NIGHT VISION DISTURBANCES AFTER PHOTOREFRACTIVE CORNEAL SURGERY

Essay submitted

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Mohamed A. Hendy

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List of abbreviations

ACP	**Average Corneal Power**
CEI	**Corneal Eccentricity Index**
CL	**Contact lens**
D	**Dioptre**
EOZ	**Effective Optical Zone**
FOZ	**Functional Optical Zone**
HOAs	**Higher-Order Aberrations**
IOP	**Intra-ocular pressure**
LASEK	**laser sub epithelial keratomileusis**
LASIK	**Laser in situ keratomileusis**
OZ	**Optical Zone**
PAI	**Potential acuity index**
PCVA	**predicted corneal visual acuity**
PRK	**Photo refractive keratectomy**
PSF	**Point-Spread function**
RMS	***Root Mean Square***
ROC	**local radius of curvature**
SD	**Standard Deviation**
SimK	**The Simulated Keratometry**
SAI	**Surface Asymmetry Index**
SRI	**Surface Regularity Index**

Introduction

Refractive surgical procedures attempt to improve unaided visual acuity and correct spherocylindrical errors by reshaping the central cornea which is the most powerful refractive element of the eye and the easiest to access surgically ***(Endle et al; 2001).***

Photo refractive corneal surgical procedures include Photo refractive keratectomy (PRK) ***(Trokel et al; 1983),*** Laser in situ keratomileusis (LASIK) *(**Pallikaris et al; 1990)***, laser sub epithelial keratomileusis (LASEK) ***(Camellin and Cimberle, 2000)*** and EPI-LASIK ***(Pallikaris et al; 2003)*. ** Laser in situ keratomileusis (LASIK) is the most commonly performed refractive surgery in the United States ***(Bains et al; 2000 and lane et al; 2005).***

Different forms of night vision disturbance have been described among patients who had undergone refractive surgery procedures. Early reports attributed that to atypically transient loss of transparency in the postoperative period (haze), while halo phenomena will be caused by the margin of corneal ablation within the papillary area. ***(O'Brart et al; 1994)***

Jabbur et al in 2004 documented night vision disturbances as a leading cause of complaint for patients undergoing refractive surgical procedures with 43.5% of patients having such difficulties. ***(Villa et al; 2007)***

The difficulty in distinguishing different forms of night vision disturbances by patients and practitioners according to their description, night vision disturbances include glare disability, decrease in visual contrast sensibility and image degradation. ***(Villa et al; 2007)***

The increases in High complaints of□Order Aberrations are known to be responsible for patients glare, halo and disturbances in night vision. It is claimed that, laser in situ keratomileusis (LASIK) induces more HOAs than photorefractive keratectomy (PRK) in the scotopic condition ***(Lee et al; 2004).***

The reasons for these halos and glare are complex. They can result from irregular astigmatism due to the laser ablation, residual myopia, aberrations due to a large difference between the treated and the non – treated cornea, or a large pupil diameter in relation to treatment zone diameter. For this reason, enlargement of the optical zone can be effective in reducing halos and glare ***(Melki and Azar, 2001).***

Different approaches have been proposed to minimize night vision disturbances after refractive surgery, including creation of artificial pupils with contact lenses, surgical re-treatments to enlarge the optical zone, overminussing the optical prescription and miotic drugs. ***(Villa et al; 2007)***

The optical quality of the natural cornea is highest within the central 5.4 mm and decreases toward the periphery because of spherical aberrations. This peripheral effect is exaggerated after photorefractive corneal surgery. The functional optical zone (FOZ) can be defined by ray-tracing analysis as the central part of the cornea with a high level of optical quality and few spherical aberrations that could reduce night vision disturbances after photorefractive surgery ***(Boxer Wachler et al; 2002).***

AIM OF ESSAY

The aim of this essay is to review the literature about the night vision disturbances after photorefractive corneal surgery.

Optical properties of the cornea

Corneal configuration

The cornea is a transparent avascular tissue with a smooth, convex outer surface and concave inner surface, which resembles a small watch-glass. Its structure gives some indication of the diverse functional demands upon the tissue. The cornea must be transparent, refract light, contain the intraocular pressure and provide a protective interface with the environment. The main function of the cornea is optical. It forms the principal refractive surface, accounting for some 70 %(40-45D) of the total refractive power of the eye. Refractive requirements are met by the regular anterior curvature of the cornea and the optically smooth quality of the overlying tear film. Most of the refraction of the eye occurs not in the lens but at the front surface of the cornea at the tear/air interface.

Transparency of the corneal stroma is achieved by the regularity and fineness of its collagen fibrils and the closeness and homogeneity of their packing. Water is constantly pumped out of the cornea by its posterior layer, the endothelium. This maintains the optical homogeneity of the corneal layer and prevents swelling and clouding. The cornea is thus in evolutionary compromise, being a multicomponent, thick, tough, avascular tissue with a smooth surface and uniform curvature ***(Bron et al; 1997).***

The curvature of the cornea is greater than that of the sclera so that a slight external furrow (the sulcus sclerae) separates it from the sclera.

In front the cornea appears elliptical, being 11.7mm wide in the horizontal meridian and 10.6mm in the vertical. The posterior surface of the cornea appears circular, about11.7mm in diameter. This difference is due to the greater overlap of the sclera and the conjunctiva above and below than laterally (fig 1) ***(Bron et al; 1997).***

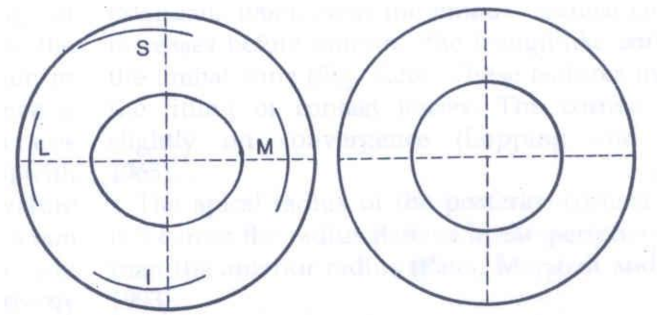

Fig (1): the anterior aspect of the cornea is transversely ellipsoid, whereas its posterior aspect is circular. S, M, I and L indicate the points of attachment of the recti *(Bron et al; 1997).*

The cornea is wider in males. The axial thickness of the cornea is 0.52mm (SD 0.04) with a peripheral thickness of 0.67mm (SD 0.08)**.**

Its surface area is about 1.3 cm^2, one-sixth of the surface area of the globe. The cornea forms part of what is almost a sphere, but it is usually more curved in the vertical than the horizontal meridian, giving rise to astigmatism" with the rule". In its central third," the optical zone", the radius of curvature of the anterior surface is 7.68 mm (SD 0.26) and that of the posterior one is 6.5mm, in adult males**.**

The peripheral cornea is more flattened. The anterior curvature of the cornea is spherical over a small zone 2-4 mm in diameter which is decentered upwards and outwards relative to the visual axis, but correctly centered for the pupillary aperture (which lies 0.4 mm temporally). This is sometimes termed the corneal apex or cap (**fig 2**).

The corneal curvature varies from apex to limbus, there is greater flattening nasally than temporally, and above than below. The posterior radius flattens in the periphery faster than the anterior radius ***(Patel et al; 1993).***Near the limbus, the corneal curvature increases before entering the trough-like contour of the limbal zone ***(Bron et al; 1997).***

The difference between the anterior and posterior radii of curvature yields an average of 43D of convergence, with the anterior surface contributing to 49D of convergence and the posterior surface contributing of 6D of divergence ***(Bores et al; 1993).***

Since the crystalline lens only contributes about 20 D of convergence, the anterior surface of the cornea is the major topographic determinant of the eye optical system and is a critical factor in proper visual function ***(Javal and Schiotz, 1881).***

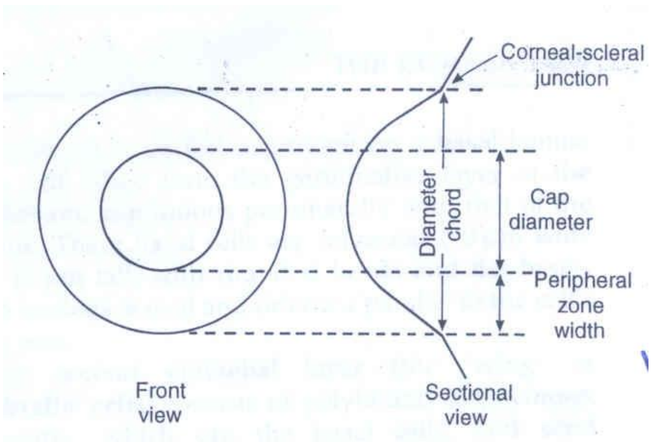

Fig (2): Drawing to show the location of the corneal cap ***(Bron et al., 1997).***

Corneal zones

The cornea is divided into surface zones. None of these areas is discrete because the cornea forms continuous curves. Conventionally, four concentric anatomic zones are recognized **(fig 3)**: central optical zone, paracentral intermediate zone, peripheral transitional zone and limbal zone ***(Bores et al; 1993).***

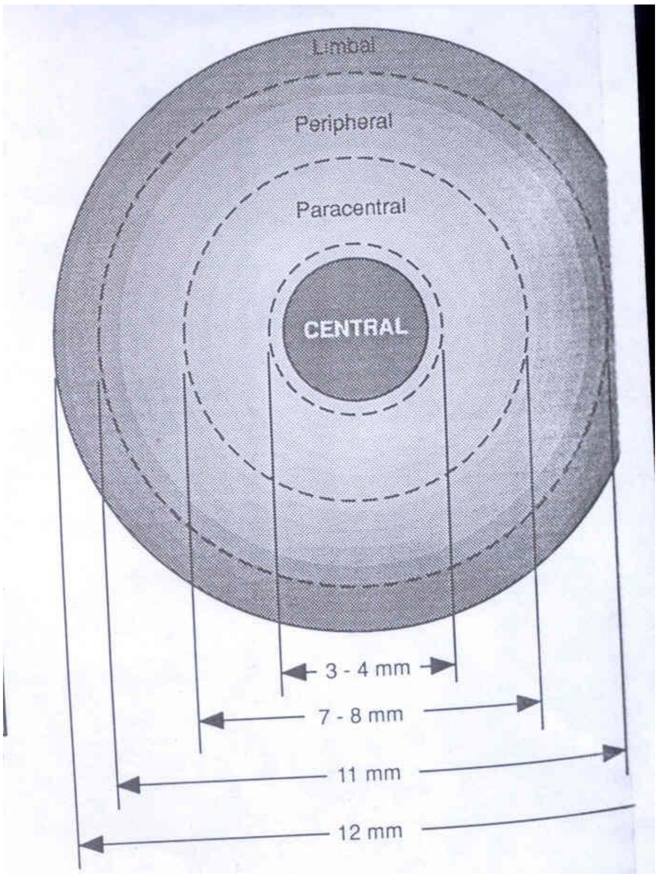

Fig (3): Corneal zone *(Bores et al; 1993).*

Central zone:

It is approximately 4mm in diameter and has been called the apical zone, the corneal cap, the optical zone, and the central spherical zone. All these terms intended to describe this region of the cornea as the more spherical, symmetrical, and optically important. The term central zone is more complex.

Now that corneal topography is requiring more careful definitions, we must distinguish among four designations:

- The anatomic central zone, which is 3-4mm in diameter
- The functional optical zone, which is the area that overlies the entrance pupil and which is smaller than the anatomic zone ***(Bores et al; 1993).***

- The spherical central part of the cornea, which is present in a minority of normal corneas.
- The apex of the cornea, which is the highest spot of the cornea. It is from this point that the corneal light reflection emanates and therefore it is the point around which the keratoscopy rings center. The apex of the cornea is close to but not coincident with the optic axis ***(Bores et al; 1993).***

Paracentral intermediate zone

It is an annulus approximately 4-7mm in diameter and has been called the mid, intermediate, or midperipheral cornea. The term midperipheral is a misnomer as this zone does not occupy the middle of the periphery ***(Bores et al; 1993).***

The central and paracentral zones together compromise what contact lens fitters call the apical zone.

Peripheral transitional zone

It is an annulus approximately 7-11mm in diameter. This is the area in which the normal cornea flattens the most and becomes more aspherical. For this reason, it has been called the transitional zone ***(Bores et al; 1993).***

Limbal anatomic zone

It is the ring of cornea approximately 0.5mm wide that abuts the sclera and contains the capillary arcades ***(Bores et al; 1993).***