Diagnostic and therapeutic use of prisms

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The study aims to investigate the present use of prisms in ophthalmic settings in patients with binocular vision problems for diagnostic and therapeutic use. The study will also investigate other methods of correction (i. e. surgical and nonsurgical) and diagnosis.

1. Introduction

Prisms are normally grounded and polished transparent materials shaped geometrically and optically. Usually materials include glass and plastic. In optics, prisms are transparent optical elements that refract light whereby two of the flat surfaces must have an angle between them. The angle, position and number of surfaces help define the function and type. Traditionally geometrical shapes are triangular prisms. (Newton Herschel, 2009, Duarte and Piper, 1982)

http://en. wikipedia. org/wiki/File: Dispersion_prism. jpg File: Light dispersion conceptual waves. gif

Figure 1. A triangular prism, dispersing light; waves shown to illustrate the differing wavelengths of light (2008)

Prisms work by the principle that light changes speed as it moves from one medium to another; for example, from air into the glass of the prism. The speed change causes the light to be refracted to enter the new medium at a different angle, according to Huygens principle; which is in brief a method of analysis applied to problems of wave propagation. According to Snell’s law; the degree of the light’s path bending depends on the angle of incident the beam of light makes with the surface, and on the difference between the refractive indices of the two media. The refractive index of many materials;

such as glass, varies with the wavelength or colour of the light used, a phenomenon known as dispersion as shown in figure 1. This causes light of different colours to be refracted differently as well as to leave the prism at different angles, creating an effect similar to a rainbow.

In optometry how prisms work is by shifting corrective lenses off axis, images seen through them can be displaced in the same way that a prism displaces images. Eye care professionals use prisms, as well as lenses off axis, to treat various orthoptics problems; such as diplopia, positive and negative fusion problems, and positive and negative relative accommodation problems. Commonly used are wedge prisms which are used to deflect a beam of light by a fixed angle. In terms of the eye beam of light; it is deflected on to the retina, ideally fovea, however can be other location on the retina which gives clearest image. The most generally found are Risley prism pair in optometric practices and hospital eye services for diagnostic use. (Newton Herschel, 2009, Duarte and Piper, 1982, Duncan et al., 2003)

1. 1 Vision therapy for Treatment of Eye Conditions

Vision therapy, also known as vision training; can be used to improve vision skills including eye movement control, eye focusing and coordination, and train the two eyes working together. It consists of a series of procedures that are carried out under professional supervision, typically by a specially-trained optometrist or orthoptist in eye services.

Vision therapy trends to be prescribed when a complete eye examination indicates that it is an appropriate treatment option for the patient. The specific program of therapy depends on the results of standardised tests,

patient’s signs and symptoms, and patient’s requirements. Programs typically include eye exercises and the use of lenses, prisms, filters, occluders, specialised instruments, and computer programs. The course of therapy is closely monitored by the therapist; the duration of therapy may take from several weeks to several months. We will primarily discuss the use of prisms in vision therapy. (Optometry and Association, 1999)

In orthoptics vision therapy; it may be prescribed to patients with problems of visual related skills required for reading, eye strain, visually induced headaches, and strabismus with or without diplopia. As mentioned earlier it is commonly practiced by optometrists as well as behavioral optometrists however, more specialised problems are co-managed between orthoptist and ophthalmologist.

Treating binocular disorders at near, behavioral optometrists believe that base-up yoked prisms can be used to treat exophoria or convergence insufi¬ ciency, and similarly, that base-down prisms can be used to treat esophoria or convergence excess. In addition, Horner, 1972/3, cited by Birnbaum, 1993 suggested that base-down prisms may be useful in cases where low plus lens power is needed at near but is not tolerated.

Rather than being prescribed for long-term use, vertical yoked prisms used to treat exophoria or convergence insufi¬ ciency or esophoria or convergence excess should be low in power for example 3D down for convergence excess, and 2D up for convergence insufi¬ ciency as suggested by Kaplan, 1978/9, cited by Birnbaum, 1993, and are provided only as training lenses to be used when, for example, speciï¬ c activities

are being carried out. One study Lazarus, 1996, examined the effectiveness of yoked base-up prisms together with base-in prisms in alleviating asthenopic symptoms associated with computer use. The basis was simply that this prism combination would reduce the amount of elevation and convergence required by the computer user. “ Lazarus’ (1996) study employed a double-blind design in which spectacles that combined prism power with plus lens power were compared with those with plus lens power alone. Overall, there was a statistically signiï¬ ¡cant preference for the spectacles containing the prisms. However, no subsequent studies have appeared to corroborate this result. Thus, the use of yoked prism power for treating exophoria or convergence-insufi¬ ¡ciency or esophoria or convergence-excess or for preventing or reducing eyestrain at the computer must be viewed as unproven.” (Barrett, 2009)

2. Therapeutic Use of Prisms

2. 1 Different types of Prism treatment

There are numerous prism prescribing options for patients with different binocular vision conditions, such as diplopia, symptomatic heterophorias and abnormal head postures using prism. These options are; to start with, corrective or neutralizing prism with the goal to stabilise normal sensory fusion by neutralising the demand for controlling fusional vergence. Using relieving prism to stabilise sensorimotor fusion, this is achieved by reducing the demand for controlling fusional vergence. Use of over corrective prism, with the goal to disrupt anomalous correspondence, by reversing the demand for controlling fusional vergence.

Other treatment options are the use of inverse prism for training or disruptive prism therapy to increase the fusional vergence ability, by increasing the demand for controlling fusional vergence. Also the use of inverse prism for cosmetic reasons; to enhance cosmesis of strabismus eye when a patient has poor treatment prognosis, this is achieved by optically displacing the image of the eyes in a direction opposite to the strabismus when an observer views the patient.

More treatment options include the use of yoked prism to stabilise binocular vision in non-concomitancy or dampen nystagmus by the action to direct the eyes into a specific gaze direction. Lastly use of sector or regional prism to stabilise binocular vision in one or more gaze positions by reducing the demand for controlling vergence in more than one gaze. (Tea)

2. 2 How it works

Referring back to what was stated before, prism in eyeglasses bends light. It is placed in the glasses so that as the eyes look through them, the objects or images are pulled into focus by the prism. The focus occurs because the bottom of the prism is on the outside of the glasses. It pulls the object in and narrows its focus as it makes its way up the prism. The object or image visualised is pulled together in both lenses to a closer point, creating a clearer picture. This makes the vision clear, without forcing the eyes to work as one. The figure below illustrates the basic principle of how the image is deviated onto the fovea with base out and base in prism when placed over left eye. The rule is to use base in prism for Exo and base out for Eso. Eye deviates towards prism apex and image towards prism base.

2. 3 In patients what are the considerations when prescribing prisms?

The decision to prescribe prism, and what value of prism to give, is subject to varying clinical opinions and practices. The conservative view in clinical practice is that prisms should not be prescribed in the absence of symptoms of binocular dysfunction.

Good candidates for prism therapy are patients with intermittent strabismus with normal sensory fusion part of time, patients with constant strabismus, but have the ability to achieve binocularity when prism is added (normal sensory fusion with prism). For prescribing Relieving Prisms generally, you want to prescribe the minimal amount of prism that allows you to achieve your goals which is to reduce or eliminate symptoms. (London)

2. 4 When should you not consider Prism as a treatment option?

Prism prescribing should not be considered when angle of strabismus is normally greater than 20 prism dioptres; patients for instance would generally be treated surgically. For prescribing prism for fusion must establish patient has normal sensory processing, if not then need to consider other options such as surgical treatment. Patients who develop strabismus from an early age learn to adapt to condition over years, they tend to develop sensory adaptations, such as suppression or anomalous sensory fusion. These patients are usually asymptomatic and don’t require prism prescribing. Patients who develop strabismus in later ages respond better to prism therapy, as they are often symptomatic and capable of normal sensory fusion. Patient with constant strabismus, avoid using prism when patient has

anomalous correspondence, peripheral suppression or amblyopia. Patient must have normal correspondence and normal peripheral sensory fusion. (Tea)

2. 5 Vertical Yoked Prism Correction

Vertical yoked prism can be incorporated into multifocal lenses to get a thinner lens, or it can be prescribed for oculomotor deficiencies. Also it occurs if the vertical placement of spectacle lenses before the eyes is unsuitable. Yoked prisms may be used to move eyes into specific field of gaze. This can also be combined with relieving prisms.

Yoked prism is defined as a pair of prismatic spectacle lenses of equal power with bases oriented the same direction before each eye. Yoked prism causes the apparent location of viewed objects to be shifted in the direction of the prism apex. Hence, if base down yoked prism is placed before the eyes of an observer who is fixating a target, the target will appear to move upward. The amount of linear upward deviation of the target is proportional to both the power of the prism and the distance between the prism and the viewed object (Prentice Method). The normal 0bserver’s adaptation to the prism-displaced image involves an ocular movement to align the retina with the new stimulus position. The corresponding adjustments in the efferent command signal to the extra ocular muscles changes the motor-sensory relationship of the past response. When a person adapts to the new response pattern presented by a yoked prism stimulus, behavioural changes in visual motor function can occur.

The term “ yoked prism” was originally used to differentiate it from the typically prescribed horizontal prism. They are defined as a pair of prism lenses of equal power with their base in the same direction. The utilisations of these prism lenses are highly selective and specific. Low powers, ranging from 1 to 4 prism dioptres are typically prescribed in and out of office. Currently, we have the means to determine the direction of the base, yet the degree of power is based on professional judgment. In the final analysis, the true value of a yoked prism is its influence on the patient’s orientation. Optometric treatment incorporating low power plus (stress reducing) lenses in combination with a low powered vertical yoked prism prescription results in a reordering and reorientation of visual function by simultaneously affecting visual motor and visual sensory processes. The effect of these prescribed lenses may often result in enhanced attention, decreased distractibility and activity, improved eye contact, and more focused visual exploration. Most often, a generalised behavioral effect is represented by a demonstrable improvement of spatial awareness and orientation.

Prisms Used as Exercising Prism

Prisms can be used to improve motor fusion, patients with phorias, convergence insufficiency with symptomatic problems to be relieved by increasing patient’s fusional reserves. How it works is by inducing prismatic effect whereby prism in front of eye used deviates image away from fovea, eyes need to converge or diverge depending on orientation of prism in front of eye, whether base in or base out, to overcome the prism power placed in front of eye. Rule is; for exophoria use base out to increase positive fusional range and for esophoria base in to increase negative fusional range. Figure

below shows an example of base in prism place in front of left eye to increase negative fusional range.

3. Diagnostic Use of Prisms

3. 1 Assessing Symptoms

Patients may have normal binocular system, however may have disproportionate symptoms, for example a small phoria with severe symptoms, such as bilateral headache, eye strain and asthenopia which can be investigated with the use of prisms. Sysmptoms are typically absent on awakening and tend to occur later on the day when the eyes are used more for example working on computer for a couple of hours or doing specific close work for a period of time.

Significance of symptoms can be assessed by the use of diagnostic prisms, to compensate for the heterophoria. If the symptoms are relieved after a period of 2-3 weeks it can be known to be due to the deviation. Other forms of assessing symptoms can be by diagnostic occlusion whereby occlusion is worn over the same period of time and symptoms due to the heterophoria should be relieved when using only one eye. Using prism is thought to be more practical than occlusion, especially more in adults than children as binocular single vision is maintained. (Ansons and Davis, 2001)

3. 2 Investigating State of Binocular Single Vision

The brain is provided with the complete view of what is in front from the two eyes. The two eyes share with one another the two images seen to produce a single image, two images or “ pictures”, a right hand picture and a left hand picture. This combination of images is carried out through a complex

neurologic organisation beginning with corresponding retinal points. (Telemedicine)

The significant of the corresponding retinal points are the two fovea’s. Once the fovea of each eye is stimulated individually, the brain registers that the object as “ seen” by each fovea regardless of the direction the eyes are pointing, the fovea’s remain in the same place. In the normal situation the two fovea’s can be considered the principal corresponding points. The fovea is also the retinal location responsible for the best visual acuity and away from the fovea, the two retinas relate to each point in the right retina has a corresponding point in the left retina. Particularly, the right nasal retina contains points that correspond to their equivalent points in the left temporal retina, and vice versa. (Telemedicine)

When there is stimulation of corresponding points that produces single vision it is said that normal retinal correspondence is present. On the other hand when there is stimulation of corresponding points, which produces diplopia or when stimulation of non-corresponding points produces single vision, it is thought that anomalous correspondence is present. Strabismus from early life, followed by suppression and sensory reorientation is said to be due to anomalous corresponding points. This response is considered as binocular anti-diplopia mechanism. (Telemedicine)

To investigate the state of Binocular Single Vision (BSV) prism adaptation test is initially used. Commonly this is achieved by overcorrecting the deviation to induce diplopia by the use of Fresnel prisms, by dividing the prism in two eyes and then assessing the presence or absence of BSV after

the initial trial wearing period of usually one or two weeks. If the angle of deviation has increased after the prism trial wearing period, then the strength of the prism is increased until no further increase in angle of deviation and maximum angle of deviation is reached. Correction of this angle with this method has shown to improve surgical outcome. (Ansons and Davis, 2001, Joseph MS and Anju, 2005)

Another way to investigate the presence of Binocular Single Vision (BSV) is by; placing a vertical or horizontal prism in front one eye displaces the image away from the fovea, which creates a deviation. In a person with normal BSV, the resultant latent deviation gradually reduces given that patient is binocularly viewing. This usually occurs quicker with base out prisms than with base in prisms. In the presence of a person with abnormal BSV, with combined horizontal and vertical deviation, usually vertical component can be corrected with prisms and the patient reassessed to make sure the patient can control the horizontal component. Also this provides an indication that vertical muscle surgery should be successful or alternatively if the horizontal component is larger than this component can be corrected and reassess for effect on vertical component before deciding on the choice of surgery. (Agarwal et al., 2002)

3. 3 Planning Surgery

The principles of surgery are to alter the muscle balance around one or more of the axes of rotation. By changing the position of insertion or the muscle length results in a change in the magnitude and direction of muscle force. Operations are of three main types: weakening, strengthening and transposing. Different procedures can be combined for greater effectiveness,

effectiveness is also influenced by the age of patient; more surgery is required in adults than in children to obtain the same effect. The duration of the strabismus influences the state of muscles. Other factors also influence effectiveness such as anatomical and mechanical features, the size of the deviation and whether the muscle is overacting. These factors are importantly considered when planning surgery. One of the main factors to be considered is the maximum angle of deviation; even in small angles it is more effective to perform less surgery on two muscles rather attempt to correct the angle by for example a single recession. (Pratt-Johnson and Tillson, 2001, Ansons and Davis, 2001)

There are a number of pre-operative assessment which need testing, these include; visual acuity testing. For visual acuity testing with an infant or a child too young to cooperate, reaction to the examiner’s face, to a light or a toy should be observed however if poor vision is suspected, an opticokinetic tape or drum should be observed. Teller Acuity Test is best for this age group and commonly used. Snellen Acuity Chart tests children and adults. In ophthalmological services usually an orthoptist carries out pre-operative assessment.

Furthermore motor evaluation of eye is carried to check for fixating eye; if either eye is used for fixation then may be indication of free alternation or cross fixation free alternation. Gross, wandering fixation may be present in the non-preferred eye. If nystagmus is present it is noted and described as latent, manifest, horizontal, vertical, pendular and jerk.

Ocular Movements should be evaluated; ductions (monocular) and versions (binocular). These should be checked in extreme diagnostic positions.

Sensory evaluation should be carried out; where there is patients with any type of intermittent deviation and bifoveal or peripheral fusion; it is imperative to have their state of stereoacuity determined initially, and then should be tested with the Worth four-dot test prior to resuming other examinations. The sensory testing is done on Synoptophore using slides for simultaneous macular perception, fusion and stereopsis. Bagolini straited glasses are the most physiological for testing retinal correspondence, which is important to determine. Sensory testing is useful both pre-operatively and post-operatively as the closer to normal the pre-operative sensory testing is a check on surgical results, and a guide to further non-surgical treatment, which should be pursued extensively if an under correction has been obtained in a potentially fusing patient.

Lastly Refraction should be carried out; and in children less than 10 years prolonged cycloplegic refraction under atropine has to be done. In children more than 10 years of age homatropine, tropicamide or cyclopentolate can be used. Fundus examinations should be done along with refraction.(Kumar)

Alternate prism and cover testing is carried out to measure the maximum deviation. This testing is performed at distance and near, with and without glasses while the patient views an accommodative target. Prism Bar Cover Test should be performed in all nine diagnostic positions. By tilting the patient’s head backward and forward up gaze and down gaze are achieved. This movement uncovers any A or V pattern. A 10 Dioptre prism difference

between up gaze and down gaze is significant for diagnosing an A pattern and a 15 prism Dioptre difference is significant for a V pattern. For diagnosis of cyclo-deviations the double Maddox rod test is useful. The 4 prism Dioptre base-out prism test may be used to uncover a scotoma in the macula of the one eye in patients with microtropia.(Ansons and Davis, 2001)

All pre-operative assessment is vitally important to assess and analyse prior to surgery to determine the type of surgery to be selected. Planning surgery allows amount of deviation to be corrected and to predict the outcome of surgery with any potential post-operative complications for patients. The information obtained from planning surgery give an indication of the best treatment option whether that being surgical or non-surgical treatment.

3. 4 Pre-Operative and Post-Operative Diplopia Test

When adult patients with longstanding strabismus are being considered for surgery to straighten the eyes, in the clinical situation they can be tested for the likelihood of post-operative diplopia, this is achieved by placing fully correcting prisms in front of the eyes whilst fixating at a distant object. Patient is then asked whether they see single or double. Though this may be a useful technique to predict transient post-operative diplopia and to show patients what diplopia will look like if they do not already know, it is rarely a reliable predictor of persistent problematic postoperative diplopia. Therefore, pre-operative diplopia testing can be considered a limited clinical tool. (Joseph MS and Anju, 2005)

Pre-operative diplopia testing in adults is very important in determining the type of strabismus, as well as determination of medical or surgical

management that should be done. It is useful in deciding whether the patient should have surgery, the type of surgery to be carried out, and when to do it. The assessment of post-operative diplopia is also helpful in determining the course of action, for example whether to wait and reassure, or manage medically with prisms, or reoperation. Orthoptists, as part of the strabismus ophthalmology service team, are outstandingly skilled in all aspects of the diplopia assessment and can help the surgeon make management decisions suitable for individual patients.

Patient with fusion, no suppression, good fusional amplitudes and no symptoms are particularly good results from treatment of strabismus. The prism adaptation test as a pre-operative diagnostic test can be useful to identify the potential for fusion. This allows predicting the risk of diplopia in patients without the potentiality for binocular single vision, prior to deciding on cosmetic surgery for realignment of angle of deviation. By pre-operative examination, the aim of the test can be; to determine the potential for fusion, to predict the risks of post-operative diplopia and to prepare the patient for sensory environment that he or she would face post-operatively.

In adults and children over the age of five requesting a strabismus surgery for cosmetic reasons, post-operative diplopia test must be considered. To accurately interpret the patients response during the test, examiner must identify the sensory status using worth’s four dot test or bagolini striated test. As mentioned earlier the post-operative diplopia test investigates the presences of diplopia or suppression in patients without the potential for binocular single vision. Patient’s visual acuity is also considered and patients with high amblyopia are not excluded from postoperative diplopia.

How the test is performed is outlined briefly. The patient is asked if they are already aware of diplopia. If not patient should be made aware of the presence of diplopia. This can be achieved by placing prism in front of one eye or both until prism induces diplopia. The patient is then asked to view a fixation target, which is appropriate to their level of visual acuity at near and distance whilst looking through prisms. The aim of the procedure is use the prism to stimulate an alignment from 20 dioptres under corrected to 20 dioptres overcorrected and assess the risk of diplopia by asking the patients of their observations. If they do not recognize diplopia, no effort should be made to induce it. However if there is spontaneous recognition of diplopia then the strength of prism should be changed until diplopia is induced and the amount of prism Dioptre required is recorded, which is taken into account when planning the surgery, if post treatment, diplopia is likely to occur the patient should be informed and diplopia demonstrated to patient with prisms.

Botulinum toxin can also be used to temporarily correct the strabismus and provide additional information about post-operative diplopia risk and its likely tolerance. (Ansons and Davis, 2001)

Figure 4. Post-operative diplopia test.

4. Conclusion

In all cases of binocular complications, the choice of prescribing prism for therapeutic use or using prism to make a diagnosis it is entirely the judgment of the clinician to make whether it is appropriate for each individual patient with binocular dsyfunction. If considering prism treatment

as an option, measurement and assessment of the associated binocular dysfunction is considered. In the case of surgical treatment for altering the muscle balance, post-operative diplopia test is carried out on patient to make patient aware of possible diplopia post treatment. This type of diplopia test with prism give reasonably accurate idea about the largest change in angle that could be made during surgery without causing diplopia.

Pre operative Prism adaptation make patients aware of sensory environment that they would face post-operatively. Those who were at a risk of diplopia could be warned, particularly those aimed at cosmesis, who could never tolerate diplopia after surgery. So prism adaptation test should be included in the routine orthoptic procedures.

Prism can be used to help determine the amount of vertical muscle surgery required for congenital and long standing vertical muscle palsies with a large vertical fusion amplitude. These patients are more comfortable if left slightly under corrected. The lowest strength of prism which results in comfortable BSV is then used as a guide on the amount of surgery to be performed. Prisms can also help determine whether symptoms are due to patient’s heterophoria, especially when there is a small esophoria which can be associated with severe symptoms, or when symptoms are uncommon. If the symptoms are relieved the prism can be given to correct heterophoria or if symptoms persist then further investigation is required.