EC OPHTHALMOLOGY
Short Communication

FreeForm Technology in the Opthalmic Industry

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The ophthalmic lens industry offers a wide range of designs and lenses, but the quality of these products can vary significantly depending on the technology used for their calculation and production. Before FreeForm technology, conventional progressive designs were molded and therefore the variety of designs were limited because of the complexity that would require having multiple designs for the different combinations of base curves, eye, insets and materials. FreeForm changed this radically making possible to have any progressive lens design for any combination of addition power, base curve, eye, insets, lengths, etc. FreeForm technology made possible to have any lens design using just spherical lens blanks, it has increased the possibilities in terms of what can be designed and produced. More specifically it allows production of individual surfaces adapted to the user's needs.

But FreeForm, by itself, is not equivalent to better quality or performance, that depends on several factors like the calculation technology used for the lens design and laboratory production quality. A laboratory can have the best lens design calculation technology but if their processes aren't stable and not fine-tuned to replicate the calculation of the lenses accurately, the final product won't perform as it was designed for. Same happens if a laboratory has the best processes to manufacture FreeForm lenses but doesn't have state of the art calculation technology to calculate FreeForm progressive lens designs.

One of the main advantages of FreeForm is, each lens can be calculated with actual parameters of the user giving the final wearer better visual performance when compared to a conventional lens. Using a ray tracing algorithm, the real perceived power of the user is simulated to calculate these personalized lenses. As can be seen in figure 1, ray trace uses a model of a lens-eye system, where rays are coming from different distances and refracted through a lens in its real position of use.

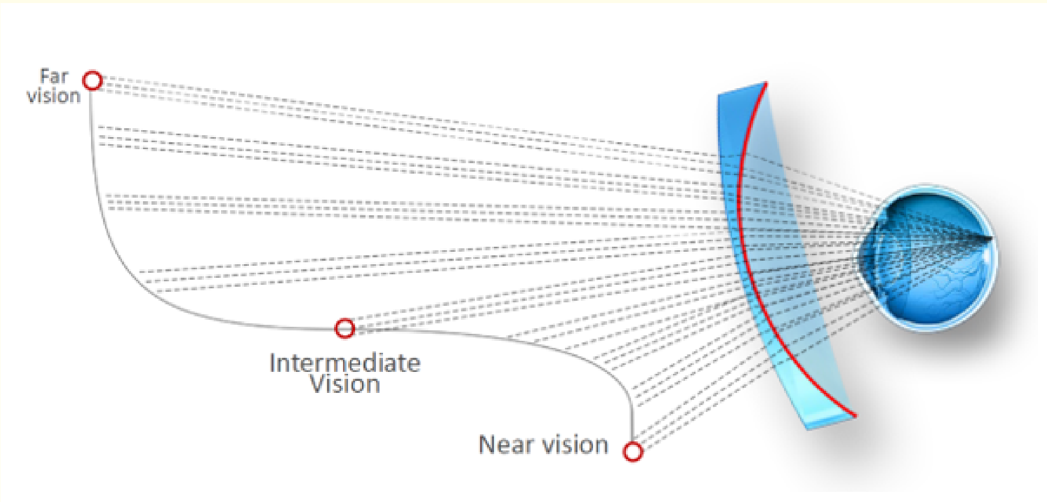

Figure 1: *Eye-Lens system model and ray tracing used to compensate patient's vision in a free-form personalized lens.*

In these calculation systems, the oblique aberrations induced by the angles of incidence of the rays over the lens surface are corrected. And, both, the tilt of the lens according to its real position of wear and gaze direction are considered for this optical simulation. As a result, wearers will perceive a better image quality than with a standard lens. Figure 2 shows an example of how the visual performance of a personalized progressive lens using an advance calculation method compares to a standard progressive lens. The maps show real perceived power by the wearer. In the standard design the level of unwanted astigmatism is much higher, this affects the main visual areas of the lens.

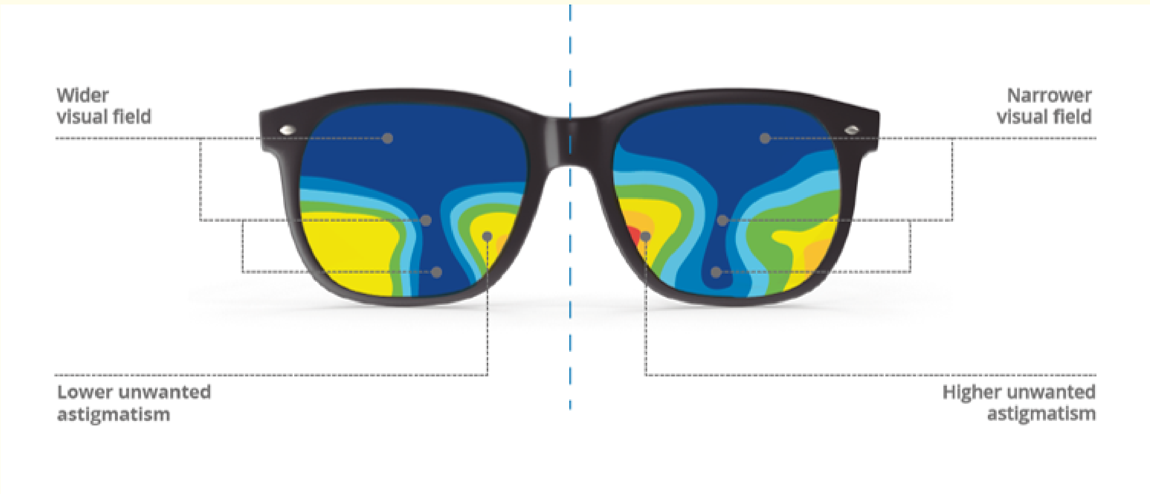

Figure 2: *Visual performance of a standard progressive versus a fully compensated and personalized free form progressive. Rx: +3.00D Add:2.00 D, Wrap10º.*

In the personalized design, the level of unwanted astigmatism is minimized offering better visual performance (As shown in figure 2). In addition to theoretical simulations like this, there are many clinical studies that show the benefits of personalized lenses using advanced calculation methods compared to standard FreeForm progressive lenses. Trial results show that the wearers prefer advanced personalized progressive lenses at all distances. This preference is even more noticeable when using high wrap frames, where compensation for personalization is even more pronounced.

Progressive lens wearers have different requirements depending on their daily visual needs. Adequately addressing these needs is key for the success of a progressive lens. Many designs can be used in a daily basis and will provide a good overall performance but, families of lenses that allow for lifestyle modifications can better adapt to each individual wearer or their specific visual task. One crucial part of the progressive lens is the add power progression profile. The progression profile defines the transition from the far vision to the near vision. Unique power progression profiles define the different visual fields of a progressive lens. If a wearer wants improved near vision for intensive use of digital devices, the progression profile of the lens can be modified in the near area resulting in a wider near zone would be preferable to the all-purpose design. The opposite is true for a far vision use. In this case it is important to favor far vision and utilize a power profile adapted specifically for that use. Apart from the progression profile the power distribution at the different areas of the design is also important. Together with the power profile, power distribution can be used to create different designs for more specific purposes. Figure 3 shows the power distribution maps of three different designs: an all-purpose design, a design more focused for near vision and another one for far vision. Although all designs are good for a daily use, if the design is selected for the individual activities of the wearer, the satisfaction obtained will be higher because the design is more ideal for the specific visual needs of the wearer. For instance, a professional driver would benefit more from an enhanced distance vision design than from a wider near design. However, a person that spends as much time reading as outdoors may prefer a balanced design for distance and near vision.

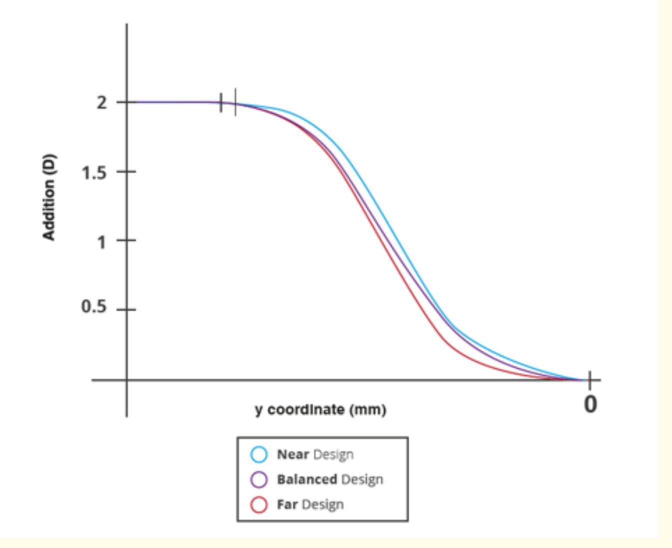

Figure 3: *Progression profile for 3 different designs: near, balanced and distance.*

Method of calculation for advanced personalization and the design flexibility are key features of a superior quality lens. The final product, however, is the sum of these technologies and the quality of laboratory production. Even if a lens is perfectly calculated, the quality of the final product depends on the process quality capabilities of the laboratory that produces it. How lenses are manufactured and mounted in the frame determine the final performance of the finished pair of eyeglasses. Furthermore, together with the calculation and manufacturing technologies of FreeForm lenses, the inspection technologies have evolved to verify accurately that the processes can replicate the calculation of the complex FreeForm surfaces. Beyond the ANSI standard, the overall quality of the lens should be determined by carefully inspecting the entire digital surface in addition to design positioning within the frame. One of the most common inspection technologies to verify FreeForm manufacturing quality is Lens Mapping Technology, which measures the entire surface of the lens and compare against the calculated lens to provide power error map. If a lens is not correctly manufactured, there can be a dramatic decrease of the optical quality of the finished lens as it is shown in figure 4.

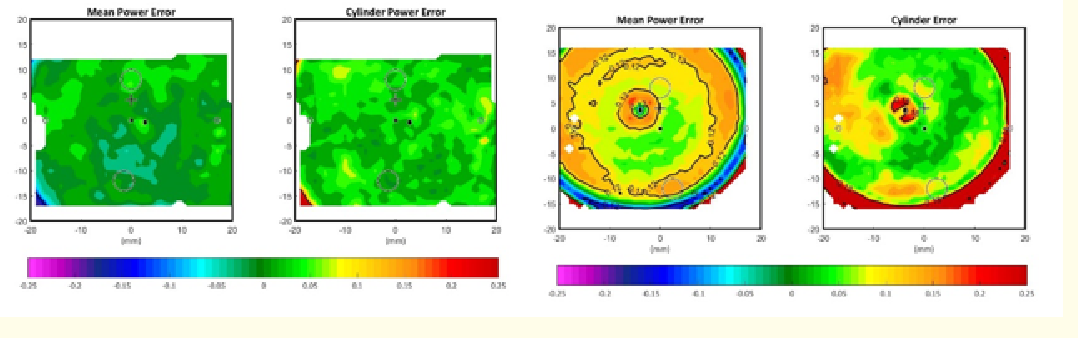

Figure 4: *Left, lens correctly manufactured. Right, lens produced with manufacturing errors.*

In summary, FreeForm lens processing gives much more flexibility in terms of what can be achieved, and there are many factors to determine if a lens has a good quality. The sum of an advance calculation method, advanced designs and superior quality of production are key to deliver the final user with the best possible product.

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