The Role of the Tear Film in Refraction: Quantitative Evaluation Before and After Rexon-Eye Therapy

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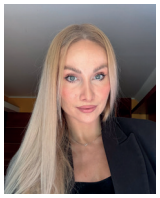

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SUMMARY

Aim: The aim of this study was to assess the effect of Rexon-Eye therapy, based on quantum molecular resonance (QMR) technology, optical parameters, tear film stability, and patients' subjective symptoms.
Material and Methods: A total of 30 patients (20 women, mean age 64.9 years; 10 men, mean age 64.6 years) diagnosed with dry eye syndrome were included in the study.
Common systemic comorbidities were recorded, most frequently arterial hypertension, hypercholesterolemia, thyroid disorders, type 2 diabetes mellitus, and hyperuricemia. Each patient underwent four treatment sessions (once weekly for 20 minutes) according to the manufacturer's recommended protocol.
Objective parameters – including objective scatter index (OSI), modulation transfer function cutoff (MTF cutoff), potential visual acuity (PVA), and vision break-up time (VBUT) – were assessed using the HD Analyzer before therapy and again 1 to 3 months after treatment completion. Subjective symptoms were evaluated using the standardized Ocular Surface Disease Index (OSDI) questionnaire.
Results: No statistically significant changes were observed in OSI, MTF cutoff, or PVA. VBUT remained unchanged. By contrast, OSDI scores improved both statistically and clinically significantly.
Conclusion: QMR therapy with the Rexon-Eye device led to significant improvement in subjective symptoms, while objective optical quality parameters showed no statistically significant changes. QMR therapy appears to be a safe and well-tolerated method that may expand therapeutic options in clinical practice.
Key words: tear film, dry eye syndromes, optical quality, visual acuity, Rexon-eye therapy

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INTRODUCTION

Dry eye syndrome (DES) is a common chronic disease of multifactorial etiology, for which a combination of subjective and objective evaluation is used in its diagnosis and monitoring [1]. One of the main manifestations of DES is impaired tear film stability. The tear film represents a crucial element in the optical system of the eye, since it forms the first and also the most significant refractive surface [2,3]. Its destabilization leads to light scattering, fluctuation of visual acuity and reduced contrast sensitivity, which may negatively influence the results of both regular refractive examination and of surgical procedures [2,4].

In recent years, methods based on an analysis of optical aberrations, measurement of light scattering or contrast sensitivity have been used for an objective evaluation of the quality of the optical system of the eye. Compared with subjective questionnaires or tests, these approaches have an advantage in their lesser dependency on patient cooperation and the higher reproducibility of their results [5,6]. One of the options for objective evaluation of the optical system of the eye is to use the double-pass technique with the aid of the HD Analyzer instrument (Visiometrics S.L., Spain), which enables measurement of Objective Scattering Index (OSI), Modulation Transfer Function cutoff (MTF cutoff), Potential Visual Acuity (PVA) and Vision Break-Up Time

(VBUT). The HD Analyzer is an instrument used in clinical practice and research, for example in evaluating the results of eye operations, quality of image after implantation of intraocular lenses or detection of early changes in DES and cataract [7–10].

Rexon-Eye® (Resono Ophthalmic, Italy) is a noninvasive therapeutic device designed for the treatment of DES (Figure 1). It uses quantum molecular resonance (QMR) technology, generating low-energy electromagnetic waves (4–64 MHz) [11,12]. These waves are transmitted through the eyelids and penetrate into the tissues, where they activate the cellular metabolism, support regeneration and modulate inflammatory processes. Preclinical trials have demonstrated that QMR influences expression of the genes MMP1, PLAT and A2M, which contribute to remodeling of the extracellular matrix, angiogenesis and healing of wounds [11,12]. Although this expression has been demonstrated especially on model tissues, it is assumed that similar mechanisms can play a role also on the ocular surface and in the region of the meibomian glands, by which they could contribute to improving tear film stability and alleviating symptoms of DES [11–13]. Based on these observations, the Rexon-Eye instrument has been approved for use in the treatment of dry eye syndrome. Therapy is contactless, pain-free, well tolerated by patients and takes place in four 20-minute sessions at weekly intervals (Figure 2).

The objective of this study was to assess the effect of therapy using the Rexon-Eye instrument on optical parameters, tear film stability and the subjective complaints of patients with DES.

MATERIAL AND METHODS

A total of 30 patients were included in the study: 20 women (mean age 64.9 years) and 10 men (mean age 64.6 years) with dry eye syndrome. The patients were observed in the period from March 2024 to July 2025.

Figure 1. The Rexon-Eye device using Quantum Molecular Resonance (QMR) technology for non-invasive therapy of dry eye syndrome

Figure 2. Application of Rexon-Eye therapy, the patient is wearing a specialized mask connected to the device

Systemic comorbidities were also recorded as part of the study. Common systemic disorders were not an exclusion criterion (with the exception of uncompensated systemic disorders); their specific representation is presented in the results.

Inclusion criteria

Patients aged over 18 years with presence of at least one of the symptoms of dry eye syndrome (e.g. feeling of dryness, burning, stinging, blurred or unstable vision, eye fatigue) and objectively demonstrated finding of dry eye were included in the study. Objective criteria were considered to cover in particular tear film instability (VBUT value) or another objective criterion evaluated according to the recommendations of TFOS DEWS II (e.g. fluorescein break-up time, Schirmer test, staining of ocular surface) [3].

VBUT was defined according to the HD Analyzer manual as the time from the beginning of measurement up to the moment when the Vision Quality Index falls beneath the set threshold; the evaluation takes place with a 10-second measurement window [8,11]. In accordance with the published literature, for analytical purposes we used VBUT < 10 s as the indicator of tear film instability [16,17]. The cohort comprised predominantly patients under long-term observation for dry eye syndrome.

Exclusion criteria / contraindications

Active eye infection or inflammation, allergic conjunctivitis, recent eye operation (less than 3 months), wearing

contact lenses during therapy, uncompensated systemic disease, pacemaker or other electrical implant, pregnancy or breastfeeding, inability to cooperate during therapy.

The therapy was realized in four outpatient sessions of 20 minutes each (1× weekly) in accordance with the recommended protocol of the manufacturer of the Rexon-Eye device [8]. All the patients underwent all four therapeutic sessions in their entirety. The evaluation was conducted before the commencement of therapy and 1–3 months after its completion.

The objective evaluation was conducted with the aid of the HD Analyzer instrument (Visiometrics S.L., Spain). The following parameters were evaluated:

OSI (Objective Scattering Index; non-dimensional): value of light dispersion in the optical system of the eye – a higher value means greater turbidity or instability of environment [14]. MTF cutoff (Modulation Transfer Function cutoff; cycles per degree, c/°): spatial frequency in which contrast decreases to 1% – indicator of quality of image and resolution [7,9]. PVA (Potential Visual Acuity; non-dimensional): estimate of visual acuity without aberrations [5]. VBUT (Vision Break-Up Time; seconds, s): time from the beginning of measurement up to the moment when the subject's vision quality index falls below the set threshold. For the actual evaluation of the VBUT parameter an ordinal scale was used with values of 1 (unstable, i.e. less than 10 s), 2 (medium stable, 10 to 20 s) and 3 (stable, over 20 s) [10].

Subjective symptoms were evaluated with the aid of the OSDI questionnaire (Ocular Surface Disease Index; non-dimensional score, scale 0–100 points).

A statistical analysis was conducted with the aid of a Wilcoxon Signed-Rank Test due to non-fulfilment of the prerequisite of normal distribution of certain data (verified by Shapiro-Wilk test). Statistical significance was set at the level of $p < 0.05$. In the case of selected statistically significant results, the size of effect r (non-dimensional) was also stated, calculated according to the formula $r=Z/\sqrt{N}$, in which Z is the statistical value of the Wilcoxon test and N is the number of evaluated pairs. The value r quantifies the power of the determined effect within the analyzed cohort and was interpreted as follows: $r \approx 0.1$ = low effect, $r \approx 0.3$ = medium effect and $r \geq 0.5$ = high effect.

RESULTS

The results are presented as medians of values before and after therapy (Table 1). Median VBUT (an ordinal scale was used for evaluation) remained on the value of 2 (medium stable) before and after therapy ($p = 0.133$). The parameters of OSI, MTF cutoff and PVA did not record statistically significant differences (Graph 1). In OSDI a statistically significant improvement was recorded ($p < 0.001$; $r = 0.87$) (Graph 2).

Common systemic comorbidities appeared in the cohort, most often arterial hypertension (12 patients), hypercholesterolemia (9 patients), thyroid disorders (7 patients), type 2 diabetes mellitus (4 patients) and hyperuricemia (4 patients).

DISCUSSION

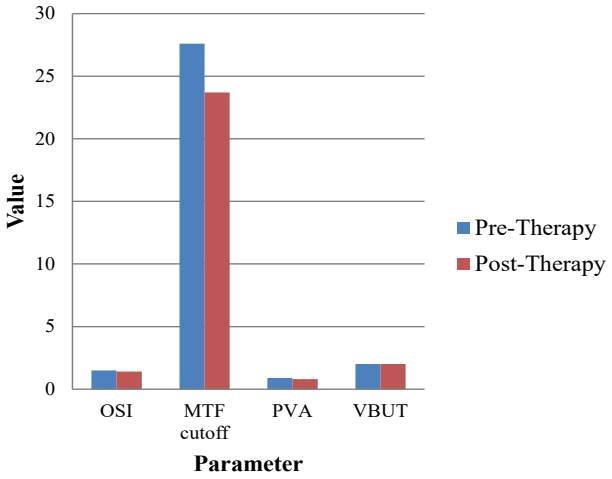
Unlike commonly used conservative procedures such as artificial tears, eyelid hygiene or pharmacological therapy (e.g. cyclosporine A), which act primarily to moisten the ocular surface or suppress inflammatory agents, QMR therapy (Rexon-Eye) represents an innovative approach with a potential regenerative effect on a cellular level and the possibility of combination with other treatment [11,12].

In the professional literature, QMR is frequently compared with the intense pulsed light (IPL) method. IPL uses non-coherent, broad-spectrum flashes within a range of approximately 500–1200 nm applied to the area of the lower eyelids. The photothermic effect on hemoglobin in the dilated blood vessels leads to a reduction of teleangiectasias and inflammation, which subsequently improves the function of the meibomian glands and the stability of the lipid layers of the tear film. However, the method is contraindicated for patients with a higher skin

Table 1. Comparison of median values of selected subjective and objective parameters of tear film quality before and after Rexon-Eye therapy

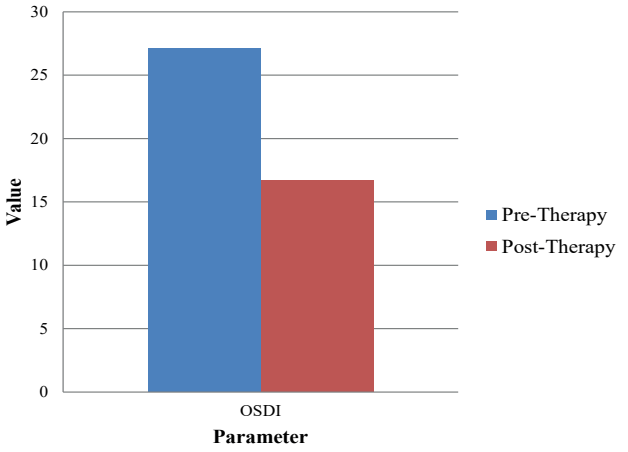
Parameter	Median Pre-Therapy (n)	Median Post-Therapy (n)	Z Statistic	p-value	Effect Size (r)
OSI	1.5	1.4	0.11	0.909	0.016
MTF cutoff	27.6	23.7	-1.13	0.258	0.15
PVA	0.9	0.8	-0.86	0.389	0.12
VBUT	2 (moderate)	2 (moderate)	1.50	0.133	0.31
OSDI	27.1	16.7	-4.27	< 0.001	0.87

OSI – Objective Scatter Index (dimensionless); MTF cutoff – cutoff spatial frequency at which contrast decreases to 1% of the original value (system's ability to resolve detail; cycles per degree, c/°); PVA – Potential Visual Acuity (dimensionless); VBUT – visual break-up time of the tear film, monitored in real time during continuous OSI measurement (seconds, s); evaluated according to an ordinal scale: 1 = unstable (< 10 s), 2 = moderately stable (10–20 s), 3 = stable (> 20 s); OSDI – Ocular Surface Disease Index (dimensionless score, range 0–100); Z – value of the test statistic from the Wilcoxon signed-rank test (dimensionless)



Graph 1. Objective parameters (OSI, MTF cutoff, PVA, VBUT) before and after Rexon-Eye therapy

OSI – Objective Scatter Index (dimensionless); MTF cutoff – cutoff spatial frequency at which contrast decreases to 1% of the original value (system's ability to resolve detail; cycles per degree, c/°); PVA – Potential Visual Acuity (dimensionless); VBUT – visual break-up time of the tear film, monitored in real time during continuous OSI measurement (seconds, s); evaluated according to an ordinal scale: 1 = unstable (< 10 s), 2 = moderately stable (10–20 s), 3 = stable (> 20 s)



Graph 2. Subjective parameter (OSDI) before and after Rexon-Eye therapy

OSDI – Ocular Surface Disease Index (dimensionless score, range 0–100)

phototype or in the case of active dermatitis. By contrast, QMR is contactless, noninvasive and well tolerated even in these cases [13].

In our study the objective evaluation of optical quality was conducted with the aid of a HD Analyzer, which provides objective quantitative values of light scattering and image quality with high reproducibility, independently of subjective patient cooperation [7–10]. In comparison with traditional tests such as the Schirmer test or fluorescein break-up time, it enables a more detailed and standardized assessment of the optical system.

Our results showed a statistically significant improvement of subjective complaints evaluated by the OSDI questionnaire, while the objective parameters of OSI, MTF cutoff and PVA remained without any statistically significant change. These conclusions are in accordance with the published studies, which have also recorded a pronounced impact of QMR primarily on patients' symptoms but not always on parameters of optical quality (Vingolo 2021 [11], Galliot 2023 [12], Shemer 2024 [17], Ballesteros-Sánchez 2025 [18]). The significant improvement of OSDI in our cohort corresponds with the results of randomized clinical trials and meta-analyses [17,18].

Tear film stability evaluated with the aid of VBUT did not show a statistically significant change. However, in order to determine the actual effect it is necessary to verify the results in a larger cohort of patients with a longer observation period [16,15].

The effect of QMR is associated with modulation of gene expression (MMP1, PLAT, A2M), which may contribute to regeneration and influence inflammatory processes [11]. These effects have been described primarily in experimental studies, and as yet direct confirmation of these effects on the ocular surface or in the meibomian glands is absent. Further research in this area is required, including verification of the effect of therapy on the expression of these genes directly in the ocular tissues.

A limitation of our study consists in the absence of a control group, the relatively small size of the cohort and the heterogeneity of the length of observation. These factors may contribute to the absence of evidence of statistically significant changes in the objective parameters. Nevertheless, the results confirm the benefit of QMR, especially in improving subjective symptoms in patients with dry eye syndrome, and provide reasonable grounds for conducting further evaluation in randomized and long-term trials.

CONCLUSION

This pilot study demonstrated that noninvasive QMR therapy with the aid of the Rexon-Eye instrument can significantly improve subjective symptoms of dry eye syndrome. By contrast, neither the objective parameters of optical quality (OSI, MTF cutoff, PVA) nor tear film stability evaluated with the aid of VBUT showed statistically significant changes.

The observed improvement of subjective complaints indicates that QMR therapy may be a valuable supplement in the treatment of dry eye syndrome, especially for patients with symptoms that are persisting despite the application of standard conservative therapy. However, in order to confirm the actual effect on tear film stability and optical quality it is essential to verify the results on a larger cohort of patients as part of randomized controlled trials with a longer observation period.

QMR therapy appears to be a safe and well-tolerated method that may expand therapeutic options in regular clinical practice.

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