PREOPERATIVE AND POSTOPERATIVE MACULAR SENSITIVITY ASSESSMENT USING MICROPERIMETRY IN EYES UNDERGOING SILICONE OIL REMOVAL

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Purpose: To evaluate the functional changes on the macula, before and after silicone oil removal (SOR) using microperimetry (MP3) in patients originally operated for macula-off rhegmatogenous retinal detachments.

Methods: Prospective interventional study, N = 20. All cases underwent complete ophthalmic examination, including determination of Snellen best-corrected visual acuity, indirect ophthalmoscopy, and MP3 for measuring retinal sensitivity. Primary outcome measure was to describe the alterations in the retinal sensitivity on the macula after SOR.

Results: Mean retinal sensitivity increased in 100% patients (20/20) after SOR with a mean value of 97.44 dB. Best-corrected visual acuity after SOR remained unchanged in 90% (18/20) and improved by 2 lines in only 10% patients (2/20). Median retinal sensitivity of central 6° of the macula was 766.95 ± 173.29 dB before SOR and 863.8 ± 181.08 dB after SOR, $P < 0.0001$. Mean best-corrected visual acuity was 20/40 before SOR (range, 20/30–20/60) (logarithm of the minimum angle of resolution 0.314 ± 0.169) and 20/40 after SOR (range 20/30–20/80) (logarithm of the minimum angle of resolution 0.315 ± 0.159), $P = 0.1628$.

Conclusion: MP3 was found to be a highly sensitive tool in detecting increased retinal sensitivity after SOR, particularly in central 6° of the macula without significant change in best-corrected visual acuity. Hence, MP3 is an important qualitative indicator of visual function.

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Silicone oil (SO) (polydimethylsiloxane) is a linear synthetic polymer composed of repetitive Si-O-units and meets all the requirements for intraocular use and can be considered as the ideal material for intraocular tamponade.[1] In the current era, the use of SO as a surgical tamponade has become a standard technique in the treatment of retinal detachments, especially in proliferative vitreoretinopathy and tractional retinal detachments, severe cases of diabetic retinopathy, endophthalmitis, viral retinitis, giant retinal tear, and ocular trauma.[2] The safety and efficacy of SO in ophthalmic surgery has been demonstrated in many studies during the past decades.[3,4] A potential toxicity of SO to the human retina has been denied.[5,6] Recently, unexpected and unexplained central vision loss has been described in patients who underwent vitrectomy with SO tamponade.[7–13] Silicone oil–related visual loss (SORVL) is characterized by a profound and irreversible visual loss occurring during silicone oil tamponade or shortly after SO removal (SOR), without any structural abnormalities.[14] Many patients complain of decreased visual function in SO-filled eyes without significant decrease in best-corrected visual acuity (BCVA) or any structural changes on retina. This can be attributed to the functional damage by SO on the retina. There are insufficient data in the literature on the functional changes on the macula in SO-filled eyes. Moreover, various macular function tests such as visual acuity, Amsler grid, two-point discrimination test, Maddox rod test, color vision, electroretinography, and visual-evoked

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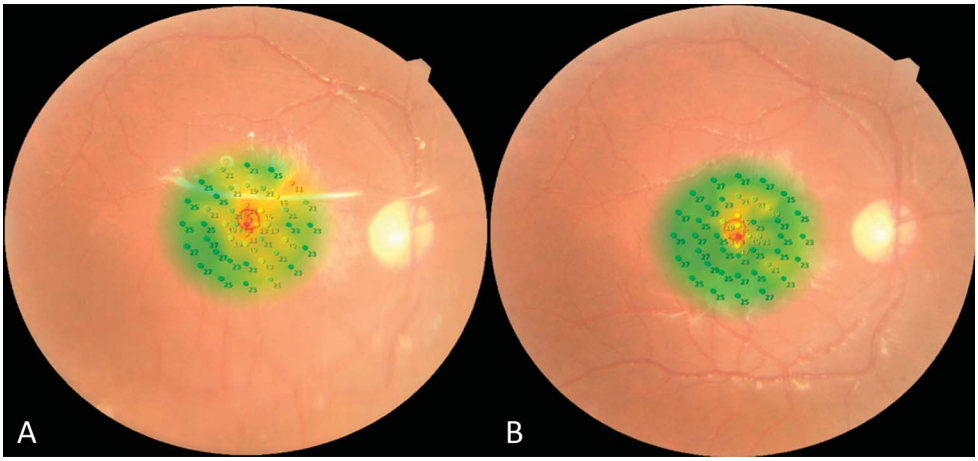

Fig. 1. Fundus photography showing retinal sensitivity using microperimetry before (**A**) and after (**B**) SOR.

potential are crude methods with low accuracy. This is overcome by the use of newer noninvasive microperimetry (MP3) which measures local retinal sensitivity for functional assessment of the retina.[15] It is a subjective, quantitative, noninvasive diagnostic examination aimed at assessing retinal functionality and puts it in strict correlation with retinal morphology.[16] MP3, otherwise known as fundus-driven perimetry, has evolved into a robust tool to evaluate the retinal function in recent years.[17] In particular, MP3 with real-time fundus imaging along with eye-tracking technology and a quicker acquisition time is considered to have an advantage over the conventional perimetry.[18] The 12-megapixel fundus camera in the MP3 acquires high-resolution images of retinal pathology and allows for easy image acquisition. The MP3 measures local retinal sensitivity in the dynamic range of 0 to 34 dB for functional assessment of the retina.[19] MP3 has a software by which it calculates and compensates for the refractive error of the patients. Hence, the aim of our study was to evaluate the functional changes on the macula, before and after SOR using MP3 in patients operated for macula-off rhegmatogenous retinal detachments (RRD).

Patients and Methods

This was a single-center, prospective, cross-sectional, interventional study in accordance with the Declaration of Helsinki and was approved by the Ethics committee of Institutional Review Board. All cases provided informed consent to be enrolled in the study. Data were collected from patients diagnosed as macula-off RRD treated with vitrectomy and SO tamponade. All cases underwent full ophthalmological examination including Snellen BCVA, intraocular pressure, indirect ophthalmoscopy, fundus photography, optical coherence tomography, and MP3 before SOR and 1 month after SOR. Primary outcome measure was to describe the alterations in the retinal sensitivity on the macula after SOR. Secondary outcome measures include correlation between retinal sensitivity and BCVA before and after SOR.

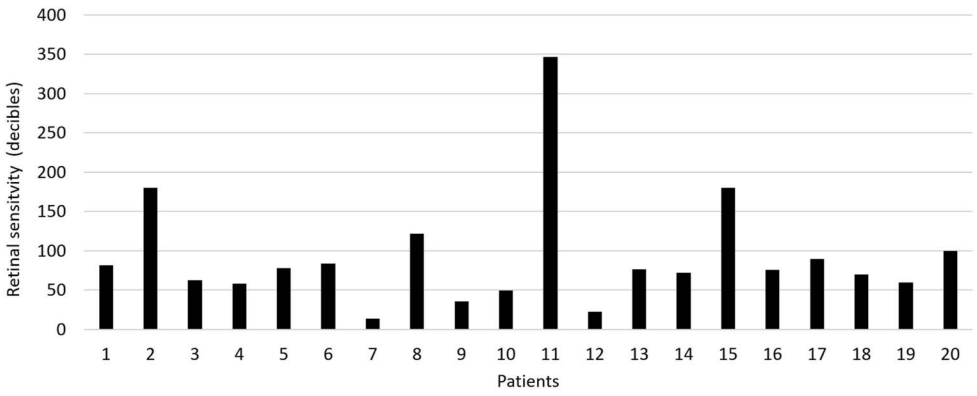

Fig. 2. Change in retinal sensitivity after SOR.

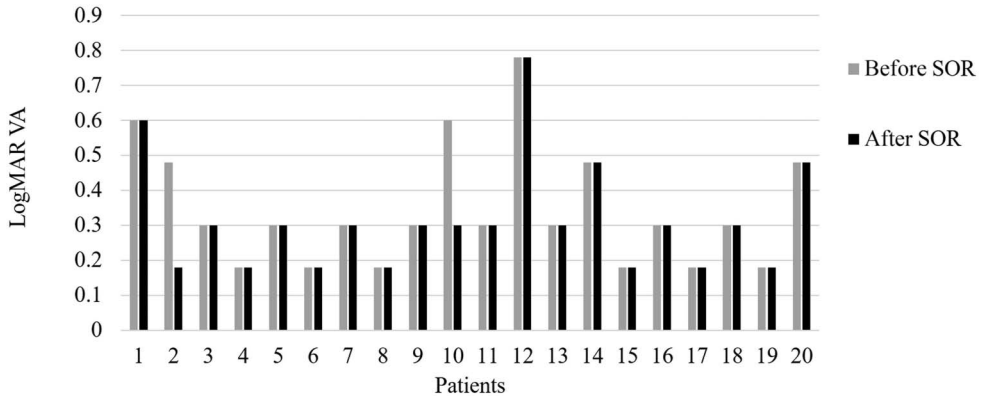

Fig. 3. Comparison of Snellen visual acuity (converted to logMAR) before and after SOR. VA, visual acuity.

Eligibility Criteria and Data Collection

Inclusion criteria were as follows: 1) age 18 to 65 years, 2) BCVA >20/200, 3) SO-filled patients operated for macula-off RRD with the normal macula, 4) follow-up of 3 months, and 5) false positive and false negative less than 15%. Exclusion criteria include eyes with cataract, glaucoma, SO bubbles after SOR, epiretinal membrane and reretinal detachment, hyperreflective spherical bodies in sub–silicone oil-foveal depression space. The examination protocol included BCVA with the help of the Snellen chart and converted to logarithm of the minimum angle of resolution (logMAR), dilated fundoscopic examination, color fundus images (Topcon 50 Dx; Medical Systems Inc, Oakland, NJ), OCT (Spectralis, Heidelberg Engineering Inc, Heidelberg, Germany), and MP3 (Nidek, Gamagory, Japan).

All patients underwent SOR by same vitreoretinal surgeon using 23-G oil extraction cannula 3 to 6 months after SO tamponade operated for macula-off RRD. All patients were followed at 1, 4, and 12 weeks (from baseline).

Data Analysis

MP3 was performed by one examiner in a dark room at least 15 minutes after pupil dilatation with 0.5% tropicamide and 5% phenylephrine and with occlusion of the nontested eye. The standardized stimulus grid consists of a 37-stimuli grid overlying the central 12°; Goldmann III stimulus with a duration of 200 ms; 4-2 threshold strategy; and red circle fixation target for MP3. Retinal sensitivity was checked using single central foveal response and four concentric rings of retinal loci at 1°, 2°, 4°, and 6° from the center point.[15] MP3 with a false-positive and false-negative rate <15% was used in the study. Fixation loss not applicable because MP3 has an auto-tracking system, which makes it possible to project the stimulus only at the predefined retinal positions. Consequently, visual field testing is reliable even if fixation is unstable. The data were documented and analyzed using SPSS statistics software (version 24.0; SPSS Inc, Chicago, IL). Student's paired *t*-test was used to compare pre– and post–retinal sensitivity, logMAR BCVA, and $P < 0.05$ was considered statistically significant.

Results

Twenty patients of 32 patients met our inclusion criteria and were enrolled in the study. The mean age at presentation was 43.7 years (range 18–65 years). The sex distribution comprised 14 eyes of male patients and 6 eyes of female patients.

In all study patients, slit-lamp examination did not show any pathological finding at initial presentation or at follow-up visits. The postoperative recovery

Table 1. Comparative Statistical Analysis of Mean Snellen Visual Acuity (logMAR) and Mean Retinal Sensitivity Before and After SOR

	Before SOR	After SOR	*P**
Mean Snellen BCVA (logMAR)	20/40 (range, 20/30–20/60) (0.314 ± 0.169)	20/40 (range, 20/30–20/80) (0.315 ± 0.159)	0.1628
Mean retinal sensitivity†	766.95 ± 173.29	863.8 ± 181.08	<0.0001

*P value from the paired *t*-test between before and after SOR.
†Central 6° from the fovea.

was uneventful in all cases, and intraocular pressure was within normal limits. Visual axis was clear at all follow-ups, and no media opacity was noted at any point during the follow-up period. The macula remained attached during the entire follow-up period.

Figure 1 shows pre-SOR and post-SOR fundus photograph with exact location of retinal sensitivity superimposed on the macula by color coding using MP3 software. Change of retinal sensitivity was very well appreciated with the corresponding change in the colors (Figure 1) using macular sensitivity mapping by MP3. Mean retinal sensitivity in central 6° of the macula was increased in 20 patients (100%) after SOR (Figure 2) with a mean value of 97.44 dB. Best-corrected visual acuity after SOR remained unchanged in 90% (18/20) and improved by 2 lines in only 10% patients (2/20) (Figure 3). Median retinal sensitivity in central 6° of the macula was 766.95 ± 173.29 dB before SOR and 863.8 ± 181.08 dB after SOR ($P < 0.0001$) which was highly statistically significant (Table 1 and Figure 4). Mean BCVA was 20/40 before SOR (range, 20/30–20/60) (logMAR 0.314 ± 0.169) and 20/40 after SOR (range 20/30–20/80) (logMAR 0.315 ± 0.159), $P = 0.1628$, which was not statistically significant (Table 1).

Discussion

On reviewing the literature, Scheerlinck et al[14] investigated the incidence, risk factors, and clinical characteristics of unexplained visual loss after macula-on RRD and found that incidence of unexplained visual loss was 0.7% in patients treated by gas and 29.7% in patients treated by SO. Visual loss occurred both during SO tamponade and after removal. In another study by Scheerlinck et al,[20] MP3 was found to be a sensitive tool to demonstrate deep central scotoma in SO-filled eyes, and it showed decreased median retinal sensitivity after SO tamponade compared with gas tamponade and a deep central scotoma was observed after SO tamponade for macula-on as well as for macula-off RRD. However, they only studied 10 eyes of macula-off RRD with SO tamponade, and the study did not include testing for pre-SOR and post-SOR retinal sensitivity using microperimetry. In a study by Uva et al,[21] for determination of contrast sensitivity in patients with SO tamponade, they found that there is no significant differences in the light-difference sensitivity. In various studies using spectral domain optical coherence tomography, inner retinal layers in the fovea/parafovea were significantly thinner in the SO group,[10] and choroidal thickness was reduced in eyes receiving SO intraocular tamponade.[22] We noted mean retinal sensitivity improvement of 79.36 dB in central 6° of the macula, after SOR which was highly significant ($P < 0.0001$). We also noted visual improvement of 2 lines after SOR in 2 (10%) of eyes; however, it remained unchanged in 18 (90%) patients. MP3 also helps in better documentation of patient's visual function and for better understanding of the disease as well to the patients. In one of our previous study by Nagpal et al,[23] we described small hyperreflective spherical bodies in sub–SO-foveal depression space using spectral domain optical coherence tomography, and we concluded that these small hyperreflective spherical bodies in the sub–SO-foveal depression space were most likely emulsified SO globules and correlated with significant visual improvement with their clearance after SOR. In this study, we have selected cases with no hyperreflective spherical bodies in sub–SO-foveal depression space. The underlying pathophysiological mechanism of SORVL remains unclear. We hypothesize that presence of SO possibly decreases the sensitivity of the macular area and SOR improves the retinal sensitivity and quality of vision. During the process of SOR, these changes were reversible in our cases,

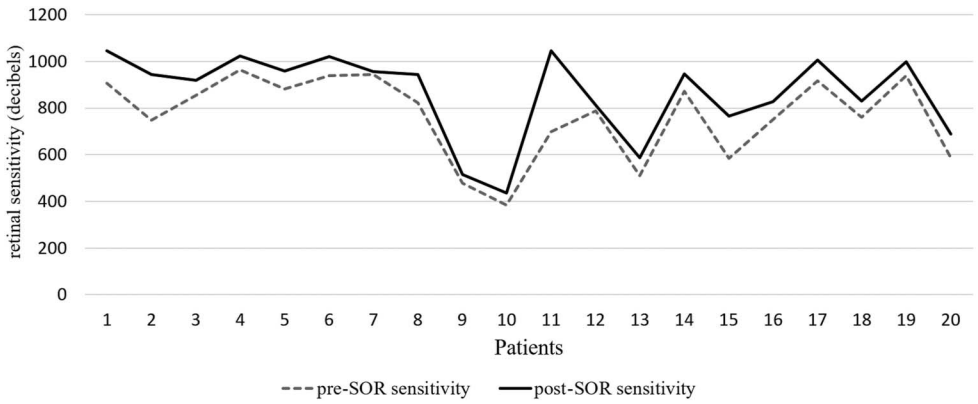

Fig. 4. Comparison of retinal sensitivity before and after SOR.

and the patient felt symptomatically better. To the best of our knowledge, there are no studies on retinal sensitivity before and after SOR using MP3. Our findings most likely demonstrate the possibly transient detrimental effect of SO on the macula and have opened up a new dimension for further research. The limitations of this study were the small sample size and short follow-up, and a larger study would help confirm these findings.

Conclusion

Silicone oil is a commonly used intraocular tamponade. MP3 was found to be a highly sensitive tool in detecting increased retinal sensitivity after SOR, particularly in central 6° of the macula in cases which did not have significant changes in BCVA. Presence of SO can cause probable transient visual function loss even before decline in BCVA. Hence, MP3 is an important qualitative indicator of visual function. The measurements of the retinal sensitivity by MP3 might be a very good tool to detect early changes in macular visual function and could have an impact on the decision of what is the safe period to remove SO. Future studies are warranted to see the relationship of time and retinal sensitivity in SO-filled eyes.

Key words: microperimetry, retinal detachment, retinal sensitivity, silicone oil tamponade, silicone oil removal.

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