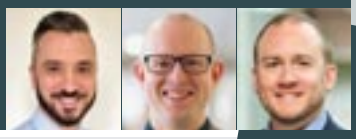

COMPETENCIES COVERED

DISPENSING OPTICIANS
Standards of Practice,
Optical Appliances

OPTOMETRISTS
Standards of Practice,
Optical Appliances

This CET has been approved for one point by the GOC. It is open to all FBDO members, and associate member optometrists. The multiple-choice questions (MCQs) for this month's CET are available **online only**, to comply with the GOC's Good Practice Guidance for this type of CET. Insert your answers to the six MCQs online at www.abdo.org.uk. After member login, go into the secure membership portal and CET Online will be found on the L menu.
Questions will be presented in random order. Please ensure that your email address and GOC number are up-to-date. The pass mark is 60 per cent. The answers will appear in the July 2021 issue of *Dispensing Optics*. The closing date is 4 June 2021.

General Optical Council
Approved CET For Dispensing Opticians

General Optical Council
Approved CET For Optometrists

C-77198 Approved for one CET Point

Digital centration

By Howard Collins BSc (Hons), MCOptom, Paul Hopkins BSc (Hons), MCOptom and Professor Leon Davies PhD, FCOptom, FAAO, SFHEA

As an integral part of ocular healthcare, eyecare practitioners (ECP) should provide patients with an accurate refraction, thereby enabling the appropriate optical appliance to be dispensed, which fully encompasses the patient's visual needs.

Providing optimal visual performance in such appliances is vital to ensuring the quality of the patient's experience, which in turn should help to maintain practice reputation and minimise rechecks, which can be costly both in terms of chair time and spectacle remakes.

Errors in dispensing account for a significant proportion of rechecks[1], therefore several important aspects should be considered during the dispensing process in order to reduce the recheck risk.

Firstly, a judicious choice of frames and lenses. Not only does the patient need to be happy with the frame choice, but it must also be suitable for the type of lens that is being dispensed. Careful advice about frame size and style, to ensure the best cosmetic outcomes, must be augmented with a knowledge of lens properties in order to provide the patient with their ideal visual solutions.

Having made these choices, it is then vital that accurate facial and frame measurements are taken and recorded, as without these values even the best possible lens will perform sub-optimally.

WHICH MEASUREMENTS SHOULD BE TAKEN?

The College of Optometrists and the Association of British Dispensing Opticians (ABDO) guidance advises that *appropriate* facial and frame measurements are taken and that the fit of the frame should be assessed[2,3]. So, what are 'appropriate measurements'? As a minimum, this includes the most common measurements required in order to dispense spectacles: interpupillary distance (IPD), either binocular or monocular, for all lens types; and the segment height or fitting height for bifocals and progressive addition lenses (PALs), respectively.

Monocular IPDs should be considered for all lens types, as they will ensure correct lens centration and assist in eliminating induced horizontal prism. According to BS EN ISO 13666:2019[4], monocular IPD is defined as the distance between the centre of the pupil and either the mid-line of the bridge of the nose or the spectacle frame when the eye is in the primary position.

However, due to the natural asymmetries inherent in faces[5], accurate horizontal positioning of the optical centres (OCs) is best achieved using 'the mid-line of the bridge of the spectacle frame' and should be taken once the spectacles have been fitted correctly; this provides what is known as the centration point (CP) of the lens (**Figure 1**).

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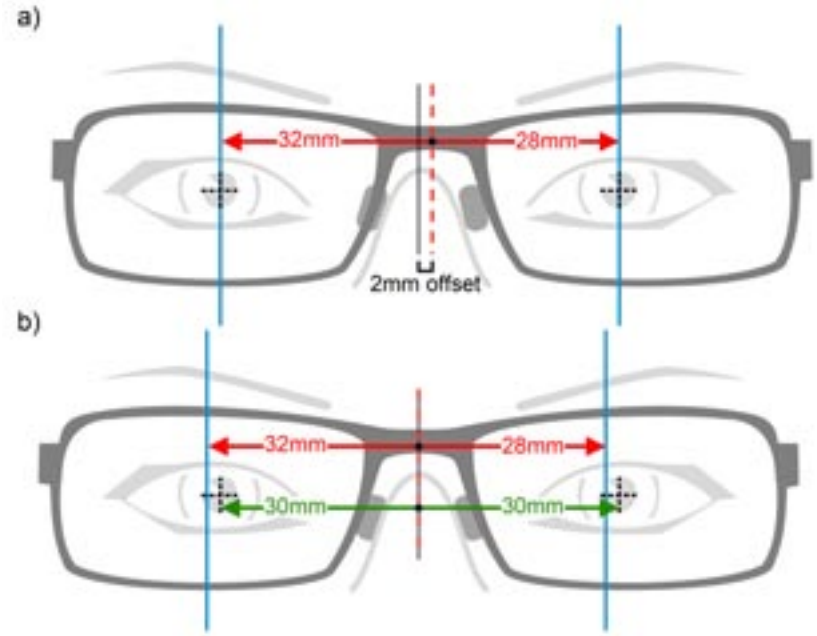

Figure 1: Illustrating the potential error of not fitting a spectacle frame correctly before taking measurements. (a) During dispensing the frame is laterally displaced 2mm to the left of the ideal fitting position (grey vertical line) due to poorly fitting nose pads. However, monocular PDs are measured appropriately, using the midline of the spectacle bridge. (b) On collection of the spectacles, the nose pads are adjusted so that the frame sits correctly, the lens OCs are now decentred 2mm in each eye relative to the patient's pupil centres

Fitting heights are required for PALs and bifocals but may be beneficial for single vision lenses to maximise the benefits of customised freeform lenses, and for higher powered, aspheric lenses (or lenses with one or more aspherical surfaces) or anisometropic prescriptions, minimise differential prism in the primary gaze position.

It is also important to remember the requirement in British Standards BS 2738-3:2004+A1:2008[6] for the ECP to measure and record the vertex distance on all prescriptions over ±5.00D – although this this could be extended to lower prescription powers, particularly for freeform lenses.

Other perhaps less commonly taken measurements include pantoscopic angle (PA) and face form angle (FFA). These are important, however, particularly for higher powered prescriptions, where the fitting heights should be adjusted in line with PA, and OCs displaced horizontally to compensate for FFA[7]. Failure to make these adjustments can result in changes to the effective lens power and induce unwanted prism[7].

WHY TAKE MEASUREMENTS?

The main reasons for taking frame and facial measurements are to ensure that: 1) the OCs (or centration points if prism is prescribed) of the lenses coincide with the patient's visual axes, thereby providing clear vision free from induced prism; and 2) that the correct lens power is provided. However, freeform lenses are increasing in popularity and have been shown to provide greater patient satisfaction than standard lenses[8].

With advances in freeform lens technology comes the possibility of ever more individualised lens tailoring[9], but in order to maximise the potential benefits that freeform lenses offer, a full range of frame and facial measurements must be taken[9].

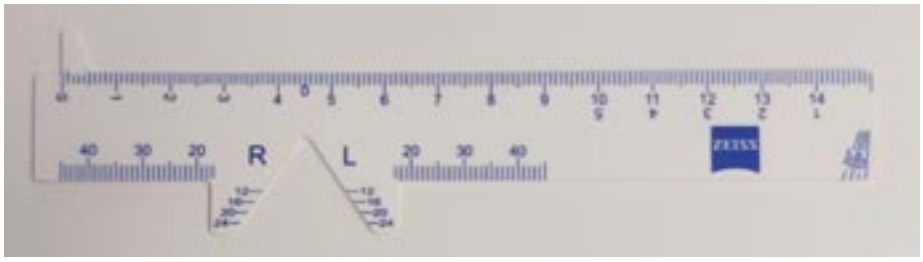

Figure 2: IPD rule

Figure 3: Pupilometer

In many cases, taking minimal measurements will prove sufficient and patients will be satisfied with the finished product. However, increasing competition both on the High Street and from online retailers means that it is more important than ever to provide a service geared at building patient confidence and maintaining practice loyalty.

HOW ARE MEASUREMENTS TAKEN?

Traditional methods

Interpupillary distance is by far the most common measurement taken when dispensing spectacles, with two popular methods employed for this purpose. The first method is by hand with an IPD rule (**Figure 2**) using Viktorin's method[10]. The zero edge of the IPD rule is lined up with an anatomical feature of the patient's right eye (e.g. pupil centre or limbus) and measured to the corresponding point on the patient's left eye. When using the limbus, the measurement is taken from the temporal limbus of one eye to the nasal limbus of the other[10].

Although this method is quick and convenient, it has been shown to have significant inter *and* intra examiner variability[10-14] – with variation of between ±1-4mm. This method may suffer from the effects of parallax where large differences between the IPD of patient and examiner exist[15,16] and whilst there are corrections that can be applied to account for this[17], it has been suggested that these are not commonly performed[10].

Literature relating to monocular IPDs taken by ruler is sparse, but Walsh and Pearce[10] found the variability to be marginally less than that of binocular IPD. However, a number of practitioners in the

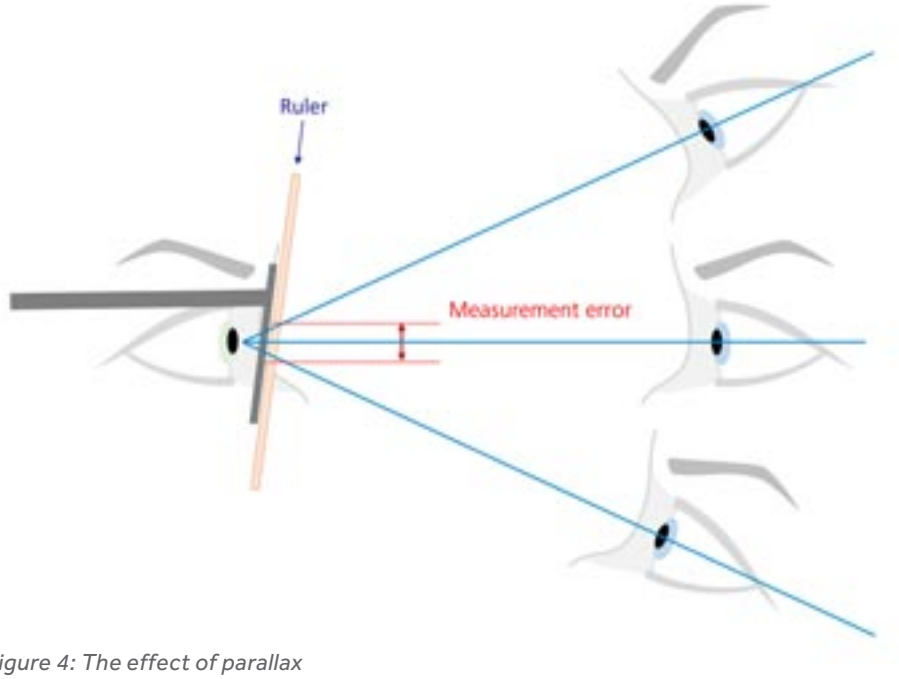

Figure 4: The effect of parallax

study admitted to ensuring the same total value for monocular and binocular IPD measures, which may cause an underestimation of the variability of the monocular results.

The second traditional method of assessing IPD is with a pupilometer (**Figure 3**), which can be used to measure both monocular and binocular IPDs for a range of working distances. Studies have shown pupilometers to give more repeatable measurements[13] with less variability[13,18] when compared to those using Viktorin's method[10,11]. However, in terms of absolute accuracy, they are by no means perfect, with average errors of up to 2mm[18].

Additionally, while some pupilometers have features to help hold the device parallel, e.g. a head rest, others do not and so can easily be held at an angle to the patient, decreasing the accuracy of the measurement.

Fitting heights are also specifically defined in British Standards[4] and are referenced relative to the horizontal centre line (HCL)[6]; these are, however, often measured as the vertical fitting distance between the centration point and a horizontal tangent to the lower lens edge.

As this is in reference to an edged lens, the measurement must include the height of the edge profile (i.e. the bevel) if present. The standard method of measuring fitting heights is for the patient to look straight ahead while the practitioner sits opposite and marks the relevant height, using the lower limbus as a reference for bifocals, and the pupil centre for PALs and single vision lenses.

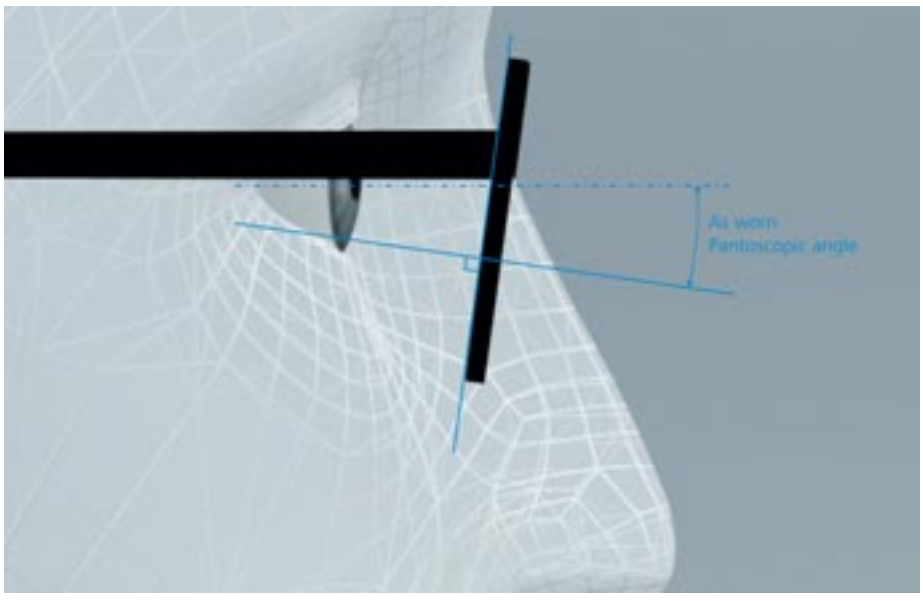

Figure 5: Pantoscopic angle

Practitioners must ensure that their eyes are level with the patient's and that the patient has their head in its customary position; failure to do so may lead to parallax errors[19] resulting in the lenses being centred too high/low (**Figure 4**). For a practitioner 30cm away from a patient wearing a frame 12mm from their eye, an alignment error of 2.5cm high or low will lead to a fitting height error of 1mm.

Vertex distance is defined in BS EN ISO 13666:2019[4] as the distance between the back surface of the lens and the apex of the cornea with the eyes in the primary position. Changes to this distance alter the effective power of the lens, with higher lens powers affected to a greater extent. Differences between the vertex distance used during refraction and that in the final spectacle frame, therefore need to be accounted for.

The measurement is taken with the patient wearing the frame and may be acquired with a ruler, although vertex callipers may be easier[7]. If using a ruler, the practitioner must be at the same height as the patient and view square on to the side of the frame to avoid the effects of parallax.

The 'as-worn' pantoscopic angle (PA) is also measured with the patient wearing the frame, and is the angle between the line of sight of the eye in the primary position (for most patients this will be horizontal) and a line perpendicular to the plane of the front surface of the frame, passing through the frame grooves[4].

PA should be measured with the patient looking straight ahead with their habitual head and body posture (**Figure 5**). Like vertex distance, changes in PA can change the effective power of the lens[7] and the fitting height should be adjusted to compensate for this: 1mm lower for every 2° increase in PA[17].

There are various gauges and instruments that can be used to take this measurement (**Figure 6**), but before taking the measurement, it is important to ensure that the frame has been fitted correctly to the patient and is in the position where it will be habitually worn. Again, as with

Figure 6: Pantoscopic angle tool

using any device to take a measurement, the practitioner must ensure alignment to avoid the effects of parallax.

Face form angle (FFA), also called wrap angle is the angle between the plane of the spectacle front and the plane of the lens shape[4] (**Figure 7**), i.e. how much the frame 'wraps around' the patient's face. FFA can be thought of as the horizontal equivalent to PA and needs to be compensated for by horizontal decentration in an equivalent fashion[20], i.e. 1mm temporal decentration for every 2°. The measurement itself is taken directly from the frame, rather than in the 'as worn' position, and can be done with a simple protractor; although specific devices are available.

ISSUES OF INACCURACY

Taking seven or more individual measurements per pair of spectacles certainly provides scope for error, but how important are these potential errors to the patient's experience of their new lenses?

The standards laid out in BS EN ISO 21987:2017 specify the manufacturing tolerances of vertex power, cylinder axis, add power and prism imbalance[21]. Whilst the exact tolerance for lens power depends on the overall sphere and cylinder of the lens, for the most commonly dispensed prescriptions a general guide would be a tolerance of ±0.12D, with the tolerance becoming slightly larger as the power of the lens increases. This is in contrast to cylinder axis where tolerance decreases on higher power lenses, with an allowed margin of error of ±2° on a cylinder power over 2.50D.

Fitting heights and monocular horizontal centration must be within ±1mm of the ordered values, meaning that a specified IPD could have a total manufacturing error of 2mm and still be within tolerance. Even taken monocularly, a -5.00D spherical lens could induce 0.5 prism dioptres (Δ) of unwanted prism horizontally or vertically, and that is before any errors of the measured IPD or heights are taken into account.

IPDs taken with a pupilometer have been shown to be subject to errors of up to ±2mm[18] with similar errors shown for fitting heights[8]. With these errors combined, monocularly the -5.00D lens could now have horizontal errors of ±2mm and vertical errors of ±3mm, generating unwanted prism of 1.0Δ and 1.5Δ respectively.

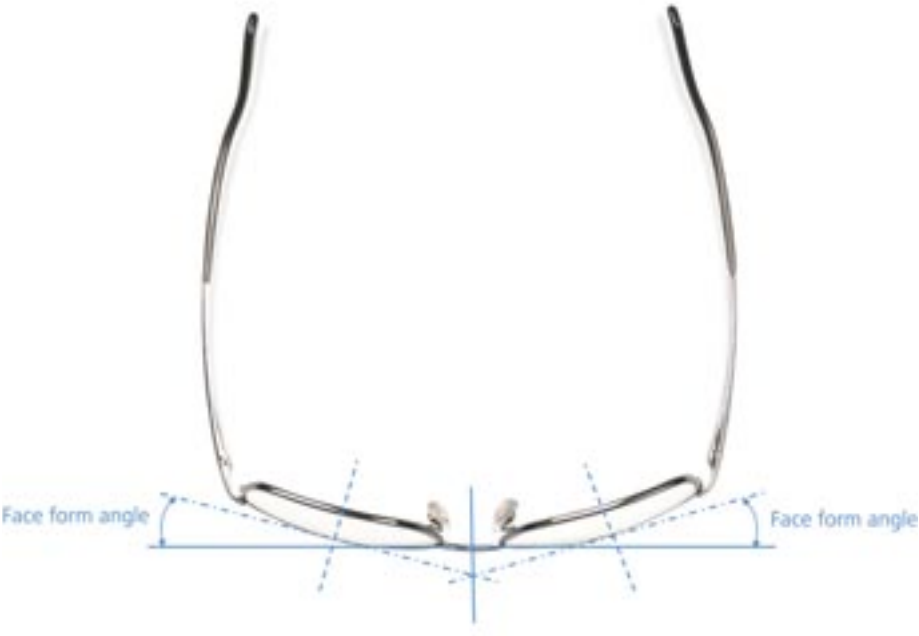

Figure 7: Face form angle

Finally, there is also a tolerance for prism at the ordered centration points (see Table 5 in BS EN ISO 21987:2017)* which for the -5.00D lens could be up to 1Δ, further compounding the problem. Leaving the manufacturing tolerance of prism aside, -5.00D spectacle lenses could easily be made 'correctly' and yet leave the patient experiencing a total of 2Δ horizontal and 3Δ vertical unwanted prism.

This is important when considering that patient tolerance to induced prism has been shown to be approximately ≤1Δ horizontal and ≤0.5Δ vertical prism[22]. Whilst the scenario of maximum error leading to 3Δ unwanted vertical prism is unlikely – large differences in vertical fitting heights would be expected to be checked for accuracy prior to ordering the lenses. This illustrates the need for accurate measurements to be taken in the first place.

Unwanted prism can potentially cause a range of symptoms from headaches and dizziness to double vision and asthenopia[22-24], which have obvious implications for patient comfort and tolerance of their spectacles. Other clinical effects have been reported, particularly for vertical prism, such as reduced stereoacuity[25,26] and contrast sensitivity[27], even for levels of induced prism which would fall within the BS tolerances for spectacle manufacture. Interestingly, the effects on contrast sensitivity were shown to be worse under lower (mesopic) lighting conditions[27], which has important implications for patients wearing their spectacles for night driving.

Induced horizontal prism can affect the vergence system[26] and base out (BO) prism has been shown to be particularly problematic in terms of inducing symptoms[28]. These symptoms possibly arise from induced exophoria, reducing the capacity for comfortable convergence. This effect may be similar to the condition of convergence insufficiency, where a reduced ability to maintain convergence has been suggested as the cause of similar symptoms such as dizziness[29,30].

The effect of BO prism is particularly relevant given that the increasing use of digital devices like computers and smartphones means that people are spending more time using near and intermediate working distances, thus placing more demand on their convergence.

Figure 8: Tablet-based digital centration device

As an aside, induced prism can also be the product of poorly fitting frames which have moved from their ideal facial position[28]. It is, therefore, imperative that both patient and practitioner are happy with the frame fit before any measurements are taken, and that patients should feel comfortable to return periodically for spectacle adjustments as required.

Other than induced prism, errors in fitting heights for PALs may lead to patients looking through an inappropriate part of the lens, either inducing blur if the lens is set too high, or causing the patient problems finding the near vision area if set too low. This is particularly relevant as PALs are associated with an increased risk of falls in general[31,32], so any errors in fitting height may potentially increase this risk.

For measurements of vertex distance, PA and FFA, the main impact of errors is from changes to the effective power of the lens; either through changes to the sphere and cylinder powers themselves in the case of vertex distance, or by inducing unwanted cylinder power in the case of PA and FFA. For example, a +5.00D lens has a manufacturing tolerance of ±0.12D, which means it could have a back-vertex power of +5.12D and fall within tolerance.

If this is coupled with a failure to account for a 5mm difference in vertex distance between trial frame and spectacle frame, the patient could experience a lens which is effectively over-plussed by 0.25D. Prescription errors even of this magnitude, particularly over-plussing/under-minussing, have been shown to be poorly accepted[33,34] and are a major cause of non-tolerance and spectacle rechecks[1,35].

THE ONLINE ISSUE

Patients are increasingly asking for their IPD to be supplied with their prescription in order to facilitate the purchase of spectacles from internet companies. However, there are also guides on these websites for patients to measure their own IPD, or for someone else to do it for them, but these 'DIY' methods have been shown to produce results which are far from accurate or repeatable[14]. Even when the IPD is supplied by a practitioner, the position of the frame on the patient's face is not taken into account, which can lead to centration errors as discussed above.

Studies have found that the standard of spectacles purchased online can be poor in terms of optical quality in general[36], with more deemed unacceptable for issues like incorrect centration than those purchased from a practice[37]. It is perhaps worth gently highlighting these issues to patients by explaining the number of measurements, and the precision which is required, in order to provide accurate lenses, alongside the availability of expertise at hand within the practice.

GOING FORWARDS

In order to provide excellent patient service and maximise the benefits of freeform lenses, a number of careful measurements must be taken, requiring familiarity with a number of different instruments. The resulting dispensing process may then take somewhat longer than simply measuring IPDs and fitting heights. Depending on the practice and the number of staff available, this could lead to delays, which are likely to have a negative impact on patient perceptions of customer service[38,39].

However, more recently a number of manufacturers have developed digital centration devices (DCDs), which are aimed at reducing the overall time, and increasing the accuracy, of frame and facial measurements. And, in a world where the majority of people use smartphones or digital technology on a daily basis[40], research has shown that investment and use of technology positively impacts the customer's perception of quality[41].

Generally speaking, DCDs come in two formats: floor standing devices such as the ZEISS i.Terminal 2 and the Essilor Visioffice; and tablet-based systems like the ZEISS i.Terminal Mobile and Hoya's visuReal. Digital images of the patient are taken and displayed on a screen where practitioners can set markings for the various measurements. The computer then calculates the measurements accurate to 0.1mm.

As the image is still, and the computer will signal if a picture is not positioned optimally, the effects of parallax or head movements are negated, allowing the possibility of much more accurate measurements. For any remaining parallax, some devices include error correction to help minimise the effect.

Many DCDs require a frame calibrating clip of some kind to provide the computer with reference points from which it can work out measurements (**Figure 8**). However, some like Shamir Spark Mi or ZEISS VISUFIT 1000 allow measurements to be taken without the use of a calibration tool, increasing the likelihood that patients will adopt their habitual head posture and further increasing measurement reliability (**Figure 9**).

As well as the potential for increased accuracy, there are also likely to be considerable savings in dispensing time. All the measurements are taken from a minimal number of pictures on one device and, at busy times, the images can be stored and the measurements calculated after the patient has left.

The recent situation surrounding Covid-19 has also raised the profile of DCDs as they enable a distance to be maintained

and minimise contact between practitioner and patient. In the case of clipless devices, the patient only makes direct contact with the frame for measurements to be accurately taken. ZEISS VISUFIT 1000 can actually take this a step further, with centration able to be performed using a virtual frame, allowing the dispensing process to be truly contactless.

In terms of their accuracy, a 2009 study[42] looking at a variety of now older model DCDs, compared their repeatability to measurements taken with pupilometers. The variation of measurements as given by the standard deviation was far less with the DCDs (0.09mm for one device), indicating very good reproducibility of results. Similarly, measures of fitting heights and PA were also found to be very accurate.

Given the continuous advances in technology, it is likely that more recent devices will be able to offer even greater improvements in accuracy and repeatability – but further studies are needed to verify this.

As well as taking fast, accurate measurements, some DCDs now go well beyond the remit of measurement device, offering support throughout the dispensing consultation including frame styling and tint/coating demonstrations.

The ZEISS VISUFIT 1000 mentioned above can even enable a virtual 'try on' by creating a 3D avatar of the patient. This allows them to try on frames from a virtual catalogue, as well as being able to display specific tints and coatings in a chosen frame so that the patient can see the finished combination before ordering. This has a number of benefits and when combined with a detailed analysis of patient needs by the practitioner, allows an individually tailored visual solution to be dispensed in a manner perhaps more in line with today's modern consumer.

CONCLUSIONS

The increasing popularity of freeform lenses, and the potential visual improvements they can offer, means that taking accurate frame and facial measurements is more important than ever – and could save a lot of unnecessary rechecks either with a dispensing optician or optometrist by minimising errors in lens power and induced prism. Increased competition for spectacle sales from online retailers and on the High Street means that practices need to be able to set themselves apart in terms of the service they can provide to patients.

Digital centration devices offer the required levels of accuracy that will maximise the benefits of individualised freeform lenses, alongside convenience, but without sacrificing the patient's perception of the service that they are receiving. This should pave the way for reduced dispensing errors, greater patient satisfaction and, ultimately, repeat business.

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Figure 9: Clipless centration device in use

* All ABDO members have access to key British Standards as a membership benefit via the **ABDO website**.

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