Multifocal electroretinogram helps quantify functional recovery after macular hole surgery: 3-year follow-up

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PURPOSE

Improvements in surgical techniques for treating idiopathic macular holes (iMH) have resulted in high success rates for anatomical closure (90%)[1] and subjective functional improvement 6 months after surgery (46 to 58%)[2]. However objective assessment of functional recovery[3,4] is much less studied, even more at long-term follow-up (>1year postoperatively). **Aim:** The multifocal electroretinogram (mfERG) could objectively and accurately assess the functional recovery of central retina after successful MH surgery over 3 years.

METHODS

Retrospective monocentric study authorized by our IRB, with a minimum follow-up of 12 months and up to 36 months of consecutive patients operated on for iMH between November 2018 and December 2022 in a French tertiary center by a single experienced operator (TG). Were excluded eye with background of diabetic retinopathy, choroidal neovascularization, traumatism, previous ocular surgery (except cataract). For all operated eyes and fellow healthy eye, examination included: far and near best corrected visual acuity (BCVA), complete clinical parameters, SD-OCT, all mfERG parameters (mean retinal electrical response (RMS), amplitude and implicit time of N1 and P1 waves) every 6 months postoperatively.

Main outcome measure: RMS evolution within central 20° (fovea/parafovea/perifovea/close periphery/midperiphery). **(Fig. 1)**

Secondary outcomes: evolution of BCVA, N1, P1 and relationship between mfERG parameters and BCVA in operated eyes ; comparison of mfERG parameters with fellow healthy eye.

All parameters were evaluated and compared at short-term (within 1° year after surgery) versus long-term follow-up (from 24 to 36 months).

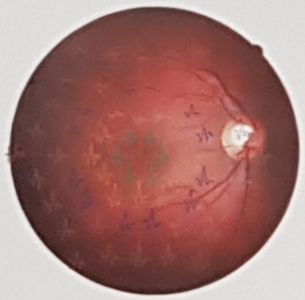


Figure 1. Overlay of RMS within the central 20°: 0-2° R1, 2°-5° R2, 5°-10° R3, 10°-15° R4, 15°-20° R5.

Table 1 . Baseline Population data (n=47 eyes). Eyes operated on for iMH were comparable to those classically studied and published[2].

Age	67.11 ± 9.06 (39-83)
Sex ratio Male/Female	16 (34 %) / 31 (66 %)
Minimal diameter iMH (µm)	400.7 ± 154.5 (140-742)
Axial Length (mm)	23.77 ± 2.11 (21.66-33.53)
Cataract surgery	10 (21 %)
BCVA far (logMAR)	0.66 ± 0.38 (0.1-2.3)
BCVA near (logMAR)	0.59 ± 0.31 (0.1-2.0)

RESULTS

47 operated eyes with mean axial length 23.77 ±2.11 (21.66-33.53) mm and 47 fellow eyes of 47 patients (age 67 ±9 years) were included. All had complete anatomical closure (type 1A or 1B)[5] with a single standardized 25G surgery for MH (tamponade: gas) with a mean diameter of 401 ±155 (140-742) microns. No post-operative complications occurred.

At baseline, 21% (n=10) of the eyes were pseudophakic, at M12 72%, at M24 and M36 90%.

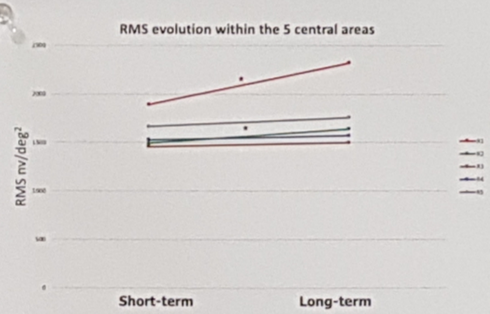
There was a statistically significant increase in mean RMS in the foveal (P=0.004) and parafoveal (P=0.02) areas with continuous improvement over 3 years. **(Fig.2)**

Far and near BCVA improved significantly and progressively over 3 years (P<0.05). In the short-term (M6-M12 postoperatively), 53.5% of the operated eyes improved their BCVA by at least 0.3 logMAR, while in the long-term (M24-M36 postoperatively), this proportion reached 84%. **(Fig.3)**

The amplitude of P1 improved significantly between short-term and long-term period within the foveal (P=0.009) and parafoveal (P=0.02) areas ; the implicit time of N1 increased significantly between short-term and long-term within the foveal area (P=0.01). **(Fig.4)**

Within the central 5°, significant correlations between RMS and near BCVA in the short-term (P=0.01) and the long-term (P=0.04). **(Fig.5)**

Within the central 5°, mean RMS and amplitude of P1 were significantly lower in the operated eye versus the fellow eye in the short-term (P=0.009), but no longer in the long-term (P=0.16). The implicit times of N1 and P1 were significantly longer in the operated eye versus the fellow eye throughout the follow-up period (all P<0.05). **(Fig.6)**



	Short-term	Long-term	P
Ring 1: 0°-2°	1892.8 ± 740.1	2319.4 ± 849.9	**0.004***
Ring 2 : 2°-5°	1494.0 ± 465.4	1638.2 ± 382.5	**0.02***
Ring 3 : 5°-10°	1456.1 ± 390.2	1499.6 ± 365.2	0.71
Ring 4 : 10°-15°	1526.8 ± 420.7	1570.7 ± 442.8	0.26
Ring 5 : 15°-20°	1665.3 ± 479.5	1756.7 ± 488.5	0.25

Figure 2. Recovery of RMS within central 20°: significant recovery occurred only within the central 5° over 3 years, with continuous improvement.

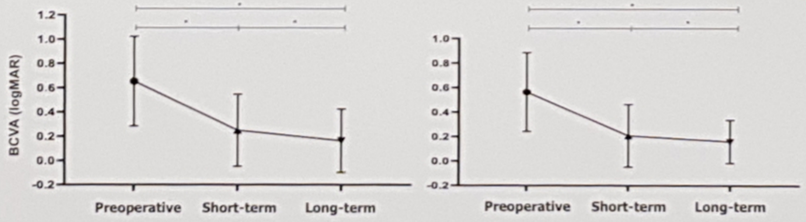


Figure 3. Recovery of BCVA: mean final BCVA were 0.16 logMAR (far) and 0.15 logMAR (near), with a high proportion eyes with improvement >0.3 logMAR at short-term and even more at long-term.

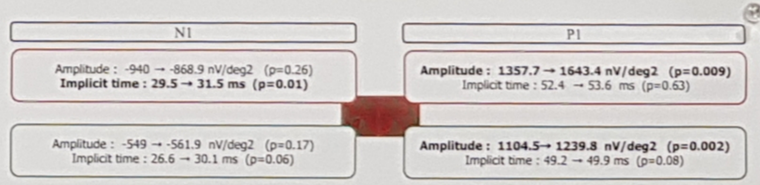


Figure 4. Evolution of N1 and P1 between short-term and long-term: only implicit time of N1 increased significantly within ring 1. Amplitude of P1 increased significantly within all rings (not only in rings 1 and 2).

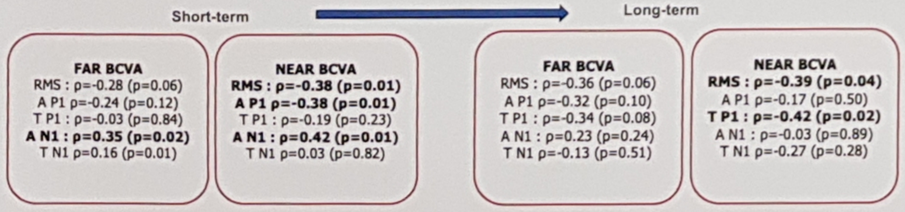


Figure 5. Correlations between mfERG and BCVA: we found significant correlations only within ring 1. Interestingly RMS was correlated with near BCVA at both short-term and long-term. Other correlations were found for N1 and P1 either at short-term or long-term.

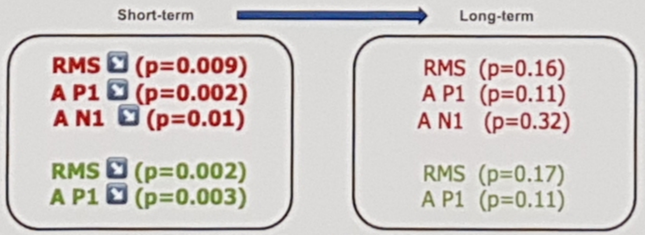


Figure 6. Comparisons between Operated (n=47) and Fellow Eyes (n=47): RMS, amplitudes of P1 and N1 were lower in operated eyes only at short-term within central 2°. Between 2°-5° same findings were observed for RMS and amplitude of P1.

DISCUSSION

1/ Recovery of internal retina (amplitude of P1) is progressive and slow in the foveal and parafoveal areas: it occurred later than 1 year after surgery.

2/ Recovery of external retina (implicit time of N1) is very slow and partial in the foveal area, with bipolar OFF cells taking more time to hyperpolarize throughout the first postoperative year.[6]

3/ RMS is a reliable variable correlated to near BCVA at short-term (M6)[3], but also at long-term (up to 36 months) in the foveal area.

4/ Electric recovery does not occur ad integrum[7] either in foveal area or in every ring up to central 20°, either at short or long-term.

CONCLUSIONS

The mfERG showed objectively progressive functional recovery of the inner and outer retina later than 1 year after surgery in the parafoveal and/or foveal areas. Interestingly, mfERG (RMS) showed correlations with near BCVA at long-term: electric recovery is a slow and progressive continuous process, while structure and BCVA appear stable. Functional recovery of outer retina is only partial even after 3 years compared to the fellow eyes. mfERG may be useful to monitor the objective functional recovery at long-term, especially if personalized follow-up is aimed.

REFERENCES: 1.Masuyama et al. 2009 Am J Ophthalmol, 2. Steel et al. 2021 Eye, 3. Ying-Jie et al. 1999 BJO, 4. Apostolopoulos et al. 2002 AJO, 5. Rossi 2020 et al. Graefe, 6. Andréasson 2014 et al. Graefe, 7. Faria 2019 et al. Journal of Ophthalmology