Goniopuncture After Non-Penetrating Deep Sclerectomy: Too Early or Too Late

Goniopunção Após Esclerectomia Profunda Não Penetrante: Muito Precoce ou Muito Tardia

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ABSTRACT

INTRODUCTION: Non-penetrating deep sclerectomy is a non-penetrating glaucoma surgery with growing interest in recent years. In this procedure, a new pathway for aqueous humor outflow is created, while preserving the integrity of the anterior chamber. If satisfactory intraocular pressure is not achieved, postoperative neodymium-yttrium-aluminum-garnet laser goniopuncture can restore aqueous outflow through the trabeculo-Descemet's membrane. Although considered a safe procedure, some complications, such as iris incarceration, have been reported. The purpose of the study is to investigate the efficacy and safety of goniopuncture in lowering IOP after surgery and to determine if there is a significant difference in outcomes based on whether the procedure is performed early or late after surgery.

METHODS: In this retrospective study, patients submitted to goniopuncture following deep sclerectomy at Unidade Local de Saúde de Matosinhos between July 2015 and July 2022 were analyzed. We recorded demographic variables, type of glaucoma, prior phacoemulsification, intraocular pressure, best-corrected visual acuity, number of glaucoma medications, time between surgery and goniopuncture, number of goniopunctures performed, success of goniopuncture, and post-goniopuncture complications. Patients were followed-up for two years.

RESULTS: Out of 220 eyes submitted to deep sclerectomy, goniopuncture was performed in 56 eyes (25.45%) of 56 patients with a median interval of 4.50 (11) months. Early goniopuncture (≤3 months after surgery) was performed in 27 eyes (48.2%) and late goniopuncture (> 3 months after surgery) in 29 eyes (51.8%). At last follow-up, the success rate was 75% (n=42). Intraocular pressure showed a significant reduction from 22.34±6.15 mmHg before goniopuncture to 12.73±4.68 mmHg immediately after the procedure (p<0.001) and 14.57±3.67 mmHg at 24 months (p<0.001). No significant difference was found between early and late goniopuncture in the success rate of intraocular pressure reduction (74.1% *vs* 75.9%, p=0.880).

The most common complication recorded was iris incarceration (n=5, 8.9%), followed by hypotony (n=2, 3.6%). At last evaluation, a significant reduction on mean number of medications was observed (0.84±0.16, p<0.001).

CONCLUSION: Goniopuncture is effective in reducing intraocular pressure long-term, with similar outcomes whether performed early or late after surgery. Despite being generally safe, complications like iris incarceration require careful postoperative monitoring.

KEYWORDS: Filtering Surgery; Glaucoma/surgery; Lasers, Solid-State; Mitomycin; Sclerostomy; Trabeculectomy.

RESUMO

INTRODUÇÃO: A esclerectomia profunda não penetrante é uma cirurgia de glaucoma não penetrante com interesse crescente. O procedimento cria uma nova via de drenagem do humor aquoso, preservando a integridade da câmara anterior. Se a pressão intraocular satisfatória não for alcançada, a goniopunção com laser de neodímio-ítrio-alumínio-granada no pós-operatório pode restabelecer a drenagem do humor aquoso através da membrana trabéculo-Descemet. Embora seja considerada segura, algumas complicações, como o encarceramento da íris, já foram descritas. O objetivo deste estudo é investigar a eficácia e segurança da goniopunção na redução da pressão intraocular após cirurgia e determinar se o momento do procedimento, precoce ou tardio, influencia os resultados.

MÉTODOS: Neste estudo retrospetivo, foram analisados os doentes submetidos a goniopunção após esclerectomia profunda na Unidade Local de Saúde de Matosinhos entre julho de 2015 e julho de 2022. Foram registadas variáveis demográficas, tipo de glaucoma, cirurgia prévia de facoemulsificação, pressão intraocular, melhor acuidade visual corrigida, número de medicamentos para o glaucoma, tempo entre cirurgia e goniopunção, número de goniopunções realizadas, sucesso e complicações pós-goniopunção. O seguimento foi de dois anos.

RESULTADOS: De 220 olhos submetidos a esclerectomia profunda, a goniopunção foi realizada em 56 olhos (25,45%) de 56 doentes, com um intervalo mediano de 4,50 (11) meses. A goniopunção precoce (≤3 meses após a cirurgia) foi realizada em 27 olhos (48,2%) e a tardia (> 3 meses após a cirurgia) em 29 olhos (51,8%). A taxa de sucesso foi de 75% (n=42). A pressão intraocular apresentou uma redução significativa de 22,34±6,15 mmHg antes da goniopunção para 12,73±4,68 mmHg imediatamente após o procedimento (p<0,001) e 14,57±3,67 mmHg aos 24 meses (p<0,001). Não foi encontrada diferença significativa na taxa de sucesso entre a goniopunção precoce e a tardia (74,1% *vs* 75,9%, p=0,880).

A complicação mais comum foi o encarceramento da íris (n=5, 8,9%), seguida da hipotonia (n=2, 3,6%). Na última avaliação, observou-se uma redução significativa no número médio de medicamentos (0,84±0,16, p<0,001).

CONCLUSÃO: A goniopunção mostrou-se eficaz na redução da pressão intraocular a longo prazo, sem diferença significativa entre procedimentos precoces ou tardios. Embora seguro, o procedimento pode causar complicações, como encarceramento da íris, o que justifica um seguimento rigoroso.

PALAVRAS-CHAVE: Cirurgia Filtrante; Esclerostomia; Glaucoma/cirurgia; Lasers de Estado Sólido; Mitomicina; Trabeculectomia.

INTRODUCTION

In recent years, there has been a growing interest in non-penetrating glaucoma surgery.[1] Of these procedures, non-penetrating deep sclerectomy (NPDS) has been demonstrated to have a similar efficacy with a lower complication rate when compared to filtering surgeries such as trabeculectomy.[2]

In NPDS, a new pathway for the outflow of the aqueous humor is created, maintaining the anterior chamber intact. Its success depends on adequate aqueous flow through the trabeculo-Descemet's membrane (TDM) and low resistance in the subconjunctival tissue. Intraoperative use of mitomycin C (MMC) and postoperative needling with 5-fluorouracil can reduce subconjunctival fibrosis.[3] Additionally, when satisfactory intraocular pressure (IOP) is not reached, postoperative neodymium-yttrium-aluminum-garnet (Nd:YAG) laser goniopuncture (LGP) can restore aqueous outflow through the TDM.[4]

LGP creates one or more full-thickness perforations in the TDM at the site of NPDS, allowing aqueous drainage into the Schlemm's canal, intra-scleral space and subconjunctival space, thus bypassing juxtacanalicular TDM and the inner wall of Schlemm's canal. It is a noninvasive and inexpensive procedure and success rates are between 64% and 83%.[4] Although generally regarded as a relatively safe

procedure, some complications have been reported, being iris incarceration one of the most commonly described.[5,6]

The goal of this work was to investigate the efficacy and safety of Nd:YAG LGP in lowering IOP after NPDS and evaluating if there is an observable difference in the outcomes when performed early or late after surgery.

MATERIAL AND METHODS

STUDY DESIGN

We conducted a retrospective study of patients submitted to LGP following NPDS at Hospital Pedro Hispano – Unidade Local de Saúde de Matosinhos (ULSM) in Matosinhos, Portugal, between July 2015 and July 2022. The study followed the tenets of the Declaration of Helsinki and was approved by local ethics committee of ULSM.

PATIENTS

We included patients submitted to LGP following NPDS for primary or secondary open angle glaucoma (OAG) not controlled with medical therapy or with ocular hypotensive eyedrops intolerance and followed-up for at least 24 months. Patients with a history of glaucoma filtration surgery prior to NPDS were excluded.

SURGICAL TECHNIQUE

Non penetrating deep sclerectomy (NPDS)

Surgeries were performed by four experienced surgeons. Anesthesia was accomplished using either a subtenon's and/or peri-bulbar block with ropivacaine. A superior conjunctival peritomy with radial relaxing incisions was executed with Wescott scissors, performing hemostasis with bipolar cautery. Subconjunctival MMC 0.02% was applied under the conjunctival flap for 3 minutes. A 5x5 mm, one-third thickness scleral flap was prepared and dissected 1.5-2.0 mm into the clear cornea. A 4x4 mm deep scleral flap was dissected from posterior to anterior, leaving a thin layer of sclera overlying the choroid. After identifying Schlemm's canal, a dissection was carried anteriorly until only an intact window of Descemet's membrane through which aqueous humor percolated spontaneously was left. A scleral non-absorbable implant was applied (Esnoper®), placed radially in the decompression chamber and inserted in the suprachoroidal space, and secured with nylon 10/0 sutures. Conjunctival sutures were performed with resorbable Vicryl® 8/0 or nylon 10/0. Postoperatively, patients received a topical steroid for at least 6 months on a dose-tapering regimen.

Nd-YAG laser goniopuncture

Patients submitted to NPDS that failed meeting the individualized target IOP, determined by the assistant ophthalmologist, and despite bleb manipulation, were submitted to LGP.

LGP was performed with Q-switched Nd:YAG laser (Optimis Fusion, Quantel Medical®) set to 3 mJ. Eyes received topical pilocarpine 2% and tetracaine, and a Latina SLT lens was positioned on the ocular surface, exposing the superior iridocorneal angle. Laser was applied to the TDM in the place where NPDS was performed previously until perforation of the meshwork was observed.

The procedure was repeated if punctures were not observed in the following appointment. In case of iris plugging to the TDM puncture site, argon laser iridoplasty and Nd:YAG laser impacts were applied in the attempt of release the incarceration.

OUTCOME MEASURES

Our study had 2 main goals: (1) assessing the efficacy and safety of LGP in eyes submitted to NPDS; (2) evaluating if there was a difference in efficacy and safety of LGP performed early (≤3 months) or late (>3 months) after NPDS. The cutoff in the time to perform LGP after NPDS was determined based on a case series that reported a higher incidence of laser complications in eyes receiving treatment within 3 months of surgery.[7]

Demographic data, including age, sex, type of glaucoma, prior phacoemulsification and medical history, were recorded at baseline. In the first evaluation and in each follow-up evaluation, the following parameters were collected: IOP in mmHg measured by applanation tonometry, best-corrected visual acuity (BCVA) in logMAR and number of glaucoma medications.

The decision to perform LGP was made by the treating ophthalmologist when the target IOP was not reached. IOP was recorded before and after goniopuncture, and the time interval between NPDS and LGP, the number of LGP performed and post-LGP complications were collected. The success of LGP was defined as achieving the target IOP established for each patient without hypotonic treatment.

All patients were examined at least at one day, one week, one month, six months, one year and two years after the procedure.

STATISTICAL ANALYSIS

Statistical analysis was performed with SPSS Statistics, version 29.0. Characteristics of the patients were presented as frequencies and percentages for categorical variables, and means and standard deviations, or medians and interquartile ranges for continuous variables without or with skewed distributions, respectively. Normality of data was evaluated using the Kolmogorov-Smirnov test. Categories variables were assessed using the Chi-square or the Fisher exact test. Continuous variables were analyzed with analysis of variance (ANOVA), the Student's t-test or linear regression. Bonferroni correction was applied for multiple comparisons. Univariate and multivariate analyses were performed using the Cox proportional hazard regression model. A p-value < 0.05 was considered statistically significant.

RESULTS

Out of 220 eyes submitted to NPDS, we analyzed all the 56 eyes (25.45%) of 56 patients that were submitted to LGP between July 2015 and July 2022. All patients were followed-up for 24 months. Demographic characteristics at baseline are summarized in Table 1.

Table 1. Demographic data at baseline of 56 eyes of 56 patients submitted to Nd:YAG laser goniopuncure following non-penetrating deep sclerectomy.

Variable	Mean ± SD, absolute number (%)	Range
Sex		
Male	30 (53.6%)	
Female	26 (46.4%)	
Age (years)	69.94 ± 10.83	46, 95
Eye		
Right	22 (39.3%)	
Left	34 (60.7%)	
Diagnosis (eyes)		
POAG	32 (57.1%)	
PXFG	22 (39.3%)	
PG	1 (1.8%)	
SIG	1 (1.8%)	
Previous phacoemulsification	5 (8.9%)	
IOP (mmHg)	21.8 ± 6.15	13, 40
BCVA (logMAR)	0.52 ± 0.45	0, 2
Medications for glaucoma	2.53 ± 1.23	0, 4

POAG – primary open angle glaucoma; PXFG – pseudoexfoliative glaucoma; PG – pigmentary glaucoma; SIG – steroid induced glaucoma; IOP – intraocular pressure; BCVA – best corrected visual acuity; SD – standard deviation.

Decision to perform LGP was made by the assistant ophthalmologist and based on individualized targets considering neuropathy severity, age and comorbidities. LGP was performed in 56 eyes previously submitted to NPDS (25.45%) with a median interval of 4.50 (11) months (range 4 days – 50 months). Goniopuncture was made at the early postoperative period before the 3rd month in 27 eyes (48.2%) and at the late postoperative period after the 3rd month in 29 eyes (51.8%). Fig. 1 represents the distribution of the timing after NPDS of LGP.

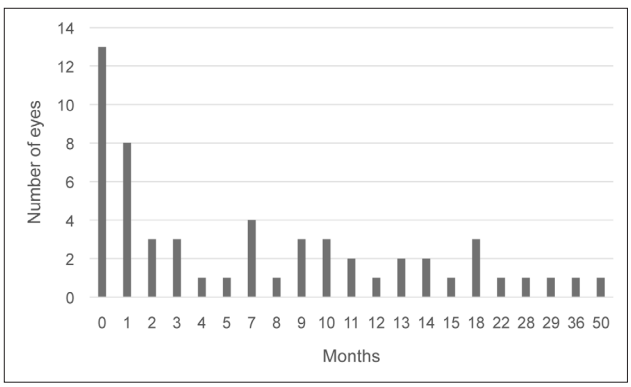

Figure 1. Distribution of the temporal span between NPDS and LGP (n=56).

After 24 months of follow-up, the overall success rate was 75% (n=42). No statistically significant difference in success rate was found in different glaucoma types (p=0.313).

IOP showed a significant reduction from 22.34 ± 6.15 mmHg (range 13 – 40 mmHg) before the goniopuncture to 12.73 ± 4.68 mmHg (range 5-25 mmHg) immediately after the procedure (p<0.001). Furthermore, when compared to the period before LGP, a statistically significant reduction to 14.57 ± 3.67 mmHg (range 4-21 mmHg) was observed at the last follow-up at 24 months (p<0.001) – Fig. 2.

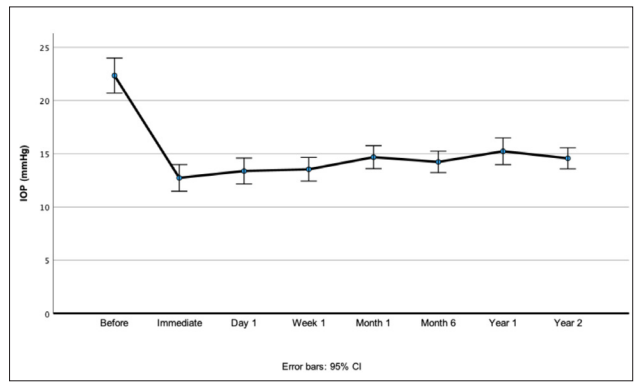

Figure 2. Intraocular pressure values before and after laser goniopuncture. Dots and bars represent intraocular pressure mean and 95% confidence intervals, respectively. IOP – intraocular pressure; 95% CI – 95% confidence intervals (n=56).

Comparison of eyes submitted to early LGP versus late LGP showed there was no significant difference in the IOP at each post-operative evaluation (Table 2). Likewise, no significant difference was observed in the success rate of the procedure between early LGP (74.1%) and late LGP (75.9%) (p=0.880).

Table 2. Comparison of intraocular pressure outcomes of early (<3 months) and late (>3 months) LGP after NPDS at each postoperative evaluation.

Time after LGP	Early LGP (mean ± SD)	Late LGP (mean ± SD)	p-value
Immediate	13.15 ± 5.00	12.34 ± 4.43	0.526
1 day	13.30 ± 4.83	13.45 ± 4.40	0.902
1 week	13.59 ± 4.50	13.48 ± 3.87	0.922
1 month	13.85 ±3.86	15.45 ± 4.08	0.139
6 months	13.89 ± 3.51	14.55 ± 4.02	0.515
1 year	15.15 ± 5.35	15.31 ± 4.01	0.898
2 years	14.26 ± 3.81	14.86 ± 3.58	0.544

LGP – laser goniopuncture; SD – standard deviation (n=56).

In order to analyze if there was a relationship between the timing of LGP after NPDS and IOP over time, we performed a linear regression model. We found that, at 2 years of follow-up, IOP increases 0.603 ± 0.988 mmHg with an increase in time of 1 month between NPDS and LGP. However, this was not statistically significant (p=0.544).

Complications observed after LGP are detailed in

Table 3. The most common was iris incarceration (n=5, 8.9%), occurring in 3 eyes (5.4%) of early LGP group and 2 eyes (3.6%) of late LGP group. Three of these cases were solved with laser iridoplasty and pilocarpine 2%; two required surgical repositioning of the iris. Hypotony was verified in two eyes. In one, LGP was performed 7 months after NPDS, resulting in choroidal effusion and an IOP of 4 mmHg. One month after the procedure, the choroidal effusion was resolved and IOP was 15 mmHg. The second case corresponded to an eye with pseudoexfoliative glaucoma with LGP performed two weeks after NPDS; hypotony persisted until last follow-up, but the patient had no complains and a BCVA of 0.05 logMAR.

Table 3. Complications occurred after Nd:YAG laser goniopuncture (n=56).

Complication	Absolute number (%)
Iris incarceration	5 (8.9)
Hypotony	2 (3.6)
Chorioretinal folds	1 (1.8)

Among the patients with no succeeded LGP, six patients (10.7%) were submitted to one more goniopuncture and three patients (5.4%) to two more goniopunctures. Table 4 summarizes the subsequent procedures performed after LGP.

Table 4. Procedures performed after laser goniopuncture (n=56).

Procedures	Absolute number (%)
Laser iridotomy and iridoplasty	3 (5.4%)
Needling	3 (5.4%)
Iris repositioning	2 (3.6%)
Tube surgery Ahmed valve Paul valve	2 (3.6%) 1 (1.8%) 1 (1.8%)
Selective laser trabeculoplasty	1 (1.8%)
Transscleral cyclophotocoagulation	1 (1.8%)

In last observation at 24 months, 23 patients (41.1%) were on medications to control IOP, with a mean number of medications of 0.84 ± 0.16, representing a significant reduction comparing to the baseline (p<0.001). When comparing early LGP and late LGP, we found no statistically significant difference in the mean number of medications (0.89 ± 1.19 in early LGP *vs* 0.79 ± 1.21 in late LGP, p=0.766). Linear regression analysis showed that, at 2 years of follow-up, the mean number of medications decreases 0.005 with an increase time of 1 month between NPDS and LGP, but this association was not statistically significant (p=0.779).

DISCUSSION

In our study, we assessed the outcomes of LGP following NPDS and compared the efficacy and safety of this procedure when performed early or late after NPDS.

As the main determinant of aqueous flow after NPDS is the TM, a good strategy to increase aqueous outflow is LGP, as it creates a direct communication between the anterior chamber and the Schlemm's canal, the intrascleral space and the subconjunctival space. Thus, Nd: Yag laser goniopuncture can reduced IOP in eyes previously submitted to no NPDS,[6] acting by perforating the TDM and increasing the aqueous outflow, like this improving long-term surgical success.[8]

With the increasing number of publications on non-penetrating surgery, more goniopuncture outcomes have been reported. In different series, the LGP rate after NPDS reached 10% to 71% and the success rate was around 80%.[1,9-13] In our study, goniopuncture was performed in 25.45% of eyes submitted to NPDS and the success rate was 75%. A longer follow-up period would be required to evaluate the procedure rate in long term.

Our results showed that LGP is associated with a significant reduction in IOP in long term. The timing to perform LGP after NPDS is a question of debate. Early goniopuncture has been associated with inadequate dissection, while late goniopuncture has been related to a decrease in permeability at the level of TDM due to fibrosis developed over time.[9,14] In our study, the comparison of outcomes in eyes submitted to early *vs* late NPDS found no significant difference in terms of efficacy and safety. This conclusion does not support the conception that LGP should be avoided in the early period post-NDPS due to the chance of sight-threatening complications.[5] Several studies concluded that complications are more common in early LGP after NPDS. In a retrospective study with 350 eyes, Penaud *et al*[15] showed that goniopuncture was associated with some complications, being iris incarceration the most frequent one (17.6% of eyes) and having as a predicting factor being performed early after NPDS. In turn, Vuori[5] analyzed retrospectively 31 eyes submitted to goniopuncture 3.2 ± 3.2 months after surgery. Even in these early goniopunctures, a good safety profile was reported, with only 3 cases (9.7%) of iris incarceration and no hypotony.

Although considered a safe procedure, laser goniopuncture is associated with some significant complications. Iris incarceration is the most common and may be associated with the surgical procedure, if it includes antero-posteriorly narrow window; the laser technique, if the TDM opening is overly posterior or large; or may happen spontaneously, due to the pressure differential between the anterior and posterior chamber in eyes that reach low IOP after LGP.[6] Regular gonioscopy is advised in order to detect this complication, and laser iridotomy may be performed before LGP to reduce the chances of a pressure differential after the procedure.

While some studies reported synechiolysis and peripheral iridotomy[16] or argon laser iridoplasty[17] to be effective in solving iris incarceration, in our study, surgical treatment was often required. In fact, in our case series, while conservative treatment was effective in three eyes, a surgical approach was required in two cases.

This study has some limitations. First, due to its retrospective design, a selection bias can be present, as cases

submitted to LGP were chosen by the ophthalmologist assistant of each patient and based on the IOP relative to the target IOP. Additionally, eyes were not randomized to early or late LGP. Finally, patients' compliance and tolerance to other treatments were not reported.

CONCLUSION

Our study showed that LGP is an effective and safe procedure for lowering IOP after NPDS. We found no statistically difference in the efficacy and safety outcomes between eyes submitted to LGP in the first 3 months after NPDS or later. Regular gonioscopy should be encouraged to detect iris incarceration following LGP.

CONTRIBUTORSHIP STATEMENT / DECLARAÇÃO DE CONTRIBUIÇÃO

CF: Conceptualization, drafting of the text, sourcing and editing of investigation results, and critical revision for important intellectual content.

CF, RG, RB, CV, PT: Critical revision for important intellectual content.

All authors approved the final version to be published.

CF: Conceptualização, redação do texto, obtenção e edição dos resultados da investigação e revisão crítica do conteúdo intelectual importante.

CF, RG, RB, CV, PT: Revisão crítica do conteúdo intelectual importante.

Todos os autores aprovaram a versão final a ser publicada.

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Proteção de Pessoas e Animais: Os autores declaram que os procedimentos seguidos estavam de acordo com os regulamentos estabelecidos pela Comissão de Ética responsável e de acordo com a Declaração de Helsínquia revista em 2024 e da Associação Médica Mundial.

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