Fluorescein transit test time as a tool to assess lacrimal pump function after diode laser transcanalicular dacryocystorhinostomy and external dacryocysto-rhinostomy *

Eduardo Damous Feijó[1], Roberto Murillo Limongi[2], Suzana Matayoshi[3]

[1] Department of Oculoplastic Surgery of the Ophthalmology Hospital of Anápolis, Goiás, Brazil

[2] Department of Oculoplastic Surgery of the Federal University of Goiás, Goiás, Brazil

[3] Department of Oculoplastic Surgery of the University of São Paulo, São Paulo, Brazil

Rhinology 56: 3, 274-278, 2018

https://doi.org/10.4193/Rhin17.254

***Received for publication:**

December 19, 2017

Accepted: February 8, 2018

Background: Dacryocystorhinostomy (DCR) is the gold standard surgical treatment for nasolacrimal duct obstruction. External DCR is the traditional approach (EXT-DCR); however, the advent of minimally invasive surgeries and the development of optic fiber and laser technologies have made it possible to perform laser transcanalicular DCR (T-DCR), a minimally invasive procedure. This study measured the fluorescein transit time (FTT) after EXT-DCR or T-DCR to evaluate the lacrimal drainage and lacrimal pump function after these two types of DCR.

Subjects and methods: A cross-sectional study of 50 patients who underwent EXT-DCR (EXT-DCR Group) or T-DCR (T-DCR Group), who were anatomically patent upon irrigation, with a minimum 6 months of follow up. The patients' FTT was measured; it was defined as the time from the instillation of the dye into conjunctival sac to its free flow from the rhinostomy site. This evaluation was performed through nasal endoscopy performed intranasally with a blue filter that enabled the faster detection of fluorescein from the ostium site. The mean FTTs of the two groups were compared using the two-sided Student's unpaired t-test. Other variables such as sex, age, previous lacrimal sac size, and the site and shape of the rhinostomy were evaluated to determine their possible relationships with FTT.

Results: The EXT-DCR group had 80% female patients at a mean age of 58 years. The T-DCR group had the same percentage of female patients (80%) and a mean age of 56 years. The mean FTT group was 47.48 sec in the EXT-DCR and 33.04 sec in the T-DCR group. Functional success was 88% in both groups.

Conclusion: FTT in the DCR-T Group was significantly lower than in the EXT-DCR Group. No other variables exhibited a statistically significant correlation with FTT. Lacrimal drainage was found to be better after T-DCR than after EXT-DCR, results which show that this procedure could prevent lacrimal pump damage.

Key words: epiphora, lacrimal pump, dacryocystorhinostomy, laser dacryocystorhinostomy, Jones test

Introduction

Dacryocystorhinostomy (DCR) is the gold standard surgical treatment for nasolacrimal duct obstruction (NLDO)[(1)]. External DCR is the traditional approach (EXT-DCR), yielding 90% of anatomic success [(2-4)]. Recently, the development of optic fiber and laser technologies, has made it possible to perform laser transcanalicular DCR (T-DCR), a minimally invasive procedure [(5-8)]. Minimally invasive surgery has been performed in all areas of modern surgery, including ophthalmology. This minimally invasive T-DCR is a shorter procedure, that does not produce skin scars or orbicularis oculi muscle damage and which results in shorter osteotomies, thus enabling less intraoperative bleeding and the use of local anesthesia with faster patient recovery [(8-11)].

There is a gap between anatomical and functional success rates in DCRs: even when some patients are patent through irrigation (anatomical success), the procedure does not necessarily im-

prove their symptoms of tearing (functional failure) [12]. A quantitative assessment of lacrimal drainage using fluorescein transit test time (FTT) was first proposed by Delaney and Khooshabeh [13], who demonstrated that slow postoperative transit time causes epiphora and may indicate lacrimal pump dysfunction which precedes surgery. Furthermore, orbicular muscle and lacrimal sac incisions in EXT-DCR may explain slow transit time in some patients as a result of damage to the lacrimal pump mechanism. We hypothesized that the absence of incisions in the orbicularis muscle and the lacrimal sac can prevent lacrimal pump damage, resulting in better tear drainage in patients who have undergone T-DCR. The purpose of this study was to use FTT as a surrogate endpoint to quantitatively evaluate the lacrimal drainage, after EXT-DCR or T-DCR and to correlate with functional outcomes.

Subjects and methods

Study design

This is a cross-sectional and comparative study of 50 patients who underwent EXT-DCR (EXT-DCR Group – 25 patients) and T-DCR (T-DCR Group – 25 patients). All the DCRs procedures were performed by the same surgeon from Ophthalmology Hospital of Anapolis, in Anapolis, Goiás, Brazil, between January 2015 and January 2017. Fifty-seven patients were eligible to this study, 27 who underwent EXT-DCR and 30 who underwent T-DCR. All patients were found to be anatomically patent through irrigation, as confirmed by positive syringing with little or no reflux from the opposite canaliculus, and the minimum follow-up was 6 months [13].

Inclusion criteria were EXT-DCR or T-DCR for treatment of NLDO, and anatomical patency to irrigation. Exclusion criteria were: age under 18 years, secondary lacrimal obstruction, a history of facial trauma, facial palsy, canaliculi obstruction, trichiasis, ectropion, entropion, nasal synechiae, polyps, accentuated nasal septum deviation, and/or middle turbinate hypertrophy. All patients signed the informed consent form. The protocol for the current study was approved by the medical research ethics committee of the University of São Paulo (USP) and the study followed the guidelines established by Declaration of Helsinki. The patients were distributed by sex, age and laterality of the procedure. Preoperative lacrimal sac size (small or enlarged) and the type of NLDO (partial or complete) were assessed by reviewing the patients' chart and previous dacryocystography.

Rigid endoscopy was performed intranasally to assess the location (in front of or behind the axilla of the middle turbinate) and shape (circular/oval or crescentric/vertical) of the postoperative ostium in the nasal cavity [14].

FTT was defined as the time from instillation of 1 drop of 2% fluorescein into the conjunctival sac and to its free flow from the rhinostomy site. All the patients were sitting in upright position and they were asked to blink as natural as possible. FTT was assessed through the intranasal use of a rigid endoscope coupled with a blue filter that enabled the more rapid detection of fluorescein from the ostium site [15]. Two evaluators performed the test, one who put the drop into the eye and another who assessed the nasal ostium. FTT was measured in seconds using a chronometer (Figure 1). Since FTT is an objective endpoint, this could minimize measurement bias.

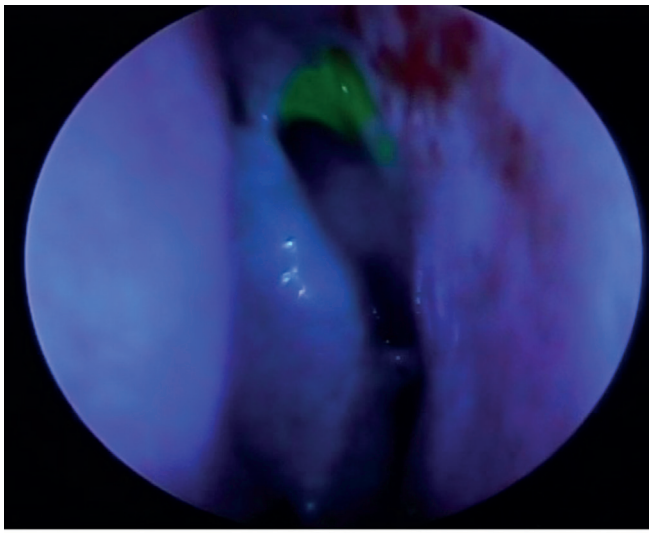

Figure 1. Rigid endoscopy performed intranasally with cobalt blue filter and showing the outflow of fluorescein from the ostium in front of the axilla after T-DCR.

Postoperative improvement in watering was evaluated by the Munk´ scale [16] (0: no epiphora; 1: epiphora requiring dabbing less than twice a day; 2: epiphora requiring dabbing 2 to 4 times a day; 3: epiphora requiring dabbing 5 to 10 times a day; 4: epiphora requiring dabbing more than 10 times a day and 5: constant epiphora). Functional success was defined as the resolution or improvement of epiphora (Munk´ score of 0 or 1).

Statistical analysis

We calculated the sample size accounted for a potential dropout rate of 10%. The sample size was calculated from the target difference of 20% in FTT between the two groups and pooled standard difference (SD) from a previous study (FTT: 45 seconds SD:10 seconds). A power of 80% and confidence level of 95% yielded a sample size of > 19 in each arm. Given the sample size of 25 subjects per arm, the study had a power higher than 80% to show the primary endpoint. The primary null hypothesis was no between-group difference in FTT. The alternative hypothesis was that there was between-group difference in FTT (2-sided t-test). The mean FTTs of the two groups were compared using Student´s unpaired T-test. Other variables such as sex, age, preoperative lacrimal sac size, type of NLDO (partial or complete),

Table 1. Patient data.

	EXT-DCR (Group 1) n=25	T-DCR (Group 2) n=25	p-value
Gender (F/M)[a]	20/5 (80% / 20%)	19/6 (78% / 22%)	1.000
Age (years) – mean	58	56	0.802
Side (R/L)[b]	8/17	14/11	0.154
Enlarged lacrimal sac	15 (60%)	19 (76%)	0.364
Obstruction/ Estenosis	18/7 (72% - 28%)	19/6 (76% - 24%)	1.000

a: F, female; M, male; b: R, right; L, left.

Table 2. Intranasal rigid endoscopy evaluation.

	EXT-DCR n=25	T-DCR n=25	p-value
Location of the ostium: Front / Behind axilla	17 / 8 (68% / 32%)	14 / 11 (56% / 44%)	0.561
Shape : Oval / Crescentric	19 / 6 (76% / 24%)	19 /6 (76% / 24%)	1.000
FTT[a] Mean Range (in seconds)	47.48 (17 to 105)	33.04 (6 to 80)	0.024

a: FTT, fluorescein transit test time

and the location and shape of the rhinostomy were evaluated using Fisher´s exact test, and a value of $p < 0.05$ was considered statistically significant.

Results

Fifty patients were included in this study. Two patients in EXT-DCR group and 5 in T-DCR group were excluded due anatomic failure. The patients were divided into two groups: EXT-DCR Group and the T-DCR Group. The EXT-DCR Group was composed of 25 patients (20 women – 80%) at a mean age of 58.32 years (ranging from 38 to 84 years; SD: 12.77). The T-DCR Group was composed of 25 patients (19 women – 78%) at a mean age of 56.32 years (ranging from 29 to 92 years; SD: 16.91).
The laterality of the procedure was also considered: 8 out of 25 procedures in the EXT-DCR Group and 14 out of 25 in the T-DCR Group were performed on the right eye ($p = 0.154$). Fifteen patients in the EXT-DCR Group (60%) and 19 patients in the T-DCR Group (76%) had an enlarged preoperative lacrimal sac ($p=0.364$). Eighteen patients in the EXT-DCR Group (72%) and 19 patients in the T-DCR Group (76%) exhibited complete NLDO ($p = 1.000$; Table 1)

The average length of follow-up was 12 months in the EXT-DCR Group and 10 months in the T-DCR Group ($p=0.235$; Table 1)

In seventeen patients from the EXT-DCR Group (68%) and 14 patients from the T-DCR Group (56%), the ostium was located in front of the axilla of the middle turbinate ($p=0.561$). Most of the patients in the EXT-DCR Group (19 out of 25 – 76%) and in the T-DCR Group (19 out of 25 – 76%) had a circular/oval shaped ostium.

The mean FTT in the EXT-DCR Group was 47.48 seconds (range from 17 to 105; SD: 25.16) and 33.04 seconds in the T-DCR Group (range from 6 to 80; SD: 18.02) ($p=0.024$; Table 2).

Functional success was the same in the two groups. Twenty-two patients in each group (44 out of 50 – 88%) exhibited improvement or complete resolution of epiphora. Three patients in each group (6 patients -12%) reported that postoperative epiphora was the same or had improved slightly. Five out of this six, had FTT > 60 seconds.

No other variables exhibited a statistically significant correlation with FTT.

Discussion

External and endonasal DCR remain the gold standard surgical treatments for NLDO, yielding 90 to 95% of anatomic success rates [1, 17, 18]. In the era of minimally invasive surgery, T-DCR is often requested by patient wishing to avoid facial scars, the risk of bleeding, general anesthesia and a longer surgical recovery time [19]. As we know, the surgical success of this type of DCR is lower than that of EXT-DCR and endonasal DCR [20]; however, some technical modifications have been incorporated into T-DCR in order to improve its success rate. These changes include early cleaning of the surgical ostium [21], the use of the laser at a low energy output [22], the creation of larger nasal ostium [14], applications on patients older than 45 years [5], the use of mitomycin C in the rhinostomy [23, 24] and nasal mucosa blade excision prior to laser osteotomy to avoid thermal injury [25].
The challenge of minimally invasive surgeries is to achieve the same success rates of the gold standard techniques while maintaining the advantages, such shorter procedure times and quicker patient recovery [26].
There is a gap between anatomical and functional success rates in DCR. Anatomical success is determined primarily by patency to irrigation and a positive Jones I test. However, this assessment can overestimate success rates since some patients continue to exhibit symptomatic epiphora even when they are patent to irrigation, as the results of this study have demonstrated. It is

believed that the presence of slow lacrimal drainage can cause epiphora [13]. In this study, 5 out of 6 patients (83%) had an FTT > 1 minute, a finding which confirmed this hypothesis. Tucker and Codere [27] demonstrated that the median dye transit time was 8 minutes with a single drop, as we used, and 1.4 minutes with two drops or more. We also used a cobalt blue filter accoupled on a rigid nasal endoscope as described by Enzer and Schorr [15] for more accurate examination of the dye from rhinostomy. The results of their study showed a six-fold increase in the ability of the Jones test to detect fluorescein dye within the nasal cavity over the conventional Jones I test.

In our study, FTT was significantly lower in the T-DCR Group than in the EXT-DCR Group (33.04 sec and 47.48 sec, respectively). This finding may indicate that orbicularis muscle incision, medial canthal tendon injury, large incisions in the medial wall of the lacrimal sac in EXT-DCR, could led to lacrimal pump damage. These factors may explain the higher FTT in this group relative to the T-DCR Group; it is important to note that the features of the two groups were similar, which minimized the possibility of selection bias. Hagele et al. [28] used the Jones test to assess whether lacrimal transit time varies with age and confirmed that lacrimal transit time slows with age. In their study, subjects younger than 45 years of age passed dye in 6 minutes whereas subjects 45 years of age and older passed dye in 12 minutes. In our study, there was no significant difference in age between the two groups, which also prevented selection bias.
Using scintigraphy, Malbouisson et al. [29], showed that EXT-DCR itself may affect the lacrimal pump mechanism. We believe that lacrimal scintigraphy is an excellent tool to assess functional success or failure, however, as we know, the exposure to radiation can increase the risk of cancer. In another study, magnetic resonance imaging dacryocystography was used to evaluate the signal intensity at the rhinostomy site before and after blinking. This study confirmed that epiphora following anatomical success was associated with a reduced post-blinking signal, implying lacrimal pump mechanism damage after EXT-DCR and endonasal DCR, however the lacrimal pump may be better preserved in endonasal DCR. Using manometric measurement of lacrimal sac pressure after endonasal and EXT-DCR, Kamel et al. [30] detected that the lacrimal pump is affected but that its function is restored after successful DCR. The suction power of the pump mechanism was found to be more effective after endoscopic DCR than after external DCR, results which confirm the findings of our study. There are no objective mechanisms to measure the lacrimal pump pressure. Lacrimal manometry is interventional and thus may not reflect physiologic lacrimal outflow. So, we used FTT as a surrogate endpoint to estimate lacrimal pump function.
We also accept that FTT´s are influenced by other variables, as frequency of blinking, ostium size, intra-operative manipulations and post-operative care, however, the studies cited above can confirm our alternative hypothesis.
Approximately 10% of patients continue to exhibit epiphora following an anatomically successful DCR; these cases are referred to as "functional failures". SUMP syndrome, ostium abnormalities, common canaliculum stenosis are causes of persistent epífora despite anatomical success. Shams et al. [12] showed that benefits can be achieved in most patients with lacrimal intubation or eyelid tightening. Eyelid tightening may improve the lacrimal pump mechanism and lacrimal drainage.

Conclusion

In conclusion, FTT was found to be significantly lower after T-DCR than after EXT-DCR. This finding may indicate that T-DCR could protect the lacrimal pump mechanism.

Acknowledgement

Approved by the Research Ethics Committee of the University of São Paulo.

Authorship contribution

EDF: Acquisition of data, analysis and interpretation of data; RL: Statistical analysis, critical revision; SM: research group leadership, statistical analysis, final approval.

Conflict of interest

No conflict of interest. No financial relationships.

References

1. Alnawaiseh M, Mihailovic N, Wieneke AC, Prokosch V, Rosentreter A, Merte RL, et al. Long-Term Outcomes of External Dacryocystorhinostomy in the Age of Transcanalicular Microendoscopic Techniques. J Ophthalmol. 2016;2016:5918457.
2. Savino G, Battendieri R, Traina S, Corbo G, D'Amico G, Gari M, et al. External vs. endonasal dacryocystorhinostomy: has the current view changed? Acta Otorhinolaryngol Ital. 2014;34(1):29-35.
3. Tarbet KJ, Custer PL. External dacryocystorhinostomy. Surgical success, patient satisfaction, and economic cost. Ophthalmology. 1995;102(7):1065-70.
4. Yoon SW, Yoon YS, Lee SH. Clinical results of endoscopic dacryocystorhinostomy using a microdebrider. Korean J Ophthalmol. 2006;20(1):1-6.
5. Akay F, Ilhan A, Yolcu U, Gundogan FC, Yildirim Y, Toyran S. Diode laser-assisted transcanalicular dacryocystorhinostomy: the effect of age on the results. Arq Bras Oftalmol. 2015;78(3):164-7.
6. Alanon Fernandez FJ, Alanon Fernandez MA, Martinez Fernandez A, Cardenas Lara M. [Transcanalicular dacryocystorhinostomy technique using diode laser]. Arch Soc Esp Oftalmol. 2004;79(7):325-30.
7. Dogan R, Meric A, Ozsutcu M, Yenigun A. Diode laser-assisted endoscopic dacryocystorhinostomy: a comparison of three different combinations of adjunctive procedures. Eur Arch Otorhinolaryngol. 2013;270(8):2255-61.
8. Maeso Riera J, Sellares Fabres MT. [Transcanalicular diode laser dacryocystorhinostomy: technical variations and results]. Acta Otorrinolaringol Esp. 2007;58(1):10-5.
9. Kaynak P, Ozturker C, Yazgan S, Karabulut

GO, Akar S, Demirok A, et al. Transcanalicular diode laser assisted dacryocystorhinostomy in primary acquired nasolacrimal duct obstruction: 2-year follow up. Ophthal Plast Reconstr Surg. 2014;30(1):28-33.
10. Plaza G, Betere F, Nogueira A. Transcanalicular dacryocystorhinostomy with diode laser: long-term results. Ophthal Plast Reconstr Surg. 2007;23(3):179-82.
11. Yildirim Y, Kar T, Topal T, Cesmeci E, Kaya A, Colakoglu K, et al. Comparison of Transcanalicular Multidiode Laser Dacryocystorhinostomy with and without Silicon Tube Intubation. J Ophthalmol. 2016;2016:6719529.
12. Shams PN, Chen PG, Wormald PJ, Sloan B, Wilcsek G, McNab A, et al. Management of functional epiphora in patients with an anatomically patent dacryocystorhinostomy. JAMA Ophthalmol. 2014;132(9):1127-32.
13. Delaney YM, Khooshabeh R. Fluorescein transit test time and symptomatic outcomes after external dacryocystorhinostomy. Ophthal Plast Reconstr Surg. 2002;18(4):281-4.
14. Ali MJ, Psaltis AJ, Wormald PJ. Dacryocystorhinostomy ostium: parameters to evaluate and DCR ostium scoring. Clin Ophthalmol. 2014;8:2491-9.
15. Enzer YR, Shorr N. The Jones IE test: cobalt blue endoscopic primary dye test of lacrimal excretory function. Ophthal Plast Reconstr Surg. 1997;13(3):204-9.
16. Munk PL, Lin DT, Morris DC. Epiphora: treatment by means of dacryocystoplasty with balloon dilation of the nasolacrimal drainage apparatus. Radiology. 1990;177(3):687-90.
17. Ali MJ, Psaltis AJ, Wormald PJ. Long-term outcomes in revision powered endoscopic dacryocystorhinostomy. Int Forum Allergy Rhinol. 2014;4(12):1016-9.
18. Cokkeser Y, Evereklioglu C, Er H. Comparative external versus endoscopic dacryocystorhinostomy: results in 115 patients (130 eyes). Otolaryngol Head Neck Surg. 2000;123(4):488-91.
19. Moore WM, Bentley CR, Olver JM. Functional and anatomic results after two types of endoscopic endonasal dacryocystorhinostomy: surgical and holmium laser. Ophthalmology. 2002;109(8):1575-82.
20. Koch KR, Cursiefen C, Heindl LM. [Minimally invasive bypass surgery for nasolacrimal duct obstruction : Transcanalicular laser-assisted dacryocystorhinostomy]. Ophthalmologe. 2017;114(5):416-23.
21. Yener HI, Gul A, Caglar C, Ozcimen M. The effectiveness of postoperative early ostium cleaning in transcanalicular diode laser-assisted dacryocystorhinostomy. Ophthal Plast Reconstr Surg. 2014;30(6):476-9.
22. Gupta SK, Kumar A, Agarwal S, Pandey P. Transcanalicular laser dacryocystorhinostomy using low energy 810 nm diode laser. Oman J Ophthalmol. 2012;5(3):171-4.
23. Alanon Fernandez MA, Alanon Fernandez FJ, Martinez Fernandez A, Cardenas Lara M. [Results the application of mitomicyn during endonasal and endocanalicular dacryocystorhinostomy by diode laser]. Acta Otorrinolaringol Esp. 2006;57(8):355-8.
24. Kar T, Yildirim Y, Topal T, Colakoglu K, Unal MH. Efficacy of adjunctive mitomycin C in transcanalicular diode laser dacryocystorhinostomy in different age groups. Eur J Ophthalmol. 2016;26(1):1-5.
25. Feijo ED, Caixeta JA, de Souza Nery AC, Limongi RM, Matayoshi S. A comparative study of modified transcanalicular diode laser dacryocystorhinostomy versus conventional transcanalicular diode laser dacryocystorhinostomy. Eur Arch Otorhinolaryngol. 2017.
26. Christenbury JD. Translacrimal laser dacryocystorhinostomy. Arch Ophthalmol. 1992;110(2):170-1.
27. Tucker NA, Codere F. The effect of fluorescein volume on lacrimal outflow transit time. Ophthal Plast Reconstr Surg. 1994;10(4):256-9.
28. Hagele JE, Guzek JP, Shavlik GW. Lacrimal testing. Age as a factor in Jones testing. Ophthalmology. 1994;101(3):612-7.
29. Malbouisson JM, Bittar MD, Obeid HN, Guimaraes FC, Velasco e Cruz AA. Quantitative study of the effect of dacryocystorhinostomy on lacrimal drainage. Acta Ophthalmol Scand. 1997;75(3):290-4.
30. Kamel R, El-Deen HG, El-Deen YS, El-Hamshary M, Assal A, Farid M, et al. Manometric measurement of lacrimal sac pressure after endoscopic and external dacryocystorhinostomy. Acta Otolaryngol. 2003;123(2):325-9.

Eduardo Damous Feijó, MD
Av Faiad Hanna
235. Cidade Jardim
Anápolis-GO CEP 75080-410
Brasil

E-mail: eduardodff@yahoo.com.br