

# New thoughts on the correction of presbyopia for divers

Quentin M Bennett

## Key words

Eyes, vision, optometry, diving, equipment

## Abstract

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Some new ideas on the correction of presbyopia for divers, particularly those with demands for critical near vision underwater, are discussed. Progressive lenses cannot be satisfactorily bonded to a dive mask, so efforts to mimic the properties of progressive lenses using bifocal lenses are described.

## Introduction

From the age of early to mid-forties, the amplitude of accommodation declines and those in this age group and older begin to have difficulty with near tasks. This is presbyopia, yet another of the signs of maturity that strike at this stage of life.<sup>1</sup>

One relevant fact for divers is that poorer light conditions prevail underwater. This can result in increased or earlier presbyopic effects, probably due to slightly dilated pupils in the reduced light. This is more marked in dirty water or high-latitude, cold water diving. In the latter, the sunlight is at a much lower angle and less penetrates the water column. Should a diver have interests such as underwater photography, which demands critical near vision underwater, they may well notice presbyopic changes underwater before they notice them in normal life.

## Choices in the correction of presbyopia for divers

Correction of presbyopia in normal life comes in many forms. Simple reading spectacles, progressive lenses, bifocal lenses or bifocal contact lenses are the most common. Diving masks certainly bring constraints and limitations. Contact lenses may have physiological compromises imposed.<sup>2</sup> Another factor can be the diver's standard of uncorrected vision, or their refractive error.

The easiest situation is when there is no great distance refractive error so that a near-vision correction is required only for reading a gauge or computer. In this case a small plus-powered reading segment like a small bifocal can be bonded to the lower inside of the mask glass. This is usually on the non-dominant side, where most divers hang their pressure or combi-gauge. The front surface of the lens has to be flat or plano in order for it to be bonded to the inside of the dive mask without any bubbles being trapped in between.

Also available are plastics lenses with a negative electrostatic charge, some with Fresnel optics, that adhere to the inside of the dive-mask glass without adhesive. These are adequate

for reading a gauge or combo. Some early presbyopes have discovered that a carefully placed pinhole can be sufficient for them to read a gauge if they are diving in conditions with reasonable light levels. This aid is insufficient for any critical tasks.

Many divers have a distance refractive error in addition to their presbyopia. During their day-to-day life they wear progressive spectacles which enable them to focus at any distance from far to near. Progressive lenses are generally regarded as the most convenient everyday form of spectacle correction for presbyopes.<sup>3</sup> Because these lenses utilise very complicated curves split between the back and front surfaces it is not possible to bond them to the flat posterior glass surface of a dive mask.

Therefore, in order to be able to see at both distance and near, one has to use bifocal lenses because they can be ground with a flat front surface with all the power on the back surface. Because the facemask utilizes a flat, toughened glass plate, a glass-fused bifocal lens is normally used. The flat front surface of the lens is bonded to the back surface of the mask glass plate in the appropriate position before the eyes. Such a glass-fused bifocal lens has a segment of glass of a higher refractive index fused to it and annealed under prolonged high temperature.

Generally a bifocal lens suffers from the disadvantage of offering sharp vision at distance and at near, but not at intermediate distances. On the other hand, the progressive lens has the great advantage of also offering sharp vision at intermediate distances, such as when viewing a computer monitor. The difference in power between the top distance portion and the lower, reading portion of a bifocal or progressive lens is termed the addition.

When underwater, critical intermediate vision is generally necessary only for specialised interests such as underwater photography, observation of macro life, and some scientific requirements. A technique for achieving this for divers is described below.

## Method

Using a variation of a technique known in contact lens practice and refractive surgery as simultaneous vision or monovision, we have been trying to mimic aspects of the effects of a progressive lens for diving. For these techniques, as used above water, the dominant eye is usually corrected for distance and the non-dominant eye for near. Underwater we utilise only the technique for near and intermediate vision.

Monovision works well for some people, but is disliked by others. It does compromise binocular vision and could never be recommended for occupations requiring either good distance judgement or constant work at a single distance. Examples of occupations requiring good binocular vision and accurate distance judgement, making them unsuitable candidates for monovision, would include drivers, pilots and crane operators.

With the variance that we have utilised for diving, distance vision in both eyes is properly corrected and balanced. We use monovision or simultaneous vision at intermediate and near distance only, and this is done by providing different bifocal additions in each eye. We utilize this type of correction only for persons who have good binocular vision with its resulting ability to fuse slightly different images.

An easy illustration would be an emmetrope who requires no correction for distance. Depending on his or her exact requirements we may give them bifocal segments with reading powers of +3.00 diopter in the right eye and +1.50 in the left. With these lenses the right eye's focus is theoretically at about 0.30 m and the left at 0.66 m. Assuming the diver has good binocular functions the then fused image from both eyes gives a depth of field not dissimilar to that of a progressive lens.

Requirements underwater are very different from those in our normal life on land where an average progressive spectacle addition for someone over 55 years of age is likely to be about +2.25, theoretically giving sharp focus from around 40 cm to infinity. For a presbyopic diver who uses an underwater digital camera and needs to inspect the screen, and who also uses a wrist-mounted computer, I will frequently suggest a +3.00 addition in the dominant eye, and a +1.25 or +1.50 in the non-dominant eye. This way they can comfortably see their camera screen or computer, and yet are able to examine things on the reef at almost a metre away. But they also have distance vision at the top of their lens, so we are mimicking a progressive lens fairly satisfactorily.

Obviously different divers have different requirements or interests and the near addition will differ with regard to these and the diver's age and degree of presbyopia. If the manifest presbyopia is quite low and the diver is able to

see their camera screen or computer well with a reasonably low addition, then simultaneous vision at near may not be necessary. This is because a lower addition has a greater depth of field.

## Comments

One thing that is very helpful to those outside the ophthalmic professions who may be giving advice on corrections is a basic understanding of the dioptric power system. The dioptric power of a lens is the reciprocal of the focal length in metres. For example, a lens with a focal length of 0.50 m has a power of 2 diopters. One with a focal length of 0.33 m is 3 diopters power and so on. If we could look at the earlier example of having a 3 diopter addition before the dominant eye, the focus of the bifocal addition would be at about 0.33 m with this eye, and the other eye with a +1.50 addition would have its focus at 0.66 m. So, from knowing the required focus distance, one can work out an approximation of the required lens power. Remember, however, that if the diver still has some remaining accommodation these figures won't be exact and the focus will be closer, so a lower addition would be called for.

As with everything when dealing with human beings, there is great variance and no two people are the same, so one must remain flexible when prescribing lens power, and think carefully of the diver's requirements.

## References

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*Quentin M Bennett, FCOptom FAAO DipCLP MRSNZ, is a clinical optometrist in private practice and an elected full member of SPUMS.*

## Address for correspondence:

*P O Box 79, Napier 4140*

*New Zealand*

*Phone: +64-(0)6-835-1234*

*Fax: +64-(0)6-835-5002*

*E-mail: <qbennett@oceanfocus.co.nz>*