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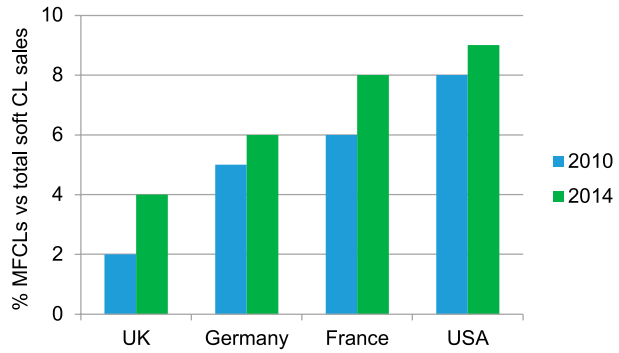
Understanding Multifocals and getting them to work

A number of factors contribute to the success of soft multifocal contact lenses, Dr Trusit Dave examines the design principles and material considerations behind current designs.

Despite the increasing availability of multifocal contact lens options, presbyopes remain under-represented among contact lens wearers. While in the five years from 2010 the number of multifocal contact lens wearers in the UK grew,[1] they still represent a very small proportion of the total 3.7m contact lens wearer market;[2] just 4 per cent in volume terms.

In other countries, uptake of multifocals is higher. In Germany, for instance, the proportion is 6 per cent and in France 8 per cent (Figure 1).[3] In the US, 9 per cent of total lenses sold are multifocal, representing nearly 2m wearers. However, these data all identify the unmet need for lens designs that effectively correct presbyopia.

Figure 1: Proportion of multifocal contact lenses sold compared to total sales 2010-2014



Fitting data also reveal that only 15,000 UK fits were switched from single-vision to multifocal lenses in 2014 and almost as many switched out of multifocals.[1] This highlights a major opportunity, not just to increase prescribing rates among new and existing wearers but also to improve on success rates with current multifocals.

KEY POINTS

- We all have spherical aberration; it is usually positive and pupil size is one of the factors that can affect SA
- Current soft multifocal contact lenses, whether centre near (CN) or centre distance (CD) in design generate spherical aberration to give depth of focus

To achieve success with soft multifocal contact lenses you need to consider:

- Pupil size varies with age and refractive error so choose a lens brand that takes this into account
- Choose a lens design that provides good on-eye centration to provide maximum visual quality
- Use an optimal contact lens material for the ageing tear film (for good visual stability)
- Set positive, but realistic patient expectations
- Daily disposability may be beneficial for the presbyope, who for lifestyle reasons wants both spectacles and contact lenses

Table 1: Factors contributing to success with multifocal contact lenses

Eye	Lens	Fitting	Patient
Optics; spherical aberration	Centre near/ centre distance	Power selection	Who / when / where
Pupil size	Balanced design	Centration	Modality
Crystalline lens clarity	On-eye effect	Contact lens material	Expectations

Dropout remains a major issue with multifocal lenses. The most recent study among new wearers shows a one-year retention rate of only 57 per cent among multifocal lens wearers compared with 78 per cent for spherical lenses.[4] Discontinuation from multifocals may be due to dissatisfaction with vision but also to issues relating to the ageing eye, such as tear film changes and reduced comfort. Many presbyopic lens wearers are currently prescribed monovision, although this form of correction has major limitations.[5] Binocular high contrast visual acuity is lower with monovision compared to and stereopsis is also reduced.[6,7] And when wearers have experienced both modes of correction, most prefer multifocals to monovision (76 per cent vs 24 per cent).[7] Monovision offers a limited window of opportunity for our patients. By the time wearers are ready to move out of monovision, multifocal correction is positioned later into presbyopia and medium to high adds are required. Ultimately this places more difficult adaptation conditions on patients, potentially lowering success rates and increasing dropout. This article will examine factors contributing to success with multifocal contact lenses, as summarised in Table 1. It will describe the design principles and material considerations incorporated in current lenses, including a new daily disposable option: 1-DAY ACUVUE® MOIST MULTIFOCAL.

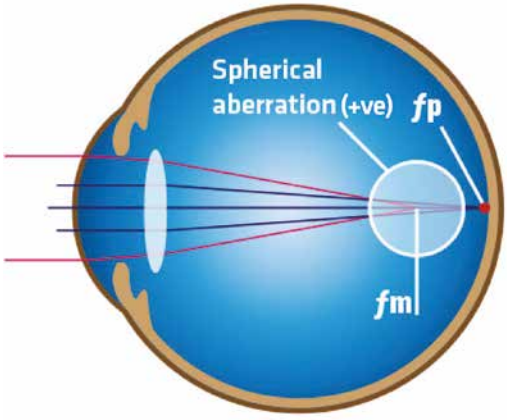
Eye factors

Spherical aberration

Of all the aberrations of the normal human eye, spherical aberration (SA) is the most relevant to multifocal contact lens correction. We can measure ocular aberrations using aberrometry. Qualitatively, this displays aberration data in wavefront error maps which provide information on the emergent wavefront of an eye from a point source on the retina.[8] While most forms of aberration are, on average, close to zero, SA is the most significant.[9] It is important to note that, between individuals, SA of the whole eye varies and, unlike other high order aberrations, is invariably positive in nature. With positive SA, marginal rays are focused in front of the retina and paraxial rays near the optical axis are focused on the retina. In negative SA, marginal rays are focused behind the retina and central rays on the retina. SA results in depth of focus at the retina; in object space it results in depth of field (Figure 2).

Whether positive or negative, both forms of SA provide depth of field and that is exactly what most current simultaneous vision multifocal lenses, whether centre-near (CN) or centre-distance (CD), exploit in order to give clear vision over multiple distances.

Figure 2: Spherical aberration results in depth of focus at the retina



***fp*: paraxial focal point**
***fm*: marginal focal point**

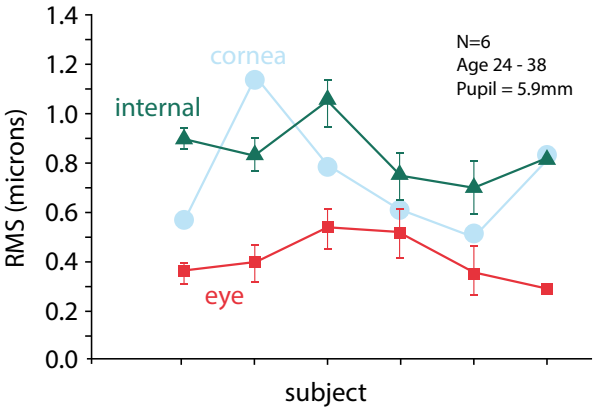
SA, like other optical aberrations, is affected by pupil size. The same aberration in the same eye with a 6mm pupil results in considerably greater defocus than with a 3mm pupil. This is a reason why a multifocal contact lens can perform very differently on the patient's eye and between patients.

The optical system of the eye is principally composed of the cornea and lens. Corneal shape therefore also impacts on the optical system. A spherical corneal shape would have positive SA. Fortunately, the cornea has a prolate elliptical shape – flattening in the periphery – creating the eye's own correction mechanism to reduce SA. 'Optical coupling' by the eye's internal optics is a natural correction of the eye within itself whereby corneal and lenticular aberrations partially compensate for each other (Figure 3).[10]

The result is that, in young eyes, higher order aberrations of the whole eye are less than the sum of their parts, cancelling each other out to create a robust ocular system.

The aberrations of the internal eye increase progressively with age, due mainly to crystalline lens changes; in fact, around 10X greater aberrations are induced by the crystalline lens over time than by the cornea.[10] Since SA increases and becomes increasingly more positive in the ageing eye due to changes in the lens, depth of field is increased. If SA alone were to increase, it would be quite an ingenious adaptation of the eye; however, along with increases in SA, there are increases in other, unwanted aberrations.

Figure 3: Root mean square of the wave-front aberration of the eye (squares), the cornea (circles), and the internal optics (triangles) for six eyes after defocus was removed (adapted from Artal *et al*[10])



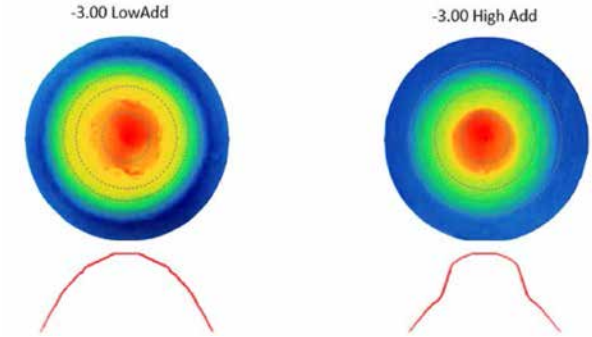
The combination of the patient's SA and the SA of the multifocal contact lens can explain some of the variations in results (see On-eye effect). While it is important to understand how aspheric multifocals work, and why they work better for some patients than others, remember that we cannot control SA in the eye or in a given lens design. Other design features therefore need to be considered.

Pupil size

Pupil size is known to decrease with age, as well as when looking at near objects and, of course, under photopic conditions. If a CN multifocal contact lens design is not optimised and has a fixed design for all reading additions, overall clarity or distance vision could be lost as the pupil size diminishes with age.

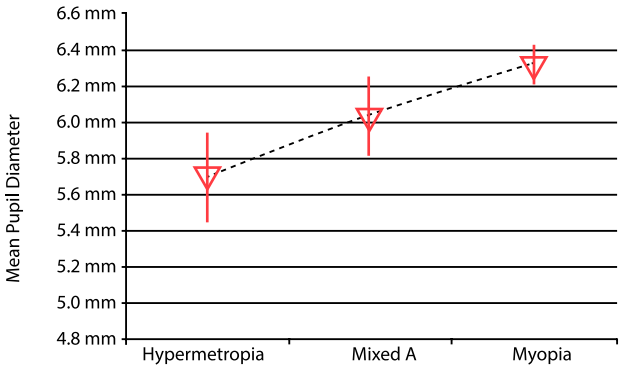
Most, but not all, current multifocal designs (Figure 4) are adapted to reflect this age change as the reading addition increases (if one makes the reasonable assumption that higher reading adds will be required for older patients).

Figure 4: Lens design modification for pupil size changes as the reading add increases, which is present in some multifocal options



However, a more recent finding is that not only does pupil size vary with age but refractive error may also influence pupil size, myopes tending to have larger pupil size than hyperopes. Cakmak *et al*[11] found that mean pupil diameter is larger in myopic eyes than in hyperopic eyes under mesopic conditions, and this difference is statistically significant (Figure 5).

Figure 5: Mean pupil diameter with refractive group in mesopic conditions (after Cakmak *et al*)[11]



Although mean difference in pupil size between myopes and hyperopes may seem small, it represents a difference in pupil area of as much as 24 per cent. Another study[12] has recently confirmed this finding and discussed the implications for multifocal design.

So, with a hyperopic group, although a multifocal contact lens may have a full range of powers – transitioning from near to intermediate to distance – if the design is not optimised for refractive error (Figure 5) or age, there may be reduced distance power over the pupil area. If differences in pupil size are not factored in, designing a multifocal for a myopic population would not lead to as successful a design for hyperopes, and *vice versa*.

An opportunity therefore exists to optimise lens design not just for age differences in pupil size but also for distance refractive error. The new 1-DAY ACUVUE® MOIST MULTIFOCAL has been designed to leverage mean differences in pupil between myopic and hyperopic groups to help optimise multifocal correction within these refractive groups.

Manufacturers need individually designed optical profiles across the prescription and reading addition range to optimise optics in this way, but fortunately this is not a concern for practitioners who simply select the appropriate lens based on distance correction and addition in the usual way.

Lens clarity

In addition to SA and pupil size, crystalline lens clarity can also influence success with multifocal contact lenses. Multifocal intraocular lenses have a distinct advantage over contact lens forms of correction in that removing the crystalline lens provides clear optics. It is important to check the clarity of the patients' media before fitting since this can impact on vision with multifocals and may, in part, account for variation in success.

Lens factors

Centre near / centre distance

Common soft multifocal contact lenses utilise various design concepts, the principal categories being CN or CD designs (Table 2).

Power profiles of multifocal designs from different manufacturers show significant variations between lens

Table 2: Examples of some daily disposable and reusable multifocal soft contact lens designs (based on manufacturer details)

Brand name (manufacturer)	Material	Daily wear modality	Design	Power range (D)	Add powers (D)
1-DAY ACUVUE® MOIST MULTIFOCAL (Johnson & Johnson Vision Care)	etafilcon A (hydrogel)	Daily disposable	Aspheric CN	+6.00 to -9.00	3 adds - low (+0.75D to +1.25D); mid (+1.50D to +1.75D) & high (+2.00D to +2.50D)
Dailies AquaComfort Plus Multifocal (Alcon)	nelfilcon A (hydrogel)		Aspheric CN	+6.00 to -10.00	3 adds – low (to +1.25), med (to +2.00) & high (to +2.50)
Clariti 1day Multifocal (Sauflon)	somofilcon A (SiH)		Aspheric CN	+5.00 to -6.00	2 adds - low (to +2.25); high (to +3.00)
ACUVUE OASYS® for PRESBYOPIA (Johnson & Johnson Vision Care)	senofilcon A (SiH)	Reusable – 2-weekly replacement	CD Zonal asphe-ric	+6.00 to -9.00	3 adds – low (to +1.25), mid (to +1.75) & high (to +2.50)
Air Optix Aqua Multifocal (Alcon)	lotrafilcon B (SiH)	Reusable – monthly replacement	Aspheric CN	+6.00 to -10.00	3 adds – low (to +1.25), med (to +2.00) & high (to +2.50)
Biofinity Multifocal (CooperVision)	comfilcon A (SiH)		CD or CN; multizonal	+6.00 to -10.00	4 adds - +1.00, +1.50, +2.00, +2.50 D lens, N lens
PureVision Multifocal (Bausch + Lomb)	balafilcon A		CN aspheric	+6.00 to -10.00	2 adds – low (up to +1.50D) & high (+1.75 to +2.50D)

types. A recent study by Wagner *et al*[13] found power profiles provided helpful information for prescribing lenses for presbyopes. These authors observed that negative SA occurred for most of the multifocal lenses they tested and some (such as PureVision Multi-Focal, Bausch + Lomb) seemed to rely predominantly on the SA component to provide the multifocal effect.

Of the CN lenses, 1-DAY ACUVUE® MOIST MULTIFOCAL (Johnson & Johnson Vision Care) and Air Optix Aqua Multifocal (Alcon) are aspheric CN designs with three reading additions (low, medium and high). PureVision Multi-Focal and SofLens Multi-Focal (Bausch + Lomb), along with the Clariti Multifocal range (Sauflon), are also CN aspheric designs with two reading additions (low and high).

Practitioners should note that with CN multifocals of the same distance and near prescription, the lens design differs not only between manufacturers but may also differ between brands.

Of the CD lenses, ACUVUE OASYS® for PRESBYOPIA is a multi-zone multifocal or zonal aspheric optical design with three reading additions (low, mid and high).

Given these differences, having several multifocals available in practice offers the opportunity to try more than one type of design to meet the individual patient's needs. Where one design may not work in a given patient, another lens with a different design may be successful.

Zonal aspheric designs

The reusable Proclear and Biofinity Multifocals (CooperVision) are aspheric lenses and come in four add powers, with CN and CD options. With these lenses, the CN lens is fitted to the non-dominant eye and the CD to the dominant eye.

In these lenses, unlike other designs, the optics are not optimised for age as the reading addition increases. With the Proclear Multifocal, for instance, the CN lens has an approximately 2mm central spherical zone followed by an approximately 1mm transitional zone where the lens power transitions to the distance prescription. Finally, there is the distance zone which appears to have an aspheric surface.

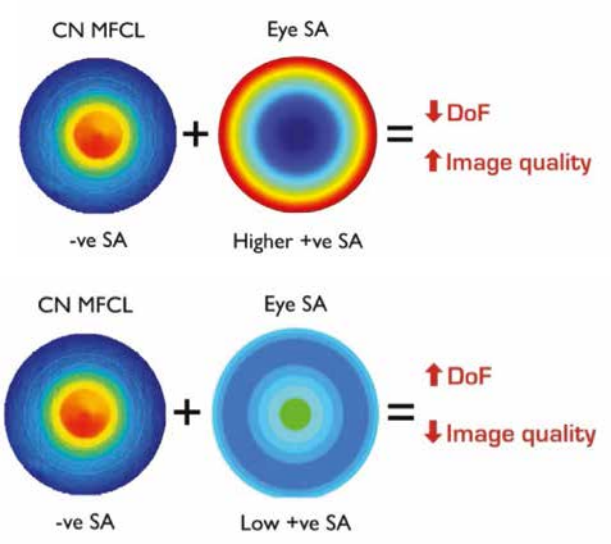
The CD lens has a central aspheric zone of approximately 3mm and a steep transitional zone, with the peripheral optics of the lens containing an aspheric near prescription. Both CN and CD designs have fixed optical zones regardless of add power.

On-eye effect

Lens design cannot be considered in isolation from the optics of the eye. The same powered multifocal lens fitted to eyes with the same optical prescription and pupil size may not result in the same vision.

Bakaraju et al[14] found that the image quality of model eyes with greater positive spherical aberration was greater with a CN multifocal (which has negative SA); however, the depth of focus was reduced. In essence, eyes with greater positive SA will have improved acuity for closer/intermediate vision, but less multifocal effect when wearing CN lenses (Figure 6).

Figure 6: Power profiles showing the on-eye effect of a centre-near multifocal on eyes with low (left) and higher (right) spherical aberration (SA) on depth of field (DoF) and visual acuity (VA)



Fitting

Power selection

Eye care practitioners will know from experience that very small changes in multifocal lens power, whether for distance or near, can make a marked difference to a patient's vision and visual comfort. An extensive distance power range, with small increments throughout the range, is therefore desirable, as is a range of reading additions. In daily disposable options, available powers have been somewhat limited to date.

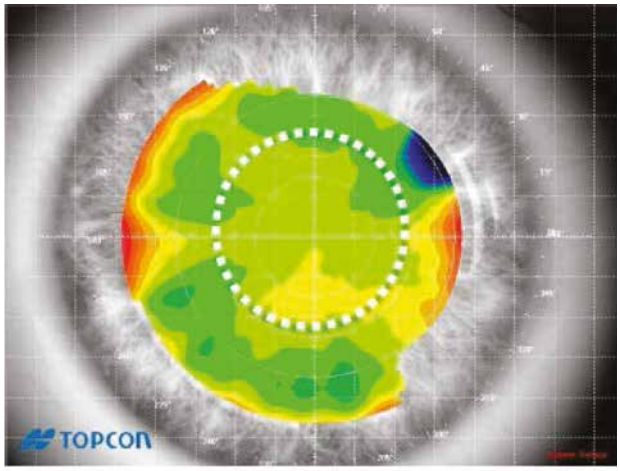
Very few multifocal toric soft lenses are as yet available, and none in a daily disposable modality. This is an area that practitioners will be watching closely in future as success rates with toric soft lenses and with soft multifocals improve.

Centration

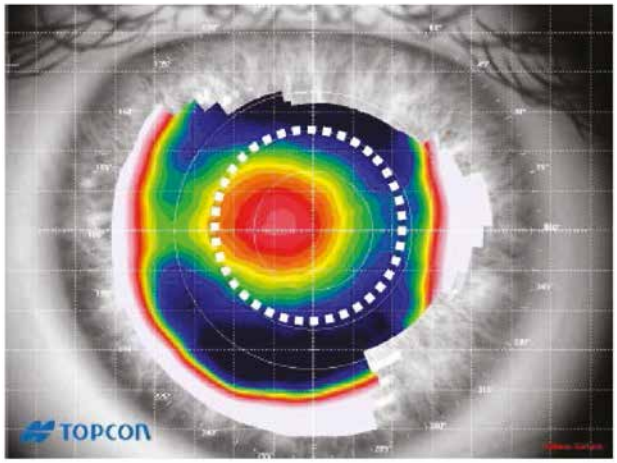
Of course placing a lens on a model eye does not reflect the dynamic situation that exists when a lens is actually worn. A key fitting characteristic for all multifocal contact lenses is centration. If a multifocal lens decentres it will induce unwanted aberrations (principally coma), thus reducing vision. Recently, Lampa *et al*[15] proposed that corneal topography may be a useful method to evaluate lens centration and the authors recommended using tangential (instantaneous curvature difference) maps to quantify centration.

The author of this article, however, considers that a better method to check optical centration may be to use elevation maps with the difference in height subtracted from a spherical or aspheric surface. This approach enables visualisation of the apex of the cornea (with or without the multifocal) with respect to the pupil centre (Figure 7).

Figure 7: Using elevation maps (difference from sphere) to visualise the apex of the cornea with respect to the pupil centre. On this RE, the multifocal lens shows temporal, optical decentration



No lens



Air Optix High Add

Being able to predict this effect from topographic maps is an excellent method of objective assessment of optical centration to confirm subjective visual acuity findings. In conjunction with this objective method can be gaining feedback on subjective vision performance, by asking patients if they notice any doubling or splitting of vision at distance or near.

Lens material

Choice of material is a neglected factor in multifocal contact lens prescribing. In fact material is almost as important as design, especially in presbyopic eyes since tear stability reduces with age.[16] Environmental factors such as increased use of computers also challenge the ageing eye. The aim is to select a material which maintains a stable tear film and thus provides more consistent vision as well as minimising symptoms of dryness and discomfort. Real-time topographic aberrometry of the pre-lens tear film is helpful in revealing differences in tear film stability between lens materials. Koh *et al*[17] investigated whether the polymer composition of disposable soft contact lenses affects sequential changes in higher-order aberrations.

Table 3: Examples of managing expectations with multifocal wearers

Avoid	Consider
Compromise	Balance between distance and near
Not perfect	All-round vision
Not as good as specs	Reduced dependence on reading glasses

In symptomatic daily disposable lens wearers, total higher order aberrations and subjective ocular dryness with a lens with embedded polyvinyl pyrrollidone (PVP; 1-DAY ACUVUE® MOIST) were significantly decreased when compared with a lens of the same material without PVP.

Patient factors

Who, when and where

As well as choice of lens material, modality is a key consideration in multifocal prescribing. Daily disposability offers particular advantages for presbyopes who, for lifestyle reasons, may want to wear a combination of spectacles and contact lenses.[18]

Patients do want a choice. Low myopes, for instance, may function well without any correction in some situations, such as indoors, but there may be other occasions when they want to have that multifocal effect.

Having experienced both progressive-addition spectacles and multifocal contact lenses, most patients (78 per cent) prefer a combination of both correction methods.[19] Presbyopes may prefer progressive addition spectacles for stationary and solitary activities, but multifocal contact lenses for social and active pursuits since they provide a wider field of view and a more natural vision experience. Patients perceive the benefits of the two modalities as complimentary.

A multifocal is ideal in a daily disposable modality since patients can wear the lenses part time if they wish; currently a third of multifocal wearers use their lenses on a part-time basis.[20] However, once patients get started with multifocals they may organically grow into wearing them more often if they so choose. It is prudent to consider the applications for which patients will be wearing the lenses and use materials that perform well in those situations that can exacerbate dryness symptoms, such as office environments.

The advantages of daily disposability, along with the increasing number of lens options available, are reflected in the uptake of multifocals in this modality in the UK.[3] Nearly one in four multifocals (22 per cent) sold here in 2014 were daily disposable lenses, compared to 10 per cent in 2010. The current UK figure is also much higher than in other countries such as Germany (8 per cent), and France and the US (both at 4 per cent), although daily disposable prescribing in multifocals has increased four-fold recently in both Germany and the US (from 2 per cent and less than 1 per cent respectively in 2010).

Expectations

Communication is the final consideration when discussing multifocals with presbyopes. Give patients the most positive impression of correcting their presbyopia but avoid over-technical terms. Use language that resonates with them and talks about their expectations. 'Reducing your dependence on reading lenses' is just one way of adapting your language to manage patient expectations (Table 3).

Other authors have suggested ways of opening a discussion with long-term contact lens wearers about how their visual and lifestyle needs change over time.[21,22]

Conclusions

Multifocal contact lenses all differ between lens manufacturers and behave slightly differently on the eye. As a result, practitioners are advised to have a number of different lens designs available within their practices.

The question each practitioner must ask is: 'What will be my first-choice multifocal?' The author recommends that the first-choice lens should be one that:

1. Uses an optimal material for the ageing tear film (for good visual stability)
2. Has pupil optics that are optimised both for age and refractive error
3. Provides good on-eye centration
4. Offers flexibility and comes in a modality that is easy for patients.

There are several multifocal lens options with a number of manufacturers offering centre-near lenses. We often see innovation in a crowded, technology-driven marketplace. Small steps in the development of optical design and lens materials, when combined together, could well provide a first-choice lens that stands out from everything else.

The arrival of 1-DAY ACUVUE® MOIST MULTIFOCAL from Johnson & Johnson Vision Care, with its enhanced multifocal design and proven material properties, offers practitioners the potential for good success rates with multifocal contact lenses. Ultimately, clinical performance results and personal, hands-on experience will help practitioners decide if this is the multifocal contact lens to choose as their first fit lens.

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About the Author

Optometrist Dr Trusit Dave is founder and director of Optimed. This article is based on a presentation at the Johnson & Johnson Vision Care 2015 Clinical Roadshow in the UK, "A New View"

References

1. Internal analysis based on independent third party data, 2015.
2. Association of Contact Lens Manufacturers, 2014.
3. Johnson & Johnson Vision Care, Data on file; Internal analysis based on independent 3rd party volume data 2014 US, UK, France and Germany; and internal estimates annual consumption based on frequency, seasonality and compliance from Independent MR survey 2014, 7 markets across Europe and Russia via online questionnaire n=5,076 contact lens wearers aged 15+.
4. Sulley A, Young G and Hunt C. Factors in the success of new contact lens wearers. *Optom Vis Sci* 2014 E-abstract 145020
5. Evans B. Monovision: a review. *Ophthalmic Physiol Opt* 2007;27:5 417-39.
6. Rajagopalan AS, Bennett ES and Lakshminarayanan V. Visual performance of subjects wearing presbyopic contact lenses. *Optom Vis Sci* 2006;83:8 611-615.
7. Richdale K, Mitchell GL and Zadnick K. Comparison of multifocal and monovision soft contact lens corrections in patients with low-astigmatic presbyopia. *Optom Vis Sci* 2006;83: 5 266-273.
8. Dave T. Wavefront aberrometry. Part 1: Current theories and concepts. *Optometry Today* 2004; November 19: 41-45.
9. Porter J, Guirao A, Cox IG *et al*. Monochromatic aberrations of the human eye in a large population. J *Opt Soc Am A Opt Image Sci Vis* 2001;18:8 1793-1803.
10. Artal P, Guirao A, Berrio E *et al*. Compensation of corneal aberrations by the internal optics of the human eye. *J Vis* 2001;1 :1 1-8.
11. Cakmak HB, Caqil N, Simavli H *et al*. Refractive error may influence mesopic pupil size. *Curr Eye Res* 2010;35:2 130-6.
12. Dumbleton K, Guillon M, Theodoratos P *et al*. The effects of age and refraction on pupil size and visual acuity: Implications for multifocal contact lens design and fitting. Presentation at British Contact Lens Association Clinical Conference, May 2015.
13. Wagner S, Conrad F, Bakaraju RC *et al*. Power profiles of single vision and multifocal soft contact lenses. *Cont Lens Anterior Eye* 2015;38:1 2-14.
14. Bakaraju RC, Ehrmann K, Ho A *et al*. Inherent ocular spherical aberration and multifocal contact lens optical performance. *Optom Vis Sci* 2010;87:12 1009-22.
15. Lampa M, So K, Caroline P *et al*. Assessing multifocal soft contact lens centration with the aid of corneal topography. Poster presentation at Global Speciality Lens Symposium, January 2012.
16. Patel S, Boyd KE and Burns J. Age, stability of the precorneal tear film and the refractive index of tear. *Cont Lens Anterior Eye* 2000;23:2 44-7.
17. Koh C, Maeda N, Hamano T *et al*. Effect of internal lubricating agents of disposable soft contact lenses on higher-order aberrations after blinking. *Eye Contact Lens* 2008;34:2 100-5.
18. Aslam A. Contact lenses and spectacles: a winning combination. *Optician* 2013; 246:6425 26-28.
19. Neadle S, Ivanova V and Hickson-Curran S. Do presbyopes prefer progressive spectacles or multifocal contact lenses? *Cont Lens Ant Eye* 2010;33:262-263.
20. Johnson & Johnson Vision Care. Data on file. Incidence study 2014, EMA.
21. Bharuchi S and Donne S. Conversations in practice: managing the long-term wearer. *Optician* 2014;248:6472 23-30.
22. Hudson C. How to succeed with multifocal contact lenses. *Optometry Today* 2011; February 11: 45-48.