12

Non-Surgical Treatment of Astigmatism

Luciane B. Moreira
Ophthalmology Department, Federal University of Paraná, Curitiba
Brazil

1. Introduction

People with astigmatism have several options available to regain clear vision. They include eyeglasses, contact lenses, orthokeratology and refractive surgery procedures. In this chapter, we will talk about non-surgical treatment only.

2. Eyeglasses

Eyeglasses are a choice for correction for people with regular astigmatism and it doesn't improve vision for irregular astigmatism. They will contain a cylindrical lens prescription for the astigmatism in a specific meridian of the lens which designates the axis of the lens power. Myopia or hyperopia can be associated to astigmatism. Generally, a single vision lens is prescribed so as to provide clear vision at all distances. However, for patients over the age of 40 who have presbyopia, a bifocal or progressive addition lens may be needed in order to focus effectively for near vision work.

A wide variety of lens-types and frame designs are now available for patients of all ages. Eyeglasses are no longer just a medical device that provides needed vision correction, but also a means of enhancing appearance. However, any astigmatism correction numerically higher than a cylinder +1.50 or -2.50 should warrant special consideration of lenses and frames.[1]

Some consideration must be made with the intention of obtaining the best adaptation of the patient to their eyeglasses. A good frame should be lightweight, strong, fit comfortably and suit the wearer's sense of style. Over-sized lenses or much curved frames need to be avoided because they can induce distortion in the periphery of the lens. Eyeglasses with small scaffoldings have a minor possibility of producing alterations in the periphery of the lens. The lesser the distance-vertex, the less will be the disparity in the magnification of the image as it enters the meridians of the astigmatism. The use of negative cylindrical lenses for this sends information to locate the correction of the astigmatism in the posterior part of the lens and consequently next to the ocular globe.[2]

The design of the lens influences the adaptation of the eyeglasses. The lenses of spectacles for correcting astigmatism should have a toric or cylindrical surface in order to give a single focal point in the retina. The thickness of the lens is not the same across its surface. This difference in thickness is increased due to the strength of the astigmatism.[3]

Aspheric lenses are not like conventional lenses in that they do not have a spherical front curvature but instead have differing degrees of curvature. This allows wearers to see clearly whether they are looking directly ahead or to either side. Aspheric lenses can also be combined with a high index material so as to produce extremely thin lenses which provide the same great vision improvement.(1)

Lens material is also important. In general, lenses are made from three materials: plastic, glass, and polycarbonate.(3) Glass is still used for lenses and it is scratch resistant, but it is also heavy and breakable. Polycarbonate and Trivex lenses are designed for high impact resistance and are ideal for occupational hazards, children and athletes. They provide the best eye protection. Plastic is the most used material for lenses. The ones made of high index resin are thin, lightweight, provide good optical quality and do not magnify the eyes as with the others. The term 'Index of refraction' is used to describe the speed at which light travels through a material: a higher index results in thinner lenses.

The lenses of eye glasses can also be upgraded with scratch protectant, anti-reflective, UV-protectants, colour tints, or photochromics. A scratch protectant coating helps the lenses become more resistant against most abrasions. A UV coating helps to reduce the amount of UV rays that enter the eyes by blocking it through the lens. Anti-reflective lenses diminish glare and reflections, and allow people to see your eyes without any problem. They are designed to lighten up the tint when in the shade and darken the tint when in direct sunlight. Polarised lenses are like sunglasses in that they are tinted with a polarisation filter and they block vertical light from placing stress on the eyes. They are good for outdoor activities where the sun will be glaring down.(3)

Doctors should instruct patients about the best glasses for their needs, checking the history and the eye exam of each one. The ideal method is to prescribe the spectacles after eyeglass trials, giving the patients the opportunity to see how they feel in the situations that are common in their everyday life. Often, the physician will try to give the best monocular correction at the refractor to their patients; however, when the patient uses the eyeglasses, with both eyes open, they will not obtain much comfort and will sometimes feel dizzy and get a headache. Ultimately, one needs to take into consideration the binocular vision, the differences between the eyes, the interpupillary distance and the pantoscopic angle of the scaffolding.(4) (figure 1).

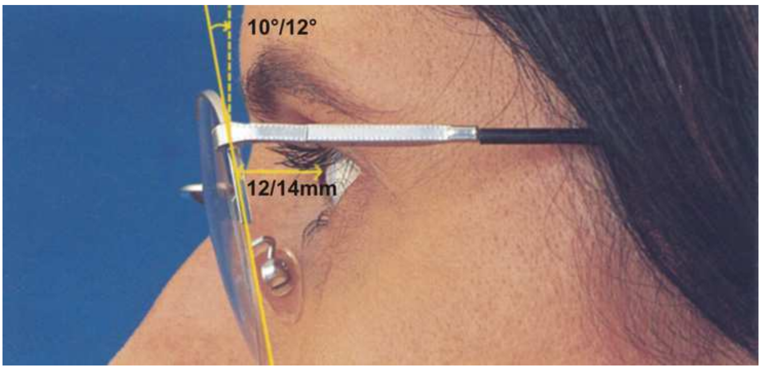


Fig. 1. Pantoscopic angle of glasses.(4)

3. Contact lenses

For some individuals, contact lenses can offer better vision than eyeglasses. They can be used for people with regular and irregular astigmatism, such as keratoconus. They may provide clearer vision and a wider field of view. However, since contact lenses are worn directly on the eyes, they require regular cleaning and care to safeguard eye health[5]

Contact lenses are the first choice for difficult cases such as corneal ecstasies (e.g. keratoconus, keratoglobus and pellucid marginal degeneration). For these cases, there are special lenses with a variety of designs. In this current chapter we will focus only on regular astigmatisms, since to address this kind of adaptation would require a whole chapter to itself.

Almost everybody has the option of using contact lenses. Before initiating any contact lens fitting, it is important to evaluate the patient's motivation, ocular needs, and ocular and medical history. There are four principal indications for contact lens fitting: 1) optical indications (myopia, hyperopia, astigmatism and presbyopia); 2) medical indications (keratoconus, irregular astigmatism, corneal opacification, anisometropia, unilateral aphakia, nystagmus, after refractive surgery or keratoplasty); 3) cosmetic or prosthetic indication to hide imperfections of the eye; 4) therapeutic indications for corneal abrasion.[4]

The contraindications are generally relative, and they will depend upon the criteria of the ophthalmologist's evaluation. Unmotivated patient; poor personal hygiene; inability to follow directions of lens maintenance and handling; inability to understand the risks associated with contact lens use; allergies that affect the eye; immunosuppressed patients, diabetic patients, and alcoholics have a large risk of complications; any effective eye disease affecting the cornea, the conjunctiva and lids as, for example, with inflammations, infections, dry eye, lagophthalmos and glaucoma; moreover, psychological intolerance can be a contraindication for contact lenses use.[4]

Contact lens can be classified by the nature of the material, by their design or by their wearing and replacement schedule, as will seen. A well-made clinical history, along with a complete ophthalmological examination and the patient's needs, determines whether contact lenses are appropriate for each patient[5]

As to the nature of the material of the lens, it can be hard, soft or hybrid. Hard lenses can be non-gas permeable or gas permeable. Polymethylmethacrylate (PMMA) is the polymer from which hard non-gas permeables are made. The disadvantage with this is a lack of gas permeability. The rigid gas permeable lenses (RGP) permit the passage of oxygen and carbon dioxide gas but they contain no water. The general categories of gas permeable polymers are: cellulose acetate butyrate, pure silicone, silicone acrylate and fluorocarbonate. The soft lenses can be hydrogel or silicone hydrogel, both of which have a low water-content (less than 50% water) or high water-content (greater than 50% water). The oxygen transmissibility of a hydrogel lens is directly related to its water-content. For the silicone hydrogel, a higher water-content gives more comfort because it diminishes the roughness of the lens.[6]

There are many designs of lenses. In this chapter, the three basic designs that exist will be addressed: spherical (having anterior and posterior spherical surfaces); aspheric (different radii of curvature in the centre and periphery, simulating the structure of the cornea); and toric (two principal meridians having different radii of curvature; this may be the anterior or posterior surfaces of the lenses or both).[6] Other designs, such as multi-curvature, reverse curve, progressive and bifocal, are related to other refractive errors besides astigmatism and will not be considered here.

The wearing schedule can be: 1) continuous wear (overnight lenses – utilised both during waking and sleeping hours); 2) daily wear (removed daily and not utilised during sleep); 3) flexible wear (removed daily with sporadic sleepers wearing lenses); 4) occasional wear (utilises glasses most of the time and lenses only sometimes, in social activities or sports).[5]

The replacement schedule can be done in three ways: 1) a traditional or conventional way is used when the lens must be replaced annually; 2) the planned replacement way which is nowadays the most used and where the lens needs to be replaced every 15, 30 or 60 days (as defined by the manufacturer's guidelines); 3) disposable lenses, which are probably are the easiest way, because they are immediately discarded after use and do not need maintenance.[5]

Many people ask whether or not RGP lenses are better than hydrogel lenses. The answer to this question depends upon vision accuracy, the comfort and satisfaction of the patient and corneal health. The adaptation of contact lens is different for each person. Generally, to get used to them, the patients need between 1 and 15 days and seem to be easier for those wearing hydrogel lenses than for the ones who wear RGP lenses.

There are many pamphlets to help and teach users how to put on and take off contact lenses, as well as how to store them and keep them clean. However, it is necessary to review these steps at every follow-up visit to the ophthalmologist. The control of contact lens use needs to be done with a specialist every year or else every 6 months, depending on the lens fitting and eye condition.

3.1 Soft contact lenses

Soft contact lenses conform to the shape of the eye. Spherical soft lenses may not be effective in correcting astigmatism;[7] however, toric soft contact lenses can provide a correction for regular astigmatism similar to that of eyeglasses.

A strategy for correcting low degrees of astigmatism with spherical soft lenses is to increase the thickness of the lens. Considering that a thicker or stiffer lens may drape less on the cornea and mask more astigmatism, thicker lenses associated with a special design can give good vision even for irregular astigmatism, such as keratoconus.[5] Another strategy that has been described is the use of lenses with low water-content, since it is not so malleable. However, a low water-content spherical silicone hydrogel material has been shown to have no significant impact on the amount of astigmatism masked.[8]

Visual acuity with a spherical equivalent refraction remained at tolerable limits with the use of spherical contact lenses. Spherical lenses failed to mask corneal toricity during topography, while toric lenses caused central neutralisation and a decrease in corneal cylinder in low and moderate astigmatic eyes.[9]

Soft aspheric contact lenses have been recommended for low astigmatic patients because its design could decrease the level of spherical aberration that is a distortion in image formation. However, clinical studies have reported that non-toric aspheric soft contact lenses did not improve visual acuity significantly when compared to spherical lenses on low astigmats. One reason for why these non-toric lenses do not improve visual acuity is that aspheric soft contact lenses do not correct astigmatism. Additionally, decentration of spherical aberration correction has been shown to induce a coma-like aberration that is another distortion in image formation.(9)

Visual acuity with toric lenses is better than with spherical or aspheric lenses, but initially lens quality and stability was a problem. Nowadays, improved lens designs and the availability of disposable toric contact lenses have resulted in improved health benefits and adaptation(10) Well-fitted hydrogel toric lenses can provide visual acuity and visual performance equivalent to that of spherical RGP lenses.(9)

All the literature agrees that the best way to fit a soft lens is by considering the response to the trial lens fitting. By slit lamp, the physician observes centralisation, the movement of the lens and the lens-cornea relationship. After this, over-refraction has to be done.(5) However, the fitting without trial lens has proven to be an efficient way to prescribe it. 50% to 80% of patients are being fitted successfully with this method for soft toric contact lenses.(11) To fit a soft contact lens, keratometry needs to be done. The base curve of the lens should be approximately 0.6 to 0.8 mm flatter than the average corneal curvature measurement. The lens diameter should be approximately 2.0 mm larger than the horizontal visible iris diameter. The dioptric power of the contact lens should consider the total eye refraction and, if it is greater than 4.00 D, a table for the correction of the vertex distance should be used.(6) It can also be calculated using the following formula:(5)

$$DL = \frac{DA}{1 - d \cdot DA}$$

DL= dioptric power of contact lens.
DA= dioptric power of glasses.
d= vertex distance (which has an average of 12mm).

There remains some disagreement as to when to fit soft toric lenses or else spherical lenses. In practice, high myopia associated with low astigmatism has good acuity with spherical contact lenses; however, low myopes with higher astigmatism had significantly better acuity with toric lenses than with the spherical equivalent.(5)

3.2 Rigid gas permeable lenses

Rigid gas permeable contact lenses maintain their regular shape while on the cornea, and they offer an effective way to compensate for the cornea's irregular shape and improve the vision of persons with astigmatism and other refractive errors.

Gas permeable (GP) lenses could be very acceptable as a viable option for the correction of moderate to severe astigmatism. Patients preferred RGP lenses for visual acuity, especially at near and intermediate distances.(12)

Spherical lenses can compensate for corneal astigmatism up to 3.00 D, although it is known that using them on corneas showing more than 2.00 D of toricity may be inappropriate. Because of this, it is recommended that spherical fittings should be done where the base curve of the lens is equal to the cornea's flattest meridian. The limits of this approach are reached on highly toric corneas where the lens may alter the tear film flow, leading to peripheral desiccation of the cornea (known as 3–9 o'clock staining). This is why a spherical GP lens should be used with extreme caution on a cornea presenting toricity greater than 2.00 D. At present, it is recommended that reliance should be placed on a topographic map of the cornea so as to determine the optimal parameters.(13)

Many methods can be used to find the base curve. That most frequently used by practitioners involves adding 1/3 to 1/4 of the astigmatism measure to K (the flattest meridian of the topographic corneal map).(12) The diameter of the lenses is dependent to the base curve. A great diameter needs a flatter adaptation (table 1). Another tip is to remember is that steeper corneas require lenses with a smaller diameter, and that flatter corneas require lenses with a greater diameter (table 2).(5)

The selected trial lens is placed on the cornea and then, for the evaluation, it is necessary to take into account its comfort, position, movement and stability. The slit lamp evaluates the relationship between the lens and cornea with fluorescein. After the fitting is complete, the over-refraction should be done.

Corneal cylinder	8.6 mm diameter lens	9.2 mm diameter lens	10.2 mm diameter lens
0,00 to 0,50 D	0.25 D STK	On K	0.25 D FTK
0,75 to 1,25 D	0.50 D STK	0,25 D STK	On K
1,50 to 2,00 D	0.75 D STK	0.50 D STK	0.25 D STK
2,25 to 2,75 D	1.00 D STK	0.75 D STK	0.50 D STK
3,00 to 3,50 D	1.25 D STK	1.00 D STK	0.75 D STK

STK = steeper than K / FTK = flatter then K.

Table 1. Base curve lens determination in dependence of lens diameter and topographic corneal cylinder.

Corneal curvature (K)	Lens diameter
38.00 to 42.00 D	9.8 mm or bigger
42.25 to 44.25 D	9.1 to 9.7 mm
44.50 to 50.00 D	9.0 mm or smaller

Table 2. Correlation between corneal curvature flattest meridian of the topographic corneal map (K) and contact lens diameter

Aspheric lenses will always move in the direction of least resistance: this implies that a lens that is restricted along the vertical meridian and which is free along the horizontal meridian will move freely up and down. Conversely, if there is a restriction along the horizontal meridian, the lens will decentre on the nasal or temporal side.(13)

For those wearing RGP contact lenses, only 18% to 22% wear toric correction, suggesting that many practitioners tend to mask astigmatism using spherical equivalence with contact lenses. One reason for this behaviour is that toric gas permeable lenses are more complex to fit and have variable results.[13] Some practitioners will consider toric lenses only if the patient reports unsatisfactory vision in spherical contact lenses or else when the corneal toricity is too great and the fitting has become unstable. Toric lens designs can have different radii of curvature on the front surface, back surface or both of what are known as bitoric lenses.

Back-toric design implies that the back surface of the lens is toric and that its front surface is spherical. This design is most successful when the corneal toricity represents more than two thirds of the refractive astigmatism. Back-toric gas permeable lenses are not designed with prism ballasts; their stabilisation is mainly achieved by the correspondence between the back curves and the corneal toricity. This type of lens is designed with only 66% corneal toricity so as to provide more comfort. However, because of this, the lens will quite certainly rotate in the eye. Clinically, this translates as induced astigmatism that can disturb the visual outcome where it exceeds 0.75 D.[5]

Front-toric designs are designed with the astigmatic correction on the front surface of the lens, leaving the back surface spherical. They are stabilised with a base-down prism and represent the best choice for correcting residual astigmatism, in which the cornea is spherical.[5] Residual astigmatism results from causes other than the shape of the anterior corneal surface and can refer to astigmatism of the posterior cornea surface, lens, and retina.

A bitoric lens offers both surfaces as toric. The back toric surface curves are designed to be aligned with the corneal toricity. Optically speaking, this generates an over-correction of the refractive astigmatism. This is why a front toric surface is needed to compensate the power of the lens. Bi-toric designs are the most popular toric design in RGP contact lens practice, and represent the best choice if corneal toricity is less than or exceeds refractive astigmatism.[5]

For RGP toric lenses, I believe that the most appropriate fitting method is a 4-step approach, known as the two-thirds rule, as seen below.[14]

Step 1. Calculation of corneal toricity: calculate the difference between the two principal meridians of the cornea.

Step 2. Calculation of Base curve 1 (BC-1): the base curve 1 of the lens is determined by dividing the corneal toricity (found in Step 1) into two-thirds and then adding it to the flattest meridian of the cornea.

Step 3. Calculation of base curve 2 (BC-2): the base curve 2 of the lens is determined by flattening the steepest meridian of the cornea according to Remba's rule (Table 3).

Step 4. Calculation of lachrymal lens power and induced astigmatism: this type of astigmatism is induced by the relationship of the back surface of the lens to the cornea, and can be seen doing the over-refraction. If this value is less than 1.00 D, a back-toric design should be ordered because the induced astigmatism is not considered to be a contributing factor affecting visual acuity. At this point, a spherical equivalence is made in order to determine the final power of the back-toric lens. However, if the induced astigmatism value exceeds 1.00 D, a bitoric design should then be selected because the induced astigmatism should be corrected by the addition of the cylinder power to the front-surface of the lens.

Cornea toricity	Flattening of the steepest meridian
2.0 D	0.25 D
3.0 D	0.50 D
4.0 D or more	0.75 D

Table 3. Usable values according to Remba's rule

3.3 Orthokeratology

Orthokeratology (ortho-k) involves the fitting of specially designed rigid contact lenses to reshape the cornea so as to temporarily reduce or eliminate refractive error. The contact lenses are worn for limited periods, such as overnight, and then removed. Persons with mild to moderate myopia and mild astigmatism may be able to temporarily obtain clear vision without lenses for most of their daily activities. Ortho-k does not permanently improve vision, and if the person stops wearing the retainer lenses, the cornea may return to its original condition and vision will be bad again. Ortho-k is a good option for people who need RGP contact lenses to improve vision but who cannot wear common lenses for many reasons.(5) The main reasons for using this kind of lens are: workers in polluted environments or who use chemical products; boxers or water-sports athletes; people who feel discomfort with regular lenses and cannot have refractive surgery; people who have problems with blinking, dry eye, giant papillary conjunctivitis or nystagmus.

Ortho-k makes many changes to the shape of the cornea, as can be seen by topography maps, wave front measurements and pachymetry. The corneal changes induced by reverse-geometry – because of the relatively flat-fitting base curve – create a central flattened zone called the treatment zone, corresponding approximately to the lens back optic zone. Successful ortho-k treatment produces a well-centred regular treatment zone which encompasses the pupil diameter, as revealed by inspection of the difference map on the corneal topographer's data display (figure 2).(15)

The induction of higher-order aberrations with the use of reverse-geometry lenses for overnight ortho-k has been reported.(16) The significant increase in spherical aberrations is seen by the annular zone of mid-peripheral corneal steepening induced by the reverse-geometry lens, and the consequent change in corneal shape from prolate[1] towards oblate[2] asphericity.(16) However, the patients do not complain about these kinds of visual problems. A higher-order aberration is a distortion acquired when light passes through an eye with irregularities. Everyone's eyes have it, but the quantity of it is what determines whether it will affect quality of vision, by giving symptoms as glare, halos, starburst effects and ghost images.

Most of the studies concern ortho-k for myopia of 4.0D and with-the-rule corneal astigmatism of less than 1.50D showing rapid results, with most change after the first night of lens wear and most stability in refractive change after 4 weeks.(17) However, a few studies show good results for irregular astigmatism, such as keratoconus.(15)

Spherical reverse-geometry lenses can be used on toric corneas in order to reduce astigmatism. In a retrospective analysis, Mountford and Pesudovs(18) demonstrated that up

[1] The normal cornea is a prolate surface - steeper in the centre and flatter in the periphery.
[2] The oblate surface is a surface after myopic laser photorefractive keratectomy – flatter in the centre and steeper in the periphery.

to 50% of corneal astigmatism could be reduced with standard reverse-geometry ortho-k lenses, provided that the toricity was with-the-rule and restricted to the central region of the cornea. Corneal toricity reaching from limbus to limbus on the topographic map was less amenable to modification by ortho-k lenses.

Toric ortho-k lenses were created for an oval treatment zone and different meridional topographic changes, with more corneal flattening in the meridian requiring more myopic refractive error correction. Details of corneal topographic changes induced by these different ortho-k lens designs over longer periods of wear are yet to be published.(19)

There is slight regression of effect (about 0.25 to 0.75 D) during the day, and lenses must be periodically worn overnight (from every night to every three to four nights) to retain the effect. No serious adverse events have been reported from published clinical studies, although overnight lens adherence and clinically significant corneal staining in the morning after lens removal appear to be relatively common and have caused some clinical concerns in some studies.(20)

Patient satisfaction with overnight ortho-k has been reported as similar to or better than other popular modalities of contact lens wear. Unlike refractive surgery, if patients fail to achieve a subjectively successful outcome, they can cease lens wear and return to other corrective options, such as spectacles or conventional contact lenses. The corneal changes induced by overnight ortho-k are fully reversible on cessation of lens wear.(20)

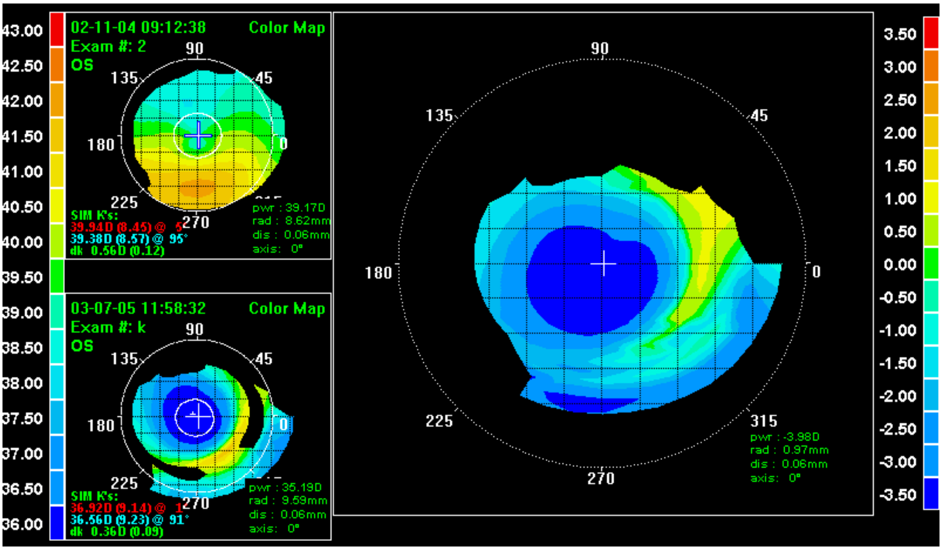


Fig. 2. Topography before and after orthokeratology in a case of irregular astigmatism (keratoconus).(15)

4. Visual stimulation

Brain plasticity in the visual functions of adults has been shown to improve with repetitive practice on specific controlled visual tasks. Through these repetitive practices are initiated neural modifications that lead to an improvement in neuronal efficiency. These neural modifications can enhance image quality by compensating for blurred retinal images due to optical defocus for all the refract errors.(21) It is indicated by those who have good Snellen visual acuity but still have symptoms of ghost images. This commonly happens to people with low astigmatism.

RevitalVision by NeuroVision (NeuroVision Inc., Singapore), based on visual stimulation, have developed a computer programme for amblyopia, post lasik (laser assisted in situ keratomileusis) and post cataract. However, it can be extended for others refractive errors. During training sessions, the user is presented with a series of precise visual tasks consisting of Gabor patches with subtle differences in orientation, size and contrast. Through repetitive practice, the brain is trained to be more efficient and to improve visual processing by improving contrast sensitivity and visual acuity.(22)

Studies showed mean improvements of visual acuity of about 2.0 LogMar, and the contrast sensitivity function also improved at all spatial frequencies. However, the mean refractive error remained unchanged after treatment. Follow-up data for up to 12 months post-treatment showed that the gains were retained.(23) This method has never been proven. The effect is probably related to the memory of the patients, and this would be the reason that the refractive error remains unchanged.

Besides this, it requires more evaluation to see the real value of this kind of stimulation for the treatment of astigmatism.(21-23)

5. Advantages and disadvantages for each correcting method

There are many differences between contact lens and glasses, as can be seen in the chart below, but both need an eye doctor's prescription and periodic evaluation.

Eyeglasses	**Contact Lenses**
The distance between your eye and the lens sometimes creates distortion.	When worn right on the eye it sometimes can blur because of tears.
Glasses correct only regular astigmatism.	Contact lenses can also correct irregular cornea shape that distorts vision.
Glasses can be inconvenient during games and sports.	Contact lenses are a favourite among athletes.
Poor peripheral vision (visual field) because of the frame.	Your entire field of view is in focus.
Eyeglasses can get dirty and decrease vision.	Contact lenses can form deposits on the lens and blur the vision acuity.
Glasses must be sprayed and wiped several times a day.	Contact lenses should be cleaned, disinfected and stored properly after each use.
Periodic need for tightening or other adjustment.	Maintenance and handling of the lens every day.
Sometimes an uncomfortable weight on your face and ears.	Sometimes uncomfortable in the eye as a strange body, dry eye or allergy.
Glasses are fashionable, functional and complement your outfit.	Cosmetic lens may alter the colour of the eye.

Also, there are advantages and disadvantages associated with various types of contact lens, as seen below. All of the contact lenses require visits to the ophthalmologist for follow-up care.

Lens Types	Advantages	Disadvantages
Soft lenses	Very short adaptation period. More comfortable and more difficult to dislodge than RGP lenses.	Maintenance and handling every day. Do not last long comparing to RGP lenses. Vision may not be as sharp as RGP lenses.
Daily wear disposable lenses	Thinner lenses. Require no cleaning. Minimal risk of eye infection if the wearing instructions are followed.	Do not correct all vision problems.
Extended ware disposable lenses	Can usually be worn up to several days without removal (the wearing period is defined by the manufacturer's guidelines). Require no cleaning.	Do not correct all vision problems. Increases risk of complication with night and day wear. Requires regular monitoring and professional care.
Planned replacement lenses	Require simplified cleaning and disinfection. Good for eye health. Available in most prescriptions.	Vision may not be as sharp as RGP lenses. Maintenance and handling every day.
Rigid gas permeable lenses (RGP)	Excellent vision. Easier than the soft lens for maintenance and handling. Correct most vision problems. Durable, with a relatively long life.	Require consistent wear to maintain good vision. Can slip off the centre of the eye more easily than other types. Debris can easily get under the lenses. Longer period to get used to compared to soft lenses.
Ortoceratologia	Worn only at times of sleeping. Eliminates the use of the lens on walking hour. Short adaptation period. Comfortable to wear. Less friction with the lid. Durable, with a long life.	Correct only low astigmatism and low to moderate myopia. Vision may not be as sharp as with other lenses.

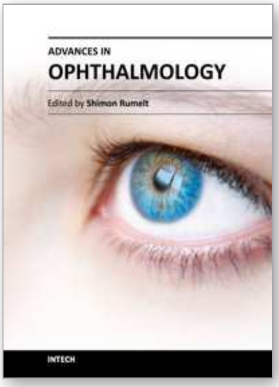
6. Conclusion

Individuals with astigmatism have a wide range of options to correct their vision problems and, together with an eye exam, the selection of the best treatment that meets vision and lifestyle needs must be done.

7. References

[1] Guyton DL. Prescribing cylinders: the problem of distortion. Surv Ophthalmol. 1977 Nov-Dec; 22(3): 177-88.
[2] Moreira ATR. Astigmatismo: atualização continuada – Sociedade Brasileira de Oftalmopediatria. Arq. Bras. Oftalmol. 2001; 64(3): 2712-272.

[3] Stein HA, Freeman MJ, Stenson SM, Kara José N, Coral-Ghanem C, Oliveira PR. Guia CLAO para refração e óculos: um manual para oftalmologistas. Contact Lens Association of Ophthalmologists Inc. (CLAO). Copyright 1999.
[4] Uras R. Optica e refração ocular – coleção de manuais básicos cbo. Cultura Medica, Rio de Janeiro, 2008.
[5] Moreira SB, Moreira H, Moreira LB. Lente de contato. 3° Ed, cultura médica, Rio de Janeiro, 2004.
[6] Mannis MJ, Zadnik K, Coral-Ghanem C, Kara-Jose N. Contact Lens in Ophthalmic Practice. Springer-Verlag, New York, 2004.
[7] Kurna SA, Şengör T, Ün M, Aqui S. Success rates in the correction of astigmatism with toric and spherical soft contact lens fittings clinical ophthalmology 2010: 4 p959-966.
[8] Edmondson L, Edmondson W, Prince R. Masking astigmatism: Ciba focus night and day vs focus monthly. Optom Vis Sci 2003; 80(12): 184.
[9] Berntsen DA, Merchea MM, Richdale K, Mack CJ, Barr JT. FAAO Higher-Order Aberrations when wearing Sphere and Toric Soft Contact Lenses. Optom Vis Sci. 2009 February; 86(2): 115-122.
[10] Morgan PB, Efron SE, Efron N, Hill EA. Inefficacy of aspheric soft contact lenses for the correction of low levels of astigmatism. Optom Vis Sci. 2005; 82(9): 823-828.
[11] Richdale K, Bernsten DA, Mack CJ. Visual acuity with spherical and toric soft lenses in low- to moderate- astigmatic eyes. Optom Vis Sci 2007; 84(10): 969-75.
[12] Giovedi Filho R. Correção do astigmatismo com lentes de contato rígidas: atualização continuada – Sociedade Brasileira de Lentes de contato e córnea – SOBLEC. 2001; 64(5): 485-487.
[13] Michaud, L, Barriault, C, Dionne, A, Karwatsky, P Empirical fitting of soft or rigid gas-permeable contact lenses for the correction of moderate to severe refractive astigmatism: A comparative study Optometry (2009) 80, 375-383.
[14] Michaud L. Understanding and designing toric gas permeable contact lenses: As easy as 1-2-3. Can J Optom 2007; 69(5): 171-81.
[15] Moreira LB. Ortoceratologia nos casos com contra-indicação de cirurgia refrativa por ceratocone incipiente. Universo visual, November 2006.
[16] Hiraoka,T, Matsumoto, Y, Okamoto, F, Yamagushi, T, Hirohara, Y, Mihashi, T, Oshika, T. Corneal higher-order aberrations induced by overnight orthokeratology. *Am J Ophthalmol* 2005; 139: 429–436.
[17] Kang SY, Kim BK, Byun YJ. Sustainability of orthokeratology as demonstrated by corneal topography. Korean Journal of ophthalmology 2007; 21(2): 74-78.
[18] Mountford, J, Pesudovs, K. An analysis of the astigmatic changes induced by accelerated orthokeratology. *Clin Exp Optom* 2002; 85: 284–293.
[19] Baertschi M. Correction of high astigmatism with orthokeratology. Paper presented at the Global Orthokeratology Symposium, Chicago, July 2005.103.
[20] Swarbrick , HA. Orthokeratology review and update *Clin Exp Optom* 2006; 89: 3: 124-43.
[21] Durrie. D. McMinn, P. Computer-based primary visual cortex training for treatment of low myopia and early presbyopia. Trans Am Ophthalmol Soc 2007; 105: 132-140.
[22] http://www.revitalvision.com/doctors/scientificbackground/
[23] Tan, DT and Fong, A. Efficacy of neural vision therapy to enhance contrast sensitivity function and visual acuity in low myopia. J Cataract Refract Surg, 2008. Apr 34(4): 570-7.



Advances in Ophthalmology
Edited by Dr Shimon Rumelt

ISBN 978-953-51-0248-9
Hard cover, 568 pages
Publisher InTech
Published online 07, March, 2012
Published in print edition March, 2012

This book focuses on the different aspects of ophthalmology - the medical science of diagnosis and treatment of eye disorders. Ophthalmology is divided into various clinical subspecialties, such as cornea, cataract, glaucoma, uveitis, retina, neuro-ophthalmology, pediatric ophthalmology, oncology, pathology, and oculoplastics. This book incorporates new developments as well as future perspectives in ophthalmology and is a balanced product between covering a wide range of diseases and expedited publication. It is intended to be the appetizer for other books to follow. Ophthalmologists, researchers, specialists, trainees, and general practitioners with an interest in ophthalmology will find this book interesting and useful.

How to reference
In order to correctly reference this scholarly work, feel free to copy and paste the following:

Luciane B. Moreira (2012). Non-Surgical Treatment of Astigmatism, Advances in Ophthalmology, Dr Shimon Rumelt (Ed.), ISBN: 978-953-51-0248-9, InTech, Available from: http://www.intechopen.com/books/advances-in-ophthalmology/non-surgical-treatment-of-astigmatism

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821