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Original Research

Comparative Analysis of Pain and Duration in Panretinal Photocoagulation: Navilas Laser versus Conventional Laser in Proliferative Diabetic Retinopathy

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Abstract

Objectives: To compare the pain perception and treatment duration in patients undergoing panretinal photocoagulation (PRP) for high-risk proliferative diabetic retinopathy (PDR) using Navilas laser versus conventional laser.

Methods: A study was conducted involving 40 patients with bilateral high-risk PDR. Each patient underwent PRP with conventional laser in one eye and Navilas laser in the other. Laser parameters, including spot size and pulse duration were standardized. Pain perception was evaluated using Verbal Rating Scale (VRS) and Visual Analogue Scale (VAS).

Results: The Navilas and conventional laser groups showed no significant differences in baseline visual acuity, lens status, intraocular pressure, cup-to-disc ratio, or cystoid macular edema. The duration of laser treatment was significantly shorter with Navilas laser group (517.3±48.78 seconds, $p<0.001$). Pain scores (VAS and VRS) were significantly lower in the Navilas laser group ($p<0.001$, $p=0.002$ respectively) than in conventional laser group. There was no correlation between VAS and VRS scores and laser time in both the Navilas and conventional laser groups ($p>0.05$).

Conclusion: Utilizing the Navilas laser for PRP in PDR patients offers advantages over conventional lasers, including reduced pain and expedited procedures. These findings contribute valuable insights for optimizing clinical decisions, potentially enhancing patient compliance and minimizing the risk of visual deterioration in diabetic retinopathy treatment.

Keywords: Conventional laser, Navilas laser, pain perception, panretinal photocoagulation, proliferative diabetic retinopathy

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Macular edema resulting from diabetic retinopathy is a significant contributor to visual impairment.[1] Nevertheless, a ray of hope emerges through the prospect of averting vision loss with timely intervention—specifically, through early diagnosis coupled with photocoagulation treatment.[2] The pivotal role of photocoagulation becomes particularly pronounced in high-risk patients grappling with proliferative diabetic retinopathy (PDR), a fact substantiated by the consistent findings of numerous multicenter studies.[3,4] The management of PDR has been significantly influenced by the findings from two important studies: The Early Treatment Diabetic Retinopathy Study (ETDRS)[5] and the Diabetic Retinopathy Study (DRS).[4] These pivotal studies have established a standardized protocol for treating PDR, which primarily involves the use of laser photocoagulation.

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In the year 2009, a noteworthy advancement in laser photocoagulation technology emerged with the introduction of fundus camera-based navigated laser photocoagulation, featuring retinal eye-tracking capabilities, known as Navilas (OD-OS GmbH, Berlin, Germany).[6] Initially, research efforts focused on focal treatment applications; however, this laser technology exhibits a range of navigation functions conducive to panretinal laser therapy.[7,8] These functions include imaging and the delivery of both single-spot and multispot laser patterns to the far periphery, achieved by continuously adjusting the laser beam based on real-time eye movements. The system's stable fixation point allows for the implementation of multi-point treatment patterns with extended pulse durations, such as 100 milliseconds or longer. Consequently, the technology facilitates navigated panretinal pattern photocoagulation, a methodology that aligns with and ensures compliance with the established ETDRS protocol. This innovative approach not only expands the scope of laser therapy but also enhances precision and adherence to standardized treatment protocols in the context of diabetic retinopathy management.

Despite significant modifications to the pattern laser protocol, panretinal photocoagulation (PRP) remains a procedure often associated with patient discomfort, with many individuals reporting it as a painful experience.[9] Shorter pulse durations in laser therapy have been reported to reduce pain perception.[10] The advent of the new navigated laser technology, which includes systems such as Navilas, has been noted for causing less discomfort during PRP compared to pattern laser systems.[10] In our study, we aimed to evaluate the comparison of pain responses in bilateral PDR patients who underwent PRP with conventional multispot laser (Quantel Medical) in one eye and the Navilas laser in the other eye. Additionally, our study aimed to explore the correlation between the levels of pain experienced and various patient characteristics, thereby providing a more nuanced understanding of patient experiences and outcomes in the context of PDR treatment.

Methods

This cross-sectional study was conducted at the Ophthalmology Clinic of Basaksehir Cam and Sakura City Hospital, adhering to the ethical guidelines set by our local ethics committee and in accordance with the principles outlined in the Declaration of Helsinki. (Ethics Committee approval number/date: E-96317027-514.10-229976028 / 27.11.2023)

Patients

The inclusion criteria mandated participants to be aged over 18 years, diagnosed with type 2 diabetes mellitus, and presenting with bilateral high risk of PDR. High-risk PDR is characterized by specific clinical criteria indicating a significant risk of severe vision loss. According to the ETDRS, these criteria include the presence of neovascularization at the disc (NVD) greater than one-quarter to one-third disc diameter or neovascularization elsewhere (NVE) with vitreous or preretinal hemorrhage.[5] Additionally, vitreous or preretinal hemorrhage associated with less extensive neovascularization, such as NVD less than one-quarter to one-third disc diameter or NVE without hemorrhage that meets the size criteria, also defines high-risk PDR. Fundus fluorescein angiography was performed on all patients before laser treatment. Baseline clinical data collected included the duration of diabetes mellitus, HbA1C levels, visual acuity, lens status, intraocular pressure, cup-to-disc ratio, and the presence of cystoid macular edema. The cup-to-disc ratio was determined through fundus examination. Patients with poor cooperation, focal/grid photocoagulation or prior history of PRP were excluded. Patients exhibiting inflammatory markers, a history of orbital trauma, or significant ocular abnormalities such as corneal opacity, marked increase in lens opacity, or vitreous hemorrhage were also precluded from the study. Patients with total optic disc pallor were excluded from the study.

Laser Application

To mitigate potential orientation bias or patient habituation to the laser procedure, PRP was randomly performed in one eye with Navilas (OD-OS GmBH, Teltow, Germany) or conventional multispot laser (SupraScan Multispot 577, Quantel, Nice) and in the other eye of the same patients with the alternative laser system. The application sequence was determined randomly, with the Navilas laser applied to the first eye in half of the patients and the pattern laser to the first eye in the other half.

In this clinical evaluation, each patient was subjected to a single session of PRP, a procedure uniformly conducted by the same ophthalmic surgeon (MK). Laser therapy was exclusively administered to the inferior and nasal regions. The procedure was divided into two sessions to mitigate the risk of inflammation. The administration of PRP was performed under conditions of topical local anesthesia.

Conventional Multispot Laser

Inferior and nasal quadrants were completed using the SuperQuad 160 PRP lens system (Volk Optical, Inc., Mentor, OH, USA). The PRP procedure was standardized: spot size was controlled between 390 micrometers (μm), a pattern size of 5 × 5 with a spacing of 0.75 and pulse duration was consistently set to 20 milliseconds (ms). This protocol was designed to achieve a uniform white-gray discoloration on

the retinal surface, a clinical indicator of effective photocoagulation. The PRP was delivered in a 'multi-spot mode', ensuring that multiple therapeutic impacts were administered in a single session. PRP applications were targeted to analogous areas (inferior and nasal quadrants) across the retinas of different patients. The session was considered complete when the entirety of the visible area within the specified quadrants was thoroughly covered with spots.

Navilas Multispot Laser

The Navilas system was employed for the fellow eye, targeting the same quadrants. The procedure began with the visualization of the designated quadrant through the Navilas system, followed by the capture of a color fundus photograph using a 160 PRP contact lens. Maintaining the contact lens in position, the operator proceeded to plan the PRP. This planning involved a process where the operator, employing a swiping motion with a finger over the Navilas interface, delineated all areas requiring laser application. During this procedure, the macular region between the two vascular arcades and optic disc were safeguarded, ensuring that the vascular structures were not included. The designated areas were marked with spots arranged in an equidistant pattern, akin to hexagonal packing, ensuring uniform coverage. The parameters for the laser treatment (spot size of 390 µm and a spacing of 0.75) were consistent with those utilized in conventional multispot laser treatment. The macula and the optic nerve head were marked as caution zones. The laser was applied with a duration of 20 milliseconds and an adjusted power setting to achieve a mild photocoagulative effect, characterized as a light burn. This process was iteratively conducted until all accessible areas within the targeted quadrant were comprehensively covered with laser spots.

Pain Perception

Following the application of PRP to the inferior and nasal quadrants, patients were allotted a rest period of 30 minutes. At the conclusion of this rest phase, patients were engaged in a structured pain evaluation process. To facilitate a comprehensive assessment of pain perception, two distinct scales were employed. Initially, patients were requested to convey their level of discomfort using a Verbal Rating Scale (VRS). This scale offered a range of descriptors – 'none', 'mild', 'moderate', 'severe', or 'very severe' – enabling patients to qualitatively express their pain levels. In conjunction with the VRS, a Visual Analogue Scale (VAS) was utilized to obtain a more precise and quantifiable measure of pain intensity. Patients were instructed to assign a score between '0' (indicating 'no pain') and '10' (representing 'severe pain').

Statistical Analysis

In the study, statistics related to continuous variables were reported as mean±standard deviation and median (min-max) values, while descriptive statistics for categorical variables were presented as numbers and percentages. The normal distribution suitability of continuous variables was assessed using the Shapiro-Wilks test. The independent-samples t test was employed for normally distributed variables, and the Mann-Whitney U test was used for non-normally distributed variables. The relationships between categorical variables were analyzed using the Pearson chi-square test. Correlations between variables were examined using the Spearman correlation coefficient. The statistical analyses were conducted using IBM SPSS Statistics Version 28 (Armonk, New York: IBM Corp.). A significance level of 95% was considered, and the results were interpreted as statistically significant for a p-value less than 0.05.

Results

A total of 40 patients diagnosed with high-risk PDR were included in the study. These patients underwent Navilas laser treatment in one eye (40 eyes) and conventional laser treatment in the other eye (40 eyes). The age range of the patients was between 42 and 73 years, with a mean age of 60.3 (±7.76) years. The average duration of diabetes mellitus among the participants was 15.85 (±7.34) years. The study group comprised 52.5% males and 47.5% females.

There was no statistically significant difference observed between the Navilas and conventional laser groups regarding best corrected visual acuity (LogMAR), lens status, intraocular pressure, cup-to-disc ratio, and cystoid macular edema (All p-values were greater than 0.05), as detailed in Table 1. However, as indicated in Table 2, the mean time of laser treatment in patients treated with the pattern laser was significantly longer than that in the Navilas group, with this difference being statistically significant ($p<0.001$). The comparative analysis between the Navilas and conventional laser groups revealed no statistically significant differences in terms of the number of spots applied and the power used ($p=0.202$, $p=0.563$ respectively).

The mean VAS and VRS in the Navilas laser group were significantly lower than those in the pattern laser group ($p<0.001$, $p=0.002$ respectively), as illustrated in Table 3. Figure 1 presents the distribution of VAS scores across both groups, while Figure 2 depicts the distribution of VRS scores.

Table 1. Clinical characteristics of participants

	Navilas Laser (n=40 eyes)		Conventional Laser (n=40 eyes)		p
Lens Status					
Phakic	21 (52.5)		20 (50.0)		0.823[a]
Pseudophakic	19 (47.5)		20 (50.0)		
Cystoid Macular Edema	25 (62.5)		23 (57.5)		0.648[a]
	Avg±SD	**Median (Min-Max)**	**Avg±SD**	**Median (Min-Max)**	**p**
Visual Acuity (LogMAR)	0.92±0.38	1 (0.1-1.3)	0.86±0.35	1 (0.05-1.3)	0.739[b]
Cup/Disc Ratio	0.35±0.13	0.3 (0.2-0.7)	0.37±0.14	0.3 (0.2-0.7)	0.723[b]
Intraocular Pressure (mmHg)	18.13±3.61	19 (11-26)	17.85±3.72	18 (11-25)	0.738[c]

[a]Pearson Chi-Square test. [b]Mann Whitney U test. [c]Independent Samples t test. *p<0.05.

Table 2. Laser parameters overview

	Navilas Laser (n=40)		Conventional Laser (n=40)		p
	Avg±S.D	**Median (Min-Max)**	**Avg±S.D**	**Median (Min-Max)**	
Number of Spots	1118.5±179.93	1100 (840-1620)	1175.9±217.39	1150 (840-1605)	0.202[b]
Power (mW)	291.88±26.18	300 (250-350)	295±28.98	300 (250-350)	0.563[a]
Laser Duration (sec)	517.3±48.78	510.5 (436-625)	639.4±54.23	634.5 (486-802)	<0.001[a*]

[a]Mann Whitney U test; [b]Independent Samples t test. *p<0.05.

Table 3. Pain scores of Navilas laser and conventional laser groups

	Navilas Laser (n=40 eyes)		Conventional Laser (n=40 eyes)		p[a]
	Avg±SD	**Median (Min-Max)**	**Avg±SD**	**Median (Min-Max)**	
VAS Score	2.62±1.43	2.5 (0-7)	4.60±1.48	5 (2-9)	<0.001*
Verbal Score	1.12±0.65	1 (0-3)	1.60±0.71	1 (1-3)	0.002*

[a]Mann Whitney U test. *p<0.05.

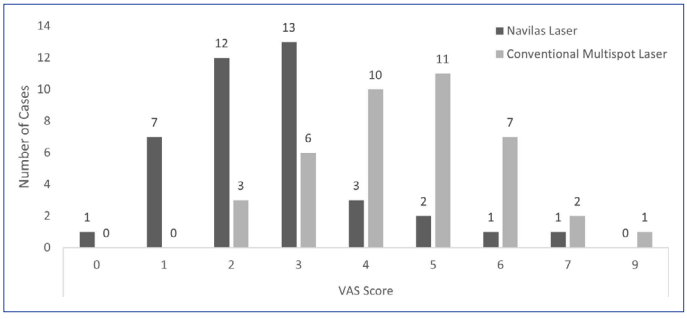

Figure 1. Distribution of VAS scores of Navilas laser and conventional laser groups.

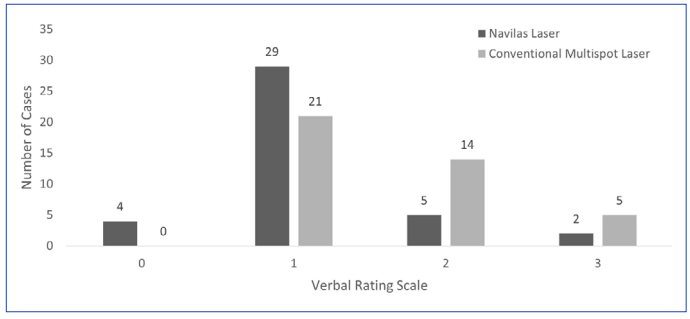

Figure 2. Distribution of Verbal Rating Scale scores of Navilas laser and conventional laser groups.

The relationship between pain scores and the duration of diabetes mellitus, the hemoglobin A1c values, the number of laser spots, and time is analyzed in Table 4. No statistically significant correlation was observed between VAS and VRS scores and other variables in both the Navilas and conventional laser groups (p>0.05).

Table 4. Correlations between pain scores and other variables

	Navilas Laser		Conventional Laser	
	r	p	r	p
VAS Score				
Duration of DM (year)	0.000	0.998	0.171	0.291
HbA1C	0.160	0.323	-0.009	0.956
Number of Spots	-0.021	0.896	-0.300	0.060
Time (sec)	0.297	0.063	-0.023	0.886
Verbal Score				
Duration of DM (year)	-0.204	0.208	0.024	0.883
HbA1C	0.189	0.243	0.055	0.738
Number of Spots	0.087	0.593	-0.139	0.391
Time (sec)	0.056	0.855	0.654	0.004

r: Spearman's rho.

Discussion

The introduction of photocoagulation in 1967 marked a pivotal advancement in the therapeutic option for addressing PDR.[5] However, the potential for significant pain and discomfort associated with PRP has been acknowledged, posing a challenge to treatment adherence and, consequently, visual outcomes. The pursuit of effective anesthesia and analgesia techniques to enhance patient compliance with PRP treatment has been a focal point in laser treatment. Various methods, including peribulbar anesthesia, oral analgesia, topical drops, and inhaled therapies, have been explored to alleviate the discomfort associated with PRP.[11–13] However, these techniques are not without their challenges and limitations. Recognizing this concern, there is an opportunity to enhance patient experience by refining laser parameters.[14] In our study, we set out to investigate the impact of laser system selection on patient comfort during PRP treatment. Specifically, we compared the Navilas system with the conventional laser system. Our findings reveal a noteworthy difference: patients undergoing PRP treatment with the Navilas system reported significantly less pain compared to those treated with the conventional laser system.

Chhablani et al.[8] pioneered the use of a VAS to quantify the pain associated with laser treatments, presenting insights into the efficacy of the Navilas system in mitigating discomfort during peripheral procedures. The pain experienced by patients receiving peripheral treatment with Navilas was reported to be less pronounced compared to those treated with conventional laser systems. In addition to assessing pain levels, the study also delved into treatment efficiency. Chhablani et al.[8] reported a notable decrease in the mean treatment time for PRP when using the Navilas system (averaging 8 minutes and 5 seconds) as compared to the pattern laser PRP method (11 minutes and 28 seconds). This finding suggests that Navilas not only enhances patient comfort but also improves procedural efficiency. Kim and Kim[15] reported that the experience of pain as measured by the VAS was similarly high for patients treated with the conventional laser. In the present study, the principal outcome was the observation of a statistically significant reduction in pain, quantified using both the VRS and VAS, in eyes subjected to Navilas PRP in comparison to those treated with conventional lasers. This outcome corroborates the findings reported in other publications, which collectively underscore the diminished pain associated with the use of the Navilas system for such treatments.

The targeting of the retinal pigment epithelium while concurrently safeguarding adjacent photoreceptors through the generation of micro-air bubbles around melanosomes represents an innovative therapeutic approach in laser photocoagulation. A pivotal factor in this technique is the critical threshold between thermal and mechanical damage, established at 50 ms.[16,17] Utilizing shorter pulse durations, these novel laser therapy methods induce predominantly mechanical rather than thermal damage. This selective targeting effectively confines the damage to the retinal pigment epithelium, thereby preserving the integrity of the inner retinal layers and the sensory-rich chorioretinal tissues.[18] As a consequence of this precision, patients typically report reduced pain levels, which is likely due to the better preservation of retinal sensitivity compared to more traditional, conservative approaches. The duration of diabetes and the levels of HbA1C may potentially influence the pain scores reported during photocoagulation procedures. However, it is noteworthy that in this study, no significant correlation was found between the duration of diabetes or HbA1C levels and the pain scores, as measured by the VAS and the VRS, in both the Navilas laser group and the conventional laser group. This outcome suggests that factors other than the duration of diabetes and glycemic control might play more substantial roles in pain perception during photocoagulation in these patient groups.

The subjective experience of pain can differ considerably among individuals, influenced by a range of factors including gender, inherent pain threshold, cultural background, the extent of fundus pigmentation, and history of prior laser treatments.[19] In the context of this study, none of the participating patients had a history of previous laser treatment. In addition, in this study design, laser application to different eyes of the same patient in varying order facilitated a more objective assessment of pain experiences.

To the best of our knowledge, this is the first study to analyze the VAS and VRS pain experiences associated with various laser systems in patients with PDR. Given the inherently subjective nature of pain experiences, a notable strength of our study lies in its design, where each patient underwent treatment with both laser systems. This design choice effectively mitigates inter-personal variability in pain perception, enabling a direct comparison of the laser-induced pain experiences arising from distinct application principles. Such an approach enhances the internal validity of our findings and contributes novel insights to the understanding of pain responses associated with different laser modalities in PDR patients.

A primary limitation of our study lies in its modest sample size, which may constrain the generalizability of our findings. In the case of the Navilas laser, the duration of PRP application is notably brief; however, the adjustment time is prolonged. The combined evaluation of adjustment and PRP durations in our study represents a limitation. Additionally, the absence of blinding among operators and patients regarding the treatment system introduces a potential source of bias. Upon examination of images from the same patients, we observed comparable lesion intensities between the two systems. However, a subjective observation emerged, indicating a lower incidence of gaps or doubled spots when utilizing the Navilas laser.

Conclusion

The utilization of the Navilas laser for PRP sessions demonstrated notable advantages over conventional lasers. The application of Navilas laser resulted in expedited procedures with reduced discomfort for patients. Notably, the Navilas laser delivered a high-quality output characterized by equidistant spots, the absence of gaps or doubled patterns, all contributing to a more efficient and less painful experience for the patients in terms of both application time and perceived pain level. By demonstrating the superior comfort associated with the Navilas system, our study contributes valuable insights that may inform clinical decision-making, potentially fostering increased patient compliance with treatment regimens and, subsequently, minimizing the risk of visual deterioration.

Disclosures

Ethics Committee Approval: The Basaksehir Cam and Sakura City Hospital Ethics Committee approved the study (number: E-96317027-514.10-229976028, date: 27.11.2023).

Authorship Contributions: Concept – M.K., E.O.; Design – M.K., S.E.; Supervision – M.K., S.A.O.; Fundings – M.K.; Materials – M.K.; Data collection &/ or processing – M.K., S.G.; Analysis and/or interpretation – M.K., S.A.O.; Literature search – M.K., S.G.; Writing – M.K., E.O.; Critical review – M.K., S.A.O.

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