OCT (OPTICAL COHERENCE TOMOGRAPHY) AS A DIAGNOSTIC TOOL IN CORNEAL DISORDERS

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ABSTRACT

BACKGROUND

OCT is an attractive modality for imaging the eye, because it can image both the anterior segment (cornea, angle, crystalline lens) and the posterior segment (retina) of the eye. OCT provides the cross-sectional retinal image in vivo. OCT has high image resolution (1-15 µm)[1] and is capable of scanning a large area (up to 20 mm scan diameter). It perfectly fits the eye's size. Our study included patients suffering from various corneal pathologies who underwent routine ophthalmic checkup followed by OCT. A detailed quantitative cross-sectional imaging of the cornea was obtained with regards to the localisation, size, shape, depth, texture and surface of corneal ulcer and infiltrates, extent of corneal oedema, depth of corneal opacity, surface and texture of graft-host junction in patients who underwent penetrating keratoplasty. The study was done to find out whether OCT could be valuable in the diagnosis and prognosis of corneal disorders keeping in mind the various studies conducted so far.

The aim of the study is to study the diagnostic and prognostic role of OCT in various corneal pathology.

MATERIALS AND METHODS

Study included 85 patients (males and females) visiting a tertiary healthcare centre with corneal pathologies diagnosed on slit-lamp biomicroscopy following which OCT was done over 2 years period (February 2014 to February 2016).
Design- Observational, cross-sectional, non-comparative study.

RESULTS

Corneal thickness is increased in corneal oedema (average 616 microns), while it is reduced in corneal ulcer (average 519 microns) and post keratoplasty patients (average 516 microns). The corneal thickness was normal in corneal degenerations (535 microns) and corneal opacity (545 microns). Texture was abnormal in 24 out of the 25 patients with corneal oedema. The corneal texture was abnormal in all 20 patients of corneal opacity and 18 out of 20 patients with corneal ulcer. All 5 patients post penetrating keratoplasty showed abnormal texture. Only 3 out of 15 patients with corneal degeneration showed abnormal texture. Depth assessment- Out of 20 patients with corneal ulcer, 12 were stromal and 8 were epithelial. Corneal surface was irregular in all 20 patients with corneal ulcer and 16 out of 20 cases of corneal opacity. In 8 patients of corneal oedema with bullous keratopathy, the corneal surface was irregular.

CONCLUSION

OCT provides objective documentation of corneal pathologies that cannot be provided by routine slit-lamp examination. Thus, OCT definitely plays an important role as far as the diagnosis and prognosis is concerned.

KEYWORDS

OCT, OCT Cornea, OCT Anterior Segment.

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BACKGROUND

Optical Coherence Tomography (OCT) is a novel technique for cross-sectional imaging with micron scale resolution in ocular and other biological tissues. OCT is similar to B mode ultrasonic imaging except that it uses infrared light instead of ultrasound. It uses low-coherence optical interferometry to resolve the position of reflective or optical backscattering sites within the sample. OCT is noncontact, noninvasive and has superior resolution one to two orders over conventional clinical ultrasound.

OCT was first reported in 1991 imaging human retina and coronary artery in vitro-[2] The first in vivo OCT imaging of the human anterior eye was demonstrated in 1994.[3] Soon the in vivo imaging of the human retina was reported in 1995.[4] In addition to Ophthalmology, OCT has also demonstrated its potential for imaging a wide range of tissues, including gastrointestinal tract, teeth, skin, blood vessels, embryonic heart, brain, etc.[5-10]

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Aims and Objectives- To study the diagnostic and prognostic role of OCT in-

1. Corneal oedema.
2. Corneal opacity.
3. Corneal ulcers.
4. Corneal degenerations.
5. Post penetrating keratoplasty.

MATERIALS AND METHODS

Our study included 85 patients (males and females) visiting our tertiary healthcare centre with corneal pathologies diagnosed on slit-lamp biomicroscopy in 2 years period (February 2014 to February 2016). After obtaining an informed consent, the patients were taken for OCT examination. Our study was carried out after approval from the ethical committee of the hospital.

Selection Criteria

- Patients visiting the Outpatient Department of Ophthalmology of a tertiary healthcare centre having corneal pathology diagnosed by slit-lamp examination.
- Patients between the ages of 10 to 60 years.

Exclusion Criteria

- Children below 10 years as they are non-compliant.
- Prior refractive surgery.
- Contact lens wear.

Instrumentation- Anterior segment OCT system used in our study. Cirrus anterior segment OCT (Carl Zeiss Meditec, Inc.).

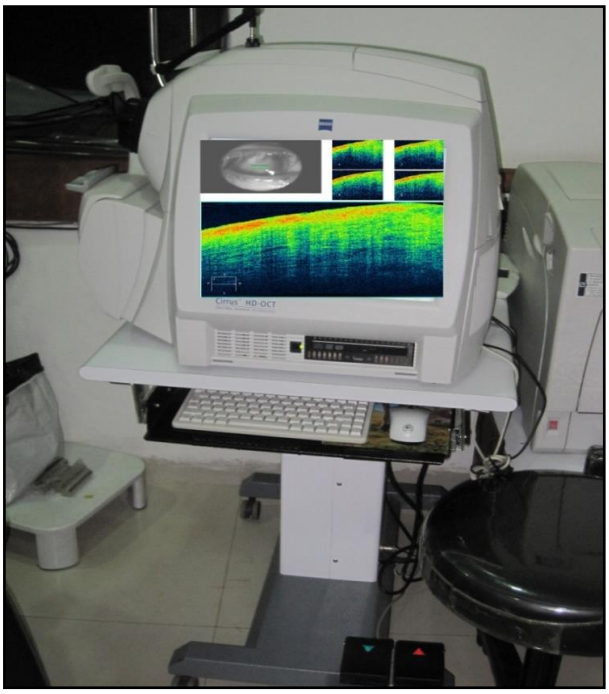

Figure 1. Cirrus OCT System

A high-speed Cirrus corneal and anterior segment OCT was used to acquire the images of my study.[11,12]

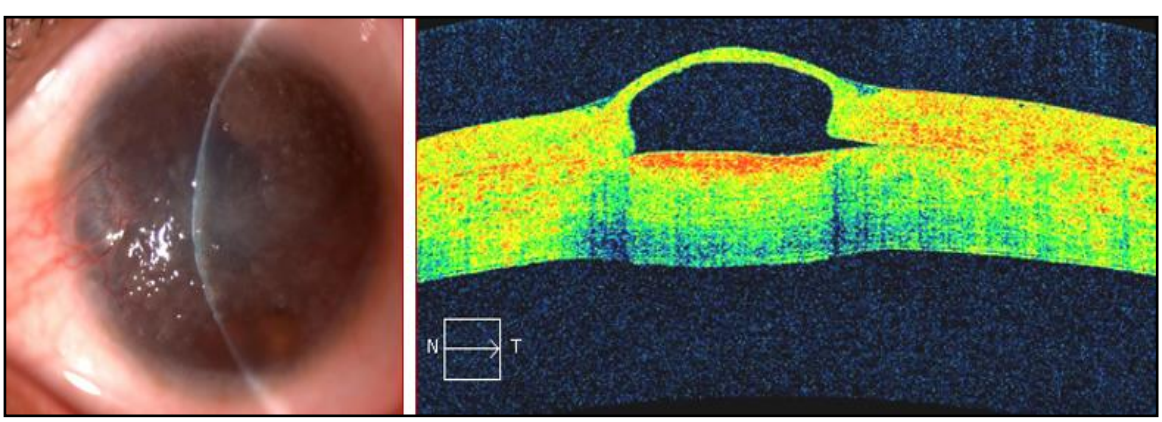

Figure 2. Bullous Keratopathy

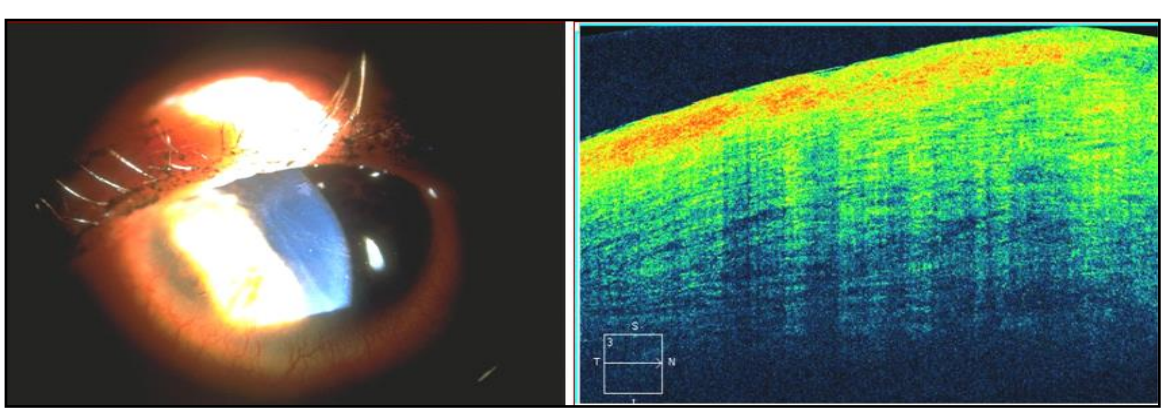

Figure 3. Corneal Oedema

OBSERVATIONS AND RESULTS

My study included 85 patients of which maximum patients were in the age group of 51-60 and minimum in the age group of 11-20.

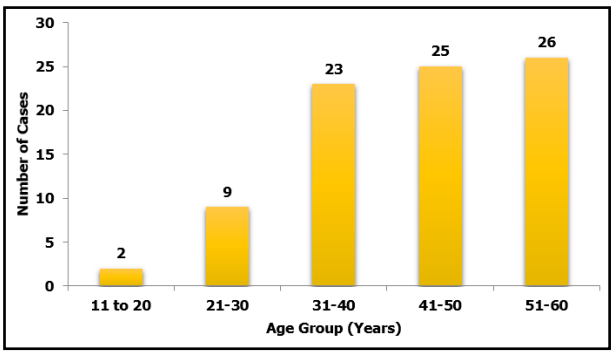

Figure 4. Age Distribution

Corneal Pathologies	No. of Patients	Percentage
Corneal degeneration	15	17.6
Corneal oedema	25	29.4
Corneal opacity	20	23.5
Corneal ulcer	20	23.5
Post keratoplasty	5	5.9
Total	**85**	**100**

Table 1. Distribution of Corneal Pathologies

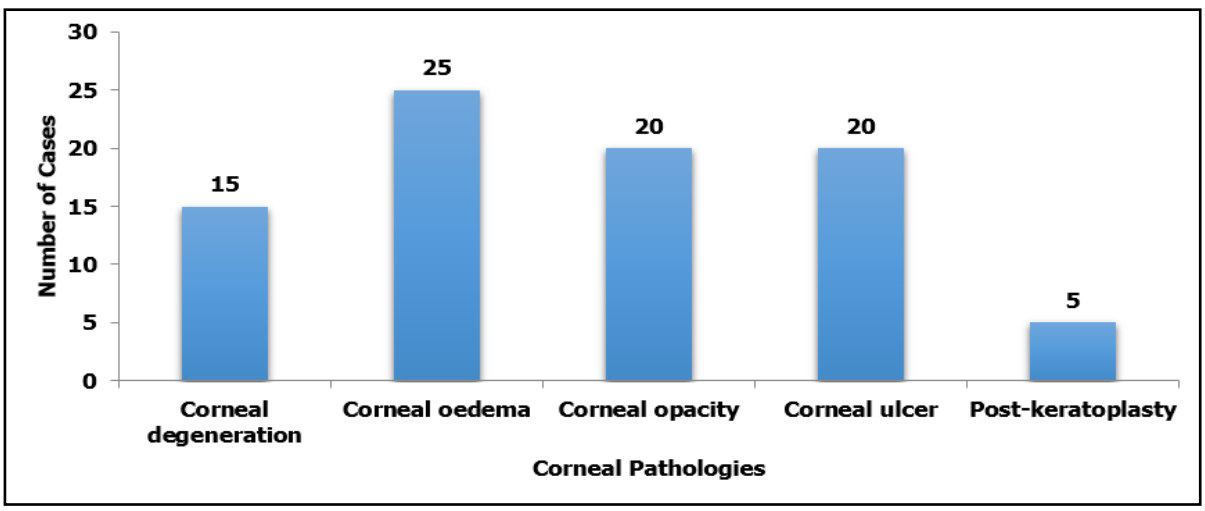

Figure 5. Corneal Pathologies

Corneal Pathology	Number of Patients	Minimum	Maximum	Mean	Standard Deviation
Corneal degeneration	15	489	566	535.93	23.885
Corneal oedema	25	545	658	616.68	32.570
Corneal opacity	20	513	580	545.95	17.866
Corneal ulcer	20	460	575	519.15	30.667
Post keratoplasty	5	511	523	516.20	5.805

Table 2. Central Corneal Thickness in Corneal Disorders

The central corneal thickness is increased in corneal oedema (average 616 microns) and decreased in corneal ulcer (average 519) microns and post keratoplasty patients (average 516 microns).

Corneal Pathology	Number of Patients	Minimum	Maximum	Mean	Standard Deviation
Corneal degeneration	15	65	255	143.20	64.232
Corneal oedema	25	125	655	543.40	149.695
Corneal opacity	20	88	495	225.25	95.882
Corneal ulcer	20	77	267	150.35	57.546
Post keratoplasty	5	355	522	461.60	65.060

Table 3. Lesion Depth in Corneal Disorders

Corneal Pathology	Corneal Texture		Total
	Abnormal	Normal	
Corneal degeneration	3 (4.3%)	12 (80%)	15 (17.6%)
Corneal oedema	24 (34.3%)	1 (6.7%)	25 (29.4%)
Corneal opacity	20 (28.6%)	0 (0%)	20 (23.5%)
Corneal ulcer	18 (25.7%)	2 (13.3%)	20 (23.5%)
Post keratoplasty	5 (7.1%)	0 (0%)	5 (5.9%)
Total	**70 (100%)**	**15 (100%)**	**85 (100%)**

Table 4. Corneal Texture in Corneal Disorders

Corneal Depth	Number of Patients	Percentage
Endothelial	6	7.1
Entire	13	15.3
Epithelial	19	22.4
Stromal	47	55.3
Total	**85**	**100**

Table 5. Corneal Depth in Corneal Disorders

	Corneal Depth				Total
	Endothelial	Entire	Epithelial	Stromal	
Corneal ulcer	0	0	8	12	20

Table 6. Corneal Depth in Corneal Ulcer

Surface	Number of Patients	Percentage
Irregular	43	50.6
Regular	42	49.4
Total	**85**	**100**

Table 7. Corneal Surface

DISCUSSION

Study included 85 patients in the age group of 11-60 years of which 41 were females and 44 were males. Of these patients, 25 had corneal oedema, 20 had corneal opacity, 20 had corneal ulcer, 15 had corneal degeneration and 5 were post penetrating keratoplasty.

The aim of my study is to prove the usefulness of OCT in different corneal conditions.

Corneal Thickness- The corneal thickness is increased in corneal oedema (average 616 microns), while it is reduced in corneal ulcer (average 519 microns) and post keratoplasty patients (average 516 microns). The corneal thickness was normal in corneal degenerations (535 microns) and corneal opacity (545 microns).

These findings support the study by Koji Hirano, Yasuki Ito, Toshimitsu Suzuki, Takeshi Kojima, Shu Kachi and Yozo Miyake[13] who performed OCT on normal corneas and compared the findings with abnormal corneas. They found that the corneal thickness was increased in patients with corneal oedema with bullous keratopathy. OCT showed intense backscattering from the thick tissue over the stroma and the epithelial bullae were imaged as a dark region in the anterior tissue.

Hirano[13] et al also studied the role of OCT in patients post penetrating keratoplasty and revealed fluid spaces suggestive of graft-host junction oedema in these patients. There was no significant difference in the corneal thickness in these patients. In my study, the corneal thickness was reduced in post penetrating keratoplasty patients.

A study by Gary R. Fishman[14] revealed that OCT is an accurate, noninvasive and reproducible technique for evaluation of Central Corneal Thickness (CCT). This significantly correlates with my study.

The findings of my study support the study done by Konstantopoulos A et al[15] who investigated the imaging capabilities of Anterior Segment Optical Coherence Tomography (AS-OCT) in microbial keratitis. The aim of this study was to assess whether measurements of the quantitative parameters, infiltrate thickness and corneal thickness were possible. Corneal infiltration was imaged as a hyperreflective area in the corneal stroma on high-resolution AS-OCT scans. Retrocorneal pathologic features and anterior chamber inflammatory cells could be imaged. Corneal and infiltrate thickness could be measured with calipers in six cases. In one case, corneal and infiltrate thickness could not be measured because of a thick inflammatory plaque attached to the endothelium. In this case, the width of the plaque was measured on serial scans. AS-OCT imaging provides a range of parameters that can be used to assess microbial keratitis and the treatment response objectively.

Texture- With OCT, it is possible to study the texture of epithelium, stroma and endothelium accurately.

In corneal oedema, there is a diffuse increase in the intensity in all the layers of the cornea. We could also assess the presence and localisation of bullae in some patients with corneal oedema. The size of multiple bullae at various points over the cornea could be measured. There was abnormal texture in 24 out of the 25 patients with corneal oedema.

In corneal opacity and corneal ulcer, diffuse irregularity of the texture was noted.

The corneal texture was abnormal in all 20 patients of corneal opacity and 18 out of 20 patients with corneal ulcer.

In penetrating keratoplasty patients, the graft-host junction evaluation in terms of healing and fluid collection could be made out. All 5 patients post keratoplasty showed abnormal texture.

In corneal degeneration, there was not much significance in the texture of cornea. Only 3 out of 15 patients with corneal degeneration showed abnormal texture.

A study by Kaluzny et al[16] revealed that with spectral OCT, objective assessment of the localisation, size, shape and light scattering properties of the changed tissue is possible. Corneal and epithelial thickness and the depth and width of lesions can be estimated. This study correlates well with my study.

Depth- The extent of the ulcer and its depth could be studied. Out of 20 patients with corneal ulcer, 12 were stromal and 8 were epithelial.

Surface- The corneal surface was found to be irregular in all 20 patients with corneal ulcer and 16 out of 20 cases of corneal opacity.

In 8 patients of corneal oedema with bullous keratopathy, the corneal surface was found to be irregular. Thus, with OCT, the epithelium, stroma and the endothelium could be seen separately and their involvement in disease process evaluated.

OCT has few advantages over routine slit-lamp examination in certain conditions and it definitely plays an important role as far as the diagnosis and prognosis is concerned.

These findings correlate with a study by Hirano K et al,[13] which was done to determine the Optical Coherence Tomographic (OCT) characteristics of normal corneas and to characterise the OCT images of abnormal corneal lesions. The study revealed that OCT can provide objective documentation of corneal disorders that cannot be obtained by slit-lamp examination.

A study done by Khurana et al[17] to evaluate corneal opacities using OCT revealed that OCT could be valuable in the planning of surgical treatment of corneal scars.

Our study also revealed that OCT helps in measuring the corneal thickness in corneal disorders and thus helps in deciding the type of surgery to be done.

Summary- In our study, we studied the role of OCT in different corneal disorders with respect to corneal thickness, surface, texture and depth of the lesion.

With OCT, we can study the texture of corneal oedema as well as localise the extent of corneal oedema. We can differentiate the oedema as epithelial, endothelial or stromal. The size of the bullae could be measured in corneal oedema with bullous keratopathy. This would definitely help us in planning the type of surgery to be conducted.

In corneal opacity, surface and depth evaluation could be done very well with OCT. This would help us in planning whether to perform a penetrating or lamellar keratoplasty.

In corneal ulcer, all the parameters like depth, thickness and extent of the ulcer as well as thickness and surface of the cornea could be studied. This would definitely help in planning the type of surgery to be performed.

In post keratoplasty patients, the graft-host junction thickness and surface could be studied well with OCT.

However, we found that OCT does not play any significant role in corneal degenerations.

CONCLUSION

OCT provides objective documentation of corneal pathologies that cannot be provided by routine slit-lamp examination. Thus, OCT definitely plays an important role as far as the diagnosis and prognosis is concerned. OCT helps in measuring the corneal thickness in corneal disorders and thus helps in deciding the type of surgery to be done.

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