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SPHERICAL ABERRATION

Spherical aberration is probably the most clinically important aberration that clinicians come across on a regular basis. We are taught that spherical lenses focus light to a single point, while cylindrical lenses focus light to a single line. However, these are simplifications and do not take into consideration spherical aberration.

Spherical aberration occurs because light passing through a spherical lens is not focused to a single point but rather to a zone of focus immediately anterior to the focal point. Light passing through the middle of the lens, the part closest to the nodal point (July 2), will be focused nearest to the focal point. However, light rays passing through the part of the lens closest to the periphery will be focused farther anteriorly, closer to the lens. Rays of light passing through the mid-periphery of the lens will be focused in between.

In the human eye, spherical aberration is related to pupil size. During the daytime when the eye is exposed to bright light, the iris blocks light rays destined for the peripheral and mid-peripheral lens, and thus spherical aberration is minimized. At night the pupil dilates, and more peripheral rays are allowed through the lens and onto the retina. This phenomenon contributes to the decrease in quality of vision that many patients notice at night.

The human optical system is not spherical but is aspheric in a way that minimizes spherical aberration. An optical system that is steeper centrally than peripherally is not spherical but is prolate. Prolate systems have narrower depths of focus than do oblate ones. Examples of prolate lenses include the 20-, 78-, and 90-diopter lenses that clinicians use in the eye clinic. Because they are prolate, the entire lens, even the very periphery, focuses light to a single point, helping to keep the image in sharp focus for the clinician.

Oblate systems are the opposite of prolate ones. Here, the central parts of the lens are flatter than the peripheral. In oblate systems, the zone of focus is wider than that for a spherical system, with light rays coming through the periphery of the lens being focused farther forward. Although corneas are prolate by nature, they are turned into oblate ones when flattened by certain corneal refractive surgical treatments. Excimer laser techniques, such as LASIK (August 25) and surface ablation (June 16), and incisional techniques, such as RK (April 9), create an oblate corneal shape, contributing to haloes, starburst, and decreased night-time vision. Although wavefront technology (February 26) decreases the amount of spherical aberration created, it does not do away with it altogether. Intrastromal corneal ring segments (July 31) are the only refractive surgery procedure that cures myopia because they do not create an oblate corneal shape.