The Comparison of Fixation Disparity and Fusional Reserves

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Introduction

For clear stable binocular vision there must be both motor fusion and sensory fusion of the two eyes.
Any inaccuracy in these two processes will cause stress on the visual system and a variety of asthenopic symptom. For children this can lead to difficulty learning to read.

Asthenopic symptoms vary enormously, so how do we as optometrists decide what to treat and how. Testing children's eyes can be particularly challenging as they often will not be able to tell us how they feel.

In a perfect system, two corresponding retinal points (i.e. the foveae) of each eye fixate upon the same object of interest.
Retinal disparity is stimulation of non-corresponding retinal points.
Fusional vergence occurs in response to retinal disparity and binocular single vision (BSV) can still occur as long as the images fall within Panum's fusional area (corresponding areas of visual space). Therefore a certain amount of retinal disparity can occur and BSV can be maintained.
Fusional vergence can be positive (convergent) or negative. The larger the amounts of retinal disparity the more stress the visual system comes under to maintain BSV. Once the limits are met diplopia occurs.
It is normal for a person to use fusional vergence but symptoms/ reading difficulties occur when the system comes under stress.

Determining the Amount of Stress on the Fusional System

Fixation Disparity

The Mallett unit is the method of choice for determining how to correct symptoms of asthenopia.
It measures the amount of prism (aligning prism) that is necessary to correct the misalignment of corresponding foveal points i.e. the fixation disparity. The amount of aligning prism required to reduce the fixation disparity to zero is not proportional to the
size of the disparity. This test has been shown to have good sensitivity (75%) and specificity (78%) for detecting symptomatic heterophoria, however it is not perfect. Some people have fixation disparity without symptoms and some have symptoms without fixation disparity. The test is difficult for patients to understand and cannot be used with young children. There is no objective information provided from it. As the near Mallett is big it is not lifted or held at the habitual working distance easily.

Fusional Reserves

Fusional reserves can be measured by placing prisms in front of the eyes until single binocular vision can no longer be maintained. This is essentially a measurement of how much power the fusional system has over that which is already being used. There are several criteria that can be used to determine if the fusional vergence is under stress:

Sheard’s criteria states that an accompanying heterophoria is decompensating if the phoria is more than half that of the opposing fusional reserve. The reserve (R) should be twice the phoria.

\[ S = \frac{2}{3}D - \frac{1}{3}R \]

Percival’s criteria is more longstanding and is thought to have more meaning for near vision. It states that the positive and negative reserves should be equal but certainly one should be no more than twice the other so that fusional demand lies within the middle third of its overall range.

\[ P = \frac{1}{3}G - \frac{2}{3}L \text{ (where G is the largest reserve and L is the least)} \]

A negative value for both S and P means the system is fine, a positive value tells how much prism to prescribe.

Fusional reserves can be measured easily with prism bars and phoropters. Using prism bars allows objective assessment of the break point. It’s easy to understand and explain to children. It is compact and unobtrusive and the patient can hold the reading material at their habitual working distance.

Objective

To determine if measuring the fusional reserves can be used as an alternative to measuring fixation disparity to assess whether the visual system is under stress.
Method

Nine pre-presbyopic subjects participated in the study; ranging in age from 8yrs to 29yrs. None of the subjects had a manifest deviation on cover testing.

The subjects were asked about any symptoms of visual stress, such as headaches, sore eyes and difficulty reading. A full refraction was carried out and best corrected visual acuity recorded. The following near tests were conducted with a working distance of 33cm and full distance prescription in place:

- A cover test to determine the direction of deviation and how well compensated it was.
- Maddox Wing was used as a simple and fast way to estimate the size of a heterophoria at near.
- Fixation disparity was measured using a near Mallett unit with polarized filters; using the vertical nonious strips only for horizontal slip. Specific questions were asked to determine if there was any slip, suppression or imbalance. Prisms were inserted 1PD at a time to determine the aligning prism.
- Fusional Reserves were measured using the phoropter head, the rotary prism associated with it and a card with a single column of small numbers. The Risley prism on the phoropter had a maximum prism of 23. The patient was asked to report when the text first goes blurry and then when it doubles, once this break point was reached the subject was asked to report when single vision was again achieved. Positive fusional reserves (PFR) were measured with base-out prisms and negative fusional reserves (NFR) were measured with base-in prisms. The blur point, break point and recovery were recorded for each horizontal measurement. The blur point was used for calculating fusional reserves as it is more relevant than the break point, describing the limit of clear single vision.

Sheard’s criteria and Percival’s formula were used to calculate if any correcting prism was required.

Results

Out of the nine subjects; subjects 1, 2 and 3 had no underlying heterophoria, showed no retinal slip on the Mallett unit and had no blur or break point for fusional reserves. Subjects 1 and 2 were asymptomatic, whilst subject 3 had symptoms.

Subject 4 was asymptomatic. She was emmetropic and had an exophoria of 1 prism dioptre (PD). She had no slip with the fixation disparity. The positive fusional reserve was 18 (blur point with no break point). The negative fusional reserve had no blur point, break at 4PD and recovery at 2PD. Sheard’s criteria gave a negative value. Percival’s criteria suggested 3.33 base out prism is required.

Subject 5 was asymptomatic. He wears spectacles for myopia. He had an exophoria of 1 prism dioptre. He had 1.5
Base In retinal slip. His positive fusional reserve was break at 11PD, recovery at 10PD (there was no blur point). His negative fusional reserve was blur at 6PD with no break. He requires no prism according to both Sheard’s and Percival’s criteria.

Subject 6 complained of dry eye, tiredness, transient horizontal diplopia and an inability to stay awake whilst reading. She is a myopic spectacle wearer. She had an exophoria of 2PD. No retinal slip. The positive fusional reserve was (no blur) break at 6PD and recovery at 4PD. The negative fusional reserve was blur at 10, break at 12 and recovery at 8. Sheards and Percival’s criteria both gave a negative value, indicating that no prism was required.

Subject 7 dislikes reading and cannot concentrate for very long. He had an exophoria of 1PD. He had no retinal slip. His positive fusional reserve blurs at 7PD but he had no break point. His negative fusional reserve breaks at 4PD and recovers at 2PD. Percival and Sheard’s gave a negative number suggesting that prism was not required.

Subject 8 finds reading difficult and tires quickly. She has a small hypermetropic prescription which is not worn. She had an esophoria of 2PD. Fixation disparity of 1 Base Out in the right eye and ½ Base Out in the left. Positive fusional reserve had no break or blur point (in excess of 23). The negative fusional reserve had no blur point, breaks at 13PD recovers at 11PD. Sheard’s criteria was negative. Percival’s criteria suggests 1.34 base out.

Subject 9 complains of headaches and eye strain. He has uncorrected hypermetropia of +0.75 right and left. He had a 2PD exophoria, with no retinal slip. He had no blur of break point when positive fusional reserve was measured. He had a blur point of 18 but no break in his negative fusional reserve.

**Discussion**

Subjects 1 and 2 had no symptoms and fixation disparity and fusional reserve measurements were in agreement that no correction was required.

Subject 3 had symptoms but no signs. She was found to have uncorrected hypermetropia prior to this trial and wore the correction for the test. This suggests that the hyperopia was the cause of her symptoms.

Subject 4’s negative fusional reserves are clearly weak; as such as esophoria would be expected, however, she had an esophoria. This could be a sign of adaptation such as anomalous retinal correspondence. Fixation disparity and Sheards criteria suggests no prism is required; that the phoria is adequately compensated, this correlates with her lack of symptoms. Using Percival’s principle makes us aware of the imbalance in PFR and NFR. It suggests as much as 3.33 Base Out prism is used to move the fusional reserves and
make sensory fusion more efficient.

Subject 5 was asymptomatic and his fusional reserve measurements agree with this. His negative fusional reserve is limited by blur, so his positive fusional reserve and negative fusional reserve are equal and balanced. Fixation disparity measurements suggest that he is having problems. If his positive fusional reserve results are compared to a table of normal values, it becomes clear this measurement is below average.

For subject 6 both measurements suggest that the underlying heterophoria is well compensated but the symptoms suggest otherwise. Allen et al. suggested a fusional amplitude of less than 20PD is a sign of binocular instability and this is certainly the case for this participant. What the fusional amplitude does not tell us is how to remedy this instability. When instability is noted from the Mallett unit it can be eliminated with prism/lenses however no instability was noted today. This suggests that fusional reserves may be more sensitive to instability.

Similarly, subject 7’s symptoms suggest he has a problem with binocular vision, however, both measurements indicate that he has no problems. In this case he has limited negative fusional reserve/ divergence. Further test must be carried out.

For subject 8, Percival’s principle cannot be accurately used as the positive fusional reserve exceeded the amount of prism available. If we look at a table of normal results and we consider 30 as the average positive break point and then apply it to Percival’s formula we would get 1.34PD. A similar result would be found with fusional reserves and fixation disparity measurement, however, only the fixation disparity gives us the information that it needs to be split between the two eyes.

For subject 9, prism limits for both positive and negative fusional reserves were reached. As they both exceed limits we could assume that they are similar, if so Percival’s criteria would be negative. Measurement of fixation disparity and fusional reserve would then agree that no prism is required.

**Conclusion**

In some cases fixation disparity gave a little more information, for example when splitting correction between the two eyes and considering how to correct binocular instability. Measuring fixation disparity is easier and faster but it can be difficult for patients to understand.

In other cases fusional reserve measurement correlated more closely to the symptoms. Measuring the fusional reserves allows an objective assessment, the test is more portable and easier to understand but it is time consuming and requires complex equations to calculate the amount of prisms required.
Due to lack of sensitivity/specificity neither test should be used alone as a predictor of symptoms associated with visual stress. The two tests are not interchangeable but both have value.