Graefe's Archive for Clinical and Experimental Ophthalmology (2021) 259:2425–2430
https://doi.org/10.1007/s00417-021-05165-5

OCULOPLASTICS AND ORBIT

Long-term outcomes of primary transcanalicular laser dacryocystorhinostomy

Rafal Nowak[1,2] · Marek Rekas[3] · Izabela Nowak Gospodarowicz[3] · Mohammad Javed Ali[2]

Received: 13 January 2021 / Revised: 27 February 2021 / Accepted: 12 March 2021 / Published online: 26 March 2021

Abstract
Purpose To assess the long-term outcomes of transcanalicular laser dacryocystorhinostomy in cases of primary acquired nasolacrimal duct obstruction (PANDO).

Methods Retrospective interventional case series was performed on all patients diagnosed with PANDO and who underwent a primary transcanalicular laser dacryocystorhinostomy from Jan 2014 to June 2016. The procedure was performed using 980 nm diode laser. All the patients additionally underwent intraoperative adjunctive procedures: mitomycin C application and silicone intubation. Patients were followed for up to 3 years after surgery. Anatomical success was defined as patent ostium on irrigation, and functional success was defined as resolution of epiphora. The parameters studied include patient demographics, clinical presentation, type of anesthesia, duration of surgery, laser energy delivered, complications, and anatomical and functional success. The variables influencing the outcomes were assessed. Statistical analysis was performed using the package Statistica (version 10.0, Statsoft, Poland).

Results A total number of 205 patients were assessed. Of these, 73.17% (150/205) were females. The mean age of patients was 62.92 years. The mean laser energy used was 1060.09 J, and the mean operating time was 22.33 min. Approximately, 95% and 68% of the patients completed 1 year and 3 years of follow-up, respectively. The anatomical and functional success rates dropped significantly beyond the 3 months and 6 months postoperative period and maintained the lower success rates beyond 1-year follow-up for up to 3 years. The anatomical and functional success at the end of 3-year follow-up was 56.12% and 33.81%, respectively. The functional success was not affected by gender ($P = 0.132$), age ($P = 0.956$), laser energy ($P = 0.626$), or duration of the surgery ($P = 0.906$). However, the intraoperative pain scale was influenced by the laser energy ($P < 0.001$) and the duration of the surgery ($P < 0.001$).

Conclusion The anatomical and functional outcomes of primary transcanalicular laser dacryocystorhinostomy are suboptimal and not encouraging in the long term.

Key messages

What was known before:

- Transcanalicular laser DCR have variable success rates
- The long-term outcomes are unclear

What this review adds:

- The long-term outcomes of transcanalicular laser DCR are suboptimal
- Nearly all the failures occur by 1-year postoperative period, and good outcomes at 1-year are maintained beyond it.

This is part of a topical collection on *Updates in Ophthalmic Plastics*.

✉ Rafal Nowak
raf.nowak1971@gmail.com

✉ Mohammad Javed Ali
drjaved007@gmail.com

Extended author information available on the last page of the article

Keywords Lacrimal · Laser · DCR · Dacryocystorhinostomy · Outcomes · Long-term

Introduction

Transcanalicular approach for a dacryocystorhinostomy (DCR) was conceptualized by Jack in 1963 [1]. Silkiss et al. [2] and Levin et al. [3] demonstrated the first transcanalicular laser DCR (TCL-DCR) in cadavers which was followed by its use in patients by Christenbury [4]. Subsequently several studies used different laser types, but the diode laser (980nm) TCL-DCR, introduced by Elloy in 2000, remains the commonly used one [5]. TCL-DCR emerged as a minimally invasive alternative to an external or endoscopic DCR and had several advantages like absent skin incision and preservation of medial canthal structures and could be performed under local anesthesia, less operative time, minimal bleeding, faster postoperative recovery, and low morbidity [6]. The disadvantages include initial steep learning curve, additional expense, inadequate osteotomies, and potential charring of lacrimal tissues. Despite the advantages, the success rates are widely variable, ranging from 34 to 97%, and the long-term outcomes are still unclear [7–12]. A recent systematic review and meta-analysis assessed available treatment options for the distal acquired lacrimal duct obstructions and did not recommend TCL-DCR as a treatment of choice based on the outcomes [13]. The current study specifically assessed long-term outcomes of primary TCL-DCR in a large cohort of patients with PANDO.

Methods

The manuscript adhered to the Tenets of the Declaration of Helsinki. The study was approved by the local ethics committee, and informed consent was obtained from all the patients. A retrospective interventional case series was performed on all patients diagnosed with PANDO and who underwent a primary transcanalicular laser DCR from Jan 2014 to June 2016. The procedure was performed using 980 nm diode laser. All the patients were operated by a single experienced surgeon (RN). The exclusion criteria included age less than 18 years, history of any previous interventions, co-existing lacrimal disorders like punctal and canalicular stenosis, acute dacryocystitis, mucoceles, co-existing nasal disorders like deviated septum, concha bullosa, atrophic rhinitis, and any ocular or nasal trauma. Other than unilateral patients, only the first operated eye in cases of bilateral patients was included in the study for simplicity of analysis and to get longer follow-up assessments. The parameters studied from the patient records include patient demographics, clinical presentation, type of anesthesia, duration of surgery, laser energy delivered, intraoperative pain, complications, pre- and postoperative Munk scale reading, and anatomical and functional success. The variables influencing the outcomes were also assessed.

Surgical technique

All the procedures (except 5 cases) were performed on an outpatient basis under topical (10% lidocaine nasal spray) and infiltrative (2% lidocaine with 1:80,000 adrenaline) local anesthesia (infratrochlear and anterior ethmoidal nerve blocks). Nasal decongestion was achieved with 0.1% xylomethasoline spray into nasal cavity followed by a 10-min nasal packing with 2% lidocaine and 1:80,000 adrenaline. The energy of the 980nm diode laser (DiodeLX Smart M, Lasotronix, Poland) was delivered through a 600μm semi-rigid optical fiber at a setting of 10W (Fig. 1). After the lacrimal puncta were dilated with a Wilder dilator, the fiber was introduced through the upper canaliculus. As it reached the lacrimal sac, the red aiming beam was identified in the endoscopic view of the lateral nasal wall. The laser energy was applied and the ostium was enlarged until a large osteotomy was created (Fig. 1). The debris in and around the ostium was meticulously removed under endoscopic guidance. A sponge soaked in mitomycin C (MMC) 0.5mg/ml was applied on the rhinostomy site with Blakesley forceps for 3 min. At the end of the procedure, silicone Crawford bicanalicular stents were placed and secured in the nasal cavity. Time of surgery was measured from removal of nasal packing to completion of intubation. Intraoperative pain was evaluated on a 3-point scale (1, absent; 2, tolerable pain; 3, need for a reinforced local anesthesia).

The postoperative medical therapy consisted of oral antibiotic, antibiotic-steroid eye drops, nasal steroid spray, and saline nasal douching. Postoperative follow-up visits were scheduled for 1 week, 1 month, 2 months, 3 months (stent removal), 6 months, 1 year, 1.5 years, 2 years, 2.5 years, and 3 years. At each visit, the ostium was evaluated (Fig. 1). Anatomical success was defined as patent ostium on irrigation, and functional success was defined as resolution of epiphora. Pre- and postoperative Munk scale was recorded to quantify the subjective changes in the epiphora.

Statistical analysis

The statistical analysis was performed using the package Statistica (version 10.0, Statsoft Poland). The compliance of distributions with the normal distribution was tested using the Shapiro-Wilk test. Given the fact that the assumptions concerning the use of parametric methods were not met, the

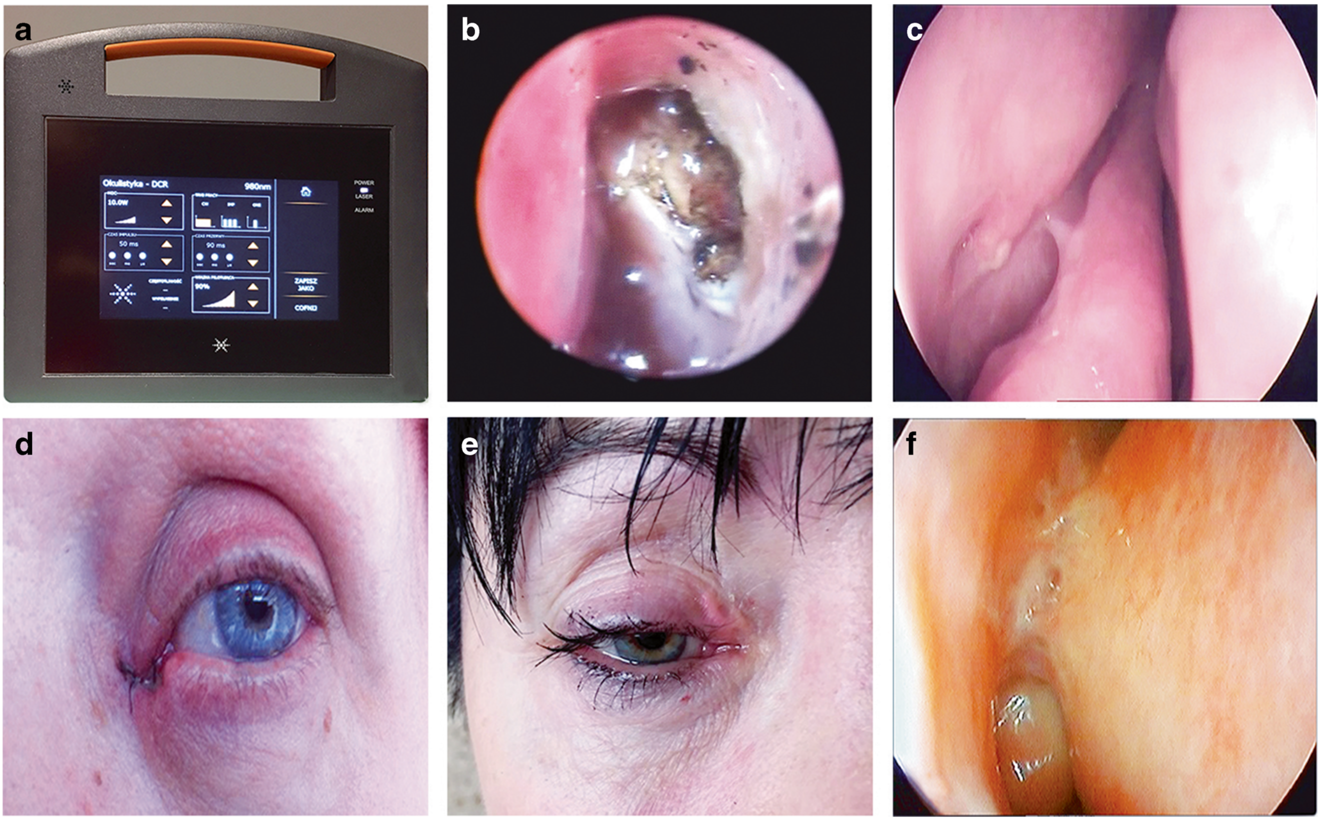


Fig. 1 Image showing the diode laser console used in the study (**a**). Endoscopy image of the left nasal cavity demonstrating the large ostium created by the lasers (**b**). Endoscopy image of the right nasal cavity demonstrating a small but patent ostium (**c**). Clinical external image showing canalicular injury (**d**) and healed thermal burns (**e**). Endoscopy image showing extensive ostio-septal synechiae (**f**)

statistical hypotheses were verified with non-parametric methods. The methods used were Spearman's rank-order correlation, Mann–Whitney *U* test, Kruskal-Wallis *H* test, or one-way ANOVA on ranks (including Dunn post hoc test), and chi-square test of Independence. A *P*-value of <0.05 was considered statistically significant.

Results

A total number of 205 patients were assessed. Of these, 73.17% (150/205) were females. The mean age of patients was 62.92 years (range: 19–84 years). The mean laser energy used was 1060.09 ± 551.18 J (1.06 ± 0.55 kJ), and the mean operating time was 22.33 ± 4.97 minutes (Table 1). Of all the patients, 95% (*n*=194), 87% (*n*=178), and 68% (*n*=139) completed 1-, 2-, and 3-year follow-up, respectively (Table 2). The anatomical and functional success rates were good and comparable to other approaches till postoperative 3 months (Table 2). However, it dropped significantly beyond the 3 months and 6 months postoperative period and maintained the lower success rates beyond 1-year follow-up (anatomical, 56.7%; functional, 31.4%) for up to 3 years (Tables 2 and 3, Graph 1). The anatomical and functional success at the end of 3-year follow-up was 56.12% and 33.81%, respectively (Graph 1). Complete cicatricial closure of the ostium was the common cause of anatomical failures. The common complications were intraoperative bleeding (10.7%, *n*=22), nasal synechiae (5.36%, *n*=11), and DCR ostium granulomas (4.39%, *n*=9) (Fig. 1). Although very uncommon, canalicular complications noted were burns (0.97%), obstructions (1.4%), and slitting (1.4%) (Fig. 1). The functional success was not affected by gender ($P = 0.132$), age ($P = 0.956$), laser energy ($P = 0.626$), or duration of the surgery ($P = 0.906$) (Table 4). However, the intraoperative pain scale (3, needing a local anesthesia reinforcement) was influenced by the increasing laser energy ($P < 0.001$) and the duration of the surgery ($P < 0.001$) (Table 4).

Table 1 Demographics, laser energy, and time of surgery

Variable	Mean	SD	Min	Max
Age	62.92	15.17	19	84
Laser energy (J)	1060.09	551.18	151	3270
Time of surgery (min)	22.33	4.97	14	40

Table 2 Anatomical and functional success of TCL-DCR

Total number	Post-op	Anatomical success		Functional success	
		Number	%	Number	%
205	1 month	201	98.05	185	90.24
205	2 months	200	97.56	183	89.26
205	3 months	200	97.56	180	87.80
203	6 months	149	73.40	85	41.87
194	12 months	110	56.70	61	31.44
189	18 months	99	52.38	59	31.22
178	24 months	94	52.81	55	30.90
165	30 months	91	55.15	54	32.73
139	36 months	78	56.12	47	33.81

Discussion

The current study describes the long-term outcomes, factors influencing the outcomes, and complications of primary transcanalicular laser dacryocystorhinostomy. There was a significant decrease in the successful outcomes upon following the patients beyond 6 months. The outcomes at the end of 1 year were maintained for up to 3 years of follow-up. The anatomical and functional success at the end of 3-year follow-up were poor and at 56.12% and 33.81%, respectively.

Several studies that assessed the outcomes of TCL-DCR showed a wide variation in the success rates ranging from 34 to 97% [6–13]. These variations could be explained by significant heterogeneity in the methodologies including multiple surgeons, non-uniform protocols, different laser sources, variable definitions for success, and variable follow-up periods. The sample size for several studies which assessed outcomes of TCL-DCR has been less than 100 patients, even for comparative and randomized studies [9, 14].

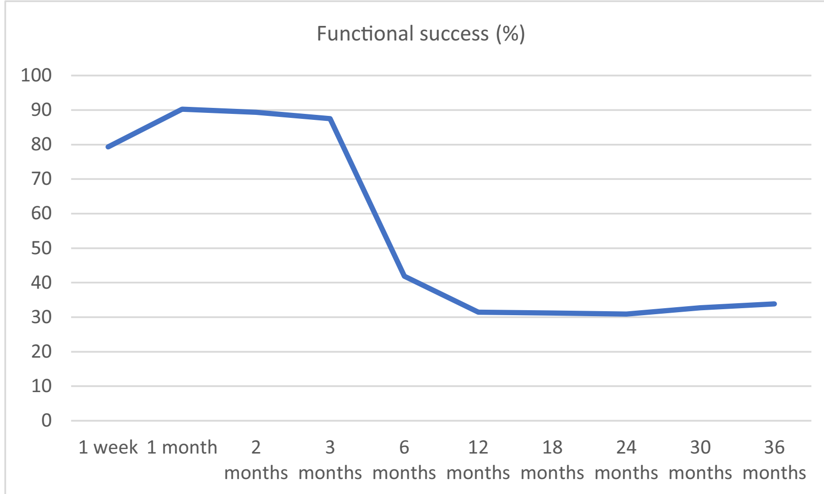
Few studies have looked at the long-term outcomes of TCL-DCR [10–12, 14–16]. Akcam et al. [14] reported a success rate of 86.6% at a mean follow-up of 93 ± 2.9 months. However, there were only 15 eyes assessed. Zengin et al. [15] performed TCL-DCR in 54 patients and found a success rate of 85.2% at a mean follow-up of 18.9 ± 2.07 months. The anatomical and functional success rates were not separately analyzed. Basmak et al. [16] reported a success rate of 71% at a mean follow-up of 14.6 months in 38 eyes that they studied. They however reported an increase in the success rates if adjunctive endonasal procedures like mechanical enlargement of the neo-ostium were performed. Although the mechanical enlargement appears to be a logical step, it nevertheless would confound the assessment of the efficacy of TCL-DCR. Kaynak et al. [12] performed a detailed long-term analysis of TCL-DCR for up to 2 years in a cohort of 125 patients. They found that the anatomical and functional success rates drop significantly at 1 year (69.5% and 63.3%) as compared to at 3 months (93.1% and 85.4%). The present study also showed similar trends for anatomical and functional outcomes but with a much steeper fall at 1 year (56.70% and 31.44%) as compared to at 6 months (73.40% and 41.87%) and 3 months (97.56% and 87.80%). The reason for lower functional success rates may also reflect influence of the laser burns on the pump mechanisms, and this needs to be further explored. The mean operative times were not significantly different amongst various studies and ranged from 13.4 ± 5.3 to 25.8 ± 3.1 min [10, 15]. The current study also had similar times with a mean duration of 22.33 ± 4.97 min. Another interesting aspect of the study was the heterogeneity in the use of adjunctive modalities like mitomycin C and silicone intubation. Although several studies used them, the protocols were different, and some showed higher success rates with multiple postoperative applications of mitomycin C [8].

Several factors were considered to influence the outcomes of TCL-DCR. Akay et al. [10] found age at surgery to be a significant factor with a success rate of 76% in older age group (mean age: 60.3 ± 7.3 years) as compared to 46% in younger groups (mean age: 21.3 ± 3.3 years). However, this was convincingly refuted by two other studies [12, 17]. The present study also did not find any correlation between age and success rates. Kaynak et al. [12] did not find a significant relationship between amount of laser energy or premature stent loss and the success rates. In comparison, the present study looked at several factors that could influence surgical outcomes but did not find age, gender, amount of laser energy, or duration of surgery to influence the success rates (Table 4). However, the amount of laser energy and duration of the surgery significantly influenced the intraoperative pain perception and pain scales ($P<0.001$). Hence, it may be prudent for the surgeon to keep a watch on these parameters and reinforce the local anesthesia, when required.

A finding that has been consistent in few of the long-term studies is the stabilization of results by the 12-month follow-up and no further significant changes in the

Table 3 Complications noted in the cohort

Complications	*N*	%
Intraoperative bleeding	22	10.73
Intraoperative canalicular burn	2	0.97
Canalicular obstruction	3	1.46
DCR ostium granuloma	9	4.39
Nasal cavity synechiae	11	5.36
Orbital emphysema	1	0.48
Canalicular slitting	3	1.46



Graph 1 Plot showing the overall functional success from week 1 up to 3-year follow-up

outcomes beyond 12 months [12, 17]. The present study confirmed this finding in a very large cohort with a long-duration of follow-up. Hence, it may be prudent to follow up TCL-DCR cases closely for up to one year, and further follow-ups can only be need based.

The limitations of the current study are a progressive decrease in the total number of patients completing 3-year follow-up and minimally variable success rates at different follow-ups. However, 95% of the patients completed a 1-year follow-up and nearly 70% completed a 3-year follow-up, and the minimally variable success rates at different time points beyond 1 year can be explained by the changing denominator of patients. It is important to also realize the possibility that the failed cases may be more reluctant to revisit the primary surgeon, and hence the rates of failure may be actually higher. It is also prudent now to start focused studies assessing individually the factors that contribute to lower success rates in TCL-DCR. The strengths of this study include a comparatively large cohort, single experienced surgeon with uniform protocols, very long-term follow-up, and assessment of several variables that can influence the outcomes.

Table 4 Variables influencing the functional outcomes

S. no	Variable	*P*-value
1	Gender vs functional success	0.132
2	Age vs functional success	0.956
3	Laser energy vs functional success	0.626
4	Surgery duration vs functional success	0.906
5	Pain vs laser energy	<0.001
6	Pain vs duration of surgery	<0.001
7	Laser energy vs duration of surgery	<0.001

In conclusion, the current study has demonstrated that the long-term outcomes in a large cohort of TCL-DCR's operated by a single experienced surgeon were poor as compared to long-term outcomes with other approaches like external and endoscopic dacryocystorhinostomy.

Acknowledgements The author wishes to acknowledge the help of Mr Marek Jastrzebski with the statistical analysis.

Author contribution Rafal Nowak: Concepts, manuscript drafting, and manuscript approval

Marek Rekas: Supervision, guidance, review of the manuscript, and final approval

Izabela Nowak Gospodarowicz: Review of the manuscript, guidance, and approval

Mohammad Javed Ali: Concepts, manuscript drafting and critical review, and manuscript approval

Funding Hyderabad Eye Research Foundation

Declarations

All procedures performed in studies involving human participants were in accordance with the ethical standards of the (Jozef Strus City Hospital, Poznan) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest Prof. Ali receives royalties from Springer for his treatise "Principles and Practice of Lacrimal Surgery" (2nd ed), "Atlas of Lacrimal Drainage Disorders," and "Video Atlas of Lacrimal Surgery." The other authors declare no competing interests.

References

1. Jack MK (1963) Dacryocystorhinostomy: description of a transcanalicular method. Am J Ophthalmol 56:974–977

2. Silkiss RZ, Axelrod RN, Iwach AG, Vassiliadis A, Hennings DR (1992) Transcanalicular THC:YAG dacryocystorhinostomy. Ophthalmic Surg 23:351–353
3. Levin PS, StormoGipson DJ (1992) Endocanalicular laser-assisted dacryocystorhinostomy. An anatomic study. Arch Ophthalmol 110: 1488–1490
4. Christenbury JD (1992) Translacrimal laser dacryocystorhinostomy. Arch Ophthalmol 110:170–171
5. Eloy P, Trussart C, Jouzdani E, Collet S, Rombaux P, Bertrand B (2000) Transcanalicular diode laser assisted dacryocystorhinostomy. Acta Otorhinolaryngol Belg 54:157–163
6. Henson RD (2018) Primary endocanalicular laser dacryocystorhinostomy. In: Ali MJ (ed) Principles and Practice of Lacrimal Surgery, 2nd edn. Springer, Singapore, pp 241–254
7. Balikoglu-Yilmaz M, Yilmaz T, Taskin U, Taskapili M, Akcay M, Oktay MF, Eren S (2015) Prospective comparison of 3 dacryocystorhinostomy surgeries: external versus endoscopic versus transcanalicular multidiode laser. Ophthalmic Plast Reconstr Surg 31:13–18
8. Henson RD, Cruz HL, Henson RG Jr, Ali MJ, Kakizaki H (2012) Postoperative application of mitomycin-C in endocanalicular laser dacryocystorhinostomy. Ophthalmic Plast Reconstr Surg 28:192–195
9. Feijó ED, Caixeta JA, de Souza Nery AC, Limongi RM, Matayoshi S (2017) A comparative study of modified transcanalicular diode laser dacryocystorhinostomy versus conventional transcanalicular diode laser dacryocystorhinostomy. Eur Arch Otorhinolaryngol 274:3129–3134
10. Akay F, Ilhan A, Yolcu Ü, Gundogan FC, Yildrim Y, Toyran S (2015) Diode laser-assisted transcanalicular dacryocystorhinostomy: the effect of age on the results. Arq Bras Oftalmol 78:164–167
11. Nuhoglu F, Gurbuz B, Eltutar K (2012) Long-term outcomes after transcanalicular laser dacryocystorhinostomy. Acta Otorhinolaryngol Ital 32:258–262
12. Kaynak P, Ozturker C, Yazgan S, Karabulut GO, Akar S, Demirok A, Yilmaz OF (2014) Transcanalicular diode laser assisted dacryocystorhinostomy in primary acquired nasolacrimal duct obstruction: 2-year follow up. Ophthalmic Plast Reconstr Surg 30:28–33
13. Vinciguerra A, Nonis A, Giordano Resti A, Bussi M, Timarchi M (2020) Best treatments available for distal acquired lacrimal obstruction: A systematic review and meta-analysis. Clin Otolaryngol 45:545–557
14. Akcam HT, Konuk O (2020). Mechanical transnasal endoscopic dacryocystorhinostomy versus transcanalicular multidiode laser dacryocystorhinostomy: long-term results of a prospective study. Lasers Med Sci
15. Zengin MÖ, Eren E (2014) The return of the jedi: comparison of the outcomes of endolaser dacryocystorhinostomy and endonasal dacryocystorhinostomy. Int Forum Allergy Rhinol 4:480–483
16. Basmak H, Caklı H, Sahin A, Gursoy H, Ozer A, Altun E, Yildrim N (2011) Comparison of endocanalicular laser dacryocystorhinostomy with and without endonasal procedures. Graefes Arch Clin Exp Ophthalmol 249:737–743
17. Plaza G, Beteré F, Nogueira A (2007) Transcanalicular dacryocystorhinostomy with diode laser: long-term results. Ophthalmic Plast Reconstr Surg 23:179–182

Affiliations

Rafal Nowak[1,2] • Marek Rekas[3] • Izabela Nowak Gospodarowicz[3] • Mohammad Javed Ali[2]

[1] Department of Ophthalmology, Jozef Strus City Hospital, Poznan, Poland

[2] Govindram Seksaria Institute of Dacryology, L.V. Prasad Eye Institute, Road No 2, Banjara Hills, Hyderabad, Telangana 500034, India

[3] Department of Ophthalmology, Military Institute of Medicine, Warsaw, Poland