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Full Length Article

Comparison between standard and wide-field autofluorescence in detection of retinal displacement after rhegmatogenous retinal detachment surgery

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ABSTRACT

Purpose: To analyse the differences between 30° blue autofluorescence (BAF30), 55° blue autofluorescence (BAF55) and 200° green Ultra-Wide Field autofluorescence (UWF200) imaging to detect retinal displacement (RD) after vitrectomy surgery for rhegmatogenous retinal detachment (RRD).

Methods: This cross-sectional study considers forty-nine consecutive patients who underwent RRD surgery in the time period 4–8 months previous to image acquisition. The exclusion criteria contemplate previous retinal pathology, under 18-year-olds and non-assessable images in any of the 3 devices. These images were analysed by two masked graders that assessed either the presence or absence of retinal displacement. A third observer reviewed the images that presented discordance.

Results: A total of forty-nine patients were analysed. 7 eyes were excluded due to poor quality in either of the imaging modalities. The final analysis included 42 eyes of forty-two patients with a mean age of 60.3 ± 11.9 years. All patients underwent a 3 port 23-gauge pars plana vitrectomy as the technique of choice. Any grade of RD was detectable in 45.2% of images. It was similar between BAF30 and UWF200 (42.9% of eyes). BAF55 showed RD to a lesser extent (38.1%). Agreement index between BAF30 and BAF55 was 0.901, 0.903 between BAF30 and UWF200 and 0.803 between BAF55 and UWF200. Kappa agreement index between graders was 0.775 for BAF30, 0.798 for BAF50 and 0.808 for UWF200 images.

Conclusions: All imaging modalities were able to detect RD after vitrectomy for RRD, with no inferiority of BAF30 and BAF55 over UWF200.

1. Introduction

Retinal detachment can be defined as the separation of the neurosensory retina from the underlying retinal pigment epithelium (RPE). There is an estimated annual incidence rate of 6.9–18.2 per 100000 people.[1,2] Rhegmatogenous retinal detachment (RRD) is the most common form of retinal detachment, where a break in the retina allows fluid to pass from the vitreous cavity to the subretinal space, resulting in retinal separation. The aim of a surgical repair is to reattach the retina to its original place. However, despite successful reattachment and excellent visual acuity (VA), it has been showed in most patients that the quality of vision, stereopsis and near vision may be unsatisfactory.[3,4]

Unintentional retinal displacement after RRD surgery has been described in recent years. Shiragami et al. first demonstrated this phenomenon in 2010 using fundus autofluorescence (FAF) imaging. They observed hyperautofluorescent lines running parallel to retinal blood vessels, suggesting retinal movement and have been referred to as retinal pigment epithelium ghost vessels or retinal vessel printings (RVP).[5–9] According to the literature, the risk of displacement ranges between 35% and 72% and it could be responsible for symptoms such as vertical diplopia and distorted vision, which leave patients unsatisfied despite surgical success.[2]

FAF imaging has been reported to be an accurate means of assessing retinal displacement.[6] It allows for topographic mapping of naturally or pathologically occurring intrinsic fluorophores of the ocular fundus. Dominant sources of fluorophores are those accumulating as lipofuscin in lysosomal storage bodies in retinal pigment epithelium cells. Other fluorophores may be produced in cases of disease in the outer retina and

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subretinal space.[10] The most popular imaging modalities to obtain FAF images are based on Spaide's filter retinography[11] or confocal scanning laser ophthalmoscope (cSLO). Blue light autofluorescence (BAF) uses a blue excitation light (488 nm) and a 500 nm barrier filter. It normally covers a 35° field, but it can be enlarged using different modules. Green light autofluorescence (GAF) uses a 532 nm wavelength green excitation light. Depending on the device used, it can cover up to a 200° internal field of view.[12,13]

The only study regarding different image techniques was published in 2019 by Casswell et al. in which they compared the detection of post-RRD retinal displacement between fundus camera (FC) and cSLO FAF imaging.[9] We have not found any prior or later studies about comparison between BAF and GAF images in the detection of retinal displacement.

Given the small amount of publications regarding the influence of light source (blue vs. green autofluorescence) and the field of view amplitude in the apparition of retinal displacement, we consider analysing it with the different AF image modalities obtained in our daily practice to be of interest: 30° blue autofluorescence (BAF30), 55° blue autofluorescence (BAF55) and 200° green Ultra-Wide Field autofluorescence (UWF200).

2. Methods

This is a cross-sectional study of forty-nine consecutive cases of primary macula OFF RRD who underwent RRD surgery from the time period of January to August 2019 at the Albacete University Hospital Complex, Spain. BAF30, BAF55 and UWF200 images were obtained 4–8 months after surgery.

The inclusion criteria were age >18 years and lens opacity allowing to obtain autofluorescence images.

Patients with presence of previous retinal pathology (including previous vitreoretinal surgery), high myopia (>6D and/or axial length >26 mm) and participants whose images were not evaluable in any of the 3 devices were excluded.

2.1. Compliance

The study design was approved by the Institutional Review Board of Albacete University Complex (Internal code No 2020/01/021) and adhered to the Tenets of the Declaration of Helsinki for the protection of human subjects.

2.2. Surgical technique

The surgery was performed by the ophthalmologists belonging to the retina section of the Albacete University Hospital Complex. The surgical technique was entirely at the discretion of the surgeon and based on a complete preoperative ophthalmic examination.

Local anaesthesia was induced by a retrobulbar nerve block. All patients underwent three-port 23G PPV using the Alcon CONSTELLATION Vision System (Alcon Laboratories, Fort Worth, TX). If necessary, a scleral buckle was associated to the 23G PPV. Posterior vitreous detachment was induced in all patients if not present already. Perfluorocarbon liquid was used to relocate the retina and a fluid-air exchange was performed to drain the subretinal fluid through retinal breaks. Adjuvant retinotomies were performed to achieve complete retinal reattachment if needed. Finally, endolaser photocoagulation surrounding retinal breaks and air-gas (14% C3F8 or 24% SF6) or silicone oil was applied as intraocular tamponade. All patients were positioned face down immediately after surgery and maintained this position during the first 24 h. Afterwards, they were placed depending on the location of the retinal breaks. Detachments with superior breaks were positioned upright, those with inferior breaks adopted a prone position, whereas those with nasal and temporal were positioned on the contralateral side.

2.3. Image acquisition

Four to eight months after surgery 30° blue autofluorescence (BAF30) and 55° blue autofluorescence (BAF55) images were taken by Heidelberg Spectralis imaging platform (Heidelberg engineering Co Heidelberg, Germany) and 200° green Ultra-Wide Field autofluorescence (UWF200) image was acquired with Optomap Ultra-Wide Field device (Optomap P200; Optos plc, Dunfermline, UK).

All examinations were carried out under pupillary dilatation. Firstly, patients were placed in the Heidelberg Spectralis device and BAF30 (wavelength of 488 nm) with a 100 average image scans were obtained. The same procedure was repeated afterwards with BAF50, changing the 30° lens by the 55° wide angle lens. Later, Green Ultra-Wide Field autofluorescence image was acquired with a single shot (wavelength of 532 nm). Each patient waited 30 min between each FAF acquisition in order to avoid bleaching phenomena. All images with the three devices were also obtained on the contralateral eye and analysed afterwards (Fig. 1)

2.4. Imaging analysis

Individual images were masked and randomised prior to analysis, avoiding being consecutive or related somehow. Afterwards, they were analysed by two experienced retinal physicians (S.C. and C.B.) that decided either the presence or absence of retinal displacement, defined as hyperautofluorescent lines parallel to the retinal vessels. If any of the three images (BAF30, BAF55 or UWF200) were of insufficient quality to be assessed, the participant was excluded from the analysis. All disagreements in the evaluation were resolved by a third independent observer (R.M.). Modifications of image size, brightness and contrast were allowed to check the presence of retinal displacement.

2.5. Statistical analysis

Statistical calculation was performed by SPSS version 22.0 statistical software (SPSS, Inc, Chicago, IL, USA)

Comparison of retinal displacement between the 3 imaging modalities and inter-observer agreements were assessed using Cohen's Kappa coefficient (κ). The Kappa result is interpreted as follows: Values ≤ 0 as indicating no agreement, 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement. A p value of less than 0.05 was considered statistically significant.

The chi-square test was also used to evaluate the relationship between the presence of lens opacity and retinal displacement.

3. Results

A total of 49 eyes of 49 consecutive patients were included. Of these cases, 7 were excluded due to insufficient quality for grading, being 4 of them phakic and 3 pseudophakic eyes. In 3 of them it was not possible to achieve a good quality image with any of the 3 devices, with BAF30 and BAF55 in 2 of them and only with BAF55 in the remaining 2.

The final analysis included 42 eyes. The mean age of patients was 60.3 ± 11.9 years, being 71.4% male. 54.8% of eyes were phakic. None of the patients underwent combined PPV and cataract surgery (Table 1).

42 eyes underwent PPV as the final procedure to achieve retinal reattachment. SF6 was employed as tamponade in 24 (57.1%) cases, C3F8 in 17 (40.5%) and 1 case (2.4%) had silicone oil. Scleral buckle was associated to PPV in 13 of 42 eyes (31%).

3.1. Image evaluation

Any grade of retinal displacement was detectable in 45.2% of images (19 of 42). When using UWF200, 42.9% (18 of 42) of images showed retinal displacement. This value was similar when using BAF30 (42.9%) and BAF55 showed displacement to a lesser extent, in 16 of 42 eyes

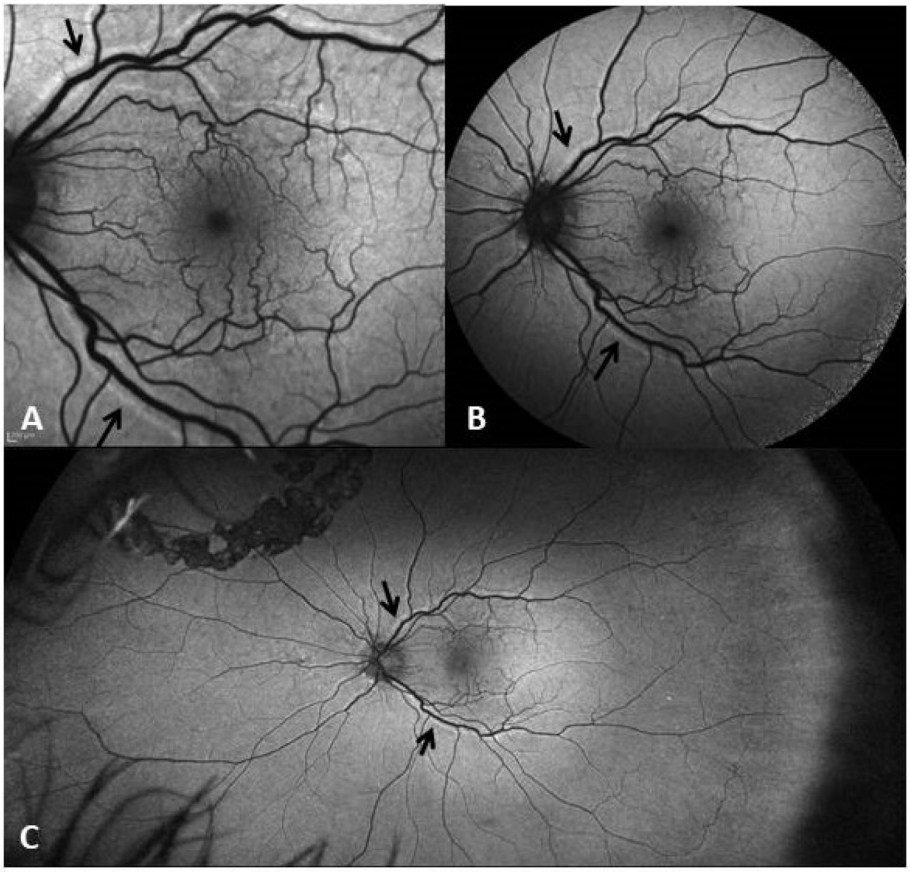

Fig. 1. Postoperative fundus autofluorescence images (FAF) following PPV showing hyperfluorescent lines (arrows) superiorly and inferiorly to the retinal vessels. A. Blue autofluorescence 30° (BAF30); B. Blue autofluorescence 55° (BAF55); C. Green ultrawide field autofluorescence 200° (UWF200).

Table 1
Patient demographics.

Mean Age, years (SD)	60.3 (11.9)
Male gender, n (%)	30 (71.4)
Lens status, n (%)	
- Phakic	23 (54.8)
- Pseudophakic	19 (45.2)
Type of tamponade employed, n (%)	
- SF6	24 (57.1)
- C3F8	17 (40.5)
- Silicone oil	1 (2.4)
Association of scleral buckle to PPV, n (%)	
- Scleral buckle associated to PPV	13 (31)
- Scleral buckle not associated to PPV	29 (69)

Table 2
30° blue autofluorescence (BAF30) versus 200° green Ultra-Wide Field autofluorescence (UWF200) comparison.

BAF30 & UWF200 Comparison				
		UWF200 n (%)		Total
		Absent	Present	
BAF30	**Absent**	23 (54.8)	1(2.4)	24 (57.1)
	Present	1(2.4)	17(40.5)	18 (42.9)
Total		24 (57.1)	18 (42.9)	42 (100)
			Value	***P*-value**
Cohen's kappa agreement			0.903	0.000

Table 3
30° blue autofluorescence (BAF30) versus 55° blue autofluorescence (BAF55) comparison.

BAF30 & BAF55 Comparison				
		BAF55 n (%)		Total
		Absent	Present	
BAF30	**Absent**	24 (57.1)	0(0)	24 (57.1)
	Present	2(4.8)	16(38.1)	18 (42.9)
Total		26 (61.9)	16 (38.1)	42 (100)
			Value	**p value**
Cohen's kappa agreement			0.901	0.000

(38.1%). Fig. 1 shows representative examples of patients following PPV for macula-off rhegmatogenous retinal detachment.

3.2. Comparison between BAF30 and UWF200 images (Table 2)

Retinal displacement was detectable in 42.9% of UWF200 images, same as with BAF30. Cohen's kappa agreement between these two modalities was 0.903 ($P < 0.01$).

3.3. Comparison between BAF30 and BAF55 images (Table 3)

Retinal displacement was observed in 38.1% of BAF55 images, being 10 (62.5%) phakic and 6 pseudophakic (37.5%) eyes. Cohen's kappa agreement between these two modalities was 0.901 ($P < 0.01$).

3.4. Comparison between BAF55 and UWF200 images (Table 4)

The differences between BAF55 and UWF200 images are reflected in Table 4. Cohen's kappa agreement between them was 0.803 ($P < 0.01$).

3.5. Comparison between phakic and pseudophakic patients

Considering phakic patients, the rate of retinal displacement was 23.8%. In pseudophakic patients, the rate of retinal displacement was 21.4%. Chi-square test showed no statistically significant differences between the presence of retinal displacement and lens status (phakic or pseudophakic) ($P > 0.05$).

3.6. Intergrader agreement

There was a good level of agreement between the two graders, with kappa scores of 0.775 for BAF30, 0.798 for BAF50 and 0.808 for UWF200 images.

4. Discussion

The aim of our study was to analyse the differences in detection of retinal displacement after PPV for RRD surgery using blue-light autofluorescence (488 nm) and green-light autofluorescence (532 nm).

We also compared the influence of field of view amplitude in the detection of retinal displacement, since visualisation of peripheral vessels is reached with Ultra-wide field imaging. Green light autofluorescence device (UWF200) covered an area of 200° in comparison with blue light autofluorescence devices (30° in BAF30 and 55° in BAF55).

It has been shown that macular tomographic changes, as well as functional tests improve significantly during the 6 months of the follow-up,[4] consistent with the period of time employed in our study.

Retinal movement after retinal detachment surgery with air tamponade was remarked in 1997 by de Juan and Vander. Subtle subretinal fluid remained at the end of surgery causing a downward movement of the retina due to the force of gravity, just before the patient took an appropriate position.[13] However, the pathogenesis of retinal vessel printings remains uncertain, existing several hypotheses for this phenomenon.[7] According to Shiragami et al., hyperautofluorescent lines were the result of increased metabolic activity from portions of RPE previously shaded by the retinal vessels and then acutely exposed to light irradiation because of retinal vessel displacement.[4] On the other hand, dell'Omo et al. proposed that a different composition and characteristics of fluorophores might exist between the RPE cells belonging to the retinal vessel printings (RVP) (normally shaded by the overlying vessels) and the neighbouring cells (normally exposed to light). The RVPs would indicate these long-standing differences, and thus, they would be not induced but simply unveiled by the displacement.[14]

The reported rate of detection of retinal displacement varies significantly according to the different studies published up to the present. The surgical technique, image technique employed and other factors are thought to contribute to this variation. Therefore, the actual rate of detection of postoperative retinal shift continues to be subject of discussion and more investigation is needed.

Shiragami in 2010 described a rate of retinal displacement of 62.8%. using Topcon fundus camera autofluorescence (FCAF).[6] cSLO imaging has also been used in order to detect postoperative retinal displacement with a rate of 35.2% using blue AF cSLO device.[8] Comparison between these two image techniques was made in 2019 by Casswell et al., resulting in similar detection of retinal displacement: 61.4% of cases if used Spaide's filter retinography and in 52.8% of cases using cSLO AF system. They also remarked that the excitation wavelength might affect the rate of detection of retinal shift, as higher rates were obtained with FCAF (wavelength of 530–580 nm) than with cSLO AF (wavelength of 488 nm).[9] Green ultrawide field AF cSLO devices have also been employed in the detection of retinal shift. Brosh et al., in a recent study, detected retinal displacement in 44.4% of cases after VPP and in 7% after Pneumatic retinopexy using Green ultrawide field AF cSLO.[15]

Blue-light AF images are usually performed with an excitation wavelength of 488 nm. At this wavelength, macular pigment can significantly absorb, resulting in a circular zone of approximately 0.5 mm of marked hypofluorescence (visible as a darker spot) overlying the fovea and the surrounding area. In contrast to blue AF imaging, green autofluorescence, with an excitation wavelength of 514 nm, is absorbed to a lesser extent by the macular pigment.[16] Thus, green AF imaging allows for an even more precise assessment of small, central changes including the differentiation between foveal atrophy and foveal sparing in geographic atrophy secondary to AMD, showing superiority over blue AF images.[17] Likewise, optic media opacities have been described to reduce the transmission of short-wavelength light possibly leading to less sharp lesion boundaries in blue AF compared to green AF.[18] Both have been proved useful in the detection of retinal displacement, but comparison between them has not been performed yet. In our study we have compared those techniques without detecting significant differences between devices of different wavelengths, considering that a good imaging technique might be more important than the influence of the device wavelength itself.

Different investigators have pointed out that a higher field of view could increase the rate of detection of retinal displacement.[9] However, in our study BAF30 and UWF200 showed similarities in retinal displacement detection (42.9% of patients). One of our hypotheses was the higher resolution of BAF30, as an average of 100 images were acquired to improve quality. One of our hypotheses was the higher resolution of BAF30, as an average of 100 images were acquired to improve the quality. Although the UWF200 imaging system enabled a good quality capture of the posterior pole and peripheral retina in a single, non-steered shot, a noteworthy decreased resolution and distortion of the far temporal and nasal peripheral retina has been described.[19] This could make peripheral displaced vessels more difficult to detect. However, it is worth mentioning that although the three devices had good detection rates, UWF200 had the smallest number of excluded images.

Furthermore, we observed that the displaced vessels appeared from the nerve disc in the majority of analysed cases. Adding this to the fact that BAF30 has a higher resolution, this could explain why the rate of retinal displacement in our case was slightly higher with BAF30 than with BAF55 (38.1%). In addition, BAF55 images associated lower brightness and resolution that made recognising hyperautofluorescent lines more challenging. (Fig. 2).

In spite of the differences in detection between the contrasted devices, a substantial correlation between them was observed. We also obtained a substantial level of agreement between graders.

Nevertheless, there are some limitations to our study. Firstly, in terms of the small sample size, along with the lack of a direct comparison of blue autofluorescence (BAF30 and BAF55) and green autofluorescence (UWF200). While the images were compared, they did not have the same area of visual field.

Despite these obstacles, our study has numerous strengths. One being the reproducibility of the assessments, confirmed by the comparison of

Table 4
55° blue autofluorescence (BAF55) versus 200° green Ultra-Wide Field autofluorescence (UWF200) comparison.

BAF55 & UWF200 Comparison				
		UWF200 n (%)		Total
		Absent	Present	
BAF55	**Absent**	23 (54.8)	3(7.1)	26 (61.9)
	Present	1(2.4)	15(35.7)	16 (38.1)
Total		24 (57.1)	18 (42.9)	42 (100)
			Value	***P*-value**
Cohen's kappa agreement			0.803	0.000

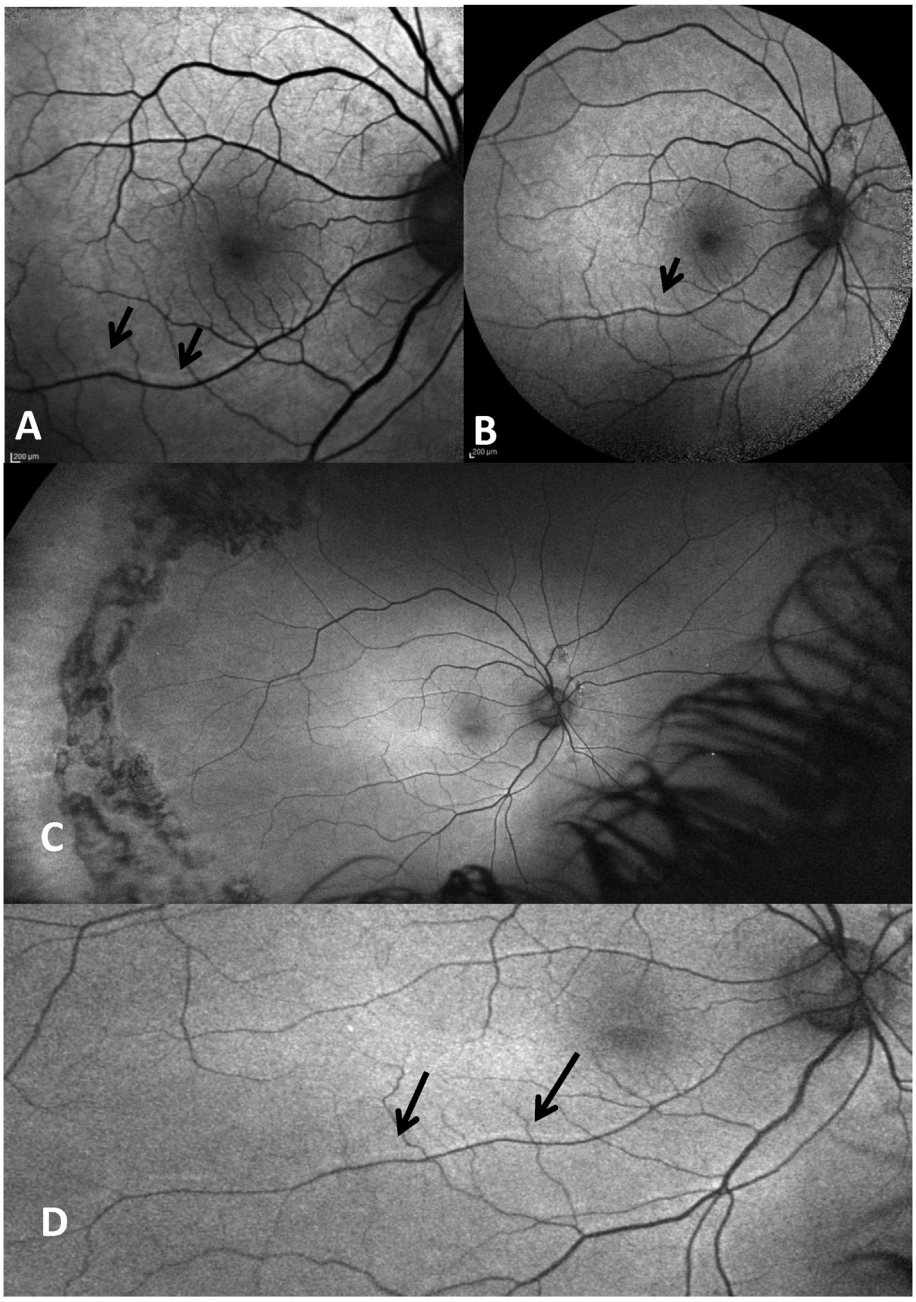

Fig. 2. FAF images showing different resolution between devices. A. BAF30 with retinal displacement; B. BAF50 with more challenging identification of ghost vessels; C. Green UWF200; D. Detail of green UWF200 showing retinal displacement.

masked, independent assessments of two different graders. Furthermore, a relatively homogeneous sample was included in the analysis. Finally, these results could be of clinical interest regarding a more efficient use of healthcare resources.

5. Conclusions

In conclusion, all imaging modalities were able to detect retinal displacement after vitrectomy for rhegmatogenous retinal detachment, with no inferiority of BAF30 and BAF55 over UWF200.

Study approval

The authors confirm that any aspect of the work covered in this manuscript that involved human patients or animals was conducted with the ethical approval of all relevant bodies and the study was performed in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Albacete University complex (approval number: 2020/01/021).

Author contributions

The authors confirm contribution to the paper as follows: Conception and design of study: RMC, CBM, TPM, SCP; Data collection: RMC, CBM, TPM, SCP; Analysis and interpretation of results: RMC, SCP; Drafting the manuscript: RMC, SCP; All authors reviewed the results and approved the final version of the manuscript.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Abbreviations

BAF30	30° blue autofluorescence
BAF55	55° blue autofluorescence
UWF200	200° green Ultra-Wide Field autofluorescence
RRD	rhegmatogenous retinal detachment
RPE	retinal pigment epithelium
FAF	fundus autofluorescence
FC	fundus camera
FCAF	fundus camera autofluorescence
cSLO	confocal scanning laser ophthalmoscope
BAF	Blue light autofluorescence
GAF	Green light autofluorescence

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