Original Article
Acta Medica Academica 2022;51(3):175-180
DOI: 10.5644/ama2006-124.386

Endoscopıc Anatomy of the Lacrımal Sac: A Cadaverıc Study

Rukiye Ozcelik Erdem[1], Mehmet Akif Dundar[1], Senanur Arbag[2], Hamdi Arbag[1], Muzaffer Seker[3]

[1]Department of Otorhinolaryngology, Faculty of Medicine, Necmettin Erbakan University, Turkey, [2]Hacettepe University Institute of Health Sciences, Turkey, [3]Department of Anatomy, Faculty of Medicine, Necmettin Erbakan University, Turkey

Correspondence: *ozcelikrukiye@gmail.com*; Tel.: + 90 553 0800514

Received: 8 July 2022; **Accepted:** 6 November 2022

Thanks to TÜBA Scientific Research Funding for obtaining cadavers.

Abstract

Objective. To describe the anatomy of the lacrimal sac in relation to the lateral nasal wall by cadaver dissection, and to measure the distances of surgically important landmarks from relevant structures for safer and more efficient surgery. **Method.** A total of 12 endoscopic dacryocystorhinostomy (DCR) were performed on both sides (right and left) of 6 fresh-frozen cadavers. The distances of the lacrimal sac to the posterior edge of the uncinate process, the frontal process of the maxilla, the maxillary ostium, the nasal vestibule, the middle turbinate attachment and the inferior turbinate were measured. In addition, the width and length of the lacrimal sac were measured. **Results.** The mean width and length of the lacrimal sac were 5.6 mm and 11.1 mm, respectively. The lacrimal sac was located at 15.2 mm from the posterior edge of the uncinate process, at 35.5 mm from the nasal vestibule, at 13.5 mm from the maxillary ostium, at 12.2 mm from the frontal process of the maxilla, at 8.7 mm from the middle turbinate attachment, and at 7.3 mm from the inferior turbinate. **Conclusion.** This study provides additional measurements regarding the lacrimal sac and its relationships with nearby landmarks for use in endoscopic dacryocystorhinostomy. The distances of the lacrimal sac to the nasal vestibule, the uncinate process and the frontal process of the maxilla are not as reliable as the middle turbinate attachment for predicting the anatomic localization of the lacrimal sac during DCR.

Key Words: Dacryocystorhinostomy ▪ Endoscopic Endonasal Approach ▪ Lacrimal Pump System ▪ Nasolacrimal duct.

Introduction

Although dacryocystorhinostomy (DCR) has been performed via an external approach in the past, it has been replaced by an endoscopic endonasal approach, with the introduction of endoscopy. One reason for this is that it prevents the cosmetic deformities caused by external methods. Other reasons are that endoscopy allows clinicians to observe the inside of the body by providing a clear and wide viewing angle in the endonasal region, and success is achieved without damaging the lacrimal pump system by predicting the localization of the nasolacrimal duct using landmarks. The endoscopic DCR technique was described in 1989 (1). Many studies have been conducted on endoscopic DCR until today. Most of these studies have emphasized that the most important point to be considered for the success of endoscopic surgery is the DCR incision site. Many landmarks, especially the middle turbinate and maxillary line, have been identified for mucosal incision and osteotomy (2, 3). Although many landmarks have been described for endoscopic DCR, there is not enough information about the relationship of these landmarks to the lacrimal sac.

This study aimed to make endoscopic DCR surgery more reliable and successful by revealing the relationships of these landmarks with the lacrimal sac using measurement data. Unlike other studies, we demonstrate the relationship of the lacrimal sac with many landmarks in the same study, and evaluate the most reliable one.

Materials and Methods

A total of 12 endoscopic DCR procedures were performed on both sides (right and left) of 6 fresh-frozen cadavers. A 0-degree rigid endoscope (0^0, Storz Hopkins, Germany) was used during this procedure. A superior-based mucosal flap was removed approximately 5 mm above and 10 mm in front of the middle turbinate attachment (Figure 1).

Before lifting the flap, information about the localization of the lacrimal sac was obtained through the nasal cavity by placing a light source parallel to the lacrimal punctum (Figure 2). After the mucosal flap was removed (Figure 3), a bone window was opened with the help of a chisel and hammer to reveal the entire lacrimal sac. The distances were measured of the anterior border of the lacrimal sac's mid-height, to the posterior edge of the uncinate process's mid-height, posterior edge of the frontal process of the maxilla's mid-height, anterior edge of the maxillary ostium, and nasal vestibule. The distances were measured between the midline of the lacrimal sac and the middle turbinate attachment, and between the lower border of the lacrimal sac's mid-width and the most medial point of the inferior turbinate (Figure 4). We evaluated the

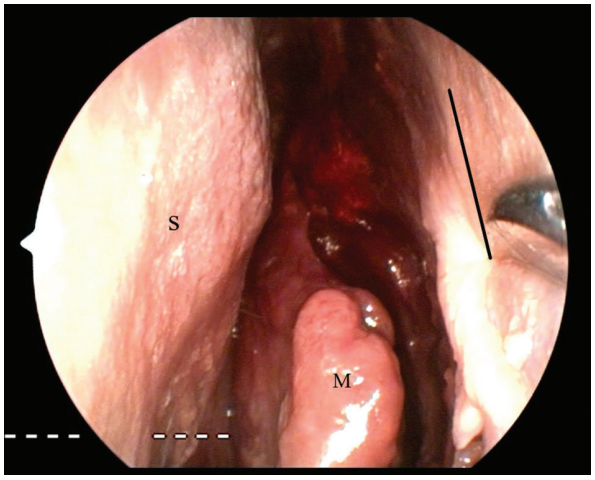

Figure 1. A superior based mucosal flap was prepared with a lancet. The line shows the anterior incision site. S=Septum; M=Middle turbinate.

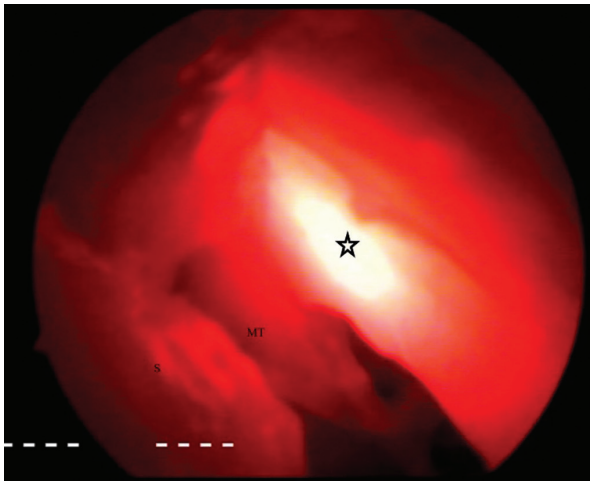

Figure 2. The lacrimal sac was located by placing a light source parallel to the lacrimal punctum. S=Septum; MT=Middle turbinate; Star=Lacrimal sac.

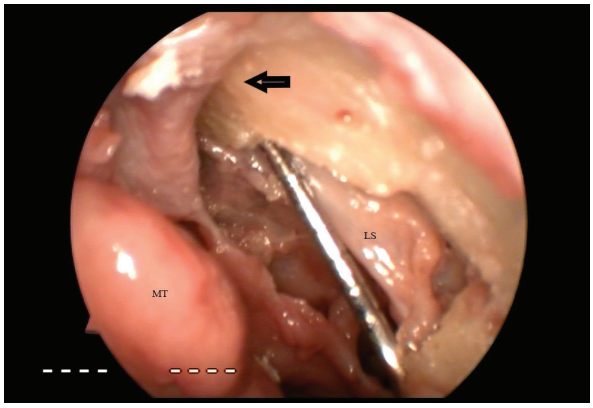

Figure 3. After the mucosal flap was removed. Arrow=Mucosal flap; MT=Middle turbinate; LS=Lacrimal sac.

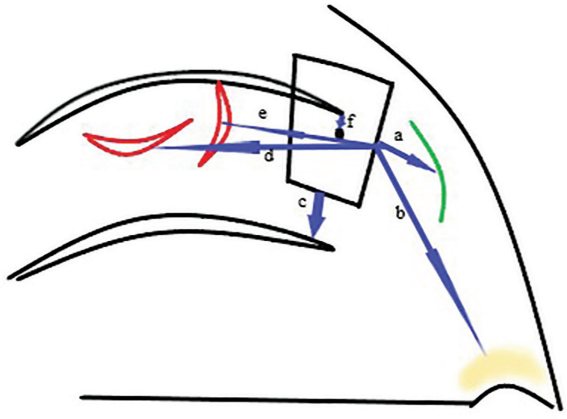

Figure 4. Diagram of the measurements. Distances from the anterior border of the lacrimal sac's mid-height, to (a) posterior edge of the frontal process of the maxilla's mid-height, (b) nasal vestibule, (d) anterior edge of the maxillary ostium, (e) the posterior edge of the uncinate process's mid-height and from the midline of the lacrimal sac to (f) the middle turbinate attachment, and (c) between the lower border of the lacrimal sac's mid-width and the most medial point of the inferior turbinate.

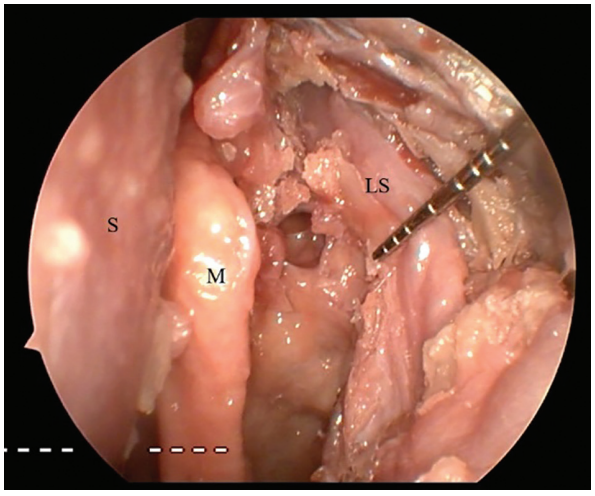

Figure 5. The measurement of the lacrimal sac width was seen on the photograph. LS=Lacrimal sac; S=Septum; M=Middle turbinate.

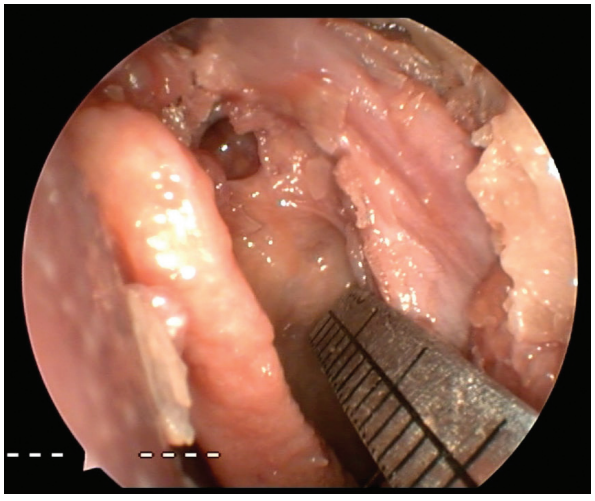
Figure 6. The specified ruler is seen on the photograph.

lower border of the lacrimal sac as upper limit of the inferior turbinate. In addition, the width and length of the lacrimal sac were measured (Figure 5). The distances were measured with a specified ruler that precision was 1 mm (Figure 6).

Ethics Approval

This study was approved by the Ethics Committee of Necmettin Erbakan University Meram Faculty of Medicine (Decision No: 2016/687 and Decision Date: 07/10/2016).

Statistical Analysis

All data were evaluated using SPSS version 20 by descriptive methods. Descriptive analyses were based on range, mean ±SD. The measurements of the right and left sides were compared with paired t-test. A p value of <0.05 was considered statistically significant.

Results

All the cadaveric heads were dissected. All the measurement data are shown in Table 1 and Figure 7. The mean width of the lacrimal sac (LS) was 5.5±3.2 mm (range 4-12) for the right side, 5.8±3.1 mm (range 4-12) for the left side. The mean distance from the LS to the nasal vestibule was 34±1.7 mm (range 32-42) for the right side and 37±2.6 mm (range 34-42) for the left side. The mean distance from the LS to the frontal process of maxilla was 13±4.8 mm (range 9-22) for the right side, and 11.5±3.2 mm (range 7-16) for the left side. The mean distance from the LS to the middle turbinate attachment was 8.5±1.7 mm (range 6-11) for the right side, and 9±2.2 mm (range 7-13) for the left side. The mean distance from the LS to the uncinate process was 15.8±5.7 mm (range 12-27) for the right side, and 14.6±4.9 mm (range 10-23) for the left side. The mean distance from the LS to the maxillary ostium was 15±3 mm (range 13-21) for the right side, and 12.1±2.8 mm (range 7-15) for the left side. The mean distance from the LS to the inferior turbinate was 7.6±4.6 mm (range 12-27) for the right side, and 7±3.1 mm (range 10-23) for the left side. The mean values were calculated separately for the right and left sides. No significant difference ($P>0.05$) was found in any variables between the right and left sides.

Table 1. Measurements between the Lacrimal Sac and the Adjacent Landmarks

Cadaver	Side	NVLS	FPMLS	MTALS	UPLS	MOLS	ITLS	LS width	LS length
1	R	33	10	10	12	15	13	5	10
	L	37	10	10	10	13	13	5	10
2	R	32	14	11	13	13	2	4	11
	L	36	12	8	13	7	7	4	12
3	R	34	9	8	17	14	12	4	10
	L	34	10	13	23	13	6	4	9
4	R	35	13	6	12	13	5	4	12
	L	36	14	7	13	14	6	4	12
5	R	33	10	8	14	14	10	4	8
	L	42	7	9	11	15	4	6	17
6	R	37	22	8	27	21	4	12	13
	L	37	16	7	18	11	6	12	10
Mean±SD	R	34±1.7	13±4.8	8.5±1.7	15.8±5.7	15±3	7.6±4.5	5.5±3.2	10.6±1.7
	L	37±2.6	11.5±3.2	9±2.2	14.6±4.9	12.1±2.8	7±3.1	5.8±3.1	11.6±2.8

Measurements=Millimeter; Adjacent landmarks=Nasal vestibule, Frontal process of maxilla, Middle turbinate attachment, Uncinate process, Maxillary ostium, Inferior turbinate. NVLS=Nasal vestibule-lacrimal sac; FPMLS=Frontal process of maxilla – lacrimal sac; MTALS=Middle turbinate attachment-lacrimal sac; UPLS =Uncinate process - lacrimal sac; MOLS=Maxillary ostium – lacrimal sac; ITLS=Inferior turbinate – lacrimal sac; L=Left sides; R=Right sides; LS=Lacrimal sac.

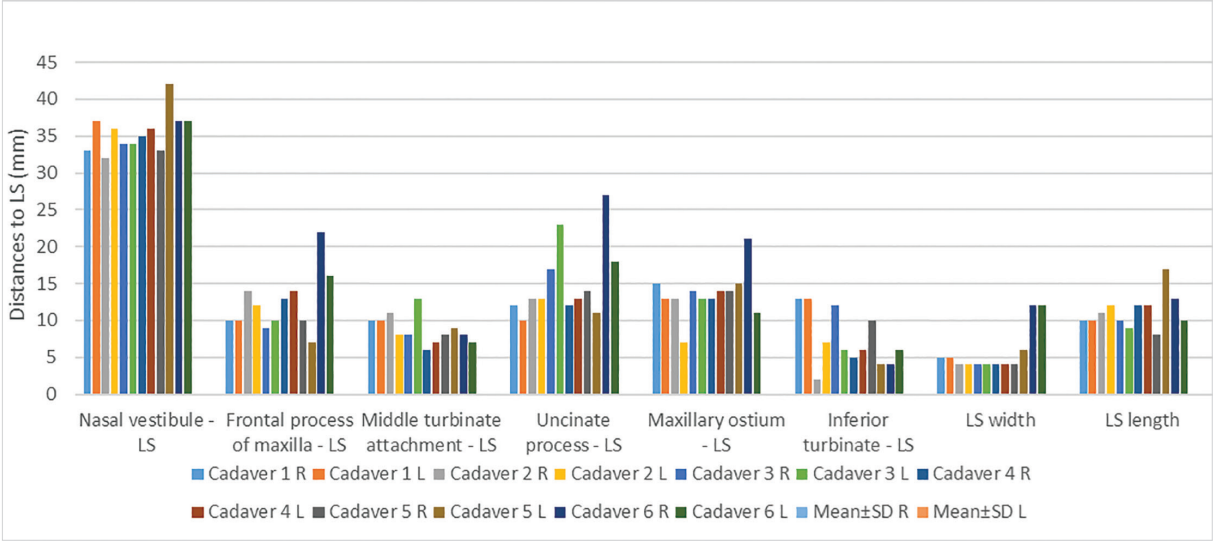

Figure 7. The graphic of the data.

Discussion

We have shown in our study that the distances of the lacrimal sac to the nasal vestibule, the uncinate process and the frontal process of the maxilla are not as reliable as the middle turbinate attachment for predicting the anatomic localization of the lacrimal sac during DCR procedures.

In our study, the nasolacrimal duct was located in front of the middle turbinate attachment in all cases. Previous studies have indicated that the nasolacrimal duct is always located in front of the

middle turbinate attachment if there is no middle turbinate hypertrophy or nasal polyposis (1, 4). In line with this information, we made a mucosal incision approximately 5 mm above and 10 mm in front of the middle turbinate attachment. The mean distance of the midline of the nasolacrimal duct to the middle turbinate attachment was measured as 8.7 mm±2 mm. The incision should be made at least 10 mm in front of the middle turbinate attachment to be careful not to damage the middle turbinate axilla during DCR procedures.

Metson et al. described the maxillary line as a curvilinear eminence along the lateral nasal wall, and it is also known to correspond to the maxilla-lacrimal bone junction (5, 6). Our study showed that the nasolacrimal duct was aligned with the maxillary line. Orhan et al. demonstrated that the maxillary line overlapped the lacrimal sac in 18/20 cadaveric specimens, and that the lacrimal sac was located posterior to the maxillary line in the other two specimens (7). Another study showed that the nasolacrimal duct ostium overlapped the maxillary line in 24 (67%) of 36 cases, was located posterior to the maxillary line in 10 cases and anterior to the maxillary line in 2 cases (8). In the light of these data, if the lacrimal sac cannot be found at the level of the maxillary line, the incision should be widened posteriorly.

There are many studies that evaluate the topography of the lacrimal sac according to the nasal vestibule. A study involving 26 Iranian patients demonstrated that the mean distance of the anterior border of the lacrimal sac to the nasal vestibule was 39 mm (9). Our study determined that the mean distance of the anterior border of the lacrimal sac to the nasal vestibule was 35.5 mm. These differences between studies may depend on gender, age and race (8). Therefore, there is a great need for large-scale studies in our country. Moreover, obtaining information on landmarks would be a guide in all cases.

This study determined that the mean distances of the anterior border of the lacrimal sac to the uncinate process and maxillary ostium were 15.2 mm and 13.5 mm, respectively. Orhan et al. found that the mean distances of the posterior border of the lacrimal sac to the uncinate process and maxillary ostium were 5 mm and 7.2 mm, respectively. We believe that this difference may be due to the fact that we measured the distance from the anterior border of the lacrimal sac, while they measured the distance from the posterior border of the lacrimal sac. In our study, the standard deviation was 5.3 for the distance between the LS and the uncinate process, and this was the highest value in all the landmarks. In our opinion, this is due to anatomical variations of the uncinate process. An investigation of paranasal sinus variations showed that variations existed in the uncinate process, such as pneumatization, medial deflection and lateral deflection (10). Anatomic variations in the uncinate process existed with a reported incidence between 15.9% and 65% in this study. We concluded that the uncinate process is not a reliable landmark for DCR, as variations in the uncinate process are common.

Identifying the lower border of the lacrimal sac has been an important factor affecting the success rate of endoscopic rhinostomy. Although most studies have emphasized that the width of the rhinostomy is an important factor for the success of endoscopic DCR, some studies have indicated that performing a rhinostomy from the lower border of the lacrimal sac leads to failure (2, 11-14). Our study determined that the mean distance of the lacrimal sac to the inferior turbinate was 7.3 mm. Similarly, Orhan et al. found that the mean distance of the lacrimal sac to the inferior turbinate was 8.2 mm. According to these data, osteotomies made 7-8 mm above the inferior turbinate would probably be successful.

Conclusion

External dacryocystorhinostomies are not preferred for common canalicular obstructions due to the widespread use and easy accessibility of endoscopy. As endoscopy maintains its popularity, the need to understand the anatomy of the nasal cavity in endoscopic surgery continues. Therefore, studies are needed to understand nasal anatomy. We obtained data in our study by applying DCR

in accordance with endoscopic technique and believe that these data will guide surgeons during endoscopic DCR. We showed in our study that the distances of the lacrimal sac to the nasal vestibule, the uncinate process and the frontal process of the maxilla are not as reliable as the middle turbinate attachment for predicting the anatomic localization of the lacrimal sac during DCR procedures.

What Is Already Known on This Topic:

Many studies have been conducted to reveal the localization of lacrimal structures. In many cadaver studies, information has been obtained on the lacrimal sac and nasolacrimal duct, and some landmarks have been identified for surgery. The nasal spine, nasal limen, inferior turbinate attachment, maxillary ostium, maxillary line, uncinate process, and middle turbinate attachment are landmarks identified by various studies (6, 7). The maxillary line and the middle turbinate attachment are the most commonly used landmarks. Current literature describes the lacrimal sac commonly anterior to the middle turbinate attachment, but it may also be overlapped by it or posterior to the middle turbinate attachment. Lacrimal sac usually overlaps with maxillary line or situated posterior to maxillary line.

What This Study Adds:

We evaluated all the nearby landmarks of the lacrimal sac such as nasal vestibule, frontal process of the maxilla, uncinate process, the middle turbinate attachment, maxillary ostium and inferior turbinate. Our study showed that the distances of the lacrimal sac to the nasal vestibule, the uncinate process and the frontal process of the maxilla are not as reliable as middle turbinate attachment for predicting the anatomic localization of the lacrimal sac during DCR procedures.

Acknowledgements: We want to thank TÜBA Scientific Research Funding for obtaining the cadavers.

Authors' Contributions: Conception and design: MS and SA; Acquisition, analysis and interpretation of data: ROE and HA; Drafting the article: MS and ROE; Revising it critically for important intellectual content: MAD and HA; Approved final version of the manuscript: ROE and MS.

Availability of Data and Material: The data is available**.**

Conflict of Interest: The authors declare that they have no conflict of interest.

References

1. McDonogh M, Meiring J. Endoscopic transnasal dacryocystorhinostomy. J Laryngol Otol. 1989;103(6):585-7. doi: 10.1017/S0022215100109405.
2. Wormald PJ, Kew J, Van Hasselt A. Intranasal anatomy of the nasolacrimal sac in endoscopic dacryocystorhinostomy. OTO Open. 2000;123(3):307-10. doi: 10.1067/mhn.2000.105416.
3. Knisely A, Harvey R, Sacks R. Long-term outcomes in endoscopic dacryocystorhinostomy. Curr Opin Otolaryngol Head Neck Surg. 2015;23(1):53-8. doi: 10.1097/MOO.0000000000000121.
4. Metson R. Endoscopic surgery for lacrimal obstruction. OTO Open. 1991;104(4):473-9. doi: 10.1177/019459989110400408.
5. Metson R. Endoscopic dacryocystorhinostomy—An update on techniques. Oper Tech Otolayngol Head Neck Surg. 1995;6(3):217-20. doi: 10.1016/S1043-1810(06)80016-3.
6. Metson R, Woog JJ, Puliafito CA. Endoscopic laser dacryocystorhinostomy. Laryngoscope. 1994;104(3):269-74. doi: 10.1288/00005537-199403000-00005.
7. Orhan M, Saylam CY, Midilli R. Intranasal localization of the lacrimal sac. Arch Otolaryngol Head Neck Surg. 2009;135(8):764-70. doi: 10.1001/archoto.2009.94.
8. Kim YH, Park MG, Kim GC, Park BS, Kwak HH. Topography of the nasolacrimal duct on the lateral nasal wall in Koreans. Surg Radiol Anat. 2012;34(3):249-55. doi: 10.1007/s00276-011-0858-y.
9. Hashemi SM, Berjis N, Eshaghian A, Nejadnic M, Samani AF. Applied endoscopic anatomical evaluation of the lacrimal sac. Iran J Otorhinolaryngol. 2015;27(80):213-7.
10. Fadda G, Rosso S, Aversa S, Petrelli A, Ondolo C, Succo G. Multiparametric statistical correlations between paranasal sinus anatomic variations and chronic rhinosinusitis. Acta Otorhinolaryngol Ital. 2012;32(4):244-51.
11. Welham R, Wulc AE. Management of unsuccessful lacrimal surgery. Br J Ophthalmol. 1987;71(2):152-7. doi: 10.1136/bjo.71.2.152.
12. Rose GE. The lacrimal paradox: toward a greater understanding of success in lacrimal surgery. Ophthalmic Plast Reconstr Surg. 2004;20(4):262-5. doi: 10.1097/01.IOP.0000131731.32241.8D.
13. Ragab SM, Elsherif HS, Shehata EM, Younes A, Gamea AM. Mitomycin C–enhanced revision endoscopic dacryocystorhinostomy: a prospective randomized controlled trial. OTO Open. 2012;147(5):937-42. doi: 10.1177/0194599812450280.
14. Pagella F, Pusateri A, Matti E, Carena P, Quiroa L, Antoniazzi E, et al. An easy method for intraoperative confirmation of lacrimal sac patency in endoscopic dacryocystorhinostomy. Eur J Ophthalmol. 2017;27(3):379-381. doi:10.5301/ejo.5000917.