QUALITATIVE CHARACTERIZATION OF SOME PATHOLOGIC CORNEAL DISEASES USING CONTACT SPECULAR MICROSCOPY

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ABSTRACT

The endothelium is a single layer of hexagonal cells lining the posterior surface of the cornea. It is responsible for the deturgescent state of the transparent cornea. Specular microscopy quantitative analysis of the endothelium is the latest method for its examination though this has not been found to be entirely predictive of corneal conditions that progress to corneal decompensation or edema. This study examined qualitative parameters to determine the association between corneal specular microscopy findings and progression or outcome of trauma (surgery) on the endothelium which causes corneal edema. Using the Konan SP5500 contact type of Specular microscope, the five areas (superior, central, inferior, temporal and nasal) of the corneal endothelium were examined. The following parameters were used: 1) regularity of posterior endothelial surface, 2) clarity of cells and their borders, 3) polymegethism and pleomorphism, and 4) presence of the intra, extra and intercellular bright or dark structures. Results showed that there were some parameters associated with prognosis of the corneal endothelium, namely: 1) the severity of endothelial surface irregularities, 2) the degree of polymegethism and pleomorphism (% of hexagonal cells), 3) the presence of early and late excrescences and inflammatory bodies, and 4) the area with the above findings. Qualitative analysis showed that area characterization is important to predict progression and outcome of corneal disease or conditions which may help in the prognostication of the corneal endothelium.

Keywords: *specular microscopy, cornea, endothelium, corneal disease, qualitative characterization, eye, Konan SP5500, polymegethism, pleomorphism, excrescences.*

INTRODUCTION

The visual sense (vision) is a result of the eye's proper functioning: 1. optical system (tear film, cornea, aqueous, lens and vitreous), 2. receptor cells (rods and cones of the retina), 3. relay system (bipolar and ganglion cells), 4. conducting system (nerve fibers, optic nerve, chiasma, and radiation), 5. integration and interpretation system (cerebral cortex). For an image to be formed and interpreted as such all these systems must be in proper and optimal condition. Among the systems mentioned, this study is concerned about the part of the optical system that contributes 60-80% of the total diopteric power of the eye, the cornea, specifically its endothelium. The corneal endothelium is a single layer of hexagonal cells lining the posterior surface of the cornea.

The corneal endothelium plays a major role in maintaining the deturgescent state and therefore the transparency of the cornea. Functionally, it acts a leaky barrier but this is obviated by its inherent capability to draw out water from the corneal stroma by its active transport pump sites. A balance between its barrier and pump function is therefore essential and must be maintained to avoid the accumulation of water in the cornea. The loss of this delicate balance or loss of too many of its cells may produce edema which will result in corneal haziness and cause blurred vision. This condition may be produced by an inherent disease of the endothelium or any injury to it usually due to trauma (surgical or nonsurgical).

The evaluation of the endothelium was in the past limited only through the use of high magnification lenses with the slit lamp microscopy. The *in vivo* observations using this method was however limited only to the area being considered and documentation through photography was still of poor resolution. The advent of specular microscopy made possible the detailed observation of the morphology of the corneal endothelial cells in an acceptable resolution.

The latest method of endothelial observation using the specular microscope is based on quantification of morphometric parameters such as cell density, number of cell sides and cell area which can be translated to its coefficient of variation. It, however, was not entirely predictive of conditions in the cornea that will result in corneal edema. This is exemplified by the diabetic endothelium where the morphometric parameters may be normal but cells are hypofunctioning and endothelium in old age where morphometric parameters are low but cells may be normally or hyperfunctioning. These observations have put up the persistent question of whether function is directly related to structure or vice versa.

This study is involved in qualitative characterization of endothelial parameters through the processes of the 3 "Ds": 1. **Describe,** 2. **Define** and 3. **Determine** the functional significance of these structural findings. These parameters may be classified into three groups: 1. **Indicative,** wherein their may be association (indirect relation) of this parameter to a certain condition, 2. **Causative,** wherein a certain parameter results (direct relation) in a certain condition, and 3. **Predictive,** wherein a certain parameter determines outcome or course of a certain condition.

METHODOLOGY

Specular Microscopy

Patients undergo contact specular microscopy (Standard Operational Procedure for Specular Microscopy) of both eyes using the Konan (SP 5500 (with standard 40X cone lens) with photographic attachment. The right eye is always done first followed by the left eye. The slit or wide view is utilized depending on the resolution obtained or if a wider area is necessary to characterize the endothelial portion being examined. Scanning of the area is done to determine the most appropriate view to be photographed. Photography of the central, superior, inferior, temporal and nasal areas is done. The film is developed and printed on a standard 3R size.

Morphometric Calculations

The prints are scanned and the best view of the endothelial area photograph is used for calculations (Morphometric Calculations). Cell density and percent hexagonality is computed per area and is recorded for later reference.

Qualitative Evaluation

Endothelial area (central, superior, inferior, temporal and nasal) descriptions are done for each cornea according to the following parameters: 1. posterior endothelial surface regularity, 2. clarity of cells and their borders, 3. degree of polymegethism, 4. degree of polymorphism, and 5. presence of bright and dark structures.

The qualitative parameters are defined and classified in the following ways:

Posterior Endothelial Surface – transition area of the endothelium and aqueous humor

Degree of Regularity	Percent Regularity
Regular	90-100%
Mildly irregular	75-89%
Moderately irregular	50-74%
Highly irregular	25-49%
Very severely irregular	10-24%
Wavy	0-9%

Clarity of Cell and their Borders

Cells	Borders
Clear	Distinct
Granulated Cytoplasm	Blurred
Not visualized	Not visualized

Polymegethism – Variation of cell sizes

Degree of Polymorphism	Percent Variation
None	0-10%
Slight	11-25%
Moderate	26-50%
Severe	51-75%
Very Severe	76-100%

Polymorphism – variation of cell shapes (sides)

Degree of Polymorphism	Percent Hexagonality
None	90-100%
Mild	175-89%
Moderate	50-74%
Severe	25-49%
Very Severe	0-24%

Bright and Dark Structures

May be extracellular, intercellular and intracellular

Bright Structures

Extracellular: amorphous substances (proteins, fibrin), edema and pigments
Intercellular: edema
Intracellular: lipid, amyloid, cytoplasmic granulations

Dark Structures:

Extracellular: depressions, folds, other causes of surface irregularities (endothelial precipitates)
Intercellular: late excrescences (guttata), inflammatory bodies, nucleus
Intracellular: early or late excrescences, inflammatory bodies

RESULTS

Among 102 eyes observed and analyzed in this preliminary study, some areal parameters and their associated implications found are as follows:

Severity of Surface Irregularities

It was observed that the more severe the surface abnormalities the more the possibility of endothelial pathology. It is therefore believed that surface abnormalities may be INDICATIVE of a pathological which may be also a result of endothelial insult or degenerative process. These are exemplified by the following conditions: a. post-trauma (insult, physical: as in surgical Descemet's tear or chemical: alkali burns) b. endothelial decompensation [traumatic (iatrogenic or surgical) and non-traumatic (pathologic: Fuch's endothelial dystrophy)] c. chronological degeneration (aged endothelium). The degree of irregularity appears to be related to the severity of the condition wherein pathological process will vary from mild to very severe irregularities, while generative which are chronologically determined varies from mild to moderate irregularities.

Visualization of Cells and their Boarders

The visualization of cells and their borders appears to be important as a status of the endothelial cells and the anterior chamber [aqueous interface, iris (as in iritis) and the chamber angle (the possibility of inflammatory glaucoma). It is therefore thought that their non-visualization is INDICATIVE of resultant endothelial dysfunction when generalized and inflammatory when focal. This is demonstrated by findings in total corneal decompensation where cells are generally nonvisible and keratouveitis where endotheliatis is present and nonvisualization of cells may be only sectoral.

Degree of Polymegethism and Polymorphism

The changes in cell sizes and shapes are INDICATIVE of pathologic or degenerative conditions that may limit the cell density of the endothelium. It may have a PREDICTIVE value when coupled with a low cellular density count. Cataract patients with moderate to severe polymegethism and polymorphism appear to have more propensity to have corneal edema post-surgery if not properly managed pre-operatively, intra-operatively and post-operatively. The enlargement and metamorphism of cells seems to be related to changes cell stability and perhaps their function wherein changes would probably reflect a compromised state. This may be particularly true if other pathological signs are present such as inflammatory cells or degenerative substances.

Presence of Excrescences

From the observations made of cases of Fuch's dystrophy and other pathological and degenerative corneal conditions, the stage, multiplicity and the aggregation of excrescences are important in prognostication of the endothelium. Pre-operatively they may have an INDICATIVE or PREDICTIVE value while post-operatively they may have CAUSATIVE or PREDICTIVE value.

Intra-, Inter-and Extracellular Inflammatory Bodies and Precipitates

These bodies when present either extra or intracellularly are INDICATIVE of the inflammatory status of the endothelium. When present intracellularly they are also INDICATIVE of cellular degeneration secondary to inflammation. Precipitates similarly maybe present to further indicate the severity of inflammatory reaction in the endothelium and anterior chamber.

CONCLUSION

Descriptive analysis of qualitative parameters used to characterize the corneal endothelium showed the following observations:

1. That area characterization is important to progression and outcome of corneal diseases and conditions which may help in prognostication of the corneal endothelium.
2. Excrescences coupled with inflammatory sides (inflammatory bodies and/or precipitates) seem to be predictive and causative of outcome and progression of corneal diseases and conditions.
3. Surface irregularities, polymegethism and pleomorphism may be indicative of degeneration and hypofunction of the endothelium of some corneal diseases and conditions.