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ORIGINAL ARTICLE

The topical azithromycin meibomian gland dysfunction survey: The effect of topical azithromycin on signs and symptoms of meibomian gland dysfunction

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Abstract

Introduction: The aim of this study was to assess the long-term effects of topical azithromycin on signs, symptoms and self-management of meibomian gland dysfunction (MGD).

Methods: Forty participants were assessed for MGD and its effect on the fluorescein tear break-up time (FTBUT). Participants were treated with topical azithromycin twice daily for 2 weeks and then once daily for a further 2 weeks. One year after treatment, 31 participants completed a survey assessing pre- and post-treatment effect on symptoms, lifestyle and self-treatment methods.

Results: Following treatment, there was a significant reduction in MGD grading from a median of grade 2 to grade 0 ($z = 4.40$, $p < 0.0001$) and an increase in FTBUT from a median of 3–8 s ($z = 4.75$, $p < 0.0001$). One year afterwards, the survey showed a significant improvement in symptoms (sensitivity to light, grittiness, burning, blurred vision, all $p < 0.03$) and reduction in required self-treatments (lid wipes, tear substitutes, both $p < 0.03$). There was also a reduced impact on lifestyle (reading, night driving, computer use and watching television, all $p < 0.0001$) and in all environmental conditions (all $p < 0.0001$).

Conclusions: This study confirms the positive effect of topical azithromycin on MGD and shows it has a long-term impact on symptoms, self-treatment methods and lifestyle. This has implications for both chair time and healthcare costs when managing patients with MGD. Pending further clinical trials in a larger population with different demographics, topical azithromycin should be considered by all eyecare practitioners as a viable pharmacological treatment when managing MGD.

KEYWORDS
dry eye, meibomian gland dysfunction, topical azithromycin

INTRODUCTION

A major factor affecting tear film quality is meibomian gland function.[1] Obstruction of these glands can often lead to symptoms of dry eye by altering the composition and stability of the tear film. This may result in significant ocular discomfort, reduced visual function and negatively impact the quality of life.[2] The role of bacteria in the development of meibomian gland dysfunction (MGD) was investigated by Jiang et al.[3] They showed that a higher level of bacteria in the conjunctival sac correlated well with the severity of MGD. They concluded that this provided a reasonable basis for the use of antibiotic therapy. Bacterial lipases are thought to degrade lipids leading to abnormal secretion of the meibomian glands. In addition, the melting point rises, leading to ductal plugging and secretion dysfunction.[4]

Modern lifestyle in a predominantly air-conditioned or centrally heated indoor environment can have a measurable impact on tear film quality.[5] Optometrists are well placed to manage MGD in the community. With an increase in the number of independent prescribing optometrists in the UK, with over 1700 being registered with the General Optical Council,[6] more prescribing opportunities are available for managing this condition. There are several treatment

options available, including tear substitutes, lid hygiene, heat and massage, but with any chronic condition, patient compliance is always a major factor in the relative success of treatment. Alghamdi et al.[7] reported that although lid hygiene was effective at managing MGD, this effect was not sustained in longer term patients due to reduced compliance. A treatment which could break the cycle of dryness, inflammation and keratinisation of meibomian glands, as well as reduce the need for the long-term management of MGD,[8] could potentially improve the patient's lifestyle. It could also reduce the cost burden of ongoing tear substitutes, which are often the first line of treatment. A review of the annual cost of managing dry eye disease in the USA estimated this as equivalent to £570 per person per year.[9]

Topical azithromycin has been proposed as a comparable treatment to oral doxycycline. Foulks et al.[10] found it to be as effective for restoring the low levels of carotenoids found in MGD and thus improved tear film stability. This finding was supported by the 2020 Royal College of Ophthalmologists systematic review and meta-analysis for treating MGD with topical azithromycin.[11] Other studies have corroborated this finding. For example, Ozlem and Gulkilik[12] observed that a regime of topical azithromycin twice daily for 2 days and then once daily for a total of 30 days had at least a short-term effect on MGD grading and fluorescein tear break-up time (FTBUT) at 1 month post-treatment. Thomas and Ami[13] concluded that topical azithromycin had a superior clinical response to erythromycin for the treatment of chronic blepharitis.

Azithromycin is an antibiotic of the macrolide family, known to have anti-inflammatory properties by inhibiting pro-inflammatory cytokines. It is also potent against the Gram-negative microorganisms commonly found on the lids and adnexa.[14] A review by Vernhardsdottir et al.[15] on the use of oral and topical antibiotics in dry eye management found that topical azithromycin had a short-term effect on MGD. However, there was little in the way of further research regarding a lasting improvement.[15] In contrast, Fadlallah et al.[16] showed no relapse after treatment with topical azithromycin over a 3-month follow-up. To date, no study has examined a follow-up period beyond 3 months.

The origin of this current study arose from the authors noting a reduced need for recurrent examinations in dry eye patients who were treated with topical azithromycin, compared with their professional colleagues who were using alternate treatments in clinical practice. This study analysed the long-term effectiveness of topical azithromycin in reducing signs, symptoms and self-treatment methods of MGD in a community optometric practice in the UK.

Key points

- Topical azithromycin produced significant long-term effects on the signs, symptoms and self-management of meibomian gland dysfunction.
- A potential projected benefit comes from the reduced lifetime use of tear substitutes on both ocular health and healthcare costs.
- Topical azithromycin led to reduced side effects and a shorter treatment regimen compared with oral doxycycline.

METHODS

This prospective observational cohort study was conducted in a community optometry practice (Jarvis Eyecare, Dundee, Scotland) over a 2-year period. Patients who had persistent MGD where previous use of lid hygiene, tear substitutes, heat and massage had been ineffective at relieving signs or symptoms were invited to participate. The first 40 patients who met the inclusion criteria were invited to take part in the study, so as to minimise selection bias. To evaluate the long-term benefit of this treatment on symptoms and self-treatment methods, each participant was asked to complete a post-treatment survey 1 year following treatment. Other than mild secondary superficial punctate staining, subjects did not have comorbidities of the ocular surface such as episcleritis, seasonal allergic conjunctivitis or marginal keratitis. No general health exclusions were included.

The treatment regime was adapted from Foulks et al.[10] and Fadlallah et al.,[16] who both gave topical azithromycin twice daily over an initial period before reducing the dosage to once a day for the remainder of a month of treatment. The majority of studies included in the Royal College of Ophthalmologists' review and meta-analysis of treatment regimens for MGD also followed this pattern.[11]

Treatment involved instilling one drop of topical azithromycin, 15 mg/g (Thea Pharmaceuticals, theapharmainc.com) into both eyes twice daily for 2 weeks and then once a day for the following 2 weeks. Participants were examined immediately before treatment and subsequently at the end of the 1-month period.

Objective data included MGD grading and FTBUT. MGD was recorded using the Efron grading scale of 0–4, where 0 = normal, no tissue change and 4 = severe, clinical action urgently required. For meibomian gland function, this relates to the appearance and expression of the meibomian glands. FTBUT was measured after instillation of 1% fluorescein (Bausch & Lomb minims, Bausch.com) and measured in seconds, counted by the examiner.[17] The same examiner assessed the participants both pre- and post-treatment to remove inter-operator error. Mou et al.[18] invited a veteran observer with over 20 years of experience to minimise variability in FTBUT findings, as was done in the present study. This study showed no statistically significant variation in successive measurements obtained by the same practitioner.

All participants provided written informed consent and gave authorisation for anonymous use of their data. This

study did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors. The study protocol under the title of TAMS (topical azithromycin meibomian gland dysfunction survey) was sponsored by National Health Service (NHS) Tayside and management approval was given by Tayside Medical Science Centre (TASC). Ethical approval was provided by Wales Ethical Approval Committee 7 (WEC7 19/WA/0253). The research complied with the Declaration of Helsinki.

Details of the survey are included in Appendix S1. In brief, participants were asked how their management of MGD had changed and which dry eye symptoms they had pre- and post-treatment (sensitivity to light, gritty/burning sensation and blurred vision). They were also asked to what extent symptoms affected their lifestyle (reading, night driving, computer use and watching television) and how they were impacted by environmental conditions (windy, dry and air-conditioned environments). The survey used a combination of yes/no responses, numerical grading of symptom frequency or use of self-management methods with a scale from 1 to 5, where 1 = never and 5 = always. Surveys were mailed to participants 1 year after completion of their topical azithromycin treatment. For participants who did not return the questionnaire, a reminder letter was sent 1 month later.

Statistical analysis

Data were analysed using Stata 13.1 (stata.com). Data were ordinal and categorical; therefore, non-parametric tests were used for analysis. Wilcoxon signed rank matched pair tests were used to determine statistical significance for changes in FBUT, MGD and frequency of use of self-treatment methods. Percentages were used to describe the use of self-treatment methods and symptoms pre- and post-treatment. McNemar's tests were used to analyse significant differences in the percentages of use/symptoms before and after treatment.

RESULTS

Thirty-one participants (age range 39–75 years, 10 males, 21 females) were treated with topical azithromycin and completed the survey. There were nine treated participants who failed to complete the survey despite follow-up by the researchers. There were strong, significant correlations between the right and left eyes for FTBUT ($r = 0.79$, $p < 0.0001$) and MGD ($r = 0.79$, $p < 0.0001$) pre- and post-treatment. Therefore, only right eye data are presented here.

There was a significant increase in FTBUT post-treatment (median 8 s, IQR 5.5–8.8 s) compared with the pre-treatment value (median = 3 s, IQR 2–3 s; Wilcoxon signed rank matched pairs, $z = -4.4$, $p < 0.0001$). MGD grading decreased significantly post-treatment (median = 0, IQR 0–1) compared to pre-treatment (median = 2, IQR 2–2) (Wilcoxon signed rank matched pairs, $z = 4.8$, $p < 0.0001$—see Table 1).

TABLE 1 Pre- and post-treatment values for fluorescein tear break-up time (FTBUT) and meibomian gland dysfunction (MGD) (grade range 0–4, Efron grading scale).

	Pre-treatment	Post-treatment
FTBUT (seconds)	3 (2–3)	8 (5.5–8.5)
MGD Grade	2 (2–2)	0 (0–1)

Note: Values are medians (IQR).

Table 2 shows the percentage of participants who used lid wipes ($p = 0.03$) and tear substitutes ($p = 0.02$) reduced post-treatment, but use of the Blepha Eyebag, a reusable warm compress (laboratoires-thea.com/en/blepha-eyebagr) did not change significantly ($p = 0.16$).

However, as shown in Table 3, the frequency of use for all three methods was significantly reduced following treatment (lid wipes [$z = 2.29$, $p = 0.02$], tear substitutes [$z = 3.73$, $p = 0.0002$], eyebag [$z = 2.16$, $p = 0.03$]). The prevalence of the four symptoms listed in Table 4 showed a significant reduction after treatment: sensitivity to light ($p = 0.03$), eyes gritty ($p < 0.0001$), burning sensation ($p = 0.004$) and blurred vision ($p = 0.008$). With regard to the everyday visual tasks examined here, the effect of MGD was reduced post-treatment as shown in Table 5, including the effect on reading, night driving, using a computer and watching television (all $p < 0.0001$).

The effect of environmental factors was shown to be significantly reduced following treatment, including the symptoms reported in windy, dry and air-conditioned environments (all $p < 0.0001$—see Table 6). Not only was the treatment effective on signs and symptoms of MGD, but participants anecdotally noted some significant lifestyle changes as listed in Figure 1.

DISCUSSION

This is the first study to investigate the longer term effects of topical azithromycin on symptoms of MGD using a 12-month follow-up period after a 4-week treatment regime. Following treatment, there was a statistically significant reduction in MGD grading and an increase in FTBUT. One year post-treatment, the survey showed a significant improvement in symptoms and reduction in required self-treatments. There was also a reduced effect on negative lifestyle impact and for all environmental conditions.

Foulks et al.[10] also showed a significant effect of topical azithromycin on quantitative measures of Meibomian gland function, which was as effective as oral doxycycline. However, hypersensitivity is common with oral doxycycline, as are other side effects such as gastrointestinal upset and ultraviolet sensitivity. Severe hypersensitivity reactions are rare with topical azithromycin, and the systemic issues described above are not listed for this drug.[19] Furthermore, the duration of treatment is much shorter,

TABLE 2 Number and percentage of participants using self-treatment methods for meibomian gland dysfunction (MGD), pre- and post-treatment with topical azithromycin.

Self-treatment method	Pre-treatment	Post-treatment	Significantly less likely to use treatment method after azithromycin therapy?[a]
Lid wipes	Yes; 19 (61.3%)	Yes; 11 (35.5%)	Yes ($p=0.03$)
	No; 12 (38.7%)	No; 20 (64.5%)	
Tear substitutes	Yes; 26 (83.9%)	Yes; 19 (61.3%)	Yes ($p=0.02$)
	No; 5 (16.1%)	No; 12 (38.7%)	
MGD Rx EyeBag®	Yes; 13 (41.9%)	Yes; 9 (29.0%)	No ($p=0.16$)
	No; 18 (58.1%)	No; 22 (71.0%)	

Note: MGD Rx EyeBag® refers to the Blepha Eyebag, a reusable warm compress (laboratoires-thea.com/en/blepha-eyebagr).
[a]McNemar's chi-square test.

TABLE 3 Frequency for self-management of meibomian gland dysfunction (MGD), pre- and post-topical azithromycin treatment.

	Used pre-treatment	Used post-treatment	Significant reduction in frequency of use after azithromycin treatment?[a]
Lid wipes	1; $n=14$ (45.2%)	1; $n=21$ (67.7%)	Yes ($p=0.02$)
	2; $n=6$ (19.4%)	2; $n=7$ (22.6%)	
	3; $n=4$ (12.9%)	3; $n=0$ (0.0%)	
	4; $n=4$ (12.9%)	4; $n=1$ (3.2%)	
	5; $n=3$ (9.7%)	5; $n=2$ (6.5%)	
	Median = 2, IQR 1–3	Median = 1, IQR 1–2	
Tear substitutes	1; $n=5$ (16.1%)	1; $n=12$ (38.7%)	Yes ($p=0.0002$)
	2; $n=5$ (16.1%)	2; $n=11$ (35.5%)	
	3; $n=1$ (3.2%)	3; $n=2$ (6.5%)	
	4; $n=7$ (22.6%)	4; $n=1$ (3.2%)	
	5; $n=13$ (41.9%)	5; $n=5$ (16.1%)	
	Median = 4, IQR 2–5	Median = 2, IQR 1–5	
MGD Rx EyeBag®	1; $n=19$ (61.3%)	1; $n=24$ (77.4%)	Yes ($p=0.03$)
	2; $n=3$ (9.7%)	2; $n=2$ (6.5%)	
	3; $n=2$ (6.5%)	3; $n=2$ (6.5%)	
	4; $n=1$ (3.2%)	4; $n=0$ (0.0%)	
	5; $n=6$ (19.4%)	5; $n=3$ (9.7%)	
	Median = 1, IQR 1–3	Median = 1, IQR 1–1	

Note: Scale 1 = never; 2 = sometimes; 3 = half of the time; 4 = mostly; 5 = always.
[a]Wilcoxon signed rank test. MGD Rx EyeBag® refers to the Blepha Eyebag, a reusable warm compress (laboratories-thea.com/en/blepha-eyebagr).

TABLE 4 Presence of symptoms pre- and post-treatment.

	Pre-treatment	Post-treatment	Significant improvement in symptoms after azithromycin treatment?[a]
Eye(s) feel sensitive to light	Yes; $n=12$ (38.7%)	Yes; $n=7$ (22.6%)	Yes ($p=0.03$)
	No; $n=19$ (61.3%)	No; $n=24$ (77.4%)	
Eye(s) feel gritty	Yes; $n=29$ (93.6%)	Yes; $n=11$ (35.5%)	Yes ($p<0.0001$)
	No; $n=2$ (6.5%)	No; $n=20$ (64.5%)	
Burning sensation in eye(s)	Yes; $n=17$ (54.8%)	Yes; $n=7$ (22.6%)	Yes ($p=0.004$)
	No; $n=14$ (45.2%)	No; $n=24$ (77.4%)	
Blurred vision	Yes; $n=18$ (58.1%)	Yes; $n=11$ (35.5%)	Yes ($p=0.008$)
	No; $n=13$ (41.9%)	No; $n=20$ (64.5%)	

[a]McNemar's chi-square test.

being 1 month compared to 3 months for oral doxycycline. This helps with compliance and the likelihood of completing the treatment.

Other studies have corroborated the results of Foulks et al.[10] For instance, Ozlem and Gulkilik[12] also concluded that topical azithromycin had at least a short-term effect on MGD grading and FTBUT (1 month after treatment). The present study shows a longer effect of at least 1-year post-treatment on MGD signs, symptoms and impact on lifestyle.

Additionally, Reiko and Shima[20] showed that azithromycin eyedrops improved eyelid inflammation, the quality and quantity of the tear film lipid layer and tear film stability. They concluded that azithromycin is a safe and effective treatment for MGD-associated posterior blepharitis. However, these authors also used additional hot compresses, whereas the results presented here

TABLE 5 Effect on symptoms when performing visual tasks pre- and post-topical azithromycin treatment.

	Pre-treatment	Post-treatment	Significant improvement in frequency of symptoms after azithromycin treatment?[a]
Reading	1; $n=4$ (12.9%)	1; $n=16$ (51.6%)	Yes ($p<0.0001$)
	2; $n=6$ (19.4%)	2; $n=8$ (25.8%)	
	3; $n=5$ (16.1%)	3; $n=2$ (6.5%)	
	4; $n=10$ (32.3%)	4; $n=2$ (6.5%)	
	5; $n=6$ (19.4%)	5; $n=3$ (9.7%)	
	Median = 4, IQR 2–4	Median = 1, IQR 1–2	
Night driving	1; $n=12$ (38.7%)	1; $n=19$ (61.3%)	Yes ($p=0.0001$)
	2; $n=1$ (3.2%)	2; $n=7$ (22.6%)	
	3; $n=5$ (16.1%)	3; $n=2$ (6.5%)	
	4; $n=8$ (25.8%)	4; $n=0$ (0.0%)	
	5; $n=5$ (16.1%)	5; $n=3$ (9.7%)	
	Median = 3, IQR 1–4	Median = 1, IQR 1–2	
Using computer	1; $n=5$ (16.1%)	1; $n=17$ (54.8%)	Yes ($p<0.0001$)
	2; $n=5$ (16.1%)	2; $n=6$ (19.4%)	
	3; $n=7$ (22.6%)	3; $n=4$ (12.9%)	
	4; $n=6$ (19.4%)	4; $n=1$ (3.2%)	
	5; $n=8$ (25.8%)	5; $n=3$ (9.7%)	
	Median = 3, IQR 2–5	Median = 1, IQR 1–3	
Watching television	1; $n=6$ (19.4%)	1; $n=18$ (58.1%)	Yes ($p<0.0001$)
	2; $n=6$ (19.4%)	2; $n=7$ (22.6%)	
	3; $n=8$ (25.8%)	3; $n=3$ (9.7%)	
	4; $n=9$ (29.0%)	4; $n=2$ (6.5%)	
	5; $n=2$ (6.5%)	5; $n=1$ (3.2%)	
	Median = 3, IQR 2–4	Median = 1, IQR 1–2	

Note: Symptoms were reported as: 1 = never; 2 = sometimes; 3 = half of the time; 4 = mostly; 5 = always.

[a]Wilcoxon signed rank test.

TABLE 6 Effect of environment on symptoms pre- and post- topical azithromycin treatment.

	Pre-treatment	Post-treatment	Significant improvement in frequency of symptoms after azithromycin treatment?[a]
Windy	1; $n=8$ (25.8%)	1; $n=18$ (58.1%)	Yes ($p<0.0001$)
	2; $n=2$ (6.5%)	2; $n=8$ (25.8%)	
	3; $n=6$ (19.4%)	3; $n=3$ (9.7%)	
	4; $n=10$ (32.3%)	4; $n=2$ (6.5%)	
	5; $n=5$ (16.1%)	5; $n=0$ (0.0%)	
	Median = 3, IQR 1–4	Median = 1, IQR 1–2	
Dry	1; $n=7$ (22.6%)	1; $n=16$ (51.6%)	Yes ($p=0.0001$)
	2; $n=3$ (9.7%)	2; $n=7$ (22.6%)	
	3; $n=8$ (25.8%)	3; $n=7$ (22.6%)	
	4; $n=9$ (29.0%)	4; $n=1$ (3.2%)	
	5; $n=4$ (12.9%)	5; $n=0$ (0.0%)	
	Median = 3, IQR 2–4	Median = 1, IQR 1–3	
Air-conditioned	1; $n=6$ (19.4%)	1; $n=13$ (41.9%)	Yes ($p<0.0001$)
	2; $n=4$ (12.9%)	2; $n=10$ (32.3%)	
	3; $n=6$ (19.4%)	3; $n=5$ (16.1%)	
	4; $n=9$ (29.0%)	4; $n=2$ (6.5%)	
	5; $n=6$ (19.4%)	5; $n=1$ (3.2%)	
	Median = 3 IQR 2–4	Median = 2 IQR 1–3	

Note: Frequency of symptoms was graded as: 1 = never; 2 = sometimes; 3 = half of the time; 4 = mostly; 5 = always.

[a]Wilcoxon signed rank test.

proved successful with azithromycin drops alone for most participants.

Azithromycin effects on MGD signs and symptoms

Azithromycin is known to be an effective antibiotic which will reduce the density of bacteria in the glands. It also has anti-inflammatory properties, reducing pro-inflammatory cytokines. It is theorised that these two properties acting in conjunction explain why it is able to break the cycle of ongoing MGD. Although signs and symptoms were not compared within each individual, as a group there was a statistically significant improvement in both measures, as well as a significant reduction in treatment methods and their frequency of use. There was also a significant reduction in both signs and symptoms. This was similarly observed by Foulks et al.,[10] where the effect on signs and symptoms from topical azithromycin was marginally better than that of oral doxycycline.

The shorter course and reduced side effects compared with oral doxycycline are factors in compliance. It is hypothesised that the strength of comments from participants in the present study was driven by the significant and lasting effect on symptoms. These observations also show how dry eye disease can have a significant impact on lifestyle. It was noted by one participant that the enhanced ocular health also resulted in improved contact lens wear. This is to be expected as Pucker and Tichenor[21] noted that 26% of contact lens users cease lens wear within 1 year due to dry eye disease.

The origin of this study arose from the authors noting a reduced need for recurrent examinations in dry eye patients who were treated with topical azithromycin, compared with their peers who were not receiving this therapy. Further studies are required to confirm this observation and collate data on the economic impact. Walsh and Jones[22] showed that many of the preservatives found in ocular tear substitutes are themselves a source of ocular irritation. While preservative free options are available, they may not be licensed for use by individual health boards. Therefore, having a treatment option that can potentially alleviate the need for ongoing ocular tear substitutes has the potential to reduce ocular surface disease.

Participant evaluation of treatment:

"My dry, red, itchy eyes with blurred vison has dragged on for years, 15 months after completion, I have not had any further problems and all issues have stopped"

"Enabled me to wear contact lenses for full day without discomfort or sticky eyes".

"In my case my eyes were quite swollen, red, and painful. Within a couple of days of using the drops the swelling and pain had helped considerably and continued use until the end of course cleared issue up".

"I have a chronic dry eye. The treatment alleviated the painful symptoms and made the after care less onerous".

"My dry eyes were affecting my mental health and hindered me as a teacher. Now my life is completely different".

FIGURE 1 Participant free-response evaluations following treatment with topical azithromycin.

Strengths and limitations

This was a practice-based study, and therefore, the objective tests adopted were representative of those most commonly used by optometrists in a standard examination. All objective measurements were made by one experienced examiner for consistency. Selection bias was minimised by only treating participants who had unsuccessfully tried tear substitutes, lid hygiene and/or warm compresses. The participant survey was completed post-treatment, which can induce judgemental bias and no control group was included for comparison. However, the reduced symptoms were supported by significant improvements in objective measures of MGD. Furthermore, the symptom questionnaire was administered 1 year after treatment, indicating the long-term effect of topical azithromycin. The length of time between treatment and survey reduces the judgemental bias that potentially was present.

CONCLUSION

This study has shown a significant long-term effect of at least 1 year on the signs and symptoms of MGD with the use of topical azithromycin. To date, this has not yet been shown in previous studies, which only looked at short-term changes. Along with the reduced side effects and a shorter treatment regime, this should lead practitioners to consider using this as one of the first-line pharmacological therapies for MGD. At present, the use of topical azithromycin is off-licence in the UK. However, as an Independent Prescribing Optometrist in the jurisdiction, there is an open formulary and a remit to prescribe off-licence when deemed appropriate. The current investigation was a small-scale, practice-based study using invasive methods to measure the tear break-up time. Nevertheless, a larger randomised controlled study using non-invasive methods could lead to a change in licence for the use of topical azithromycin, and more widespread use of this modality as a first-line treatment for MGD. There is also a potential benefit from the reduced use of tear substitutes on both ocular health and healthcare costs.

AUTHOR CONTRIBUTIONS

Ian Jarvis: Conceptualization (lead); data curation (supporting); formal analysis (equal); investigation (equal); methodology (equal); project administration (lead); writing – original draft (equal); writing – review and editing (equal). **Sara McCullough:** Data curation (lead); formal analysis (equal); investigation (equal); methodology (equal); writing – original draft (equal); writing – review and editing (equal). **John Jarvis:** Data curation (supporting); formal analysis (equal); methodology (equal); writing – original draft (equal); writing – review and editing (equal).

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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