Title: A comparison of the effect of 3M Fresnel Prisms and Trusetal Prism Foils on Visual Function.

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Abstract

Aims

This study aims to determine any differences in visual acuity (VA) and contrast sensitivity (CS) between 3M Fresnel prisms and Trusetal prisms foils.

Methods

Sixteen participants (mean age 20 years) with normal VA and CS were recruited. The effect of 5Δ, 10Δ, 20Δ and 30Δ prism strengths on monocular VA and CS was assessed using a Bailey Lovie logMAR chart, and Pelli-Robson chart respectively. This was repeated for both 3M Fresnel prisms and Trusetal prism foils.

Results

Deterioration in VA and CS was evident with increasing prism strength with both prism types. VA was more significantly reduced with the 3M Fresnel prism than the Trusetal Fresnel prism [$F_{1, 15} = 19.63$, $p < 0.001$]. There was also significant difference between the prism types with prism strength [$F_{3, 45} = 10.35$, $p = < 0.0001$]. This resulted from a larger reduction in VA with 30^{Δ} 3M Fresnel prisms where mean VA with 3M Fresnel prism was 0.70 logMAR, compared to 0.57 logMAR with 30^{Δ} Trusetal prism foil. This difference is six and a half letters (> one line). There was no statistically significant difference between the effect of 3M Fresnel prisms and Trusetal prism foils on CS, [$F_{1,15}=2.21$, $p > 0.05$].

Conclusions

This study shows that there is little difference in VA or CS, whether a 3M Fresnel or Trusetal prism foil is used, until 30^{Δ} where Trusetal prism foils give better VA. For high strength prisms it may be more beneficial for the patient to use a Trusetal prism as part of their treatment plan.

Key Words: Fresnel prism, 3M, Trusetal, visual acuity, contrast sensitivity

Introduction

Fresnel prisms have been used for treatment of binocular anomalies for many years, [1, 2,3,4,5] primarily they are used to restore binocular single vision (BSV) in the presence of diplopia. They are an attractive alternative to the conventional prism, having many advantages including cost, lightweight material, ease of fitting and removal, and the fact it is a temporary measure and can be altered with a patient's unstable condition. Commercially available Fresnel prisms for clinical use have for many years been manufactured by 3M™ Health Care and are distributed in the UK by Haag Streit. The manufacturer, Optiker Greten, Folienoptik, (Bremen, Germany), has more recently released a press on prism supplied and marketed by Trusetal Verbandstoffwerk GMBH. Trusetal claim[6] that their prism foils have 'superb optical quality' and market them at a relatively lower cost that the 3M Fresnel prism. Haag Streit has since claimed that the original 3M brand is the best form of Fresnel prism available in terms of performance, optical clarity, thickness and adhesion to lenses[7, 8]. This study aims to determine any visual difference between these two commercially available press-on prisms.

The detrimental effect of Fresnel prisms on VA[1,3,5,4,9,10] and CS[4,11,12] has been well documented, however, this current study investigates the effect of increasing prism strength on VA and contrast CS, with 3M Fresnel prisms and Trusetal prism foils. A general comparison between the two types of adhesive prisms; such as ease of fitting, thickness and effectiveness will also be reported.

Method

Sixteen participants were recruited from the student population of The University of Sheffield, including a mixture of both Orthoptic and non-Orthoptic students.

Participant ages ranged from 18 to 21 years, with a mean age of 20 years and included 3 males and 13 females. The study was approved by the University Unit Ethics Committee and conformed to the provisions of the Declaration of Helsinki 1995. Informed consent was obtained from each participant.

The testing was performed monocularly with the left eye occluded. Criteria for inclusion were: minimum visual acuity of 6/6 Snellen (0.0 logMAR) in the right eye, either with no optical correction or corrected with a contact lens, and CS level of minimum 1.65 log units in their right eye.

The prisms were prepared in advance on nine identical pairs of plano glasses, fitted onto the right lens with the left lens occluded with Durapore surgical tape. The prisms were all applied to the lenses horizontally in a base out direction and included one pair of plano glasses with no prism. The prism strengths used were 5 prism dioptres (Δ), 10Δ, 20Δ and 30Δ for each prism manufacturer type. The participants wore the prism strengths and prism types randomly to avoid order effects and were unaware of the aim of the study, strength and type of prism worn to avoid bias. For each prism strength the distance VA and the CS were assessed and recorded. VA was measured at six metres with a Bailie-Lovie logMAR chart. The participant was required to read the lowest line of letters visible and any additional letters beyond that row, with each correct letter indentified deducting 0.02 from the score. CS was measured at one metre using the Pelli-Robson chart. The Pelli-Robson consists of identical sized letters in groups of three (triplet). Each group of three letters has the same contrast and the contrast decreases from 100% to 0.5%. The participant was asked to read the letters until only two letters out of the triplet could be identified correctly to give the log score.

VA and CS were tested using counter-balancing methods; half the participants had VA tested first and the remaining half were tested on CS first, to reduce bias and order effects. Randomisation was used with two configurations of the Bailey Lovie and Pelli Robson charts, which were interchanged between prisms tested, to avoid remembrance factors occurring.

A physical comparison between the two types of prism was made by recording: the number of bases per centimetre (cm) for each strength prism and the thickness of the 30Δ Fresnel prism of each brand. The plano glasses were all of the same design and therefore had the same lens width which measured 4.5 cm. The number of bases on each lens for each prism and strength was taken and divided by 4.5 to give the number of bases / cm. The thickness of the prisms was measured by taking the mean of three measurements using a micrometer.

Statistical analysis

In order to analyse the data StatView was used to carry out each of the ANOVAS. Paired t-tests was performed using SPSS.

Results

The effect of 3M and Trusetal prisms on visual acuity (VA)

All sixteen participants completed the entire investigation. Table 1 shows the VA data collected from all each participant. The mean logMAR visual acuity with 3M Fresnel prisms and Trusetal prism foils of each strength prism is illustrated in Figure 1. As expected the main trend is that as prism strength increases, VA decreases. This is true for both the Trusetal and 3M prisms.

To determine whether this was of a statistically significant difference, a two-factor repeated measures ANOVA was performed. The factors were; prism type (3M and Trusetal) and prism strength (5^{Δ}, 10^{Δ}, 20^{Δ}, 30^{Δ}). Results showed that VA significantly reduced with increasing prism strength, [$F_{3,45} = 427.40$, $p < 0.0001$] and that VA was more significantly reduced with the 3M Fresnel prism than the Trusetal Fresnel prism [$F_{1,15} = 19.63$, $p < 0.001$]. There was also an interaction between prism strength and prism type [$F_{3,45} = 10.35$, $p = < 0.0001$], which it appears from Figure 1 may result from the larger reduction in VA with 3M Fresnel prisms with the 10^{Δ} and 30^{Δ}. With the 10^{Δ} 3M Fresnel prism, the mean VA was 0.18 logMAR, whereas the 10^{Δ} Trusetal prism foils resulted in mean VA of 0.11 logMAR. A paired t-test confirmed that the acuity with the 10^{Δ} Trusetal prism was significantly better than with the 10^{Δ} 3M prism [$T_{15} = 4.36$, $p < 0.001$], however clinically the difference is only three and a half letters, which is less than one line, difference. With the 30^{Δ} 3M prism, the resultant mean VA was 0.70 logMAR, compared to 0.57 logMAR with a 30^{Δ} Trusetal; clinically this is six and a half letters difference which is more than one line, a paired t-test showed that the acuity with the 30^{Δ} Trusetal prism was significantly better than with the 3M prism [$T_{15} = 3.87$, $p < 0.01$].

The effect of Fresnel and Trusetal prisms on contrast sensitivity (CS)

Table 2 shows the CS data collected from each participant. Figure 2 shows the mean results of all participants for both 3M and Trusetal prism types. The general trend is that as prism strength is increased, there is a gradual decline in contrast sensitivity. This trend appears fairly similar for both 3M and Trusetal prisms.

To determine whether this was a statistically significant difference, a two-factor repeated measures ANOVA was performed. The factors were; prism type (3M and Trusetal) and prism strength (5^{Δ}, 10^{Δ}, 20^{Δ}, 30^{Δ}).

The results from the ANOVA show that Fresnel prisms significantly reduce CS with increasing prism strength [$F_{3,45} = 95.64$, $p < 0.0001$], but the type of prism used, 3M or Trusetal, did not give significantly different CS results [$F_{1,15}=2.21$, $p > 0.05$]. However, there was an interaction between prism strength and prism type [$F_{3,45}= 4.29$, $p < 0.01$], which it appears from Figure 2 may result from the larger reduction in CS with Trusetal prism foils of 20^{Δ} strength and larger reduction in CS with 3M Fresnel prisms of 30^{Δ} strength . With the 20^{Δ} strength a paired t test showed that the difference was significant [$T_{15} =3.15$, $p <0.01$], however with Trusetal prisms the mean CS was 1.48 log units, whereas the 20^{Δ} 3M prism resulted in mean CS of 0.1.56 log units, a difference of less than one triplet on the Pelli-Robson test. With the 30^{Δ} strength a paired t test showed that the difference was not significant [$T_{15} = -1.86$, $p>0.05$].

Practical Considerations

A physical comparison between the two types of prism was made by recording the number of bases for each strength prism and measuring the thickness of the 30Δ Fresnel prism of each brand. Table 3 shows that as prism strength increases the number of prism bases also increase for both 3M and Trusetal prisms, but Trusetal prisms consist of less bases/cm which is particularly evident with the 30Δ. The mean thickness of the 30Δ Fresnel prism of each brand measured by micrometer was; 3M Fresnel prism 0.86mm, Trusetal prism foil 1.5mm.

Discussion

The results are in agreement with previous studies that press-on prisms do have a significant effect on VA and that the effect of the prism depends on the prism strength. The current study however adds to our knowledge of the effects of two brands of press-on prism. When comparing the two types of prism, there is little difference between the effect that 3M and Trusetal prisms have on VA, until you reach this strength of 30^{Δ}. With mean VA of -0.04 logMAR without any prisms, it gradually reduced until a mean of 0.571 logMAR was achieved with a 30^{Δ} Trusetal and 0.701 logMAR with a 30^{Δ} 3M Fresnel.

There is a significant difference with 10^{Δ} ($p = < 0.001$), shown on the paired t-tests, with Trusetal producing a better VA than the 3M Fresnel, however, clinically this is only three and a half letters difference. There is also a statistically significant difference between the 30^{Δ} Trusetal and 3M prism but this difference is six and a half letters and therefore gives valuable evidence that at this higher strength it would be more beneficial for the patient to use a Trusetal prism foil as part of their treatment plan.

Figure 3 shows how CS reduces with an increase in prism strength which was statistically significant. This is similar to that found by Woo *et al* [10] and Katz [9.] This reduction in CS with Fresnel prisms is principally due to the chromatic dispersion of these prisms. The current study shows that the reduction in CS is not significantly different with 3M Fresnel prisms compared to Trusetal prism foils with the exception of 20^{Δ} where the 3M Fresnel prism gave better contrast sensitivity than the Trusetal, whilst this was the only statistically significant difference it may be considered clinically unremarkable as it equates to less than one triplet difference on the Pelli-Robson test.

As well as considering the relationship between the two types of prisms and their effect on VA and CS with increasing prism strength, the physical properties and performance of the two prism types was also investigated. This is an important factor when in clinic and deciding which prism type to use for a patient. A number of aberrations are inherent in Fresnel prisms: spherical aberration, oblique astigmatism, chromatic dispersion and distortions. When considering materials used in the brands of press-on prisms, polyvinyl chloride and acrylic (Katz [9, 11]) it is possible that any differences will alter the amount of dispersion and aberrations that occur through the prisms and hence their affect on VA and CS. The number of bases present in a given area will affect the amount of dispersion and aberrations that occur through the prisms. The number of bases increased with an increase in strength for both prism types but it was apparent that the 3M Fresnel prisms of higher strengths (20^{Δ} and 30^{Δ}) had more bases per cm than Trusetal prisms of the same strength. This could be a factor in the significantly better VA achieved with the 30^{Δ} Trusetal compared with the 30^{Δ} 3M Fresnel prism.

When considering the structure of the prisms, 3M Fresnel prisms appeared thinner and more flexible than the Trusetal prisms. The thickness of the 3M 30^{Δ} prism was confirmed to be thinner than the Trusetal prism, 0.86mm compared to 1.56mm respectively. This may therefore have contributed to differences noted when applying the press-on prisms to plano glasses. The 3M prisms were easier to apply and usually remained stuck to the lenses after the first attempt of fitting, with little problems removing any air bubbles. However the thicker Trusetal prism foils lifted from the lenses easily, required several attempts at fitting and required a longer period of time to dry before they adhered securely. It was more difficult to remove any air bubbles present.

Conclusion

There is very little or no difference between 3M Fresnel prisms and Trusetal prism foils in terms of how they affect VA and CS for low to moderate strengths. However, when you reach prism strength of 30^{Δ} a significantly better VA can be achieved with a Trusetal prism foil rather than a 3M Fresnel prism. The mean VA using a 30^{Δ} Trusetal prism was more than six letters better than the VA achieved with the same strength of 3M Fresnel prism. This gives valuable evidence that there is a significant benefit for the patient, if a Trusetal prism foil is used when a large strength prism is required, such as 30^{Δ}, is required as part of their treatment plan.

Although there is a benefit in terms of VA practical considerations must also be taken into account. Trusetal Fresnel prisms are thicker and had more problems in relation to fitting and securing to the lens.

The authors' declare that they have no competing interests.

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Table 1: Visual acuity for each participant with 3M Fresnel prisms and Trusetal prism foils. 3M = 3M Fresnel prisms, T = Trusetal Fresnel Prisms, Δ = prism dioptre

Participant	No Prism	3M 5Δ	T 5Δ	3M 10Δ	T 10Δ	3M 20Δ	T 20Δ	3M 30Δ	T 30Δ
1	0.16	0.08	0.06	0.2	0.2	0.28	0.50	0.80	0.50
2	0.00	0.00	0.04	0.08	0.00	0.20	0.20	0.36	0.50
3	0.08	0.10	0.10	0.22	0.20	0.30	0.36	0.80	0.60
4	0.10	0.10	0.22	0.30	0.30	0.40	0.42	0.80	0.60
5	-0.10	0.00	0.00	0.10	0.10	0.40	0.40	0.80	0.52
6	0.02	0.20	0.1	0.30	0.10	0.30	0.40	0.72	0.52
7	0.04	0.00	0.06	0.20	0.12	0.32	0.20	0.64	0.60
8	-0.14	-0.10	0.00	0.00	0.02	0.10	0.24	0.60	0.30
9	-0.08	0.00	0.00	0.20	0.08	0.34	0.40	0.58	0.54
10	-0.10	0.00	0.00	0.10	0.02	0.20	0.20	0.68	0.46
11	-0.14	0.02	0.00	0.12	0.00	0.32	0.40	0.70	0.70
12	-0.20	-0.10	0.00	0.02	0.00	0.22	0.26	0.78	0.50
13	-0.18	0.10	0.10	0.20	0.02	0.30	0.40	0.80	0.70
14	0.02	0.10	0.20	0.30	0.20	0.38	0.40	0.70	0.70
15	0.04	0.10	0.08	0.30	0.24	0.46	0.40	0.76	0.70
16	-0.10	0.00	0.10	0.30	0.20	0.50	0.40	0.70	0.70
Mean	**-0.036**	**0.037**	**0.066**	**0.184**	**0.113**	**0.314**	**0.349**	**0.701**	**0.571**
SD	**0.11**	**0.08**	**0.07**	**0.10**	**0.10**	**0.10**	**0.09**	**0.12**	**0.11**

Table 2: Contrast sensitivity for each participant with 3M Fresnel prisms and Trusetal prism foils. 3M = 3M Fresnel prisms, T = Trusetal Prism foils, Δ = prism dioptre

Participant	No Prism	3M 5Δ	T 5Δ	3M 10Δ	T 10Δ	3M 20Δ	T 20Δ	3M 30Δ	T 30Δ
1	1.65	1.65	1.65	1.65	1.50	1.50	1.35	1.05	1.05
2	1.65	1.65	1.60	1.65	1.65	1.65	1.50	1.35	1.35
3	1.65	1.65	1.65	1.65	1.65	1.65	1.50	1.20	1.35
4	1.65	1.60	1.60	1.65	1.65	1.50	1.35	1.20	1.20
5	1.65	1.65	1.50	1.50	1.50	1.50	1.35	1.20	1.35
6	1.50	1.50	1.50	1.35	1.20	1.35	1.35	1.05	1.05
7	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.35	1.50
8	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.05	1.35
9	1.65	1.65	1.65	1.65	1.65	1.65	1.50	1.50	1.35
10	1.80	1.80	1.65	1.65	1.65	1.65	1.65	1.65	1.50
11	1.80	1.60	1.80	1.80	1.65	1.50	1.50	1.35	1.35
12	1.85	1.65	1.65	1.65	1.65	1.65	1.65	1.35	1.35
13	1.65	1.65	1.50	1.65	1.50	1.50	1.35	1.05	1.35
14	1.65	1.65	1.65	1.65	1.65	1.65	1.50	1.20	1.35
15	1.65	1.65	1.65	1.50	1.65	1.35	1.50	1.20	1.05
16	1.65	1.65	1.65	1.65	1.50	1.50	1.35	1.05	1.35
Mean	**1.67**	**1.64**	**1.63**	**1.62**	**1.58**	**1.56**	**1. 48**	**1.24**	**1.30**
SD	**0.08**	**0.06**	**0.08**	**0.10**	**0.12**	**0.11**	**0.12**	**0.18**	**0.14**

Table 3: Number of prism bases/cm on each type of prism. 3M = 3M Fresnel prisms, T = Trusetal Prism foils, Δ = prism dioptre

Prism strength (Δ)	3M	Trusetal
5	6.4	6.0
10	6.7	6.2
20	9.1	7.1
30	9.8	8.0

Figure 1: The effect of 3M Fresnel prisms and Trusetal prism foils on visual acuity (Δ = Prism dioptres, Error Bars = $^{+}_{-}$ 1 standard error)

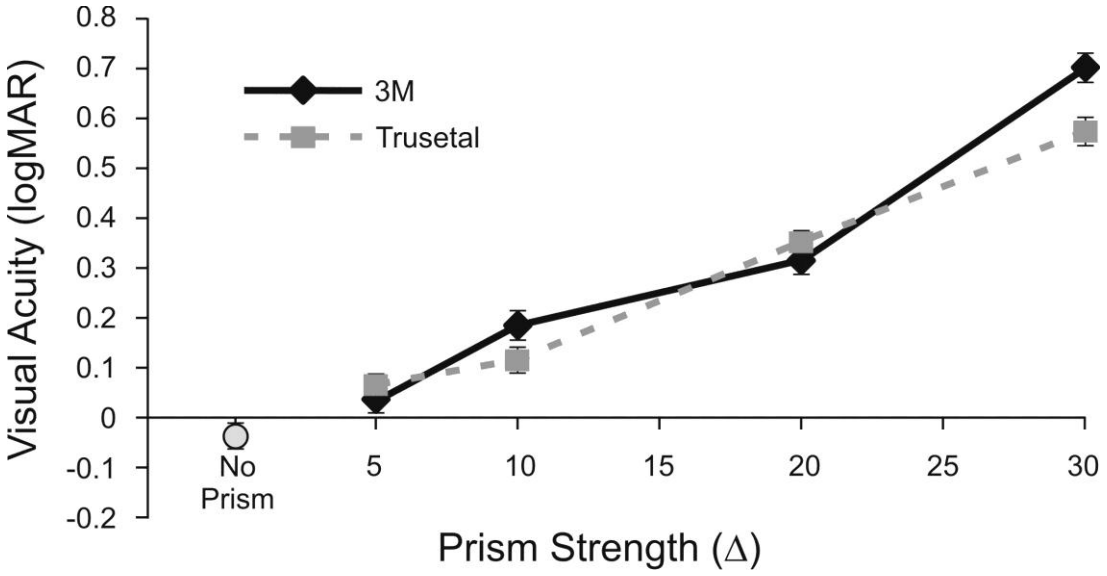

Figure 2: The effect of 3M Fresnel prisms and Trusetal prism foils on contrast sensitivity (Δ = Prism dioptres, Error Bars = $^{+}_{-}$ 1 standard error)