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Spectacle prescriptions review to determine prevalence of ametropia and coverage of frequent replacement soft toric contact lenses

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ABSTRACT

Purpose: To determine the prevalence of ametropia and astigmatism in a clinic population and to estimate the coverage of frequent replacement soft toric lenses.

Methods: A review of patient files was conducted at three clinical sites. Prescription data collected between January 2014 and March 2017 in a patient cohort 14 to 70 years of age inclusive were analyzed to determine prevalence of ametropia and astigmatism. The percent coverage of frequent replacement soft toric contact lenses has further been estimated using different ranges for sphere, cylinder and axis availability.

Results: In total 101,973 patients were included in the analysis of which 69.5% were considered myopic, 26.9% hyperopic and 3.5% emmetropic as determined by the eye with the larger absolute value of the spherical equivalent refraction. Astigmatism in at least one eye was found in 87.2% of the population, with 37.0% of the patients exhibiting astigmatism of at least −1.00DC in at least one eye. With-the-rule astigmatism was most prevalent in the 14 to 20 year-olds (53.0%), while against-the-rule astigmatism was most prevalent in the 41 to 70 year-olds (50.7%). For astigmatic eyes with a cylinder of at least −0.75DC (n = 83,540; 41% of all eyes), the coverage with toric soft lenses varied greatly depending on parameter availability and ranged between 30.7% (sphere: Plano to −3.00D, cylinder: up to −1.75DC, axes: 90 ± 10° and 180 ± 10°) and 96.4% (sphere: + 6.00D to −10.00D, cylinders: up to −2.75DC, 18 axes).

Conclusion: Currently available frequent replacement soft toric contact lenses provide coverage for up to 96.4% of potential patients.

1. Introduction

Astigmatism is a common form of ametropia and early descriptions date back at least 150 years: “Astigmatism may occur either alone or in connection with any of the refractive or accommodative anomalies; it may exist in one eye only, or in both eyes; and it may be symmetrical or unsymmetrical, equal or unequal, in the two eyes.” [1] Small levels of uncorrected astigmatism may not always result in a significant reduction in visual acuity, however, it has been linked to both ocular discomfort and eye strain with digital device use [2,3]. Some degree of astigmatism is found in more than 73% of the population [4,5], while a cylinder of at least -0.75DC has been reported in up to 45% of people, but the incidence varies greatly with age, race, gender and ametropia [6–9]. Nemeth et al. [4] investigated the magnitude of astigmatism in Hungarian eyes and reported at least -0.50 DC in 74%, at least -1.00DC in 33%, and at least -2.00DC in 7% of their study population. Their findings differ from an Australian population [5], who reported at least -0.75DC in 81%, at least -1.00DC in 19% and at least -3.00DC in 1% of their study population. Young et al. reported that the prevalence of astigmatism of at least -0.75DC in a practice-based population is significantly higher in myopes compared to hyperopes (31.7% vs. 15.7%) [9]. They further reported that the prevalence of with the rule (WTR) and against the rule (ATR) astigmatism is similar (32.9% vs. 29.1%) [9].

Soft toric contact lenses were approved by the FDA in 1976 and are frequently fitted to astigmatic patients, accounting for approximately 26% of all contemporary contact lens fits [10]. Frequent replacement lenses in either hydrogel or silicone hydrogel materials primarily cover the most prevalent astigmatic prescriptions and the available prescriptions vary widely between manufacturers and lens types. In order

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to manage a cost-effective stock of toric lenses, prescriptions for moderate to high hyperopia, high myopia, oblique axes or higher cylinder prescriptions are sometimes omitted. This is particularly true for daily disposable toric lenses. Apart from custom order lenses, soft toric lenses replaced on a bi-weekly or monthly schedule currently provide the broadest prescription spectrum. To cover a spherical prescription range between +6.00D to -9.00D (assuming 0.50D steps above ± 6.00D) only 55 different lens prescriptions, known as stock-keeping units (SKUs), are needed. In contrast, an astigmatic correction over the same spherical range with four cylinder options from -0.75DC to -2.25DC in 10° axis steps (18 axes) requires a total of 3960 SKUs.

Apart from one manuscript [9], there are currently no other peer-reviewed publications on the percent coverage of soft contact lenses in a practice-based population. Prevalence studies typically focus on the level of ametropia and astigmatism in general, but these data are not detailed enough to determine the combinations of sphere, cylinder and axis, in order to predict how many patients can be fitted with a certain contact lens prescription range [7,11]. Young et al. [9] estimated the current coverage for potential contact lens patients with toric prescriptions by analyzing clinic data from a UK optical retail chain (11,624 patients). They estimated 90% coverage in a power range from +6.00D to -9.00D using three cylinders and 18 axes. However, more recently a number of lens manufacturers have broadened their ranges by adding a higher cylinder correction of -2.25DC, and for some lens types -2.75DC, but how this would impact the coverage of potential contact lens wearers is unclear. Therefore, the purpose of this manuscript was to firstly determine the prevalence of astigmatism and subsequently the potential coverage of contemporary soft toric contact lenses, in a large practice-based population.

2. Methods

Ethics clearance was obtained for this data review from the research ethics committee at the University of Waterloo, Canada. Three eye care institutions provided de-identified spectacle prescription data from their clinic population for analysis: Eye Care Center with multiple locations in Alabama (United States), a large Optometry office in Hereford (United Kingdom), and the School of Optometry & Vision Science in Waterloo (Canada). All available patient prescription records within the practice database collected between January 2014 and March 2017 in a patient population 14 to 70 years of age inclusive were analyzed. For patients who had multiple records during this time period, only the most current spectacle prescription information was considered. Overall prevalence data are presented using the patient's spectacle prescription by dividing the patient pool into three different age groups: 14–20 years, 21–40 years and 41–70 years (Table 2). The eye with the larger absolute value of measured spherical equivalent refraction was used to categorize each patient's refractive state (myopic, hyperopic, and emmetropic). For emmetropic patients, both eyes had a spherical equivalent of 0.00D. The distribution of ametropia has further been calculated for patients with a low, medium, and high cylinder and is presented as an overall count and in percent (Fig. 1A, B, Table 3).

For the toric lens coverage calculation, vertex-corrected contact lens prescriptions (each meridian was converted independently) were calculated for a 12 mm back vertex distance and rounded to the nearest 0.25D step. Patients or eyes were categorized to be myopic, hyperopic or emmetropic according to the spherical component of their prescription, rather than the spherical equivalent. This method was chosen to accommodate contact lens prescription availability. This is highly relevant, as is seen with the example of an eye with a prescription of +0.50/–2.50DC x180. The spherical equivalent would be -0.75D and the eye could be considered myopic. However, a hyperopic contact lens (+0.50D) with a negative cylinder (-2.25DC x180) would be fitted clinically. Thus, this eye was treated in this manuscript as being hyperopic.

The cylinder axis was rounded to the nearest 10° step and axes midway between steps (e.g. 15 or 105 degrees) were rounded to the horizontal or vertical meridian, whichever was closer. Oblique axes of 45 and 135 degrees were moved clockwise in the left eye and anticlockwise in the right eye, as suggested by Young et al [9]. The distribution of astigmatism among all astigmatic patients with a cylinder in at least one eye, and for all toric eyes, has been calculated for a cylinder range -0.25DC up to larger than -3.50DC in 0.25DC steps (Table 4).

To determine patient coverage with commercially available frequent replacement soft toric lenses all patient eyes with a vertex corrected cylinder of at least -0.75DC were included. Manufacturer's fitting guides were reviewed and applied, as described in Table 1. Commonly, toric soft lenses available up to -1.75DC are recommended for spectacle cylinders up to -2.50DC, contact lens cylinders of -2.25DC are recommended to cover spectacle cylinders up to -3.00DC and contact lens cylinders of -2.75DC cover spectacle cylinders up to -3.50DC [12,13].

Soft toric contact lens prescriptions with different spherical ranges up to +6.00D and -10.00D, cylinder ranges from -0.75DC to -2.75DC and axis steps for horizontal and vertical meridians including ± 10, ± 20, ± 30 degrees and all axes in 10° steps (18 axes) have been chosen for the analysis (Figs. 3–5).

Manufacturers typically suggest the range of spectacle cylinder powers that can be fitted with each contact lens cylinder power. These ranges were used to determine the percentage of eyes that can be fitted with toric lens cylinders of up to -1.75DC, up to -2.25DC and up to -2.75DC respectively (Table 5) [12,13]. All eyes with a spectacle cylinder of at least -0.75DC after vertex correction were included. As an example, all eyes with a spectacle cylinder ranging from -0.75DC to -2.50DC were included to determine the percent coverage with toric lenses up to -1.75DC.

Counts and percentages were used to describe the study data. Since the purpose of the study was to present an overview of the prevalence of astigmatic population, statements on comparisons between groups are intended to allow for easier interpretation of the data and are not based on inferential statistical analysis.

3. Results

3.1. Study population

The study population consisted of 101,973 eligible patients, including 59,631 female (58%) and 42,342 (42%) male patients. The majority of patients came from the US (93%), followed by the UK (6%) and Canada (1%). Patients were grouped according to their age (Table 2) and further divided with respect to their prescription (myopes, hyperopes, emmetropes and astigmats). The percentage of astigmatic patients with a spectacle cylinder in both eyes of up to -2.50DC was very similar for the data from North America (US and Canada) and the UK, indicating 94.8% and 94.6% respectively. The data are therefore presented for the combined patient pool. In all age groups, more than 50% of patients were found to be myopic, with the largest proportion of myopes (84%) found in the 21–40 year group. Emmetropes accounted for no more than 4% in each age group. The overall proportion of astigmatic patients was 87.2%, with a slight increase seen with age (Table 2).

3.2. Ametropia and astigmatism

The distribution of ametropia and astigmatism is shown in Fig. 1A, 1B and Table 3. The eye with the higher astigmatism was used to categorize the patient in one of three cylinder groups (cylinder up to -0.75DC, cylinder -1.00DC to -2.50DC and cylinder -2.75DC or higher). The majority of patients (63%) had a low cylinder of up to -0.75DC, (range 54.7%–92.6%) across the different age groups and ametropia. A cylinder of -2.75DC or higher was found in less than 6% of each group.