Vision Correction with Adaptive Spectacles

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There have been many attempts over many years to produce single element lenses of variable power and to apply them to vision correction, as reviewed by Bennett (1973). For some reason, however, none of the devices described by Bennett nor any of those developed subsequently but prior to the present work appears to have come into widespread use. We describe here the application of novel and simple spectacles having variable power or *adaptive* lenses to vision correction in Ghana. The starting point for this work was the observation that there are about one billion people in the world who could benefit from vision correction with spectacles but are as yet uncorrected (Thylefors 1994) and that it should be possible to provide inexpensive adaptive spectacles which would enable these people to correct their own vision with a minimum of instruction. Such an approach was thought to be worth investigating, since a major problem in the provision of vision correction world-wide especially in the developing world, is a lack of professionally trained staff which puts conventional spectacle correction effectively out of the reach of around one fifth of the world's population.

It was decided to develop a pair of spectacles where the lenses would be fluid filled and have the feature that each lens could be simply and independently adjusted over the range +6 to -6 diopters. This range was chosen in consultation (Hill 1996) so as to give good spherical correction to something over 90% of a typically distributed population. The spectacles developed, which are in the form of a sealed unit incorporating the fluid-filled lenses, are shown in figure 1. Our analysis of the adaptive lenses suggests that the optical quality of the lenses is comparable to the optical quality of the typical human eye as established by Walsh and Charman (Walsh and Charman 1985). So as to establish the usefulness and effectiveness of the device directly in a Developing World country, two limited trials were carried out in Ghana.

The first trial was in the field, and involved correcting the vision for just six people who had reported problems with their vision, four with near vision, and two with distance vision. In each case, the adaptive spectacles were applied by one of the authors, and adjustments were made until the wearer reported that they had clear vision. In two cases, the wearers were also invited to adjust the lenses themselves. When clearest vision was reported, the adaptive spectacles were removed and the power of each lens measured. In four of the cases, a conventional refraction was also carried out, and the results of the two procedures were noted and are given for these four subjects in table 1. Parts of this small field trial were also filmed for BBC TV(*). It will be seen that the results are reasonably consistent. One of the subjects needing near vision correction for his work was loaned the adaptive spectacles for the purposes of the trial over a six-month period with regular monitoring, and the device appeared to work well, giving good correction, over the complete six month period. The other subjects who were loaned the spectacles for the purposes of the trial lived in remote areas and unfortunately the trial was not sufficiently well resourced to provide regular monitoring far from Accra. All the spectacles were returned by the subjects at the end of the trial.

The first trial was designed to investigate whether it was possible to take a single manufactured device out in the field in the Developing World, and apply it to someone needing vision correction, bringing them useful correction "on the spot" and in that, it was reasonably successful. It left unanswered another question about this method of vision correction, namely what is the visual acuity which may be achieved with adaptive lens correction, using the spectacles shown in fig 1. We decided of attempt to answer this question by carrying out a small clinical trial in Korle-Bu Hospital in Accra, by comparing the results of refraction with our adaptive lens, and conventional lenses, on twenty-one patients aged between 16 and 63 years. The tests were carried out with illuminated Snellen's Test Types (both letters, and E charts) used for distance vision and Jaeger and

N-type (letters, numbers, pictures, and E) near cards used for the near vision test. The distance vision test distance was 6 metres, achieved by means of a mirror placed 3 metres from the patient and test chart. At the commencement of the test, a history and then entrance vision were taken for each patient. The vision was measured monocularly in each case. For the conventional examination, both retinoscopy and subjective methods were used on every patient to determine best correction - the lens Rx, and corresponding VA. For the adaptive lens examination, to avoid taking too much of the patient's time and hence to ensure maximum co-operation from each patient, the adaptive spectacles were used either for near vision or for distance vision only. For distance vision, the spectacles were put on the patient set at zero power and she or he was asked to read down the distance chart. The spectacles were then adjusted until the best VA was attained. The Rx of the adaptive lenses were then measured using a focimeter. The procedure was similar for near vision, the spectacles being worn and adjusted until the best NVA was obtained, after which the Rx of the adaptive lenses was measured with the focimeter. The results are shown in table 2.

Discussion

The small field trial was the first known attempt to apply a new adaptive lens technology so as to bring "on the spot" good vision correction in the field with just a single manufactured device. Although applied to a very small number of subjects, it was quite successful, and suggests that good correction can be provided in the field in this way for those subjects who only have refractive errors, and who need spherical correction for near vision.

The hospital trial was carried out to establish whether the adaptive lens correction with our device gives good visual acuity. The entrance vision for patients seen ranged between CF and 6/6. As may be seen from table 2, Rx's from the conventional test and Rx's from the adaptive spectacles compare well. Where these are not the same, the difference is mostly within +/-0.25 D, and the VA is

almost the same in both. Interestingly, the results also show the very useful result that for astigmatic patients, the Rx found for the adaptive lens is a good approximation to the spherical equivalent of the astigmatic Rx obtained from the conventional test. Other general observations are that the adaptive lens gave very good correction for the age group seen, with the range of powers for the group being -0.50 to -5.75D and +0.75 to +3.25 D. Within this range of powers, it was also noted that if the adaptive lens was not able to correct further, the conventional lens could not do any better, and this suggested that apart from cases of relatively large astigmatism, there was most probably some non-refractive problem such as lens opacity etc. This in turn suggests that in widespread use apart from their direct application to vision correction, the adaptive spectacles could also be helpful as a simple screening device for non-refractive problems.

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References

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(*) A television programme was shown in the BBC QED Series on 20 May 1997 on BBC 1 in the UK. Copies of the programme may be obtained from the Video and Educational Training Department, BBC Worldwide, Woodlands, 80 Wood Lane London W12 0TT.

Table 1

Subject	Age & Sex	Adspecs	Conventional	Comment
1	46 Male	R +2.00 L +1.25	R+2.00 L+1.25	Able to do accurate close work with adspecs
2	49 Female	R +1.50 L +2.75	R +2.00 L +3.00	Able to read with adspecs
3	35 Female	R + 1.50 L + 1.00	R + 1.00 L + 1.00	Able to read with adspecs
4	52 Male	R + 1.50 L + 1.25	R + 1.50 L + 1.25	Able to read with adspecs

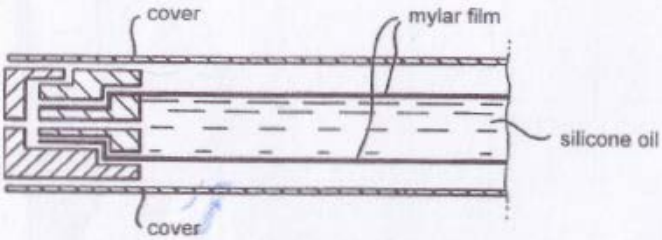
Table 2

Comparision of conventional Test and ADSPEC Rx, Korle-Bu, Ghana

Subject	AG/Sex	V	Conv Test	VA	ADS PE	VA	RE
1	51M	6/12 6/9	+1.50 +1.25/-0.50x130 Add +2.50	6/5 6/5 J_1	+1.25 +1.25	6/5- 6/5-	DV Only
2	56M	6/9 6/6	+0.75/-1.00x90 +0.25/-0.75x90 Add +2.25	6/5 6/5 J_1	+3.00 +1.50	J_1 J_1	NV Only
3	M	6/12 6/12	-1.75 -1.75/-0.50x90	6/5 6/5	-1.50 -2.25	6/5 6/9	Const wear
4	44F	6/36 6/36	+3.50 +3.25	6/5 6/5	+3.00 -	6/5 -	
5	48M	6/36 6/18	+1.50 +1.75/-0.50x90 Add +2.00	6/5 6/5 J_1	+1.50 -	6/5 -	DV Only
6	18F	CF CF	-5.50 -8.00	6/5 6/5	-5.75 -	6/5	Const wear
7	F	6/9 6/5	+0.75 PI Add +1.50	6/5 6/5 J_1	+1.75 +0.75	6/5 6/6	diff to adjust L of Adsp
8	F	6/12- 6/12	-1.00/-1.00x90 -0.75/-0.75x90 Add +2.25	6/5 6/5 J_1	-2.00 -	6/5-	
9	(48) M	6/9+ 6/20	+1.50/-1.00x40 +0.75/-1.50x155 Add +1.75	6/5 6/12- N5	+1.50	6/5-	

Subject	AG/Sex	V	Conv Test	VA	ADS PE	VA	RE
10	(63)M	6/20 6/9-	-0.50 -0.25/ -1.00x10 Add +2.50	6/9 6/9+ N6	-0.50 -	6/9	Bil cent. Vit + Lo
11	(43)M	6/9- 6/20	+0.50/-1.00x90 +0.50/-1.50x90 Add +2.00	6/4- 6/5 N4.5	-0.50 -	6/5	
12	(53)F	6/20 6/20-	-2.00/-1.50x45 -2.25 Add +2.00	6/5 6/5 N4.5	-2.75	6/9+	
13	(42)M	6/9 6/12+	+1.25 +1.25 Add +1.50	6/4 6/4- N5	+1.25	6/4	
14	(54)F	6/12+ CF	+1.75 +12.00 Add+2.00	6/6 6/15 N4.5	+1.50	6/6	L Apha-kia
15	(45)M	6/18-- 6/18	+1.50 +1.25 Add +1.50	6/5 6/5 N5	+2.50	6/6	
16	(16)F	6/60dif CF(2m	-4.25 -5.00	6/5 6/5	-4.00	6/6+	
17	F	6/12 6/36-	-1.50 -2.00	6/6 6/5	-1.50	6/6	
18	(49)M	6/6 6/6	P1 P1 Add +2.50	6/6 6/6 J1	+2.50	J1	Near
19	(36)F	6/12 6/12	-2.00/-0.75x180 -0.75/-1.50x180	6/5- 6/5-	-2.75	6/5-	
20	(49)M	CF CF	-4.50/-1.50x95 -3.50/-1.50 x 80 Add +2.00	6/5 6/5+ J1	-5.25	6/5-	
21	(57)M	6/12 6/9	+1.00 +0.75/-0.75x110 Add + 2.50	6/5 6/5 J1	+3.25	J1	Near only

The Adaptive Spectacles as used in the Ghana Trials



Section through the adaptive lens

Fig1.