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Original Article

Digital Evaluation of the Changes in Eyelid and Ocular Surface Measurements and the Correlation of These Parameters with Visual Field Parameters After Upper Eyelid Blepharoplasty

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Abstract

Objectives: We aimed to evaluate the change in eyelid and ocular surface parameters that were measured using a digital measurement program, the change in the visual field (VF), and the correlation between ocular surface area (OSA) and VF parameters in patients who underwent upper eyelid blepharoplasty for involutional dermatochalasis.

Methods: Patients who underwent upper eyelid blepharoplasty for involutional dermatochalasis between August 2015 and August 2019 were included in the study. The difference between preoperative and postoperative 3rd month values of manually measured margin reflex distance 1 (MRD1), digitally measured eyelid and ocular surface parameters (MRD1, MRD 2 [MRD2], upper eyelid crease height [ECH], pretarsal show height [PTH], eyebrow line-height [EBH] and OSA), and VF parameters were evaluated. The correlation between preoperative and postoperative values of manually and digitally measured MRD1 and also preoperative and postoperative values of OSA and VF parameters were analyzed.

Results: Thirty-six eyes from 36 patients were included in this study and the mean age of patients was 57.93±7.64 years. There were statistically significant changes between preoperative and postoperative values in means of the manually measured MRD1 and the digitally measured MRD1, PTH, OSA, and ECH ($p<0.001$). However, the postoperative changes in the mean MRD2 and EBH were not statistically significant ($p=0.664$ and $p=0.983$). There were moderate positive correlations between pre- and post-operative OSA values and pre- and postoperative values of manual and digital MRD1. A statistically significant agreement was observed between the change in OSA and the change in all VF parameters (Bland–Altman analysis test).

Conclusion: Digital measurements can be used to evaluate the changes in eyelid and ocular surface parameters in patients who underwent upper eyelid blepharoplasty surgery. OSA provides fast results in accordance with linear measurements and is compatible with the change in the VF.

Keywords: Blepharoplasty, digital measurement, ocular surface area, visual field

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Introduction

Upper eyelid blepharoplasty is a procedure performed for dermatochalasis surgery, which improves the aesthetic appearance and eliminates the constricting effect of excess eyelid skin in the functional visual area (1,2). Dermatochalasis causes visual field (VF) defects, which result in difficulty in maintaining the primary gaze and in reading (3). Improvement in the superior VF after blepharoplasty is well known and has been reported in the literature (2,4,5). VF testing is a common practice during dermatochalasis evaluation, and it is required to provide objective preoperative evidence of functional VF defects for medicolegal and insurance coverage criteria (6-8).

In upper eyelid blepharoplasty surgery, it is useful to make objective measurements before and after surgery that are important in terms of objectively comparing esthetic and functional outcomes, planning before surgery, and comparing different surgical techniques (9). Performing detailed measurements of the eyelid and surrounding structures that are known to change after eyelid surgery, such as margin reflex distance 1 (MRD-1), MRD 2 (MRD-2), upper eyelid crease height (ECH), pretarsal show height (PTH), and eyebrow line-height (EBH), helps to characterize the eyelid and ocular surface features as well as the facial appearance features and allow pre- and post-operative evaluation using quantitative data. However, these are one-dimensional measurements that measure the vertical distance between the pupillary light reflex and the lid margin, lid crease, and brow line, and they may be misleading for patients with more prominent temporal or nasal skin folds. There may also be inter-observer differences.

A two-dimensional measurement, ocular surface area (OSA) can be automatically calculated by software as the area surrounded by the upper and lower margins of the eyelid (10). It is expected to change after eyelid surgery and is an important parameter for characterizing the features of the eyelid, ocular surface, and facial appearance (10,11).

This study evaluated the changes in eyelid and ocular surface parameters measured both manually and digitally and the change in the automatic static VF before and after surgery, and the correlation between OSA, manually and digitally measured MRD1 and VF parameters in patients who underwent upper eyelid blepharoplasty surgery for involutional dermatochalasis.

Methods

Data from patients who underwent upper eyelid blepharoplasty for involutional dermatochalasis in the Oculoplastic Surgery Department of our hospital between August 2015 and August 2019 were included in the study. Informed consent to use information about the surgery and photographs was obtained from all patients in accordance with the Declaration of Helsinki. This study was approved by the Ethics Committee of the University of Health Science Turkey Prof. Dr. Cemil Taşçıoğlu City Hospital. (Date: 22.09.2020, Number: 377).

Dermatochalasis classification of the patients was made according to the suggestions of Jacobs et al. (9) Patients with moderate and severe dermatochalasis, in which the eyelid skin droops over the eyelashes or eye, were included in the study. Patients who had a history of eyelid and intraocular surgery, trauma, ptosis, conjunctival or ocular surface problem, eyelid infection, dry eye syndrome or ocular surface disorder, any neuroophthalmological disease, retinal disease, or suspicion of glaucoma that could affect a VF test or who had the inability to perform a VF test were excluded from the study. All patients underwent blepharoplasty surgery with skin excision only that was performed by the same surgeon (GOK) under local anesthesia.

All patients underwent detailed ophthalmological examination including best-corrected visual acuity, anterior segment and fundus examination, and intraocular pressure measurement. The right eye of all patients was evaluated. A ruler was used to measure MRD1 manually and the distance between the corneal light reflex that was created by a penlight and the upper eyelid margin at the 12 o'clock position was calculated, ensuring that the brow was stabilized to prevent the recruitment of the frontalis muscle. All patients were photographed in the frontal view by the same author (GOK) under the same light conditions with the eyes in the primary position and with a distance of 1 m between the camera and the patient. A digital camera (Canon G3X, Tokyo, Japan) that was kept at eye level was used. The digital images were analyzed using Image J software (version 1.45, NIH, Bethesda, MD, USA), with the Java platform version 1.6' program. The setting scale accepted white to white 11 mm. The MRD1 (the vertical distance between the corneal light reflex and the upper eyelid margin), the MRD2 (the vertical distance between the lower eyelid margin and the corneal light reflex), EBH (the vertical distance between corneal light reflection and mid-eyebrow line), PTH (the vertical distance between upper eyelid margin and upper eyelid fold in primary position), ECH (the distance between the upper eyelid margin and the eyelid fold when the eyes are in the closed position), and OSA (the area surrounded by the upper and lower eyelid) were calculated using the program (Fig. 1).

The VF test was performed using the Humphrey Automatic Static VF (Humphrey 705, Carl Zeiss Meditec Inc., Dublin, CA, USA). The Swedish interactive threshold algorithm fast 30–2 algorithm was used to measure the VF for

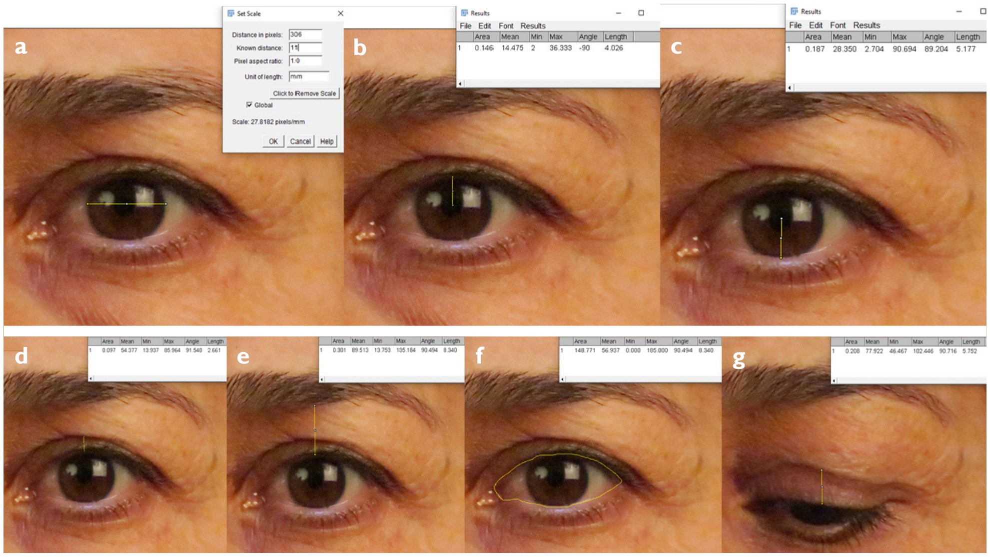

Figure 1. (a) Measuring white to white as 11 mm, **(b)** Margin reflex distance 1 measurement, **(c)** Margin reflex distance 2 measurement, **(d)** Pretarsal show height measurement, **(e)** Eyebrow line height measurement, **(f)** Ocular surface area measurement, **(g)** Eyelid crease height measurement.

all patients. The mean deviation (MD), pattern standard deviation (PSD), and VF index (VFI) were evaluated in patients whose fixation reliability criteria were appropriate. The mean of 38 points sensitivity that was threshold-scanned in the superior VF above the horizontal raphe was calculated in decibels (upper half VF sensitivity).

All eyelid measurements and VF tests were performed before the procedure and 3 months after the surgery. The VF tests which did not meet the reliability criteria were excluded from the study.

Statistical Analysis

All statistical analyses were performed using SPSS 20.0® for Windows (IBM Corporation, Armonk, NY). Descriptive statistics included the mean±standard deviation (SD), percentage, minimum (min), and maximum (max) for normally distributed variables. The distribution of variables was measured using the Shapiro–Wilk test. For quantitative analysis, a dependent-sample t-test was used for normally distributed variables, and the Wilcoxon signed-rank test was used when the measurements did not fit the normal distribution. In addition, $p<0.05$ was considered to be statistically significant. The Pearson correlation analysis was used for normally distributed variables, and the Spearman correlation analysis was used when the measurements did not fit the normal distribution. The area under the receiver operating characteristic (ROC) curve was performed to determine the relation between manually and digitally measured MRD1. To assess the agreement between the differences of post-operative–preoperative measurements, the Bland–Altman test was used.

Results

The study included 36 eyes from 36 participants (24 women [66.67%]; 12 men [33.33%]) who underwent upper eyelid blepharoplasty surgery due to involutional dermatochalasis. The mean age of patients was 57.93±7.64 years (range, 45–73 years).

The mean manually measured preoperative MRD1 value increased from 2.61±0.56 mm to 3.74±0.44 mm at 3 months postoperatively. There was a statistically significant increase in means of the digitally measured MRD1, PTH, OSA, and ECH ($p<0.001$). However, the changes in the mean MRD2 and EBH were not statistically significant [$p=0.664$ and $p=0.983$, respectively; (Table 1)].

The area under the ROC curves for preoperative digital measured MRD1 was 0.925 (95% confidence interval [CI] 0.812–1.00), for postoperative digital measured MRD1was 0.934 (95% [CI] 0.896–1.00) ($p<0.001$ for both). When the correlations between the preoperative values were evaluated, moderate positive correlations were found between the OSA value and manually measured MRD1 value ($r=0.375$) and OSA and digitally measured MRD1 value ($r=0.397$). For the correlations between the postoperative values, there were moderate positive correlations between the OSA and the manually measured MRD1 values ($r=0.345$) and the OSA and the digitally measured MRD1 values ($r=0.306$).

When the preoperative global VFIs were compared with postoperative values in 3rd month the increase in the mean VFI, upper half VF sensitivity, and MD values were statistically significant ($p<0.001$). The mean PSD value decreased from 5.94±3.99 dB to 2.20±0.77 dB, which was also statistically significant [$p<0.001$; (Table 2)].

Table 1. Comparison of preoperative and postoperative values of manually and digitally measured parameters

	Preoperative	Postoperative 3rd month	p
Manual MRD1			
Mean±SD (min-max)	2.61±0.56 (2.00–4.00)	3.74±0.44 (3.00–5.00)	<0.001*a
Digital MRD1			
Mean±SD (min-max)	3.07±0.67 (2.19–4.25)	4.10±0.42 (3.20–4.78)	<0.001* a
Digital PTH			
Mean±SD (min–max)	1.11±1.13 (0.00–4.10)	3.08±1.37 (1.16–6.60)	<0.001* a
Digital OSA			
Mean±SD (min–max)	111.82±25.95 (62.32–175)	135.85±22.91 (92.22–189.00)	<0.001* a
Digital ECH			
Mean±SD (min–max)	3.24±1.59 (0.00–3.24)	6.24±1.77 (3.32–10.31)	<0.001* a
Digital MRD2			
Mean±SD (min–max)	5.45±0.91 (3.73–7.67)	5.37±0.93 (3.62–7.60)	0.664 a
Digital EBH			
Mean±SD (min–max)	15.02±2.82 (10.00–21.40)	15.02±2.67 (10.00–20.00)	0.983 a

[a]Paired sample t test; *Statistically significant (p<0.05). MRD1: Margin reflex distance 1, MRD2: Margin reflex distance 2, PTH: Pretarsal show height, OSA: Ocular surface area, ECH: Eyelid crease height, EBH: Eyebrow line height.

Table 2. Comparison of values of visual field indexes preoperatively and postoperative 3rd month

	Preoperative	Postoperative 3rd month	p
MD			
Mean±SD (min–max)	-5.49±3.36 (-12.58–-1.12)	-2.38±1.51 (-4.63–1.10)	<0.001*a
VFI			
Mean±SD (min–max)	91.29±9.28 (69–99)	97.87±1.89 (92–100)	<0.001*a
The upper half visual field sensitivity			
Mean±SD (min–max)	20.76±6.68 (7.27–27.73)	26.93±1.84 (24–30.98)	<0.001*a
PSD			
Mean±SD (min–max)	5.94±3.99 (1.61–12.09)	2.20±0.77 (1.20–5.32)	<0.001*a

[a]Paired sample t-test; bWilcoxon signed-rank test, *Statistically significant (P<0.05), MD: Mean deviation, PSD: Pattern standard deviation, VFI: Visual field index.

When the correlation of OSA with VF parameters was analyzed, there were moderate positive correlations between the preoperative OSA and VFI (r=0.412), MD (r=0.423), PSD (r=0.321), and the mean upper half VF sensitivity (r=0.491) (Table 3) Moderate positive correlations were detected between the postoperative OSA and VFI (r=0.470), MD (r=0.419) and PSD (r=0.383), and the mean upper half VF sensitivity (r=0.452) (Table 3).

When the agreement between the changes before and after surgery was evaluated, a statistically significant agreement was observed between the change in OSA and the change in all VF parameters [23.3313; 95% limit of agreement: lower limit, 3.0069; upper limit, 43.4357; Bland–Altman analysis test; (Fig. 2)].

Discussion

Determining the changes in measurements of the eyelid and surrounding structures and the VF before and after surgery is important clinically and medicolegally (12). The change in palpebral fissure height and pretarsal height after upper blepharoplasty is the most important factor that affects patient satisfaction (13).

The MRD1 and MRD2 measurements are the conventional palpebral fissure examination parameters. The development of digital measurement programs has made it possible to make such one-dimensional measurements more accurately and quantitatively. It also helps to perform measurements that are difficult to calculate using conven-

Table 3. Correlations between continuous variables

	Preoperative	Postoperative
Manual MRD1-Digital MRD1 r value	0.859	0.792
Manuel MRD1-OSA r value	0.375	0.345
Digital MRD1-OSA r value	0.397	0.306
VFI-OSA r value	0.412	0.470
MD-OSA r value	0.423	0.419
PSD-OSA r value	0.321	0.383
The upper half visual field sensitivity -OSA r value	0.491	0.452

MRD1: Margin reflex distance 1; OSA: Ocular surface area measurement; MD: Mean deviation; PSD: Pattern standard deviation; VFI: Visual field index.

tional methods, such as OSA, which is a two-dimensional measurement. Digital analyses of photographs provide the ability to standardize eyelid measurements (11). The advantages of digital analyses of photographs are speed, achieving more quantitative results, and repeatability. In addition, manual measurements have some disadvantages such as weak repeatability and reproducibility along with learning curve effects, which make these measurements less reliable (14). One of the other disadvantages of manual measurements is difficulty with patient cooperation during the examination especially for children or cognitively impaired adults.

Recent studies have reported a strong correlation between manually and digitally measured MRD1 and they suggested that digital image analysis allows an objective as-

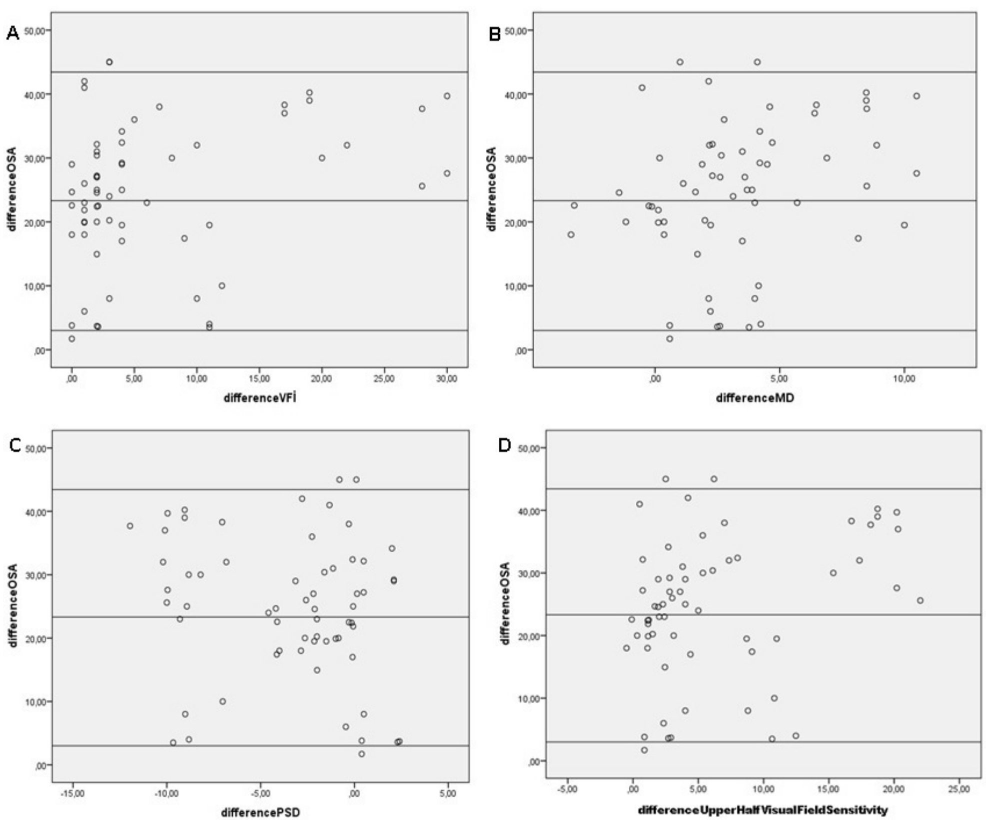

Figure 2. Bland–Altman analyses for postoperative–preoperative changes in the ocular surface area and visual field parameters. Difference OSA: The preoperative and postoperative ocular surface area difference, Diffference VFI: The preoperative and postoperative visual field index difference, Diffference MD: The preoperative and postoperative mean deviation difference, Diffference PSD: The preoperative and postoperative pattern standard deviation difference, Diffference Upper Half Visual Field Sensitivity: The preoperative and postoperative upper half visual field sensitivity difference.

sessment of the upper eyelid parameters after ptosis repair (15-17). Nunes et al. compared the manual and digital height measurements of the palpebral fissure, and they found that the digital measurements were reliable and compatible with manual measurements (18). In the present study, a strong positive correlation was found between manually and digitally measured MRD1 before and after surgery.

Multiple methods for the measurement of eyelid and ocular surface parameters have been described in the literature. Park et al. compared corneal exposure area in patients who underwent aesthetic eyelid surgery, which was measured as the ratio of visualized corneal area to total corneal area and they suggested that digital photography of the measured area of corneal exposure will provide surgeons with a guideline for preoperative blepharoplasty planning (19). Koushan et al. compared the preoperative and postoperative OSA values, in patients who underwent ptosis surgery and supposed that OSA was useful for showing postoperative changes (11). In accordance with the previous studies, a significant increase was found in the postoperative OSA compared to the preoperative OSA in the present study. In addition, a moderate positive correlation was detected between OSA and both manually and digitally measured MRD1 before and after surgery. These results show that digital measurements are quantitative methods that can be used instead of conventional methods and that they are useful because of their speed, and accessibility in terms of documentation.

No change in MRD1 was reported in cases where only the upper eyelid blepharoplasty was performed (20-22). because only the anterior lamella was excised in blepharoplasty surgery and no changes were made to the levator or muller muscle (23). However, there are also studies reporting a significant increase in MRD1 after upper blepharoplasty (24,25). In the present study, a significant increase was found in both manually and digitally measured MRD1 in the 3rd month after surgery. The amount of mechanical weight on the eyelid decreased due to the resection of skin in blepharoplasty surgery, which allowed the upper eyelid retractors (Muller muscle and levator palpebra superiors) to work effectively. Thus, it is possible to detect an increase in MRD1 in cases where only blepharoplasty was applied.

One of the parameters that affect patient satisfaction after eyelid surgery is the pretarsal height, which is important for esthetic facial appearance. In dermatochalasis, a decrease is seen in ECH and pretarsal height due to loss of skin elasticity, and an increase in these parameters is expected after surgery due to the removal of the excess skin (25). A significant increase in the ECH after blepharoplasty has been reported in both manual and digital measurement studies (25-27). There was also a significant increase in the ECH and PTH parameters after the surgery, as detected using digital measurement in this study.

Elevation in the eyebrows with excessive activity in the frontalis muscle to compensate for the narrowing of the VF can be seen in patients with dermatochalasis. However, in the literature, there have been studies that evaluated the effects of blepharoplasty on eyebrow position and detected no significant change in the eyebrow position (21,23,28). Consistent with previous studies, there was no significant difference in the eyebrow position after surgery in this study.

Dermatochalasis is a cosmetic and functional problem. Difficulty in opening the eyelid and narrowing of the superior VF are some of the functional problems due to sagging in the loose upper eyelid skin in patients with dermatochalasis (2). Narrowing of the superior VF should be shown while planning a surgery that is covered by health insurance and as proof of the functional problem in many countries. Mean deviation, which is the common VF defect index, and PSD, which is a sensitive and early index of a localized defect, are frequently used global indexes, and they are effective for monitoring and detecting changes in the VF (29). The correlation between MRD1 and superior VF narrowing that was detected using the Goldmann perimetry has been reported in several studies (30-32). Kosmin et al. investigated the effect of dermatochalasis on the central 24° VF using static Humphrey automated perimetry, and they found an improvement in MD and PSD in the patients who underwent blepharoplasty surgery (33). Rosa et al. reported a strong and significant correlation between the VFI MD and PSD in a multicenter study evaluating 122 eyes (34). Ho et al. tested 35 points in the 48° superior to the VF in the modified Humphrey VF, and they found a significant improvement after blepharoplasty (35). MD, PSD, and VFI, which are among the global VFI, and the upper half VF sensitivity were analyzed in the present study, and an increase in MD, VFI, and the upper half VF sensitivity and a decrease in PSD were detected postoperatively.

In addition to other studies, the correlation between the OSA and VF parameters was investigated in the preoperative and postoperative periods in this study. There was a moderate correlation between OSA and all VF parameters before and after surgery. In addition, when the agreement between the OSA value difference and the all-visual-field parameter difference before and after surgery was evaluated, a statistically significant agreement was observed.

The limitation of our study was our relatively small sample size and the lack of long-term results. However, to the best of our knowledge, this is the first report analyzing the correlation of digitally measured OSA and VF parameters.

Conclusion

Digital measurements of the eyelid and ocular surface parameters can be used to evaluate the eyelid and ocular surface features of patients who underwent upper eyelid blepharoplasty surgery. OSA, which is compatible with the change in the VF, provides a benefit in the documentation and tracking of surgical results. The confirmation of an increase in the OSA and an increase in the VF after blepharoplasty surgery has been objectively demonstrated in this study.

Disclosures

Ethics Committee Approval: This study was approved by the Ethics Committee of the University of Health Science Turkey Prof. Dr. Cemil Taşcıoğlu City Hospital. (Date: 22.09.2020, Number: 377).
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Authorship Contributions: Concept – G.G., K.F., G.O.K., K.S.C.; Design – G.O.K., K.F., K.S.C., Z.K.G., G.G.; Supervision – A.A., G.O.K., G.G.; Resource – G.O.K., K.F.; Materials – G.O.K., K.F., K.S.C.; Data collection and/or processing – D.A., G.G.; Analysis and/or interpretation – K.S.C., Z.K.G.; Literature search – G.G., G.O.K.; Writing – G.G., G.S.C., D.A.; Critical review – Z.K., D.A.

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