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Clinical Characteristics and Management of Divergence Insufficiency Esotropia

Review Article

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Abstract

Though the divergence insufficiency esotropia disorder was explained as primary as 1886 by Duane, however it has got comparatively higher consideration in later literatures. Patients demonstrating with higher deviations at distance as compared to near, an associated deviation, and diplopia impose a critical and challenging therapeutic and diagnostic mystery for the optical clinicians. Divergence insufficiency esotropia, a benign complaint, should be distinguished from other multiple divergence ailments and conditions which existent with slightly comparable signs and symptoms yet have core etiologies of a severe nature. The current review study has been designed to make a literature exploration and clarified the diagnostics, etiology, epidemiology, clinical characteristics and management strategies of divergence insufficiency and regarding set of affairs.

Keywords: Divergence Insufficiency Esotropia, Optical Disorders, Eye Complaints

Introduction:

Divergence insufficiency is a developed optical state which is characterized by a connected esodeviation of about as a minimum 10 prism diopters (PD) higher at distance as compared to near to eye. In 1896, it was classified originally by Duane as part of his coordination for categorizing horizontal strabismus (Ridley-Lane, Lane, Yeager, & Brooks, 2016). The divergence paralysis was originally described as parinaud syndrome which is characterized by an esotropia in which a patient suffers with complete deficiency of divergence and concomitant neuroanatomic pathology (Wright & Corradetti, 2017). The studies of past have used several systems to organize types of divergence insufficiency esotropia. Few of these expressions comprise divergence paresis, divergence weakness, divergence paralysis, primary and secondary divergence insufficiency (Haller, 2015). Studies have recommended that divergence insufficiency (Figure 1) , divergence paralysis and divergence paresis are a range of the similar condition, varying only by their medical severity (Repka & Downing, 2014).



Figure.1 Divergence Insufficiency Esotropia (B. G. Breidenstein, Robbins, Granet, & Acera, 2015)

The latest researches have used the terminology “age related distance esotropia” for explaining concomitant, idiopathic divergence insufficiency in the old aged people (Stager, Black, & Felius, 2013). This expression is based upon the studies of mechanical variations to the extraocular muscular positioning due to degradations of the lateral rectus muscle to superior rectus muscle pulleys (LR-SR band) (Herlihy, Phillips, & Weiss, 2013). Moreover, magnetic resonance imaging (MRI) approaches have exhibited same disruption of the LR-SR bands within the patients with high myopia and distance esotropia, regardless of ages (Xia, Cao, Peng, & Wang, 2020). As divergence esotropia can arise at any age, this review uses the system of classification defined by Jacobson, in which secondary divergence insufficiency is neurologic pathology while primary insufficiency is linked with idiopathic pathways (Chaudhuri & Demer, 2013). The characterizations of both conditions are reported with associated esodeviation which is larger at distance as compared to full and near ocular ductions (Park, Lee, & Oh, 2019).

Etiology:

The etiology linked with primary divergence insufficiency is enormously different than those related to secondary divergence insufficiency (Kohmoto, Inoue, & Wakakura, 2011). At a certain level, the primary divergence insufficiency is a benign disorder which is generally linked with loss of motor or sensory fusions, decompensation of a long-lasting esodeviation, or mechanical variations to the extraocular muscles. On the other hand, secondary divergence insufficiency is linked with neurological ailment. The pathology of neuroanatomy for secondary divergence insufficiency is remained uncertain (Kirkeby, 2014). Few researches recommend that it is caused by lesions to a center of supra nuclear divergence, while others have exhibited sixth subtle nerve palsies. Though electromyography researches have recommended that divergence is an active mechanism, a primary divergence center might be dubious due to the immense collection of pathologic disorders linked with divergence insufficiency (Li & Zhang, 2017).

Epidemiology

Since last few decades, congenital divergence insufficiency esotropia has been considered the most common kind of strabismus. Moreover the latest studies have confirmed that congenital esotropia is much less common as compared to once supposed (Wu & Del Monte, 2015). In a latest prevalence study amongst children born within the time duration of 30 years in United

States, the development of congenital esotropia was only 1 in 403 live births. Another recent study from the similar population reported analogous evidences, with childhood divergence insufficiency esotropia making up only 8.1 percent of overall kinds of esotropia (Marsh & Guyton, 2015). Accommodative esotropia, comprising both the fully and partially forms of accommodative, encompasses about one half of overall pediatric esotropia in the US and is the most predominant sort of infantile strabismus in the Western States. This kind of esodeviation has been testified to occur in 1 in 92 children across the globe (Hopkins, Sampson, Hendicott, & Wood, 2016).

Multiple studies described the occurrence of pediatric divergence insufficiency esotropia as within the range of 0.12 percent in 1.5 years aged children in Japan and 20.1 percent in a group of low birth weights (B. Breidenstein, Robbins, Granet, & Acera, 2013). Epidemiological researches, reported on the percentage of people with a particular syndrome at a prescribed point synchronized, are found most frequently in the literatures the pediatric divergence insufficiency esotropia. However, this kind of study might only explore a picture of infantile ocular deviations (Rowe, 2011). On the other hand, frequency reports comprising the proportion of new cases diagnosed throughout particular time duration, might survey any figure of characteristics and their variations with the passage of time. One all-embracing trend is that occurrence rates of divergence insufficiency esotropia differ on the basis of ethnic and racial backgrounds. Esodeviation are found with a comparatively higher frequency among Caucasus people, whereas exodeviation is the more generally reported amongst African and Asian children (Figure 2) (Nakao & Kimura, 2014).



Figure.2 Divergence Insufficiency and Vision Impairment Global Epidemiology (He et al., 2020)

European, Australian, and North American data distinct with respect to epidemiology statistics collected from various studies in Africa and Asia. Moreover, this trend is obvious amongst non-Caucasus people in the US (S. Grace et al., 2014). Another study among multi-ethnic pediatric groups regarding eye diseases described prevalence of divergence insufficiency esotropia among American, African and Hispanic children, such as, esotropia was diagnosed less frequently as compared to exotropia (Cherfan, Diehl, & Mohny, 2014). The base of this dissimilarity might be partially associated with population-based transformations in refractive errors. Esotropia is generally related to hyperopia, while exotropia is more largely detected among children with myopia (Leat et al., 2013).

Primary Divergence Insufficiency Esotropia

In history, divergence insufficiency was supposed to be triggered by reduced amplitudes of divergences. The latest researches have stated physiologic variations to the extraocular muscles. In 2006, the lecture of Alfred Bielschowsky deliberated how variations in muscle lengths and vergence tonus can effect ocular alignments (Kawai, Goseki, Ishikawa, Hoshina, & Shoji, 2018).

The postulation was issued that long-span binocular alignments require muscle length and neurological vergence adaptations (Elkamshoushy & Kassem, 2019). He specified that retinal disparity makes a fast movement inside the fusional vergence that causes the variations in vergence tonus. This variation in vergence tonus makes a corresponding transformation in muscle lengths to sustain proper alignment of eyes in patients with divergence insufficiency esotropia (Brune & Eggenberger, 2018).

It was also reported that age-associated divergence insufficiency is more dominant in people with non-cured hyperopia due to persistent activations of the near triad (Akpe, Dawodu, & Abadom, 2014). It generates the theory that increased convergence tonus with the passage of time will shorten the muscles of medial rectus. On the other hand, latest MRI researches have exhibited that age-linked distance esotropia is related to degeneration of orbital connective tissues and displacement of extraocular muscles (Goseki et al., 2020). In 2009, Demer and Rutar used orbital imaging of MRI to establish substandard displacement of the lateral rectus in old aged people of divergence insufficiency disease. They also reported degeneration of the LR-SR ligament bands. These bands stabilize and support the muscle of lateral rectus. The similar displacement of muscle and degeneration of LR-SR band was reported in extremely effected patients of nearsightedness with esotropia (Hüfner et al., 2015).

Secondary Divergence Insufficiency Esotropia

Secondary divergence insufficiency is a neurological disorder in which a patient suffers with an onset acute distance esotropia, full ocular and near fusion movements. This kind of esotropia is linked with the condition tends to be considerably less and larger variable as compared to primary divergence insufficiency. It is also related to trauma, brain tumors, increased intracranial pressure, multiple sclerosis, encephalitis, vascular lesions, lead poisoning, excessive consumption of alcohol and ultimately syphilis. Divergence insufficiency because of increased intracranial pressure is generally related to papilledema and headache. Viral infections frequently arise in the respiratory tracts and grow to encephalitis or meningitis. It has been found that 1/3rd of secondary divergence insufficiency patients do not alive last 5 years. Earlier studies have recommended that secondary divergence insufficiency is initiated by disturbance in the divergence center inside the brain, either from micro vascular ischemia or focal lesions (Chaudhuri & Demer, 2015).

Additional testing on MRI imaging exhibited increased production of IgG CSF and multiple demyelinating lesions. A diagnostics of multiple sclerosis was also reported. This research demonstrated that cortical pathology can originate divergence insufficiency, lacking neurological symptoms or lateral gaze limitations (Erkan Turan & Kansu, 2016). Concomitant neurological symptoms comprised nystagmus, spastic paraplegia and scanning speech. Various researchers have found divergence insufficiency esotropia as the presented signs for Chiari malformations. Few researches proposed that the divergence insufficiency is triggered by compressions of the cerebellar vermis in dorsal side that helps in managing eye movements. Divergence insufficiency has also been found with HIV-positive patients, acquired myopathies and myasthenia gravis (Hüfner et al., 2015).

Divergence insufficiency is common in patients with higher nearsightedness. Patients with secondary esotropia have higher nearsightedness usually present with growing horizontal diplopia faraway. In the initial phases, during small esodeviation, the patients might exhibit ghosting of images or blur vision at specific displacement (Yagasaki, Yokoyama, & Maeda, 2011). The signs of divergence insufficiency are generally worst vision during driving, particularly at night. The esodeviation might be intermittent or constant and ocular movement may perhaps be limited. Convergence spasm is referred as an overstimulation of the close response with surplus convergence, myosis, and accommodations (Mohney, Lilley, Green-Simms, & Diehl, 2011). Indicators of convergence spasms comprise a concomitant esodeviation faraway, variable myopia, and asthenopia. Reduced near vision is mostly related to convergence spasms due to variations in accommodations. Patients might also show with pseudomyopia with maximum proportion of 8 to 10 D that is eradicated with eye drops of cycloplegia. Divergence insufficiency spasms are more frequent in emotionally unbalanced young adults. It is seldom related to neurologic infection (Lembo et al., 2019).

| Subtype | Definition |
|------------------------|--|
| Esotropia | Turning strabismus inwards with unchanged angle by refractive errors |
| Intermittent exotropia | Turning strabismus outwards intermittently occurs on distance and near fixations |
| Partially | Turning strabismus inwards with decreased angle by 10 |

| | |
|-------------------------|--|
| accommodative esotropia | PD with hyperopic prescriptions |
| Exotropia | Turning strabismus outwards |
| Microtropia | Strabismus of small angle with below 10 PD and capable to attain a binocularity level |
| Distance exotropia | Turning strabismus outwards only occurs on distant fixations |
| Infantile esotropia | Turning strabismus inwards presented from age of 6 months along with other linked incongruities |
| Unaffected | No accessible manifest nonconformity |
| Accommodative esotropia | Turning strabismus inwards with decreased angle considerably with hyperopic prescriptions and an achievable binocularity level |

Table.1 Divergence Insufficiency Types and Subtypes (Bryselbout, Promelle, Pracca, & Milazzo, 2019)

Diagnostics and Symptoms

Most of the times, patients presents clinical adult strabismus with the complaints of an unexpected horizontal onset diplopia farsighted. The diplopia might observe abrupt to the patients and the patients can typically tell the doctors precisely the day of beginning and perceiving the diplopia (Khanna, Pasco, Santallier, Pisella, & Arsene, 2018). The patients mostly term blurred distant vision for rather occasionally prior to perceiving the diplopia. According to several studies, several patients confess that they have observed the local ophthalmologist or optometrist commonly and reorganized glasses frequently in the last one year or more to discourse their symptoms of distant vision (Heydarian et al., 2020). Yet, after more discussions with many patients, it was also described sometimes that cognizance of intermittent diplopia, for example more extra sets of car lights or more than one lines on the roads during driving. Once the patient loses the ability to a point of having forthright diplopia although seeing distant objects, it appears to be severe in nature from such perspectives. To end, these patients seldom

have any complication of nearsightedness. Before the process of inspection starts, the clinical experts can make few cooperative clarifications (Figure 3) (Rajavi et al., 2013).

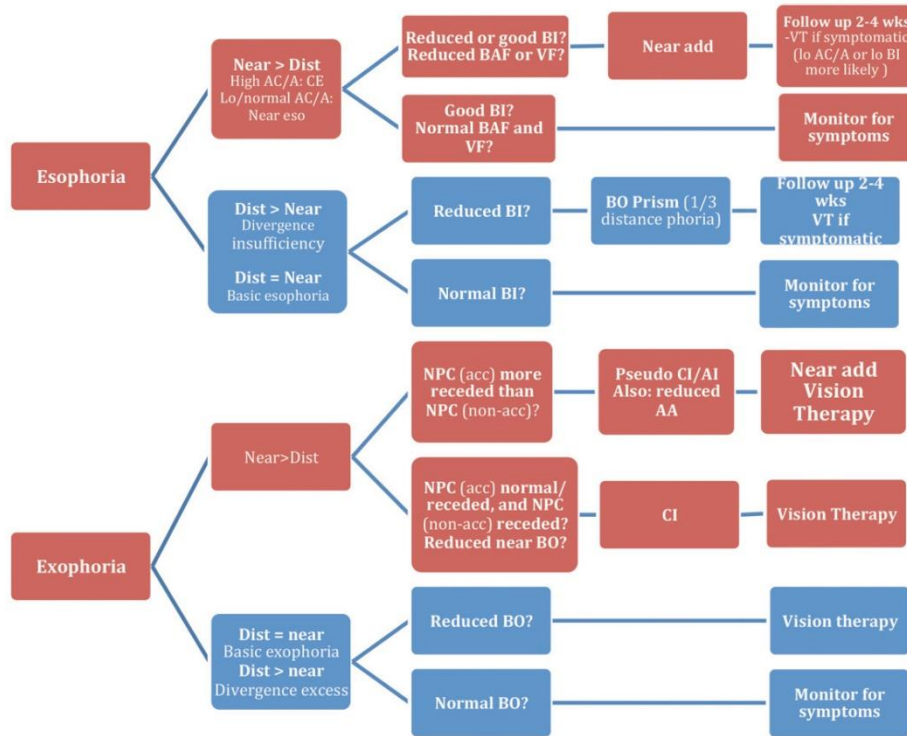


Figure.3 Divergence Insufficiency Diagnostic Chart

Symptoms because of muscular fatigue produced by way of constant use of spare neuromuscular power include aching eyes and headache stated as the muscles of which an unnecessary effort is commanded (Zheng, Han, Han, & Qu, 2018). Such indications occur all through or after long time using eyes and they disappear on closing the single eye. Another sign include trouble in changing focuses from distant to nearly placed objects or vice versa. The photophobia also reported among patients of divergence insufficiency esotropia in which patient obtained relief not through the wearing dark glasses, but also closing eyes (Iwasa, Wakakura, Kohmoto, Tatsui, & Ishikawa, 2020). However, it must be distinguished that the photophobia reported among patients with poorly recompensed exophoria linked with additional divergence, maybe decreased with photochromic lenses. Symptoms because of the failures to sustain persistent binocular visions and blurring of print and during reading, running together of words also reported (El-Sahn, Granet, Marvasti, Roa, & Kinori, 2016). Recurrent diplopia under situations of fatigue

because of defective postural sensations might be transmitted from the ocular muscles on account of modification of muscle tone triggering trouble in arbitrating position and distances, particularly moving objects. Moreover, during exophoria and esophoria on head posture, the chin may perhaps elevate or depress respectively. The head sometimes tilted to any side during cyclophoria (Pan et al., 2016).

Surgical Management of Divergence Insufficiency Esotropia

The treatment of patients with divergence insufficiency patterns of esotropia can be performed by surgery on the condition of not responding to prism therapy or another conventional technique. The treatment of divergence insufficiency esotropia by surgery can be approached by quite a lot of different methods, all of which have reasonable outcomes (Repka & Downing, 2014). With respect to divergence insufficiency etiology, it can be elucidated further and surgical treatments might develop also, so as to target the fundamental pathological characteristics.

Lateral Rectus Resection

Several authors have been advocated the surgical resection of lateral rectus muscle. Supporters of lateral rectus muscle resections statement that this surgical method is more prospective to recover the distant esotropia devoid of causing convergence insufficiency nearsightedness. In 2015, one of the most basic case series was reported (Strickland, Baker, Siatkowski, & Mapstone, 2018). This series comprised eleven patients experiencing bilateral lateral rectus resection. The rates of success could be measured lower, with merely 4 of 11 patients achieved pleasing fallouts. It was reported in 2018 that five patients undertaking bilateral lateral rectus resection, with acceptable effects of no over-alterations at near vision (Figure 4) (Gurland, Vagge, & Nelson, 2018).

It was stated the leading sequence of patients with long-span follow-ups who undertook lateral rectus resections (Ghali, 2017). In that class of 29 patients, out of which only 5 endured unilateral lateral rectus resection and 24 undertook bilateral lateral rectus resection. The number of resection was within the range of 7.5 mm and 4.5 mm for unilateral surgical procedure for deviations of 3 to 7 mm and 6 to 18 mm for bilateral surgery for deviations of 10 to 30 mm. the patients all had reasonable outcomes, with no patients primarily over-revised or necessitating

extra prisms. But, they had a reappearance frequency of nearly 10 percent throughout their average follow-up duration of 3 years (Chaudhuri & Demer, 2012).

Muscle Resection Procedure

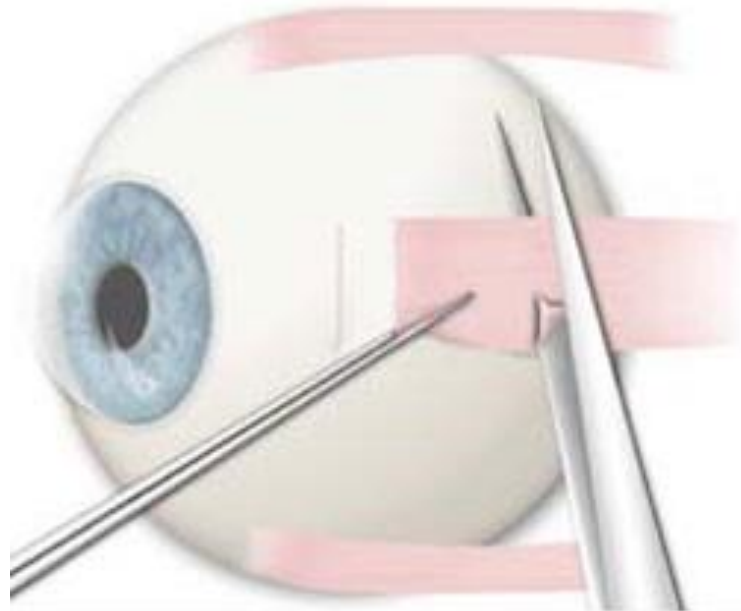


Figure.4 Divergence Insufficiency Esotropia Muscle Resection

Several studies have also found the outcomes for only unilateral lateral rectus resection. Hoover et al. described the fallouts of 6 patients undertaking only lateral rectus resection for 12 to 20 mm deviation. Their outcomes were considered pleasing and there were no reported any over-correction. In 2013, (Choi, Lee, Jung, Kim, & Cho, 2013) described a series of 57 patients of 54 to 89 years ages undertaking unilateral lateral rectus resection for distant esotropia deviation of 5 to 30 mm. The surgical treatment was performed by means of local anesthesia on the non-prevailing eye with the extent of resection within the range of 5 to 9 mm. out of 57 patients, 86 percent had reasonable outcomes with no remaining esotropia and diplopia. The prism treatment was delivered to 4 patients for achieving effective vision with no diplopia, and 2 patients requisite another surgical procedure for recurring esotropia (Chun, Freire, & Cestari, 2019).

Medial Rectus Recession

As the knowledge of divergence insufficiency is progressing, few surgeons started to promote the practices of medial rectus recession as an alternate cure (Yilmaz, Fatihoglu, & Sener, 2020). It was reported that the patients with divergence insufficiency esotropia patterns especially the young patients within the ages of 7 to 41 years impelled by questions linked with the failure of distance-near deviation. Moreover, the effects of lateral and medial rectus muscular surgical treatment for divergence insufficiency esotropia were observed with distant and nearsightedness. Assessing 267 patients who undertook medial rectus recession for divergence insufficiency esotropia, it was found that exoshift was appeared in only 9 percent among nearsighted vision problems as a whole (S. F. Grace, Cavuoto, Shi, & Capo, 2017).

Remarkably, it was reported that a greater preoperative near and distance divergence insufficiency was linked with greater decrease regardless of which muscles undertook surgical treatment (Figure 5). It was concluded that divergence insufficiency esotropia may not be a significant sign of which muscles must be operated. The study was headed by (Hopkins et al., 2016) reports of a chain of 8 patients within the ages ranges 44 to 77 years who undertook bilateral medial rectus recession extending between 3 to 4.25 mm for divergence insufficiency esotropia of 12 to 35 mm. out of 8 patients, only 3 required prisms after the surgical treatment, whereas the remaining patients showed reasonable outcomes (Pineles, 2015). Though they had not reported characteristic convergence insufficiency, the average nearsighted deviation was 1.8 mm after the surgical treatment of exophoria within the ranges of 8 mm exophoria to 10 mm esotropia nearsightedness. They also described a failure of the near and distant deviation from 15 to 5 mm before and after surgical treatment respectively (Ali, Berry, Qureshi, Rattanalert, & Demer, 2018).

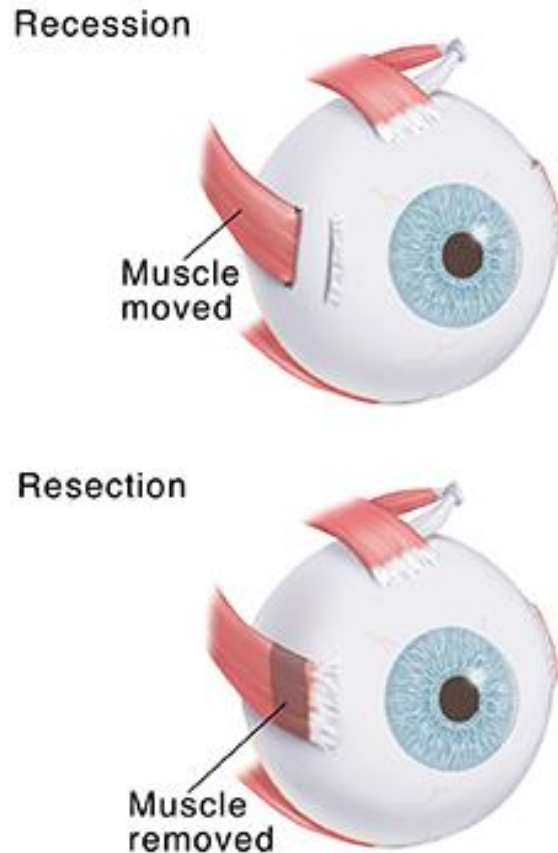


Figure.5 Divergence Insufficiency Esotropia Rectus Resection(Marsh & Guyton, 2015)

In recent times, (Wu & Del Monte, 2015) reported 24 patients with divergence paralysis esotropia patterns and matched the outcomes of those undertaking medial rectus recession (16 patients) to those undertaking lateral rectus resection (8 patients). Patients undertaking medial rectus recessions had their surgical procedure performed frequently under local anesthesia. In both sets, there was no diplopia or convergence insufficiency postoperatively, with follow-up period within the range of 8.5 to 40 months. The researchers established that medial rectus recession is more efficient than that of lateral rectus resection. Nevertheless, it was reported larger proportions of recessions obligatory in these patients, and recommended that double the angle distance of esotropia must be practiced as the medical target (B. Breidenstein et al., 2013).

Prism Management and Strength Determination

The determination of final prism strength for placing on the glasses for a short-term period or to make basis for the lenses can be a prolonged procedure (He et al., 2020). The patients with very

little deviation which is well controlled excluding during driving or quite exhausted is best prism adapted though having them fixating away from 20 feet. Meanwhile, the patients who have a modest angle with impartially poor control are certainly prism adapted in the lane and mostly can tolerate the whole offset of prisms. Few patients also keep a smaller patent deviation with a much greater latent module (Nakao & Kimura, 2014). In this condition, adaptation of prisms can be problematic, and typically the patient is inconsistent and obstructive. It is good to begin with offsetting the components of manifest and then presenting the patient an additional prism diopter and compared them with the two prisms while observing a distant object. Since this point, stay as if executing the manifest refractions (Rowe, 2011).

It is recommended that without telling the patients strength of prism just proceeds until the patients reach a stable response (S. Grace et al., 2014). During proceeding through ground-in prism, it is fine to place the final prism strength ahead of the patients with the proportion fragmented between two eyes to be sure the patient is still contented with prism alignment. In any situation, ground-in or Fresnel prisms, it is requirement of patient to sight a near object to verify that the tolerance ability at base-out prism close to eyes (Cherfan et al., 2014). If patients had normal amplitudes of nearsighted fusional convergence on earlier diagnostics, they must tolerate the prisms also, however it is still necessary to confirm. Generally, patients abide the base-out prism in good strength at near, however if not, they should shift from bifocal glass to having a distinct pair of near and distant glasses (Figure 6). On starting with Fresnel trials, the prism can be horizontally cut and placed overhead the bifocal (Leat et al., 2013).



Figure.6 Divergence Insufficiency Esotropia Prism Management

Fresnel Prism Management

During Fresnel prism placement (Figure 7), it is critical to demonstrate the patients about strength of prism in Fresnel method. There are differences in tolerate capability in few patients as they can tolerate more prism corrections occasionally in loose prism forms as compared to in Fresnel (Hüfner et al., 2015). In conclusion, after getting confirm the strength of final prism, it is essential to choose over which eye to place the Fresnel prisms. Mostly it is very simple however few situations can make the decision challenging. It is good to place the prism ahead of the non-preferred eyes. It might not have any correspondence with the readings of visual acuity, however instead perhaps have more to do with brightness, colors, distortion, or contrast (Kawai et al., 2018).



Figure.7 Fresnel Prism for Divergence Insufficiency Esotropia

In few cases, the patients may have a little vertical in addition, and in these situations, it is compulsory to precise both the vertical and the horizontal deviations with one Fresnel. This is not suggested to place a Fresnel prism ahead of both eyes (Elkamshoushy & Kassem, 2019). Thus, the final strength of prism will be greater to accurate both deviations and will essential to be sloped either base-down or base-up dependent upon over which eye the prism has been placed. The ultimate prism strengths and the angles on which to place the base of the prisms can

be measured, however it is mostly good to demonstrate the patients the prisms and tilt the prisms in either manner adjusts the vertical deviation till the patients are completely pleased with single vision (FießMD et al., 2020).

If a Fresnel prism placed with the objective to ultimately grind into glasses, the patients must wear the prisms for approximately 4 to 6 weeks to verify if the correction resolves completely all diplopic indications (Tamhankar, shuang Ying, & Volpe, 2012). Sometimes, a patient is not prepared to hold for 4 to 6 weeks however it is suggested to wear the Fresnel at least for few extent of duration to be certain before paying for a pair of prism glasses (Haller & Furr, 2014). If the patients are wearing ground-in prism currently, they might not select to have a Fresnel and may have a new prescription relatively for the improved prism adjustment. If confronted with such condition, it is suggested to have patients talk over with the optical experts regarding their policies on having glasses redesigned within a definite time period, if they are not satisfied completely with the prism configurations (Donahue, Friedman, & Strominger, 2014).

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