Medical Hypotheses 79 (2012) 368–371

Contents lists available at SciVerse ScienceDirect

Medical Hypotheses

journal homepage: www.elsevier.com/locate/mehy

Correcting corneal astigmatism by reinstating the correct neuromuscular message

John William Yee

NewGen Optical, 4675 Steeles Avenue East, Suite 2D6, Toronto, ON, Canada M1V 4S5

ARTICLE INFO

Article history:
Received 20 March 2012
Accepted 25 May 2012

ABSTRACT

The problem: The spasm of the oblique muscles contributes to astigmatism. The visual cortex interprets the tension of the oblique muscles as an eye that is in near focus mode. It overrides the information generated by depth perception to bring a distant image into focus.
Methodology: A plain contact lens "loosens" the oblique muscles by generating a "contact lens draw". This triggers the visual cortex to reinstate the proper neuromotor message to stimulate the ciliary muscle to relax along certain meridians—which in turn "flattens" the crystalline lens along those meridians to bring a distant aberrant image into focus. The design of a special contact lens to treat simple myopic astigmatism is similar to the design of a contact lens to treat mild myopia as outlined in the paper Correcting Mild Myopia by Means of Orthoculogy.
Results: The treatment takes advantage of the ciliary muscle's natural tendency to compensate for some of the distortion of the cornea prior to ortho C by stimulating the ciliary muscle to amplify the compensation. The correction only takes a few minutes because the ciliary muscle of an astigmatic eye was not compromised.
Conclusion: The correct neuromotor message immediately neutralizes the refractive error due to corneal astigmatism. It stimulates the ciliary muscle to offset the astigmatic cornea by modifying the crystalline lens.

The hypothesis

The neuromuscular message for distant focusing in response to depth perception can be interrupted before it reaches the ciliary muscle if the oblique muscles become excessively tight. The visual cortex receives this interruption as a revised neurosensory message, and it sends a revised neuromotor message—which can contribute to corneal astigmatism.

The degree of refractive error depends on how much the original neuromotor message was altered, and this in turn depends on the state of the oblique muscles [1]. If those muscles are partially tight, it would promote mild astigmatism. And if the oblique muscles are tighter, the original neuromotor message would change more to reflect this. There would be a higher degree of astigmatism.

By relieving the spasm of the oblique muscles by means of orthoculogy (or ortho C), it reinstates the correct neuromotor message for distant focusing. This message stimulates the ciliary muscle to neutralize the effect of astigmatism by modifying the crystalline lens to compensate for the distortion of the cornea.

It only takes a few minutes to correct the refractive error since the function of the ciliary muscle was not compromised by simple myopic astigmatism. Ortho C attempts to take advantage of the ciliary muscle's natural tendency to compensate for some of the distortion of the cornea by stimulating the ciliary muscle to amplify the compensation.

The inference

A common feature of a myopic eye or a compound myopic and astigmatic eye is the spasm of the oblique muscles. The oblique muscles are the pair of muscles that wrap around the upper and lower equator of the eye as illustrated in diagram 1. Their main task is to rotate the eye. But an increase in their tension can also interrupt the proper neuromuscular message whenever there is an attempt to bring a distant image into focus. Being aware that an object is far away is not enough. An excessive tense pair of oblique muscles can overwrite the typical neuromotor response for distant focusing based on depth perception [1].

The revised response is based on the information received: a blur image and the tension of the oblique muscles. The visual cortex interprets these neurosensory messages as an eye that is in near focus mode even if it is attempting to make out a distant image. The revised neuromotor message commands the eye to function differently for distant focusing.

E-mail address: johnwilliamyee@gmail.com

0306-9877/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.mehy.2012.05.039

If the spasm of the oblique muscles can cause the eye to become myopic and astigmatic (which is termed "compound myopic astigmatism"), then it may also be possible for the spasm of those muscles to produce astigmatism that exists by itself instead of in combination with myopia (which is termed "simple astigmatism").

Simple astigmatism is further broken down into simple myopic astigmatism or simple hyperopic astigmatism. To better illustrate the effect a tense pair of oblique muscles have on astigmatism, this paper deals with simple myopic astigmatism.

The proposed treatment for simple myopic astigmatism is similar to how mild myopia is treated—by just relaxing the oblique muscles as explained in: Correcting Mild Myopia by Means of Orthoculogy [1]. In both instances, the spasm of the oblique muscles is not enough to cause the sclera to deviate, but it is sufficient to cause a blur or distorted image.

Although the treatment for simple myopic astigmatism also targets the oblique muscles, the neurological outcome is different. To appreciate the difference, reference is made to the myopic eye as well as the astigmatic eye.

The problem

The visual cortex regards the astigmatic eye to be permanently in near focus mode due to the tension of the oblique muscles. Its failure to bring a distant object into focus means that the object is blur (due to the myopic aspect of simple myopic astigmatism) and aberrant (due to the astigmatic aspect of simple myopic astigmatism).

The blurriness of a distant image is due to one of the focal points that is in front of the retina, and the distortion of that image is due to its separation into two focal points. The two focal points of a simple astigmatic eye are projected by two different curvatures along two major meridians on the anterior surface of the cornea. The disparity between them is usually ninety degrees apart. With simple myopic astigmatism, one focal point rests on the retina, and the other focal point is in front of the retina [2].

When ortho C "loosens" the oblique muscles, the visual cortex regards the eye to be in distant mode. The visual cortex would then take the necessary steps to bring a distant myopic astigmatic image into focus.

The theory behind the treatment

Implication of relieving the spasm of the oblique muscles

Due to the spasm of the oblique muscles, the visual cortex interprets the eye to be in near focus mode when it regards an object that is near or far away [1]. Once ortho C "loosens" the oblique muscles, the visual cortex reinterprets the eye to be in distant focus mode instead of near focus mode when it regards an object far away. By re-establishing the eye in distant focus mode, it attends to both the blur and aberrant aspects of a distant image due to simple myopic astigmatism.

Purpose

The purpose of applying ortho C is to amplify how the ciliary muscle naturally compensates for the distortion of the cornea. Prior to Ortho C, there is often only a partial compensation. When an ortho C lens "loosens" the oblique muscles, the visual cortex activates a complete, or almost complete, compensation—depending on the severity of the corneal astigmatism. It accomplishes this by orchestrating the ciliary muscle to synchronize with a blur image as well as an aberrant image.

Attending to a blur image

The visual cortex attends to the myopic aspect of simple myopic astigmatism by transmitting the proper neuromuscular message for distant focusing to the ciliary muscle once ortho C "loosens" the oblique muscles. The ciliary muscle encircles the perimeter of the crystalline lens and is connected to it by strands. It controls the shape of the crystalline lens. It becomes "flat" for distant focusing, as illustrated in Fig. 1, when the ciliary muscle relaxes; and it assumes a "bulged" shape for near focusing when the ciliary muscle tightens up.

When the ciliary muscle receives the proper message, it "flattens" the crystalline lens along a specific meridian. (If the blur image was due to compound myopic astigmatism instead of simple myopic astigmatism, the visual cortex would "flatten" the crystalline lens uniformly as well as along a specific meridian.)

To determine this meridian, a neuromotor message is also sent to the rectus muscles in response to the astigmatic aspect of simple myopic astigmatism. The rectus muscles are the two pairs of muscles that run across the sides, the top, and the bottom of the eye as illustrated in Fig. 1. Their main task is to turn the eye outward, inward, or up and down. But if their tension is misaligned, they can also induce astigmatism by distorting the cornea [3].

The ciliary muscle would receive one message, and the rectus muscles would receive the other. It is possible to transmit these two messages simultaneously because the oblique muscles distribute them along the common neural pathway, the third cranial nerve or C3, to the ciliary muscle and the rectus muscles.

Attending to an aberrant image

Initially, the visual cortex attempts to rectify the aberrant aspect of simple myopic astigmatism by attending to the misalignment in the tension of the rectus muscles. But those muscles cannot immediately align because their misalignment is not just related to a neurological misinterpretation but also to a muscle deficiency; the vertical rectus muscles offered more slack in compliance to the tension of the oblique muscles (to allow the eye to elongate during prolonged close-up work) than the horizontal rectus muscles [3].

Since three of the four rectus muscles and the ciliary muscle are innervated by the same cranial nerve C3, the ciliary muscle also picks up the attempt to clear up a distant aberrant image. The ciliary muscle assists by manipulating the crystalline lens to neutralize the corneal distortion. A compensation is necessary because the rectus

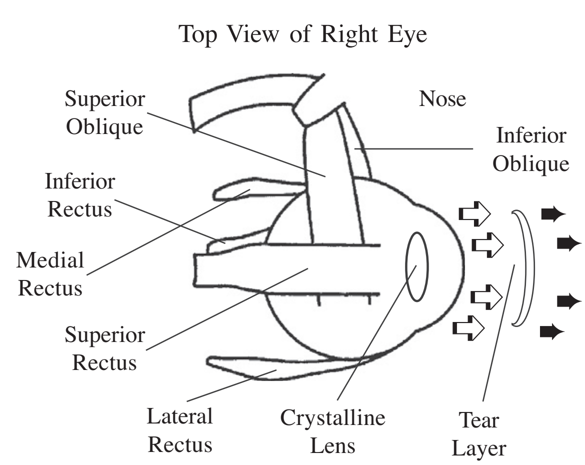

Fig. 1. Top view of right eye.

muscles cannot immediately realign their tension sufficiently to reduce the disparity in corneal curvature. It takes longer to increase the tension of the vertical rectus muscles. The slack contributes to a refractive error by causing the cornea to become too "steep" along that meridian [3].

The common neurological network allows the rectus muscles to map out the proper axis where the adjustment is to be made on the crystalline lens; and this is in addition to the adjustment that takes place when the visual cortex simultaneous attends to the myopic aspect of simple myopic astigmatism. The visual cortex needs to attend to an aberrant image as well as a blur image. Attending to an aberrant image defines which meridian on the crystalline lens to "flatten".

Once the proper meridian is determined, it allows the visual cortex to accurately activate the compensation of the astigmatic cornea by sending a neuromotor message to "flatten" the part of the crystalline lens that offsets the portion of the cornea that is too "steep"—which is usually along the vertical meridian.

If the visual cortex just attended to a blur image and somehow ignored the aberrant aspect of that image, it would "flatten" the crystalline lens uniformly instead of along a specific meridian. This would disturb one of the focal points of a simple astigmatic image that is already on the retina. With the simple myopic astigmatic eye, just one meridian on the cornea is myopic; and ortho C needs to deal with the blurriness of a distant image only along that part of the cornea.

The treatment

Two outcomes

To offset an astigmatic image due to corneal astigmatism, a "contact lens draw" from a slightly "flat" contact lens pulls outward on the cornea as illustrated in diagram 1. The "draw" is transmitted to the sclera, and it tends to expand the middle of the eye. The oblique muscles along this expanded portion tend to "loosen". The visual cortex interprets this message along with a blur image as an eye that is in distant focus mode and generates a neuromotor message to bring it into focus. It produces two outcomes: the tendency for the ciliary muscle to relax along a specific meridian to deal with the myopic aspect, and the tendency for the rectus muscles to become uniformly taut to deal with the astigmatic aspect. These conditions are necessary to reverse an eye from an astigmatic mode to distant mode.

When the correct neuromuscular message stimulates the ciliary muscle and the rectus muscles in this manner after relaxing the oblique muscles, it is not necessarily an implication of how the visual system actually operates to bring a distant image into focus. Ortho C is stimulating an astigmatic eye to compensate for the distortion of the cornea instead of enhancing a normal eye in its function of bringing an image into focus.

Targetting the ciliary muscle

The specifications for a type 1 ortho C lens to treat simple myopic astigmatism are similar to the design of a type 1 ortho C lens to treat mild myopia as outlined in Correcting Mild Myopia by Means of Orthoculogy [1]. The contact lens is designed in such a way that it relieves the spasm of the oblique muscles without "flattening" the sclera (or reducing its shape from front to back). Merely the *tendency* to expand the middle of the eye (and thus the oblique muscles that encircle it) is enough to ease or "loosen" the tightness of the oblique muscles. This generates the proper stimulation to treat corneal astigmatism.

If the sclera was forced to "flatten" with a type 2 ortho C lens, ortho C would not correct the refractive error because it did not attend to the part of the eye that had deviated. A "flatter" type 2 ortho C lens is usually adopted in the treatment of midrange or severe myopia where the sclera as well as the crystalline lens became myopic. It "stretches" the oblique muscles instead of "loosening" it. This allows the proper neuromuscular message to stimulate the rectus muscles to become taut in order to reduce the elongated shape of the sclera [3]. But the sclera does not usually assume a myopic shape in the mild myopic eye [1].

With cases of midrange and severe myopia, it is actually the sclera instead of the entire globe of the eye that is affected. Only the outermost part of the eyeball "shifted" when it became myopic; it is the sclera which defines the shape of the eye [4].

By "loosening" the tension of the oblique muscles of a mild myopic eye instead of "stretching" it, it allows the proper neuromuscular message to stimulate just the ciliary muscle (and thus affect just the crystalline lens). When a focal point from a distant image is close enough to the retina, it triggers a "focal point draw" by "flattening" the crystalline lens to bring the focal point into contact with the retina without having to "shift" the sclera [1].

This adjustment cannot take place prior to ortho C even though a locus of focal points from distant images falls within the proper vicinity in front of the retina. A "contact lens draw" needs to activate the proper neuromuscular message by "loosening" the grip of the oblique muscles. This stimulates the ciliary muscle to relax before a "focal point draw" can take place. A proper "contact lens draw" must be combined with a "focal point draw" before the crystalline lens can "flatten" out to project a proper focus [1].

The design of a type 1 ortho C lens to target just the ciliary muscle of a mild myopic eye (in order to alter only the shape of the crystalline lens for distant focusing) can also be adopted in the treatment of astigmatism. In this case, the crystalline lens does not "flatten" overall. Instead, it only "flattens" along a certain meridian to offset the astigmatic shape of the cornea.

Targetting the rectus muscles

With the mild myopic eye, only the crystalline lens became myopic; but with the simple astigmatic eye, generally only the cornea became astigmatic. It is the misalignment in the tension of the rectus muscles that physically induces "corneal astigmatism". Although "lenticular astigmatism" or the distortion of the crystalline lens, can also contribute to an aberrant image, it is the misalignment in the tension of the rectus muscles that neurologically induces it [3]. Corneal astigmatism is more prevalent than lenticular astigmatism. (The treatment for lenticular astigmatism will be discussed in a future paper.)

With an astigmatic eye, a type 1 lens permits the proper message to increase the tension of the rectus muscles—especially the vertical pair of rectus muscles. It does not increasing it to the point of causing the sclera to "shift", but only to the point of attempting to realign their tension. This occurs at the same time that the visual cortex stimulates the ciliary muscle.

Because the reduction in the disparity between the *tensions* of the two pairs of rectus muscles does not immediately reduce the difference in the curvature of the cornea, the ciliary muscle would have to participate in bringing an astigmatic image into focus. But attending to the misalignment in the tension of the rectus muscles was still necessary to determine the axis where the crystalline lens should be altered. The ciliary muscle assists by becoming relaxed in such a way that it compensates for corneal astigmatism—by "flattening" the crystalline lens along that predetermined meridian. It is comparable to wearing a pair of glasses fitted with an astigmatic lens.

Discussion

Physiological and neurological implications

According to numerous case studies, it is possible, over time, to partially reduce the distortion on the cornea as a result of simple myopic astigmatism. Although any reduction in the misalignment in the tension of the rectus muscles is not immediately reflected in the physical disparity between the horizontal and vertical curvature of the cornea, there is still the tendency for the astigmatic cornea to partially realign in the long term.

The "flexing" of the rectus muscles with the ortho C lens on and the "letting go" after removing it can gradually tone and partially align the rectus muscles for distant focusing. Eventually this is physically reflected on the cornea as a reduction in its aberrant shape (as verified by a keratometer which measures the curvature of the cornea). This merits wearing the ortho C lenses regularly as a preventative means.

It takes longer to reduce the disparity between the horizontal and vertical meridians on the corneal since it is related to a muscle deficiency. It only takes a few minutes to compensate for corneal astigmatism (as verified by performing a before and after test with trial lenses) because it is strictly a neurological function. In the simple astigmatic eye, the ciliary muscle was not compromised. It can immediately modify the crystalline lens once the ciliary muscle receives the proper message from the visual cortex.

Reinforcing the modification

The reduction in the physical distortion of the cornea alleviates the amount of compensation required from the crystalline lens. With cases of severe corneal astigmatism, less effort is required to maintain the correction, and this reinforces the modification.

Conclusion

Treating corneal astigmatism involves reinstating the correct neuromotor message. The eye must be open to allow a "focal point draw" to work in conjunction with a "contact lens draw" before this message can stimulate the ciliary muscle to modify the crystalline lens to offset the astigmatic cornea. The "contact lens draw" by itself does not produce a neurological effect. If the ortho C lens was worn with the eye occluded, nothing would happen. The astigmatic eye would remain symptomatic.

Conflict of interest statement

None declared.

References

[1] Yee J. Correcting mild myopia by means of orthoculogy. Med Hypotheses 2011;76(3):332–5.
[2] Stein HA, Slatt BJ, Stein RM, Freeman MI. Fitting guide for rigid and soft contact lenses. St. Louis, Missouri: Mosby Incorporated; 2002.
[3] Yee JW. Reversing nearsightedness. Toronto, Ontario: University of Toronto Press; 2007.
[4] Kaufman A, Alm A. Adler's physiology of the eye. St. Louis, Missouri: Mosby Incorporated; 2003.