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A comparison of the effect of 3M Fresnel prisms and Trusetal prism foils on visual function

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Abstract

Aim: **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 participated. The effect of 5^{Δ}, 10^{Δ}, 20^{Δ} and 30^{Δ} prism strengths on monocular VA and CS was assessed using a Bailey-Lovie logMAR chart and Pelli-Robson chart, respectively. Measurements were carried out for both 3M Fresnel prisms and Trusetal prism foils. A comparison of the physical properties of the two prism types was made.**
Results: **Deterioration in VA and CS was evident with increasing prism strength with both prism types. VA was more significantly reduced with 3M Fresnel prisms than with Trusetal prism foils [$F_{1,15} = 19.63$, $p < 0.001$]. There was significant interaction between prism types and prism strength [$F_{3,45} = 10.36$, $p < 0.0001$], due to 30^{Δ} 3M Fresnel prisms reducing VA by 0.13 logMAR more than the Trusetal prism foils. There was no statistically significant difference between the prism types for CS [$F_{1,15} = 2.21$, $p = 0.1582$]. 3M Fresnel prisms were thinner than the Trusetal prism foils. The thicker Trusetal prism foils consist of fewer bases per centimetre but were more difficult to fit to spectacle lenses.**
Conclusions: **There is no difference in VA or CS regardless of whether a 3M Fresnel prism or Trusetal prism foil is used until 30^{Δ}, when Trusetal prism foils give better VA. For large deviations it may therefore be more beneficial for the patient to use a Trusetal prism as part of their treatment plan.**

Key words: 3M, Contrast sensitivity, Fresnel prism, Trusetal, Visual acuity

Introduction

Fresnel prisms have been used for treatment of binocular anomalies for many years.[1–5] Primarily they are used to restore binocular single vision 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 that as a temporary measure they 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 United Kingdom by Haag-Streit. The manufacturer Optiker Greten, Folienoptik (Bremen, Germany) has more recently issued a press release on prisms supplied and marketed by Trusetal Verbandstoffwerk. 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] This study aimed to determine any visual difference between these two commercially available press-on prisms.

The detrimental effect of Fresnel prisms on visual acuity (VA)[1,3–5,8,9] and contrast sensitivity (CS)[4,10,11] 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 of the characteristics of the two types of adhesive prisms, such as ease of fitting, thickness and effectiveness, will also be reported.

Methods

Sixteen participants were recruited from the student population of the University of Sheffield, including a mixture of both orthoptic and non-orthoptic students. There were 3 male and 13 female participants with ages ranging from 18 to 21 years (mean age 20 years). 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 0.0 logMAR in the right eye, either with no optical correction or corrected with a contact lens, and a minimum Pelli-Robson CS level of 1.65 log units in the right eye.

The prisms were fitted in advance onto the right lens of nine identical pairs of plano glasses, the left lens being occluded with Durapore surgical tape. The prisms were all applied to the lenses horizontally in a base-out direction and the study included one pair of plano glasses with no prism. The prism strengths used were 5 prism dioptres ($^{\Delta}$), 10^{Δ}, 20^{Δ} and 30^{Δ} for prisms from

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Table 1. Visual acuity with 3M Fresnel prisms and Trusetal prism foils

	No prism	3M 5^{Δ}	T 5^{Δ}	3M 10^{Δ}	T 10^{Δ}	3M 20^{Δ}	T 20^{Δ}	3M 30^{Δ}	T 30^{Δ}
Minimum	0.16	0.20	0.22	0.30	0.30	0.50	0.50	0.80	0.70
Maximum	−0.14	−0.10	0.00	0.02	0.00	0.10	0.20	0.36	0.30
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

3M, 3M Fresnel prisms; T, Trusetal prism foils; $^{\Delta}$, prism dioptre.

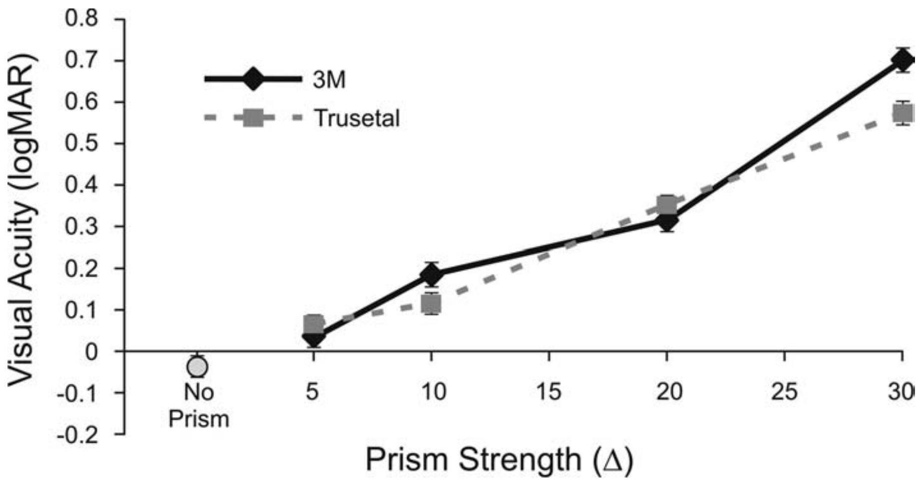

Fig. 1. The effect of 3M Fresnel prisms and Trusetal prism foils on visual acuity. $^{\Delta}$, prism dioptres; error bars represent ± 1 standard error.

each of the manufacturers. The participants wore all the prism strengths and prism types randomly to avoid order effects, and in order to avoid bias were unaware of the aim of the study, or the strength and type of prism worn. For each prism type and strength the VA and CS were assessed and recorded. VA was measured at 6 metres with a Bailey-Lovie logMAR chart; two configurations of the chart were used randomly to reduce learning effects. The participant was required to read the lowest line of letters visible and any additional letters beyond that row, with each correct letter identified deducting 0.02 from the score. CS was measured at 1 metre using the Pelli-Robson chart. The Pelli-Robson consists of identical-sized letters in groups of three (triplets). Each group of three letters has the same contrast and the contrast decreases from 100% to 0.5%. To give the log score the participant was asked to read the letters until only two letters out of the triplet could be identified correctly. Two configurations of the chart were used randomly to reduce learning effects.

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.

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 30^{Δ} prism of each brand. The thickness of the prisms was measured by taking the mean of three measurements using a micrometer.

Statistical analysis

StatView was used to carry out each of the ANOVAs. Post-hoc analysis was completed using CLR ANOVA 1.12 (Clearlake Research, USA).

Results

The effect of 3M Fresnel prisms and Trusetal prism foils on visual acuity

Sixteen participants completed the investigation. Table 1 shows the minimum, maximum and mean VA for each prism type and strength. The mean logMAR VA with 3M Fresnel prisms and Trusetal prism foils of each strength prism is illustrated in Fig. 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 a statistically significant difference, a two-factor repeated measures ANOVA was performed. 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 prism foil [$F_{1,15} = 19.63$, $p = 0.0005$]. There was also an interaction between prism strength and prism type [$F_{3,45} = 10.35$, $p = <0.0001$]. Post-hoc analysis (Tukey HSD) showed that this interaction was due to a significantly better VA achieved with the 30^{Δ} Trusetal prism foil compared with the 30^{Δ} 3M Fresnel prism ($p < 0.01$). With the 30^{Δ} prisms, the mean VA was 0.70 and 0.57 logMAR for the 3M Fresnel prism and Trusetal prism foils, respectively; this is a difference of six and a half letters (more than one line).

Table 2. Contrast sensitivity with 3M Fresnel prisms and Trusetal prism foils

	No prism	3M 5$^{\Delta}$	T 5$^{\Delta}$	3M 10$^{\Delta}$	T 10$^{\Delta}$	3M 20$^{\Delta}$	T 20$^{\Delta}$	3M 30$^{\Delta}$	T 30$^{\Delta}$
Minimum	1.50	1.50	1.50	1.35	1.20	1.35	1.35	1.05	1.05
Maximum	1.85	1.80	1.80	1.65	1.65	1.65	1.65	1.50	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

3M, 3M Fresnel prisms; T, Trusetal prism foils; $^{\Delta}$, prism dioptre.

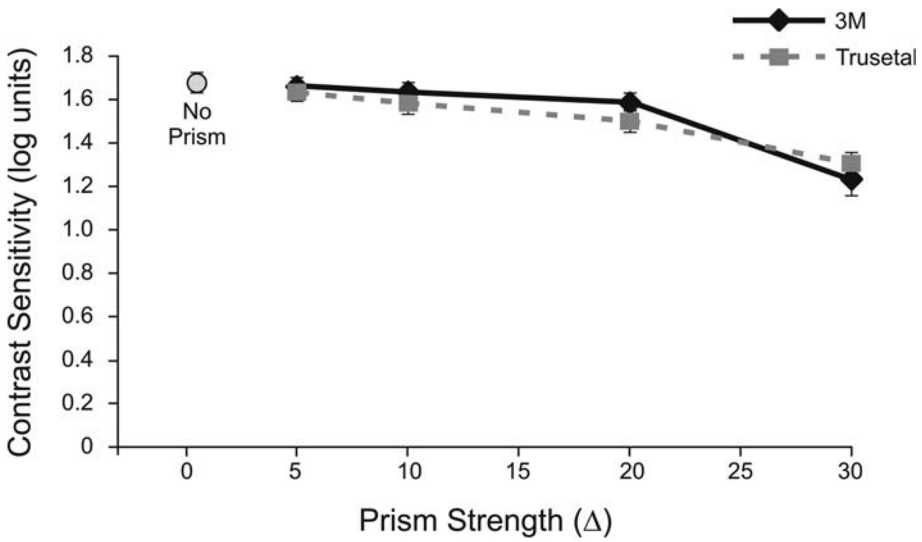

Fig. 2. The effect of 3M Fresnel prisms and Trusetal prism foils on contrast sensitivity. $^{\Delta}$, prism dioptres; error bars represent ± 1 standard error.

The effect of 3M Fresnel prisms and Trusetal prism foils on contrast sensitivity

Table 2 shows the minimum, maximum and mean CS for each prism type and strength. Fig. 2 shows the mean results of all participants for both 3M and Trusetal prism types. The general trend is that as prism strength increased there was a gradual decline in CS. This trend appears fairly similar for the 3M Fresnel prisms and Trusetal prism foils.

To determine whether this was a statistically significant difference, a two-factor repeated measures ANOVA was performed. The results 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 produce significantly different CS results [$F_{1,15} = 2.21$, $p = 0.1582$]. Although there was an interaction between prism strength and prism type [$F_{3,45} = 4.29$, $p = 0.0095$], post-hoc analysis (Tukey HSD) did not show that the differences between the prism types for each strength were significantly different.

Practical considerations

When considering the structure of the two prism brands, the 3M Fresnel prisms appeared thinner and more flexible than the Trusetal prism foils. Table 3 shows that as prism strength increases the number of prism bases also increases for both prism types, but Trusetal prism foils consist of fewer bases per centimetre, which is particularly evident with the 30$^{\Delta}$ prisms. The mean thickness of the 30$^{\Delta}$ prisms of each brand measured by micrometer was 0.86 mm for the 3M Fresnel prism and 1.5 mm for the Trusetal prism foil. These results were consistent for all three measurements taken for each prism type.

The 3M Fresnel prisms were easier to apply and usually remained stuck to the lenses after the first attempt at fitting, with few 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 also more difficult to remove any air bubbles present.

Discussion

The results of this study are in agreement with previous studies. Press-on prisms do have a significant effect on VA and CS and the effect of the prism depends on its strength.

The current study, however, adds to our knowledge of the effects of two brands of press-on prism. There is little difference between the effect that 3M Fresnel prisms and

Table 3. Number of prism bases per centimetre on each type of prism

Prism strength ($^{\Delta}$)	3M	Trusetal
5	6.4	6.0
10	6.7	6.2
20	9.1	7.1
30	9.8	8.0

3M, 3M Fresnel prisms; T, Trusetal prism foils; $^{\Delta}$, prism dioptre.

Trusetal prism foils have on VA until 30^{Δ}, when a statistically significant difference between the Trusetal prism foil and 3M Fresnel prism occurred. The improved VA of six and a half letters with the Trusetal prism foil therefore gives valuable evidence that at this higher strength it would be more beneficial for the patient to use this type of prism.

The current study shows how CS significantly reduces with increase in prism strength. This is similar to the findings of Woo *et al.*[11] and Katz[8] who determined that the 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 with Trusetal prism foils.

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 were also investigated. This is an important factor when deciding in clinic 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 the materials used in the two brands of press-on prisms, polyvinyl chloride and acrylic,[8,10] it is possible that any differences will alter the amount of dispersion and aberrations that occur through the prisms and hence their effect 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 the 3M Fresnel prisms of higher strengths (20^{Δ} and 30^{Δ}) had more bases per centimetre than Trusetal prism foils of the same strength. This could be a factor in the significantly better VA achieved with the 30^{Δ} Trusetal prism foil compared with the 30^{Δ} 3M Fresnel prism.

The 3M 30^{Δ} Fresnel prism was confirmed to be thinner than the Trusetal prism foil. This may have contributed to differences noted when applying the press-on prisms to plano glasses. In view of the fitting difficulties on plano glasses used in this study it may be that this problem would be worsened in higher curvature lenses.

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 at low to moderate strengths. However, with a prism strength of 30^{Δ} a significantly better VA can be achieved with a Trusetal prism foil than with a 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 high-strength prism is required as part of their treatment plan.

Despite this benefit of the Trusetal prism foils in terms of VA, practical considerations must also be taken into account. Trusetal prism foils are thicker and caused more problems in relation to fitting them and securing them to the lens.

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The authors declare that they have no competing interests.

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