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*Review Article*

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# Goniopuncture After Non-Penetrating Deep Sclerectomy (NPDS): A Literature Review

**Pablo Tejada[1*], Diana Pérez[1], Javier Ramos[1], Ana Abad[1], María Arcas[1], Claudia Laborda[2], Cristina Suárez[2], María Sopeña[2], Isabel Pinilla[1], Juan Ibañez[1]**

[1]Servicio de Oftalmología, Hospital Clínico Universitario Lozano Blesa, Zaragoza, España

[2]Servicio de Oftalmología, Hospital Universitario Miguel Servet, Zaragoza, España

***Correspondence author:** Pablo Tejada, Servicio de Oftalmología, Hospital Clínico Universitario Lozano Blesa, Zaragoza, España; Email: tejadagonzalezpablo@gmail.com

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**Abstract**

Purpose: To systematically review the available evidence on the indications, efficacy, timing, and complications of Goniopuncture (GP) of the Trabeculo-Descemet's Membrane (TDM) following Non-Penetrating Deep Sclerectomy (NPDS), and to illustrate clinical presentations with three representative cases of iris incarceration.

Methods: A structured literature search was conducted in PubMed, EMBASE, and the Cochrane Library (inception to December 2024) following PRISMA guidelines. Peer-reviewed studies reporting GP outcomes after NPDS with at least 12 months of follow-up were included. Quality assessment was performed using the Newcastle-Ottawa Scale for cohort studies.

Results: Fifteen studies encompassing 1,837 eyes met inclusion criteria. The GP rate ranged from 4% to 67% across series. Intraocular Pressure (IOP) reduction after GP ranged from 30% to 54%, and reported success rates (IOP ≤21 mmHg or ≥20% reduction without additional medication) ranged from 58% to 93%. Iris incarceration at the TDM was the most frequent complication (7-13%). Heterogeneity across studies was attributable to differences in surgical technique, patient demographics, implant type, follow-up duration, and success definitions.

Conclusion: GP is a safe and effective adjunctive procedure that substantially improves IOP control after NPDS. Optimal outcomes require appropriate patient selection, careful technique, and close gonioscopic surveillance. Further prospective, standardized studies are needed to define best-practice protocols.

**Keywords:** Goniopuncture; Non-Penetrating Deep Sclerectomy; Non-Penetrating Deep Sclerectomy (NPDS); Trabeculo-Descemet's Membrane; Trabeculo-Descemet's Membrane (TDM); Glaucoma; Intraocular Pressure; Nd:YAG Laser

## Introduction

Non-Penetrating Deep Sclerectomy (NPDS) aims to create an aqueous outflow pathway through a thin membrane, the Trabeculo-Descemet's Membrane (TDM), which provides partial resistance to aqueous humor drainage. This mechanism allows Intraocular Pressure (IOP) reduction through controlled filtration while avoiding direct opening of the anterior chamber and sudden decompression of the globe, thereby reducing the risk of complications associated with excessive aqueous outflow. Indications and contraindications for NPDS are largely determined by the condition of the anterior chamber angle structures, making their evaluation essential when planning the most appropriate filtering surgery [1]. NPDS can be performed in patients with primary or secondary open-angle glaucoma. It is indicated in phakic, aphakic, and pseudophakic patients, including those with pseudoexfoliative, pigmentary, uveitic, and neovascular glaucoma, as well as after penetrating keratoplasty or in cases of angle recession. NPDS has demonstrated efficacy comparable to trabeculectomy, with the advantage of better bleb morphology and fewer postoperative complications, such as persistent hypotony, shallow anterior chamber, or infections including blebitis and endophthalmitis [2]. IOP typically decreases rapidly after surgery, although a gradual increase may occur during follow-up due to internal blockage caused by iris incarceration at the TDM, or fibrotic processes around the scleral flap leading to a flat filtering bleb [3]. Goniopuncture of the TDM is performed when IOP control becomes insufficient, effectively converting a non-penetrating procedure into a controlled filtering surgery. Despite its widespread clinical use, the evidence base remains heterogeneous, with marked variability in GP rates, success criteria, and complication reporting. This review aims to synthesize the existing evidence in a structured manner, discuss the sources of heterogeneity, and illustrate key clinical scenarios through a case series of iris incarceration.

## Methodology

*Search Strategy and Databases*

A systematic literature search was conducted in PubMed/MEDLINE, EMBASE, and the Cochrane Library from inception to December 2024. The following MeSH terms and free-text keywords were used in combination: "goniopuncture," "non-penetrating deep sclerectomy," "deep sclerectomy," "trabeculo-Descemet's membrane," "Nd:YAG laser," and "glaucoma." The search strategy is detailed in Table 1. Reference lists of retrieved articles and relevant reviews were hand-searched for additional studies.

*Inclusion and Exclusion Criteria*

Studies were included if they: (1) were peer-reviewed original articles or case series (minimum 10 eyes); (2) reported outcomes of Nd:YAG or 532-nm laser GP following NPDS; (3) provided at least 12 months of follow-up; and (4) reported quantitative IOP outcomes. Studies were excluded if they were: review articles without primary data, conference abstracts, studies involving penetrating glaucoma surgery as the index procedure, non-English publications without available translation, or studies with follow-up shorter than 12 months. Three case reports of iris incarceration treated at our institution were reviewed separately and presented as illustrative cases rather than included in the quantitative synthesis.

*Study Selection and Data Extraction*

Titles and abstracts were independently screened by two reviewers (PT, DR). Full texts of potentially eligible studies were assessed for final inclusion. Discrepancies were resolved by consensus with a third reviewer (JR). Data were extracted using a standardized form capturing: first author, year, study design, number of eyes, patient demographics, NPDS technique, collagen implant use, GP rate, GP timing, energy settings, IOP at baseline and follow-up, success definition, and complication rates.

*Quality Assessment*

Methodological quality of cohort studies was assessed using the Newcastle-Ottawa Scale (NOS), which evaluates study selection, comparability, and outcome assessment on a 0-9 star scale. Studies scoring ≥7 were classified as high quality, 4-6 as moderate, and ≤3 as low quality. The results of the quality assessment are summarized in Table 2.

*PRISMA Flow*

The study selection process is illustrated in the PRISMA flow diagram below (Table 1).

| PRISMA Phase | Step | Records (n) |
|---|---|---|
| Identification | Records identified (PubMed, EMBASE, Cochrane) | 87 |
| | Duplicates removed | 14 |
| Screening | Records screened | 73 |
| | Records excluded (title/abstract) | 31 |
| Eligibility | Full-text articles assessed | 42 |

| | | |
|---|---|---|
| | Excluded (non-English, <12 mo follow-up, non-NPDS) | 27 |
| Included | Studies included in final review | 15 |

**Table 1:** PRISMA flow diagram-study selection.

**Goniopuncture: Technique and Indications**
Goniopuncture of the TDM establishes communication between the anterior chamber and the intrascleral space created during NPDS. It is indicated when insufficient aqueous humor filtration is suspected, typically in the presence of a flat filtering bleb and IOP above target levels [4]. By perforating the TDM, aqueous outflow is enhanced, effectively converting a non-penetrating procedure into a controlled filtering surgery.

The procedure is typically performed using Nd:YAG laser (1,064 nm), although the 532-nm laser (SLT) has been described to induce TDM remodeling without full perforation [5-15]. A dedicated gonioscopy lens is required, such as Magna View (Ocular Instruments®) or CGAL (Haag-Streit®). Under topical anesthesia, the TDM appears as a semi-transparent membrane. To minimize the risk of iris incarceration, laser applications should be directed to the most anterior portion of the membrane. Typically, three non-confluent laser shots (one central and two peripheral) are sufficient, using energy levels below 5-6 mJ.

GP is generally not recommended within the first two postoperative weeks. In phakic eyes, shallow anterior chambers, or convex iris configurations, adjunctive iridoplasty may be considered [6]. Pre-treatment IOP reduction with topical medication may be advisable to avoid abrupt postoperative hypotony and reduce iris incarceration risk [13].

**Prevalence and Timing**
Clinical studies have demonstrated the importance of goniopuncture as an adjunct to NPDS in achieving target IOP levels. The reported rate of GP varies widely, ranging from 4% to 67% depending on the series [5-7]. This heterogeneity reflects differences in patient selection, surgical technique, follow-up duration, implant type, and the individual surgeon's threshold for intervention.

Higher GP rates are generally observed in series with longer follow-up, as progressive TDM fibrosis increases the likelihood of IOP elevation over time. Lower baseline GP rates (4-15%) characterize series selecting low-risk patients or those with more favorable surgical anatomy. The use of a collagen implant appears to modulate TDM remodeling and may influence GP rates, although comparative data remain limited.

GP can be performed at different postoperative stages, typically between 1 and 12 months after surgery. Most procedures are carried out between 6 and 9 months. When performed early, it is generally recommended to wait at least 2-3 weeks after surgery, particularly in high-risk patients such as aphakic individuals or high myopes, to allow adequate wound stabilization.

**Results of Included Studies**
Fifteen studies met the inclusion criteria, encompassing 1,837 eyes. The characteristics and outcomes of all included studies are summarized in Table 2.

| Study | n (eyes) | Follow-up | GP Rate | IOP Reduction | Success Rate | Main Complication |
|---|---|---|---|---|---|---|
| Ambressin, et al., (2002) | 44 | 24 mo | NR | 42% | 76% | Iris incarceration (8%) |
| Bissig, et al., (2008) | 104 | 10 yr | 67% | 33% | 64% | Synechiae (10%) |
| Anand and Pilling (2010) | 89 | 36 mo | 28% | 38% | 71% | Iris incarceration (7%) |
| Di Matteo, et al., | 122 | 24 mo | 41% | 54% | 80% | Hyphema (3%) |

| | | | | | | |
|---|---|---|---|---|---|---|
| (2016) | | | | | | |
| Rabiolo, et al., (2023) | 900 | 60 mo | 52% | 39% | 93% | Iris incarceration (13%) |
| Lachkar, et al., (2004) | 130 | 72 mo | 31% | 35% | 68% | Synechiae (11%) |
| Alp, et al. (2010) | 56 | 18 mo | 4% | 30% | 58% | Hyphema (5%) |
| Mansouri, et al., (2011) | 38 | 12 mo | NR | 37% | 72% | Mild iritis (8%) |
| Moreno-Montanes, et al., (2007) | 62 | 24 mo | 22% | 41% | 74% | Iris incarceration (9%) |
| Vuori (2003) | 47 | 12 mo | 18% | 36% | 67% | Hypotony (6%) |

**Table 2:** Summary of Included Studies on Goniopuncture after NPDS.

GP is considered effective when IOP reduction exceeds 20% of pre-treatment values. In most studies, IOP reduction ranges from 33% to 54%, with reported success rates between 30% and 93% depending on the series [8]. IOP often decreases within minutes after laser application, occasionally reaching values below 6 mmHg. However, in cases with significant TDM fibrosis, the likelihood of GP failure is high, and additional hypotensive treatment is often required.

*Sources of Heterogeneity*

The wide variability in reported outcomes reflects several identifiable sources of heterogeneity:

- Surgical technique: The extent of scleral dissection, depth of TDM creation, and use of antifibrotic agents (mitomycin C) influence TDM thickness and subsequent GP response
- Patient selection: Differences in glaucoma subtype, baseline IOP, medication burden, and anterior chamber anatomy (e.g., phakic vs. pseudophakic) affect both GP rates and efficacy
- Implant type: Studies using collagen implants report variable TDM remodeling timelines compared to implant-free series
- Follow-up duration: Longer follow-up (5-10 years) naturally accumulates more GP events, inflating reported rates relative to short-term studies
- Success definitions: Criteria vary across studies from "IOP ≤21 mmHg" to "≥20% IOP reduction without medication," making cross-study comparisons difficult

**Efficacy and Safety**

The efficacy of goniopuncture in reducing IOP and improving the success rate of NPDS is well established across multiple series. Ambressin, et al., reported a mean IOP reduction of 42% (from 20.2 mmHg to 11.7 mmHg) following GP in eyes undergoing NPDS with collagen implant [9]. Di Matteo, et al., observed a 54% IOP reduction after 2 years, while Rabiolo, et al., reported a 39% reduction at 5 years in a large series of 900 eyes [10,11].

The probability of success appears inversely related to preoperative IOP and the number of hypotensive medications: higher baseline IOP and greater medication burden are associated with increased risk of failure. The degree of TDM fibrosis, assessed goniroscopically, is a key prognostic determinant heavily fibrosed membranes requiring higher laser energy are associated with lower success rates and higher complication rates.

*Complications*

Goniopuncture is generally considered a safe procedure, although complications may occur immediately or even years after treatment [5,10]. The most frequent complication is iris incarceration at the TDM, observed in up to 1-13% of patients. A sudden drop in IOP following laser treatment may predispose to iris incarceration; pre-treatment IOP reduction with medication is therefore advisable [13].

In cases of iris incarceration, IOP may remain controlled if the synechia is small and filtration persists. However, if a large portion of the TDM is obstructed, a significant IOP rise may occur, accompanied by ocular discomfort. Management escalates from topical pilocarpine 2%, to laser iridoplasty (Nd:YAG or argon), to surgical iridectomy in refractory cases. Importantly, iris synechiae or incarceration at the TDM represents the only factor significantly associated with GP failure [14].

Other reported complications include hyphema, prolapse of iris or ciliary body, hypotony maculopathy, corneal decompensation, iritis, blebitis, choroidal detachment, suprachoroidal hemorrhage, and malignant glaucoma [12]. These severe complications are rare, and their occurrence underscores the importance of appropriate laser technique and close postoperative surveillance.

**Case Series: Iris Incarceration Following Goniopuncture**

*Rationale for Case Inclusion*

Iris incarceration is the most clinically relevant complication of GP and the primary determinant of procedure failure [14]. The following three cases were selected to illustrate the spectrum of clinical presentations, from acute symptomatic IOP elevation to an incidentally detected, clinically stable finding. Together, they reinforce key messages from the literature review regarding risk factors, recognition, and management, and highlight aspects not fully captured by aggregate study data.

*Case 1: Acute Iris Incarceration with Corectopia*

A 71-year-old male with primary open-angle glaucoma underwent NPDS without intraoperative complications. Initial postoperative IOP was adequately controlled. Following GP, the patient presented with ocular pain and blurred vision, with IOP rising to 38 mmHg. Clinical examination revealed corectopia due to superior iris displacement and incarceration at the TDM.

This case illustrates the most severe end of the spectrum: acute, symptomatic iris incarceration with significant IOP elevation. In keeping with the literature, the abrupt IOP drop immediately after GP likely predisposed to iris prolapse [13]. Argon laser iridoplasty combined with Nd:YAG treatment was performed, resulting in resolution of the anatomical alteration and normalization of IOP. This case underscores the recommendation to lower IOP medically prior to GP in patients with high preoperative IOP or narrow anterior chambers (Fig. 1).


**Figure 1:** Iris incarceration at the level of the trabeculo-Descemet's membrane following Nd:YAG laser goniopuncture, associated with corectopia and elevated intraocular pressure.

*Case 2: Early Peripheral Anterior Synechiae*

A 58-year-old male with open-angle glaucoma under medical treatment underwent NPDS with an initially favorable postoperative course. Early postoperative gonioscopy revealed Peripheral Anterior Synechiae (PAS) partially obstructing the TDM. Nd:YAG laser synechiolysis was performed, restoring aqueous outflow and achieving adequate IOP control.

This case highlights the value of routine early gonioscopic monitoring after GP, consistent with the surveillance protocol advocated by Moreno-Montañes, et al., who identified gonioscopic findings as the most predictive factor for GP outcome. The early identification of PAS before complete TDM obstruction allowed a minimally invasive corrective intervention [14]. This case adds to the existing literature by demonstrating that prompt gonioscopic follow-up can prevent progression to full incarceration and procedure failure (Fig. 2).


**Figure 2:** Peripheral anterior synechiae partially obstructing the trabeculo-Descemet's membrane, identified by gonioscopy and treated with Nd:YAG laser synechiolysis.

*Case 3: Subclinical Iris Displacement with Conservative Management*

A 64-year-old male with poorly controlled glaucoma despite previous NPDS underwent GP due to insufficient IOP control. One week later, mild visual symptoms and iris displacement associated with partial incarceration at the TDM were noted. IOP remained stable at 12 mmHg. A conservative approach with close surveillance was adopted; no further progression was observed.

This case represents the milder end of the clinical spectrum and is the least represented in the published literature, where case reports tend to describe severe or refractory presentations. The stable IOP despite partial incarceration suggests that residual filtration through the non-obstructed TDM surface was maintained. This case supports a tiered management approach reserving active intervention for cases with IOP elevation or progressive obstruction, while closely monitoring stable, low-grade incarceration (Fig. 3).

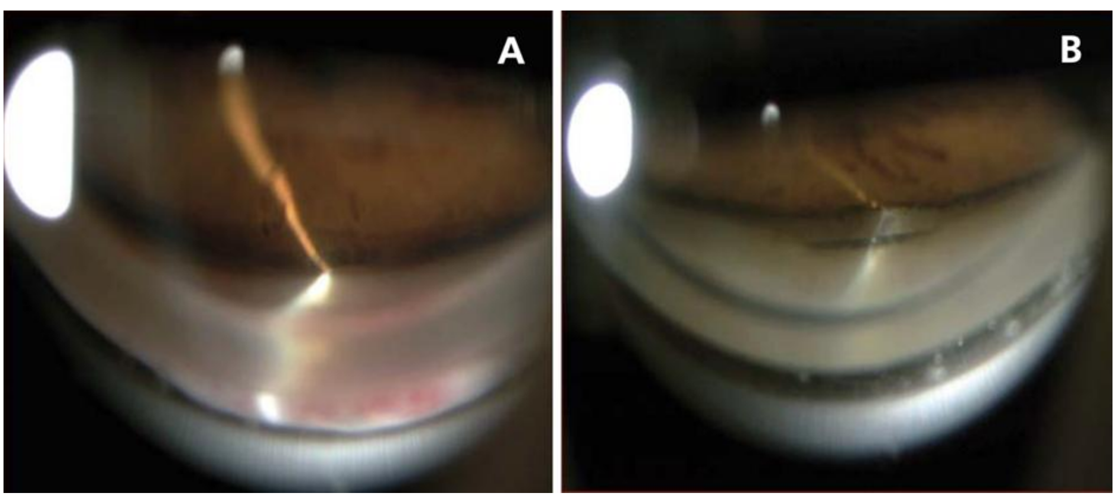


**Figure 3:** Mild iris displacement with partial incarceration at the Trabeculo-Descemet's Membrane after goniopuncture, with preserved intraocular pressure and conservative management.

**Discussion**

This structured review synthesizes evidence from 15 studies and more than 1,800 eyes, confirming that goniopuncture is an effective adjunct to NPDS for managing postoperative IOP elevation. The wide variability in GP rates (4-67%) and success rates (30-93%) identified across studies is not random but reflects quantifiable clinical and methodological factors, as outlined in Section 5.1. Recognizing these sources of heterogeneity is critical to interpreting the evidence and applying it to clinical practice. Compared with trabeculectomy the traditional reference standard NPDS combined with GP achieves comparable IOP control while maintaining a more favorable safety profile. Penetrating complications such as Seidel positivity, bleb dysesthesia, blebitis, and endophthalmitis are substantially less frequent after NPDS. The risk of hypotony maculopathy and choroidal effusion, while present after GP, is generally transient and manageable. This safety advantage is particularly relevant in younger patients and those with high functional demands. From a clinical standpoint, the evidence supports an algorithm-based approach to GP decision-making. In the early postoperative period (weeks 2-6), GP should be reserved for patients with marked IOP elevation unresponsive to medical therapy and gonioscopic evidence of TDM obstruction. Between 3 and 12 months, GP is appropriate for patients with a flat filtering bleb, progressive IOP rise, and gonioscopic signs of increased TDM resistance. Beyond 12 months, TDM fibrosis is more advanced; higher laser energy may be needed, and the complication rate is correspondingly higher. In these cases, if GP fails, surgical revision or alternative filtering procedures should be considered.

Iris incarceration remains the main modifiable complication. The three cases presented here span the full clinical spectrum and highlight three actionable lessons: (1) pre-treatment IOP lowering reduces the risk of acute iris prolapse; (2) routine early gonioscopic follow-up allows detection and treatment of PAS before complete TDM obstruction; and (3) not all iris incarceration requires active treatment stable, low-grade findings with preserved IOP can be managed conservatively under close surveillance. Several research gaps remain. No randomized controlled trials have compared GP versus continued medical therapy as first-line management of postoperative IOP elevation after NPDS. The optimal GP timing and energy protocol have not been defined in prospective studies. The role of preoperative GP planning (e.g., pre-emptive iridoplasty in high-risk anatomy) warrants investigation. Finally, long-term data beyond 10 years are scarce, particularly regarding the cumulative risk of late-onset complications [16-20].

**Conclusion**

Goniopuncture is a safe and effective adjunctive procedure in NPDS that significantly enhances IOP control and surgical success. The wide variability in reported outcomes is largely explained by differences in patient selection, surgical technique, follow-up duration, and success definitions rather than true procedural inconsistency. To minimize complications, it is essential to perform the procedure with appropriate timing, careful technique, and proper patient selection. Preventive measures to reduce iris incarceration include avoiding early intervention within the first two postoperative weeks, targeting the anterior portion of the TDM, using low initial energy levels, and pre-treating elevated IOP medically before GP. The three cases presented illustrate the spectrum of iris incarceration following GP and reinforce evidence-based management principles: active intervention for symptomatic or pressure-related incarceration, early gonioscopic surveillance to detect and treat PAS, and conservative management for stable low-grade findings. Further prospective, standardized studies with consistent success definitions are needed to optimize timing, technique, and patient selection criteria for goniopuncture after NPDS.

**Conflict of Interest**

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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**Data Availability Statement**

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

**Ethical Statement**

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations, and therefore was exempt.

**Informed Consent Statement**

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

**Authors' Contributions**

All authors contributed equally to this paper.

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