. The NLD is most often damaged when remnants of the uncinate process are removed or the maxillary sinus ostium is enlarged using back-biting forceps. This is because the uncinate process diverges as a wing of the lacrimal bone (Levine and May, 1993). Epiphora following FESS has been reported by experienced surgeons after 0.3-1.7% of middle meatal antrostomies (Kennedy et al., 1987; Davis et al., 1991). In contrast, 15% of patients during FESS have an occult injury of their LDS (Bolger et al., 1992). This suggests that injury to the LDS is more common than is reported. This may be because of the natural ability of the LDS to heal without manifesting any signs or symptoms (Silva and Stankiewicz, 1995). In addition, Bolger et al. (1992) state that "as the incidence of complications may be considerably higher for surgeons who are early in their FESS experience and as more otolaryngologists are beginning to use this new surgical technique, analysis of NLD injuries during FESS is warranted." Levine and May (1993) report that the close relationship between the uncinate process and the lacrimal bone probably results in lacrimal duct damage occurring more often than surgeons believe. Indication of such damage is a patient's comment that when he or she blows the nose, air comes into the eye. These patients have, in effect, inadvertently undergone DCR. When the duct is crushed and lacrimal outflow is blocked, however, symptoms will occur (Levine and May, 1993). In the literature, present recommendations for enlarging the natural ostium of the maxillary sinus include retrograde dissection with back-biting forceps. To avoid injury to the NLD, termination of the retrograde dissection is advised when significant resistance is encountered, as the bone around the duct is reported to be thicker than that in the contiguous region of dissection (Stammberger, 1991). Also, Bolger et al. (1992) state that back-biting forceps are used only to resect the uncinate process and its surrounding mucosa; hence, the NLD is preserved. In addition, excessive removal of the anterior fontanelle places the NLD at risk to injury, while removal of the posterior fontanelle enlarges the natural ostium safely and adequately. Levine and May (1993) also recommend that the blade of the back-biting forceps should be kept within the infundibulum and not placed in the maxillary sinus when the forceps are used to enlarge the maxillary sinus ostium antero-inferiorly. To avoid injury to the NLD when creating and enlarging an antrostomy, it is also important to consider the distance from the natural ostium of the maxillary sinus to the NLD. Silva and Stankiewicz (1995) state that the NLD is located 3-6 mm anterior to the natural ostia, and surrounded by hard bone. In addition, injury can be avoided by not enlarging the antrostomy anteriorly past the anterior tip of the middle turbinate and by stopping if the hard bone surrounding the NLD is encountered with the back-biting forceps. We determined the average distance from the natural ostium to the duct to be 5.5±1.9 mm (range: 3-9 mm; Figures 2 and 5). Calhoun et al. (1990) found this average distance to be 9±3 mm in their specimen. Rice (1994) reported that "in general the ostium is approximately 4 mm posterior to the NLD." We found the average anteroposterior diameter of maxillary ostium to be 5.7±2.9 mm (range: 3-14 mm) as well.

In 92.4% of the specimens, the position of the maxillary ostium related to the anterior surface of the bulla ethmoidalis was detected on the second and third quarters (Table 2). In Myerson's material (1932), the ostium of the maxillary sinus is situated at the posterior end of the semilunar hiatus in 23% of cases. In two other studies (Lang and Sakals, 1982; Lang, 1989) the ostium of the maxillary sinus is situated in the posterior quarter in 2%, in the third quarter in 48%, in the second quarter 28%, and in the anterior quarter in 22% of the cases. Rice (1995) stated that the ostium of the maxillary sinus usually empties into the infundibulum, generally in the second, third and fourth quarter of this groove and usually measures 7-11 mm in length and 2-6 mm in width. Van Alyea (1936) found the natural ostium to be located posteriorly in the infundibulum in two-thirds of cases, in the middle in one-fourth of cases, and in the anterior part of the infundibulum in 10% of anatomical specimens. Accesory ostia are generally found in the membranous fontanelle but may be in the infundibulum. These ostia exist in 15-40% of patients (Rice, 1994). We detected them in 50% of our specimens and thus found a higher percentage than in the literature. Furthermore, statistically significant diffrences were found between the left and right sides ($p=0.047$).

Recently, endoscopic endonasal DCR has been successfully used in either primary or revision cases (Metson, 1990; Metson et al., 1991; Weidenbecher et al., 1994; Metson et al., 1994). In this study the structures (the anterior surface of the bulla ethmoidalis, the free edge of the uncinate process, and the attachment point of the middle turbinate on the lateral wall of the nasal cavity) on which we have focussed can be employed as landmarks during endonasal DCR surgery. The distances from the NLD to the above-mentioned structures were found to be 10.2±2.0 mm, 8.8±2.1 mm and 5.4±1.4 mm, respectively (Table 1).

CONCLUSIONS

(1) In 92.4% of our specimens, the position of the maxillary ostium related to the anterior surface of the bulla ethmoidalis was detected on the second and third quarters. The average distance from the natural ostium to the duct was found to be only 5.5 mm. This close relationship should be taken into consideration to avoid traumatizing the NLD when the maxillary sinus ostium is being enlarged during FESS.

(2) The distances from NLD to the anterior surface of the bulla ethmoidalis, the free edge of the uncinate process, and the anterior attachment of the middle turbinate were found to be 10.2, 8.8 and 5.4 mm, respectively. When taking these distances into account, the NLD may be more easily identified during endonasal DCR surgery.

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