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Evaluation of Distal Occlusions accompanying Punctal Stenosis using Radionuclide Imaging in patients with Unilateral Epiphora

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ABSTRACT

Objective: Our objective was to evaluate distal occlusions accompanying punctal stenosis, which can lead to impaired nasolacrimal drainage in patients with punctal stenosis, using radionuclide imaging.

Material and Methods: Our study enrolled 42 patients who had unilateral punctal stenosis and experienced epiphora on the same side. None of the patients had previously undergone surgical intervention for this condition. Ophthalmological examination results were normal on the unaffected side. Dacryoscintigraphy was performed bilaterally, and specific regions of interest were identified. The scintigraphic images were assessed quantitatively and qualitatively by two nuclear medicine specialists. Evaluation between the nuclear medicine specialists was conducted using the McNemar Bowker test and the Kappa test.

Results: Eighty-one percent (34) of the patients were female. The mean age of the patients was 68.23±9.67 years. In patients with punctal stenosis, the punctal area exhibited edematous features. The lacrimal drainage pathway from the punctum was assessed by two nuclear medicine specialists using two different methods. In the visual quantitative evaluation to determine the localization of the stenosis, there was a low to moderate agreement between the two observers (p=0.018, kappa value=0.252). In the quantitative evaluation, there was excellent agreement between the observers (p=0.0001, kappa value=1).

Conclusion: Dacryoscintigraphy is preferred as an imaging method due to its non-invasive nature that does not disturb the physiological processes. It offers advantages such as lower radiation exposure and higher patient compliance compared to dacryocystography. However, it should be noted that the anatomical correlation in dacryoscintigraphy is relatively low compared to radiological methods. By incorporating quantitative data into the visual assessment of dacryoscintigraphy, it may be possible to enhance anatomical correlation and improve observer agreement, particularly in patients presenting with a combination of functional and anatomical obstructions.

Keywords: punctal stenosis, dacryoscintigraphy, lacrimal drainage system, epiphora

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INTRODUCTION

The lacrimal drainage system (LDS) encompasses various components, including the upper and lower punctum, canaliculus, lacrimal sac, and nasolacrimal duct (1). The lower and upper punctum is localized in the inner part of the eyelid and medially. The lower punctum is wider than the upper punctum. Punctal stenosis (PS) is more common in the lower punctum. The eyelid secretion system consists of large and small lacrimal glands (1,2). Some mechanisms work together in tear excretion. One of them is conjunctival evaporation. Others are reabsorption from the conjunctiva, canaliculi, and sac, and excretion from the nasolacrimal duct (2). Muscle contractions, capillaries, and blinking movements assist these mechanisms (1). In some localizations, some valves prevent the backflow of tears. The lacrimal sac has two parts. These are the fundus and the corpus. The lacrimal sac is approximately 1 ml in volume. It is 6-14 mm long and 1-4 mm wide. It is lined by pseudostratified epithelium. It contains abundant venous plexus. Macrophages, B and T cells are abundant in the adenoid tissue under the epithelium (1).

In patients presenting with complaints of epiphora, the diagnosis of punctal stenosis (PS) is typically established during ophthalmological examination using the biomicroscopic method. Dacryoscintigraphy (DSG), being a physiological imaging technique, is commonly preferred for evaluating lacrimal drainage. Other advantages of DSG are low radiation exposure and short examination time. It also allows bilateral evaluation of lacrimal drainage. Nasolacrimal duct stenosis is also possible in patients with PS. Distal stenoses cause epiphora complaints to continue despite local treatment of PS, thus causing treatment failure. Repetitive surgical dilatation attempts to the punctum are the cause of iatrogenic strictures. Therefore, it is crucial to determine whether there is an accompanying distal stenosis in addition to punctal stenosis in patients experiencing epiphora complaints. Low resolution and insufficient anatomic localization are disadvantages in visual quantitative evaluation with DSG (1). Although USG is used for the general assessment by ophthalmologists, it is limited in showing the junction of the lacrimal sac and nasolacrimal duct. CT may be preferred in case of a suspected mass lesion. Contrast-enhanced dacryocystography (DCG) is limited in its indications due to the fact that its application is challenging and not in line with physiological processes (1). DSG is a suitable imaging modality for the evaluation of postoperative surgical success as well as of preoperative assessment (2). The incorporation of scintigraphic quantitative data alongside visual data will enhance the effectiveness of treatment, particularly in patients with punctal stenosis (PS). Identifying the areas of stenosis beyond PS will also aid in determining the appropriate treatment approach. Thus, there will be no need for repetitive surgical dilatations, and iatrogenic strictures will be prevented.

MATERIAL and METHODs

Forty-two patients diagnosed with punctal stenosis as a result of ophthalmological examination and complaining of epiphora were included in the study. In these patients, the complaint was unilateral. Ophthalmological examination findings were also normal on the non-complaint side. None of the patients had a history of nasolacrimal operation. No interventional treatment was applied to the patients for epiphora complaints. A few patients had a history of using antibiotic eye drops. DSG was performed on the patients included in our study between 2017 and 2020. The epiphora complaint of the patients had lasted for at least 6 months. 34 (81%) of the patients were female. The mean age of the patients is 68.23±9.67. The standard method was used for scintigraphic imaging (3). The patient was placed in the supine position before the dripping of the radioactive material. Thus, the artifacts that may arise from the outflow of tears containing activity were minimized. A lacrimal sac massage was applied to the eye with punctal stenosis. The tears around the eyes dried up. 100 µCi Tc-99m pertechnetate was dropped into both eyes in a volume of 10 µl. Dynamic and static images were obtained. Dynamic images were recorded every 4 seconds as a total of 30 images. Static images were obtained at 5, 10, and 15 minutes after dynamic imaging. 3.25 zoom was used in the 128x128 matrix (**figure 1-3**). Images were acquired using a low-energy, high-resolution collimator on a Siemens E-cam dual-head gamma camera. The eyes of the patient, whose procedures were completed, were washed with a physiological saline solution. Thus, the radioactive drug remaining on the surface of the eye was removed from the eye. It was aimed to reduce the radiation dose to which the eye is exposed. For quantitative evaluation, specific areas were identified and regions of interest (ROIs) were delineated (2). ROIs were plotted bilaterally in four different areas. Average counts (total counts/pixel area) were recorded. In our retrospective study, scintigraphic images were reassessed by two nuclear medicine specialists using both quantitative and qualitative methods. Our study was retrospective and informed consent was obtained from the patients. Our study was approved by Gaziosmanpasa Training and Research Hospital Clinical Research Board on 07.07.2021 with document number 301.

Statistical Analysis: Statistical analysis was performed using SPSS version 21 software. According to the scintigraphy, the change of the level of congestion in visual and quantitative evaluation according to the two observers was evaluated using the McNemar-Browker test and the harmony between the observers was assessed by the kappa test. Situations, where the P-value was below 0.05 were considered statistically significant.

RESULTS

Forty-two patients who underwent DSG imaging due to unilateral epiphora were included in the study. All of these patients had a diagnosis of unilateral PS. Epiphora and PS were on the same side. All patients had stenosis in the lower punctum. The diagnosis of PS was made during the slit-lamp examination. On the PS side, the punctum was edematous and hyperemic. None of the patients received interventional treatment for PS. DSG data were evaluated visually and quantitatively by two observers. There was no difference between the two observers in terms of detecting impairment in visual assessment. However, agreement on the level of obstruction was low in visual evaluation (p= 0.018, kappa value 0.252) (**Table 1**). The agreement of the two nuclear medicine specialists was excellent in determining the level of obstruction in the quantitative evaluation. (p=0.0001, kappa value=1) (**Table 2**). The findings are summarized in **Tables 3 and 4**. Measures calculated from the non-complaint counter LDS are shown in **Table 5**. In patients with stenosis before lacrimal sac entry, the ROI-1 values were calculated by the observers as 5.78(5.21-6.18) and 6.21(6.01-6.39), respectively. ROI-3 was calculated as 0.64(0.61-0.67) and 0.83(0.82-0.84) in patients with pouch outlet stenosis, respectively. In these patients, ROI-2 was calculated as 40.17 (30.77-43.20) and 41.21 (39.81-43.71), respectively. The ROI-4 values were calculated as 0.62 (0.59-0.64) and 0.68 (0.64-0.71) in all patients, respectively. In 7 (70%) cases, observer 1 diagnosed stenosis at the outlet of the sac with visual data. In the quantitative evaluation, it was observed that there was stenosis in the sac entrance in these 7 cases. In 1 (5.3%) case, observer 1 diagnosed stenosis at the outlet of the sac with visual data. In the quantitative evaluation, stenosis in the canal was observed in this case. Observer 1 visually diagnosed lacrimal sac outlet stenosis in 3 cases, accounting for 23.1% of the total cases. In the quantitative evaluation, stenosis in the canal was observed in these 3 cases. Observer 2 diagnosed stenosis at the sac entrance with visual data in 2 cases (5.3%).

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In the quantitative evaluation, it was observed that there was a stenosis at the outlet of the sac. In 3 cases (15.8%), two observers diagnosed canal stenosis by visual data. In the quantitative evaluation, it was observed that there was a stenosis at the outlet of the sac.

In 4 cases (30.8%), two observers diagnosed stenosis at the sac outlet with visual data. In the quantitative evaluation, stenosis was observed in the canal.

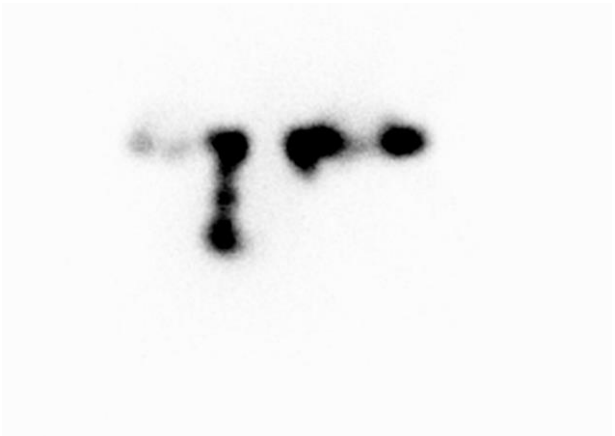
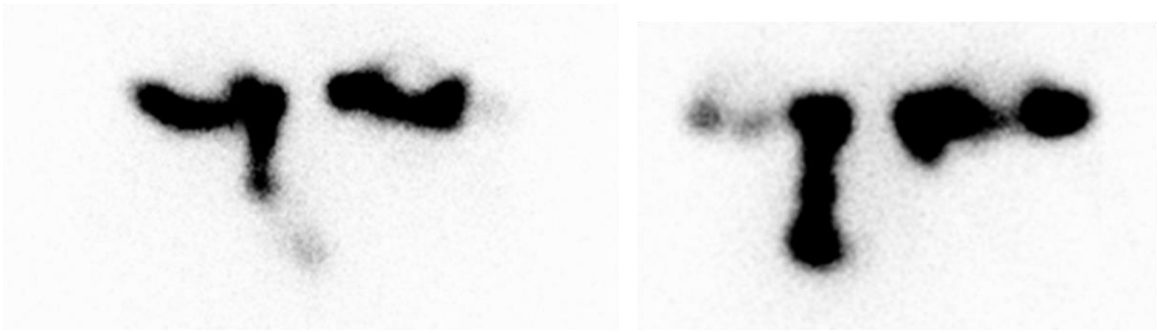
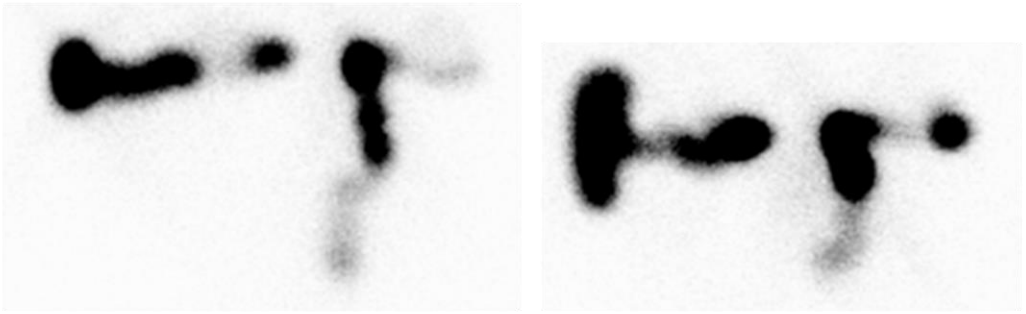


Figure 1: Accumulation in the left lacrimal sac and normal drainage in the right nasolacrimal system on late imaging



A **B**

Figure 2: Dacryosintigraphy image at the 10th minute in two different patients with epiphora on the left side **A.** Stenosis at the lacrimal sac entrance on the left side **B.** Stenosis at the lacrimal sac outlet on the left side



A **B**

Figure 3: In a patient with epiphora on the right side, **A.** Before topical steroid treatment **B.** Continuing obstruction at the entrance of the lacrimal sac after.

Table 1: As a result of the evaluation of the scintigraphic images without adding quantitative data, the number of patients according to their obstruction levels.

		Observer 2		
		Stenosis at the entrance of the sac	**Stenosis at the outlet of the sac**	**Stenosis in the canal**
Observer 1	**Stenosis at the entrance of the sac**	3	2	0
	Stenosis at the outlet of the sac	8	0	6
	Stenosis in the canal	0	14	6

Table 2: As a result of the evaluation of the scintigraphic images by adding quantitative data, the number of patients according to the obstruction levels.

		Observer 2		
Observer 1		**Stenosis at the entrance of the sac**	**Stenosis at the entrance of the sac**	**Stenosis in the canal**
	Stenosis at the entrance of the sac	10	0	0
	Stenosis at the entrance of the sac	0	19	0
	Stenosis in the canal	0	0	13

Table 3: Comparison of the number of patients according to the degree of obstruction as a result of the evaluation of scintigraphic images according to Observer 1 with and without quantitative data. With Quantitative Data

Observer 1		With Quantitative Data		
		Stenosis at the entrance of the sac	**Stenosis at the outlet of the sac**	**Stenosis in the canal**
Without Quantitative Data	**Stenosis at the entrance of the sac**	3 (30)	0 (0)	0 (0)
	Stenosis at the outlet of the sac	7 (7)	18 (94.7)	3 (23.1)
	Stenosis in the canal	0 (0)	1 (3.3)	10 (76.9)

Table 4: Comparison of the number of patients according to the degree of obstruction as a result of the evaluation of scintigraphic images according to Observer 2 with and without quantitative data.

Observer 2		With Quantitative Data		
		Stenosis at the entrance of the sac	**Stenosis at the outlet of the sac**	**Stenosis in the canal**
Without Quantitative Data	**Stenosis at the entrance of the sac**	10 (100)	1 (5.3)	0 (0)
	Stenosis at the outlet of the sac	0 (0)	15 (78.8)	4 (30.8)
	Stenosis in the canal	0 (0)	3 (15.8)	9 (69.2)

Table 5: The mean counts of regions of interest (total count/pixel area) obtained from dacryoscintigraphy images of the contralateral side (with lacrimal drainage within normal limits) in patients with unilateral epiphora.

	ROI-1 median(min-max)	ROI-2 median(min-max)	ROI-3 median(min-max)	ROI-4 median(min-max)
Observer-1	1.84(1.79-1.87)	20.58(18.71-23.82)	4.53(4.12-4.78)	2.17(2.01-2.23)
Observer-2	1.82(1.77-1.85)	22.72(21.81-24.01)	3.98(3.21-4.11)	2.21(2.07-2.29)

DISCUSSION

DSG is a non-invasive imaging method that does not disrupt the physiology of the lacrimal system. The radiation dose to which the eye is exposed ranges from 0.014 to 0.021 rad. In the case of complete occlusion, this dose can be 0.4-0.6 rad (2). It has been reported that there is no difference in terms of lacrimal drainage between lying and sitting positions (3). Radioactive drugs were administered to our patients in the supine position. Impaired tear drainage is an uncomfortable condition. However, it also threatens eye health. Recurrent eye infections are common in these patients (4). The tears accumulating in the pouch create a suitable environment for the reproduction of many microorganisms, especially pneumococci. Visual acuity decreases in the presence of epiphora. This situation creates other risks especially for those working in the industrial sector.

According to a report, patients tend to wipe their eyes approximately every 6 minutes during the day (4). Many factors are blamed in the etiology of epiphora. Punctal stenosis, turbinate nasal hypertrophy, disorders due to atrophic rhinitis and septum deviation are some of these causes. Sometimes several factors can coexist. Identifying the factors causing epiphora and clarifying the degree of obstruction increase the success of surgery (5,6). DSG is also valuable in the postoperative follow-up of patients (5). Epiphora due to punctal stenosis (PS) is more common in women. The narrow lumen in the bony part of the tear lumen in women and the fact that the vascular plexus in the membranous part is affected by the hormonal periods of women contribute to the emergence of the complaint (4).

Punctal edema and eyelash disorder may be noticed during eye examination (7). All of our patients have unilateral punctal stenosis and accompanying epiphora on the same side. Considering that punctal stenosis is a functional stenosis, it is recommended to question whether there is an additional dysfunctional disease before starting treatment. Thus, a more careful interpretation of the tests is ensured (7). Proximal and distal partial occlusions accompanying ocular surface diseases are common conditions. A combination of primary and secondary dryness tests, DSG, and DCG increases treatment success in some indications (8-11). Occlusion is generally expected to occur before the sac, after the sac, and within the canal (11). When additional occlusions accompany punctal stenosis (PS), there may be variations in visual qualitative evaluation with dacryoscintigraphy (DSG) among different observers. In our study, it was observed that there was no difference between the observers in the quantitative evaluation. The development of minimally invasive surgical methods in recent years has led to less preference for aggressive operations. Therefore, detailed information about the disease is needed before the operation. One study reported that DSG was superior to DCG in detecting mid-channel stenosis (12). Good patient compliance with the DSG allows it to be used for screening purposes in familial diseases where epiphora is common and in the elderly population (13). Dacryocystorhinostomy (DCR) is performed in cases of post-sac occlusions, creating a connection between the lacrimal sac and the nasal cavity. Determining the occlusion level before the operation increases the success of both minimally invasive methods and DCR (13). The optical lens is highly sensitive to radiation (14) In DCG, the optical lens is exposed to a dose of about 2.7 mGy. In DSG, the optical lens is exposed to a radiation dose of about 0.014-0.021 rad. The radiation dose to which the optical lens is exposed in DSG is much less than in DCG (15). In the group of patients whose epiphora continued after DCR, the sensitivity was calculated as 100% in detecting the disorder with DSG (13). Several studies have been conducted where regions of interest (ROIs) were delineated on the conjunctiva and nasolacrimal canal (16, 17). In our study, ROIs were drawn bilaterally in four different areas. In a study that reported low interobserver agreement for dacryoscintigraphy (DSG), the evaluation was based solely on visual assessment, and quantitative analyses were not performed (18). It has been reported that the tear transition time in normal individuals is 0.5-10 minutes (19-21). In our study, radioactive count rates were considered when determining the degree of obstruction. All of our patients were diagnosed with PS by the biomicroscopic method. The incidence of PS is approximately 17.3% (22,23). Stenosis is more common in the lower punctum (24–28). In 1/3 of patients with PS, the complaint of epiphora persists despite treatment (29). In our study, it is understood that visual evaluation of DSG alone is not sufficient in patients with stenosis in different localizations in addition to PS. The addition of quantitative assessment increases the agreement between observers in these patients. Repeated punctal dilatation and nasolacrimal lavage may cause iatrogenic PS (28). Quantitative evaluation of DSG in patients with PS will reduce repetitive interventions. It has been reported that only 39.6% of patients with PS have intact canaliculi (30–33). Quantitative evaluation of DSG is useful in cases where functional and anatomical impairments coexist. Punctoplasty is considered the treatment of choice for these patients (34–36). Although DCG is useful in evaluating anatomical details, ocular radiation exposure is high (37–39). Radioactive material accumulation in the medial conjunctival sac in DSG makes it difficult to visually separate the medial canthus from the lacrimal sac (40–45). This deficiency can be avoided by adding quantitative analysis. In recent years, minimally invasive procedures such as endoscopic dacryocystorhinostomy (DCR) and transcanalicular diode lasers have gained preference (46–55). DSG is also useful for assessing the success of these techniques (50-55). In our study, quantitative evaluation has provided an increase in inter-observer harmony. Scintigraphic functional imaging allows for more detailed data acquisition through numerical evaluations and calculations.

Work Limitations: The retrospective nature of our study is one of its limitations.

CONCLUSION

Dacryoscintigraphy is preferred because it is an imaging method that does not disrupt physiology. Other advantages are lower radiation exposure and higher patient compliance compared to dacryocystography. However, anatomical correlation is low compared to radiological methods. Adding quantitative data to a visual assessment in DSG may increase anatomical correlation and observer agreement, especially in patients with a combination of functional and anatomical obstruction.

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Author Contributions: SC, NY: Conceived and designed the experiments, **SC:** Writing of the manuscript, Revisions. All the authors agreed with the manuscript's results and conclusions. All the authors have read, and confirmed that they meet, ICMJE criteria for authorship.

Ethical approval: Our study was approved by the recorded Committee of Clinical Research at Gaziosmanpasa Training and Research Hospital with document number 301 on 07.07.2021. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and/or with the Helsinki Declaration of 1964 and later versions. Informed consent or a substitute for it was obtained from all patients for being included in the study.

Abbreviations:

ROI: region of interest
LDS: the lacrimal drainage system
DSG: dacryoscintigraphy
DCG: dacryocystography
DCR: dacryocystorhinostomy
PS: punctal stenosis

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