LITERATURE REVIEW

Comparison of Rigid Gas Permeable and Toric Soft Lens for Correcting Astigmatism

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ABSTRACT

Background: To compare visual acuity correction of astigmatism and comfort between toric soft contact lens and rigid gas permeable. Thus, ophthalmologists will less reluctantly propose contact lenses for the patients with astigmatism, and maximize the potential advantages of contact lenses for the wearer.
Methods: Literature review of all prospective and retrospective studies which reported management of astigmatism with rigid gas permeable of toric soft contact lenses. The articles were divided into characteristics and outcomes. Outcomes reviewd were visual acuity, lens fit characteristics, corneal staining, and subjective problems.
Results: Lens corrected visual acuity by toric soft lens showed variation, which 3 studies reported a few amount of visual loss from spectacles corrected. Meanwhile other studies reported better toric soft lens corrected visual acuity than spectacles. In RGP group, four studies reported better or the same visual acuity with spectacles, and only one study showed a few amount of visual loss. Visual clarity and poor comfort were the most frequent subjective problems in toric soft lens group. Meanwhile, dryness and poor comfort were the most frequent subjective problems in RGP group.
Conclusion: RGP is superior than toric soft lens in correcting astigmatism. Meanwhile, toric soft lens provides quick adaptation and comfort.

Keywords: astigmatism, rigid gas permeable, toric soft lens

Refractive error affects a large proportion of the population worldwide, regardless of age, sex, and ethnic group.[1,2] Such refractive errors can be easily diagnosed, measured and remediated to obtain normal vision. Spectacles provide correction of refractive error with excellent solution, which are inexpensive, noninvasive, and effective.[1,3] However, using glasses in daily routine remains a problem for some people, because of the discomfort associated with handling problems. Increasing of contact lens wear for refractive correction is being a replacement of eyeglasses for ametropia.

Astigmatism is a common refractive error affecting 4% to 30% of the population. Asians and Native Americans show a higher prevalence compared with other ethnic groups.[4,5] Previous large study group consisted of 20,000 eyes, reported 45% of corrected eyes had astigmatism higher than 0.75 D, and 2% had astigmatism higher than 3 D.[6] There are several options correcting astigmatism such as spectacles, contact lenses, and refractive surgery. Spectacles are the most commonly used to correct astigmatism. However, since spectacles are attached at a distance from the eye, it can

cause distortion of visual space due to meridional variations in image magnification which may occur with astigmatic spectacle lenses. Since contact lenses fit directly into the eye, the effect of image magnification are minimal and does not result in spatial distortion.[6,7]

Thirty nine percent of people wearing glasses in North America are being corrected for astigmatism. Meanwhile, for those wearing contact lenses, only 18% to 22% wear toric correction, showing that many practitioners tend to mask low levels of astigmatism using spherical equivalence or neglect to propose or to correct higher amount of astigmatism with contact lenses. The reason of this condition is because toric lenses are more difficult to fit and have variable results.[4,6,8]

Rigid gas permeable lenses and toric soft lenses are used to correct astigmatism. Both of them are considered to be more complex to design than for spherical contact lens correction because more parameters must be selected for their fit. Moreover they have variable results and each of it has its own advantages and disadvantages.

MATERIALS AND METHODS

Literature search was conducted through electronic databases providing journal articles that are collected from PubMed, Google Scholar, Clinical Key, and Ophsource.

An initial screening was performed by reviewing abstracts to choose articles that were related to the study purpose from achieved articles based on keywords. The complete studies related to the accepted abstracts were then screened based on the inclusion and exclusion criteria. Inclusion criteria were all studies (prospective or retrospective studies), which reported management of astigmatism with rigid gas permeable or toric soft contact lenses. Restriction for publication date was not performed. Studies were excluded if the full text article could not be accessed.

RESULTS

The characteristics of each reviewed studies are listed in Table 1. All reviewed articles were published from 1992 to 2013 and categorized in the level of evidence II to IV. Five articles were level II, six articles were level III, and four articles were level IV. Total subjects (number of eyes) varied among studies, from 8 to 634. The amount of astigmatism varied among studies, ranged from -0.25 D to -0.75 D. the lowest amount of astigmatism was -0.25 D, studied by Port et al[12], while the highest amount of astigmatism was -7.50 D studied by Brabander et al[13]. There were 10 articles reported about toric

Table 1. Characteristics of study

Study No.	Author	Year	Level of Evidence	Type of Lens	Number of Eyes	Astigmatism Amount		Follow Up (month)
						Range (D)	Mean±SD (D)	
1	Brabander et al[13]	2000	II	Toric SL	193	-1.00 to -7.50	-2.23±1.19	6
2	Kurna et al[8]	2010	III	Toric SL	47	-0.50 to -2.00	N/A	N/A
3	Sulley et al[14]	2013	II	Toric SL	396	-0.75 to -3.00	N/A	1
4	Young et al[15]	2009	II	Toric SL	20	-0.75 to -2.50	N/A	N/A
5	Michaud et al[4]	2009	III	Toric SL	38	N/A	-3.62±1.87	1
6	Chamberlain et al[16]	2011	II	Toric SL	68	-1.00 t -1.50	N/A	N/A
7	Wong et al[17]	2002	IV	Toric SL	41	-0.75 to -2.50	-1.12±0.49	N/A
8	Zikos et al[18]	2007	IV	Toric SL	40	-0.75 to -2.25	N/A	N/A
9	Lipson et al[19]	2007	II	Toric SL	100	-0.75 to -3.50	-1.05±0.48	1
10	Cho et al[20]	2011	IV	Toric SL	68	-0.75 to -1.25	-1.01±0.20	1
11	Fonn et al[21]	1995	III	RGP	32	N/A	-0.50±0.36	6
12	Michaud et al[4]	2009	III	RGP	38	N/A	-3.62±1.87	1
13	Hong et al[10]	2001	IV	RGP	8	-0.50 to -1.00	N/A	N/A
14	Gleason et al[22]	2003	III	RGP	634	-0.70 to -4.75	N/A	12
15	Port et al[12]	1992	III	RGP	112	-0.25 to -3.00	N/A	12

Toric SL: toric soft lens; RGP: rigid gas permeable; D: diopter; N/A: not available

Table 2. Lens corrected visual acuity

Study No	Author	Subject (eye)	Visual Acuity
Toric Soft Lens			
1	Brabander et al[13]	193	89% within 1 line BCVA, 51% better than BCVA
2	Kurna et al[8]	47	90% <1 line loss from BCVA, 100% 2 lines loss from BCVA
3	Sulley et al[14]	396	Mean: half letter loss from BCVA
5	Michaud et al[4]	38	Mean: half letter loss from BCVA
6	Chamberlain et al[16]	68	100% 1 line loss from BCVA
7	Wong et al[17]	41	83.3% within 1 line or better than BCVA
RGP			
11	Fonn et al[21]	32	100% within 1 line or better than BCVA
12	Michaud et al[4]	38	Mean: gain 1 letter better than BCVA
13	Hong et al[10]	8	100% within 1 line or better than BCVA
14	Gleason et al[22]	634	94.7% better than BCVA
15	Port et al[12]	112	Mean: less than 2 letters loss from BCVA

Toric SL: Toric soft lens; RGP: rigid gas permeable; BCVA: best corrected visual acuity by spectacles

Table 3. Lens fit characteristics

Study No	Author	Subjects (eye)	Good Fit	Stability	Rotation
Toric Soft Lens					
1	Brabander et al[13]	193	92%	<10° (95.5%)	<10° (94.5%)
3	Sulley et al[14]	396	N/A	N/A	<10° (96%)
4	Young et al[15]	20	N/A	<5° (100%)	11.4 to 37.4°
5	Michaud et al[4]	38	N/A	<15° (100%)	<10° (100%)
6	Chamberlain et al[16]	68	N/A	<10° (100%)	<10° (100%)
7	Wong et al[17]	41	58.6%	N/A	<20° (76.5%)
8	Zikos et al[18]	40	N/A	N/A	<10° (100%)

N/A: not available

soft lens, 5 articles reported RGP, and 1 article reported outcome of both toric soft lens and RGP, therefore mentioned repeatedly in the Table 1.[4]

Lens corrected visual acuity by toric soft lens and RGP showed in Table 2. Lens corrected visual acuity by toric soft lens group showed variation, which 3 studies by Kurna et al[8], Michaud et al[4], and Chamberlain et al[16] reported a few amount of visual loss from spectacles corrected. Meanwhile, study by Brabander et al[13], Sulley et al[14], and Wong et al[17] reported better toric soft lens corrected visual acuity than spectacles. In RGP group, 4 studies by Fonn et al[21], Michaud et al[4], Hong et al[10], and Gleason et al[22] reported better or the same visual acuity with spectacles, and only 1 study by Port et al[12] showed a few amount of visual loss.

Toric soft lens fit characteristics were listed on Table 3. Brabander et al[13] reported a high percentage of good fit among the subjects, which showed 92% of the subjects, while Wong et al[17] reported only 58.6% showed a good fit of toric soft lens. Stability of toric soft lens was reported by four studies (Barbander et al[13], Young et al[15], Michaud et al[4], and Chamberlain et al[16]). Despite different cut off point among these studies, they overall showed high percentage of good stability, which was witihin 15 degrees. Most of the studies in toric soft lens group showed the rotation was less than 20 degrees, except study by Young et al[15] which showed quite a large rotation up to 37.4 degrees.

Table 4. Corneal staining

Study No	Author	Subjects (eye)	Corneal Staining
Toric Soft Lens			
3	Sulley et al[14]	396	26%
9	Lipson et al[19]	100	12%
RGP (Rigid Gas Permeable)			
11	Fonn et al[21]	32	100%
14	Gleason et al[22]	634	8.5%

There were only two studies each group of toric soft lens and RGP reported

Table 5. Subjective problems associated with contact lens wear

Study No	Author	Subjects (eye)	Dryness	Intolerance/Poor Comfort	Visual Problems	Lens Fit/Rotation
Toric						
1	Brabander et al[13]	193	1.9%	3.8%	5.7%	1.9%
3	Sulley et al[14]	396	13%	18%	11%	4%
RGP						
14	Gleason et al[22]	634	8.7%	3.8%	5.8%	N/A
15	Port et al[12]	112	N/A	12.5%	N/A	3.5%

RGP: rigid gas permeable; N/A: not available

corneal staining (Table 4). On RGP group, Fonn et al reported all of the subjects showed corneal staining, meanwhile only 4.7% reported by Gleason. Toric soft lens group showed less corneal staining than RGP.[21,22]

Table 5 showed the percentage of patients' subjective symptoms in toric soft lens and RGP. Not all the studies reported the subjective problems. In toric soft lens group, study by Brabander et al showed visual problems was the most frequent subjective problems. Meanwhile, study by Sulley showed intolerance or poor comfort was the most frequent. From RGP group, dryness and intolerance or poor comfort were the most frequent subjective problems.

DISCUSSION

Significant visual and functional influence of uncorrected astigmatism emphasizes its clinical importance, and underline the need for its correction. Astigmatic refractive errors give rise to decrease in distance and near visual performance. Several studies showed that even relatively low amounts of astigmatism may cause reductions in visual performance. Study by Atchinson et al[23] reported that on average 0.28±0.12 D of induced cylindrical power was needed for subjects to have a reduction in clarity of a 0.1 logMAR line of letters. Many studies reported that the higher magnitudes of astigmatism, the greater reduction in visual performance. Most studies showed approximately linear declines in distance visual acuity with increasing cylindrical power, with approximately 1-2 lines of logMAR distance visual acuity reduction observed per diopter of induced cylinder.[7]

Since contact lenses fit directly on the eye, their effects on imag magnification are minimal, which means the correction of astigmatism with contact lens does not cause the same spatial distortions that can occur with astigmatic spectacle corrections. Nonetheless, the need for accurate alignment of toric contact lens axis creates a challenge. Misalignment between the toric contact lens and the ocular astigmatism can result in significant residuak astigmatism.[7]

The results in this literature review shows that the most of studies from RGP group reported better lens corrected visual acuity than spectacles. These results were similiar with study by Jupiter et al[24] which showed patients with 20/25 – 20/30 spectacle visual acuity achieved one line improvement, patients with 20/40 spectacle visual acuity achieved two lines improvement, patients with 20/50 – 20/200 spectacle visual acuity achieved four lines average improvement, and patients with spectacle visual acuity of 200/400 achieved six lines average improvement.

The valuable optical outcome of spherical RGP is that the tear fluid lens that forms between the lens and cornea has a shape at corneal surface which is equal to the cornea. Since the refractive index of the tears (n=1.336) is similiar to the cornea (n=1.376), at the tear to cornea interface, the refractive error at this surface is reduced by 89% compared to that in the air, therefore the amount of astigmatism at this surface is reduced.[7,25]

A spherical contact lens used for astigmatism less than 0.75 D cylinder result in a 21-74% increase in the contact lens

surface cylindrical power compared to the original corneal surface power, whereas a spherical contact lens fitted into a toric cornea result in 89% increase in corneal cylindric component. Meanwhile, toric soft contact lens applied on toric cornea result in 34-38% decrease in corneal cylindric diopters.[8] Different from RGP, soft lenses wrap almost completely to the underlying cornea and therefore creates tear fluid lens that has minimal optical power. Since the lens has a higher refractive index than cornea, the amount of refractive astigmatism may also increase if the lens wraps completely to the cornea. Partial flexure of toric soft contact lens due to different meridians might result in minus tear formation and residual refractive astigmatism.[7,8]

Any type of contact lens proposes a particular degree of rotation which causes misalignment induced by many factors such as eyelids, palpebral anatomy, or the type of refractive error. This misalignment represents a critical component of toric soft lens fit, especially with higher amounts of astigmatism. Besides lens rotation, poor fitting and defective lens may lead to reduced vision. Therefore, some patients may require re-fitting with different toric lens design.[26]

A good and successful les fitting typically shows that subjects will continue to wear lenses since it provides stable vision and comfort. In this literature review, study by Wong et al[17] indicated the success rate of lens fit was not so high, only about 60%. The main reason for the poor lens fit was that the lens were too loose. There were significant correlations between corneal curvatures with the degree of loosens of lens. This suggests that the smaller of corneal radius, the looser the lens, and vice versa. Since study by Wong et al[17] was conducted in Hong Kong, and the subjects were Hong Kong Chinese, the result was different from other study by Brabander et al[13], which showed high percentage, 92% of good fit. It was reported that Hong Kong, Chinese has steeper cornea than Caucasian. Therefore, it showed more loose fit in study by Wong et al[17].

There are some subjective problems related to contact lenses. The most common subjective problem to RGP wearers is ocular discomfort. Wearing RGP for the first time often gives initial ocular discomfort, whereas toric soft lens needs shorter adaptation periode.[6,29] Soft lens is more comfortable because of the inherent flexibility of materials, resulting in greater initial comfort and shorter adaptation time. Clinical management strategies and modification to lens design of RGP have been suggested to improve comfort, but these results have not been generally successful.[21] However, once patients have adapted to wear RGP, there is no significant difference in the frequency of ocular pain between RGP and toric soft lens.[29]

In contrast to RGP, which provides a good even better visual acuity than spectacles correction, toric soft lens shows variable visual acuity caused by lens rotation as one of the predominantly subjective problems.[6,13,29] However, the success rate for subjects wearing toric soft lens compared to 10 years ago was increasing from 69-94%. This improvement of success rate might be due to improvements in toric soft lens design and materials over the past decades.[14]

CONCLUSION

The most prominent advantages of RGP lenses are clear and stable vision in correcting astigmatism. RGP is superior than toric soft lens and spectacles in correcting astigmatism. Meanwhile, toric soft lens provides quick adaptation and comfort. Variable visual acuity caused by lens rotation is the most significant disadvantage of toric soft lens. Manufacturers continue imrpving lens design and material to provide visual clarity and stability, as well as comfort. The first choice of contact lens type to correct astigmatism is dependent on the patients' need, whether it is the clarity and stable visual acuity or the comfort.

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