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Meta-analysis on Corneal Changes following Phacoemulsification in Diabetic vs. Non-diabetic Cataract Patients

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ABSTRACT

Aim of the Study: was to investigate the influence of phacoemulsification on corneal endothelial cells and its injury risk factors in diabetic cataract patients and non-diabetic patients.

Methods: electronic databases were searched: Scopus, EMBASE, and Google Scholer), PubMed/MEDLINE, Scopus, The Cochrane Library, and Web of Science. Econlit from 1990 to 2017. This was completed with a manual search of references of relevant papers. Risk of bias in methodology of studies was measured using the Newcastle-Ottawa Scale.

Results: Observation of corneal endothelial cell density, coefficient of variation and percentage of hexagonal cells preoperatively, 1 day, 1week, 1 and 3 months postoperatively was carried out, and multiple Logistic regression analysis for risk factors of corneal endothelial cell injury was taken.

Results: Out of 779 retrieved papers, 9 studies with a total of 1129 individuals were finally included (579 diabetic eyes and 550 non-diabetic eyes). For the dynamic changes between preoperative and postoperative values, significant differences were identified between the two groups in endothelial cell density (ECD) and hexagon cells (HC%) at 1 day, 1 week, 1 month, and 3 months postoperatively, in central corneal thickness (CCT) at 1 month postoperatively, and in coefficient variation (CV) at 1 week and 1 month postoperatively. However, no significant differences were observed in CCT at 1 day, 1 week and 3 months postoperatively or in CV at 1 day and 3 months postoperatively.

Conclusion: it could be concluded from the current literature that aged-cataract patients with diabetes mellitus manifested poor tolerability to cataract phacoemulsification surgery in contrast to senile cataract patients.

Keywords: Phacomulsification, cataract, DM, corneal changes.

INTRODUCTION

Worldwide more than 285 million people are affected by diabetes mellitus. This number is expected to increase to 439 million by 2030 according to the International Diabetes Federation [1].

Several clinical studies have shown that cataract development occurs more frequently and at an earlier age in diabetic compared to nondiabetic patients **[2].**

Data from the Framingham and other eye studies indicated a three to fourfold increased prevalence of cataract in patients with diabetes under the age of 65, and up to a twofold excess prevalence in patients above 65**[3].** The risk is increased in patients with longer duration of diabetes and in those with poor metabolic control. A special type of cataract—known as snowflake cataract—is seen predominantly in young type 1 diabetic patients and tends to progress rapidly. Cataracts may be reversible in young diabetics with improvement in metabolic control. The most frequently seen type of cataract in diabetics is the age-related or senile variety, which tends to occur earlier and progresses more rapidly than in nondiabetics.

Many publications supported the hypothesis that the initiating mechanism in diabetic cataract formation is the generation of polyols from glucose by AR, which results in increased osmotic stress in the lens fibers leading to their swelling and rupture [4].

In addition to diabetic retinopathy, diabetic patients are more susceptible to developing corneal endothelial damage, keratoepitheliopathy, persistent epithelial defects, and superficial keratitis [5].

Phacoemulsification with intraocular lens implantation is one of the most famous surgical procedures carried out to cataract patients. The patients are mostly elderly which usually adds a negative impact to the surgical outcome behind

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increasing age which is naturally associated with loss of endothelial cells [6]. In childhood, the endothelium consists of ~4000 cells/mm 2 , while the number is reduced to about 2500 cells/mm 2 by the eighth decade [7]. Hence, two important parameters, age and the presence of diabetes, compromise the status of the endothelium, which may have a negative impact on the final visual outcome in case of surgery [6].

All surgical procedures that involve entry into the anterior chamber damage a proportion of the endothelial cells because of intraoperative corneal manipulations. After endothelial cell loss (ECL), the adjacent cells enlarge and slide over to maintain endothelial cell continuity, which is observed as a change in the endothelial cell density (ECD) and morphology. Moderate damage to the endothelium during surgery can also lead to a transient increase in corneal thickness. ECD and function can be assessed clinically using specular microscopy and pachymetry [8].

In the present systematic review and meta-analysis, we aim at investigating the influence of phacoemulsification on corneal endothelial cells and its injury risk factors in diabetic cataract patients and non-diabetic patients.

MATERIALS AND METHODS

Literature search

The present Systematic Review was reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Data Sources: electronic databases were searched: Scopus, EMBASE , and Google Scholer) , PubMed/MEDLINE, Scopus, The Cochrane Library, and Web of Science. Econlit from 1990 to 2017.

Search terms: ((diabete OR diabetes) AND cataract surgery) AND corneal; ((‘cataract extraction’/exp OR ‘cataract extraction’) AND ‘diabetes mellitus’/exp OR ‘diabetes mellitus’) AND corneal; “diabetes” AND “cataract surgery” AND “corneal”.

STUDY SELECTION

Study Selection

Search results were screened by scanning abstracts for the following:

Inclusion Criteria

1. Studies conducted in Arabic and English languages.
2. Prospective controlled studies (control subjects were a must).
3. Studies providing patient information such as age, condition and follow up duration
4. DM patients and normal patients who underwent phacoemulsification and IOL implantation.
5. study reported at least one basic dataset of corneal properties, such as ECD, CV, HC%, and CCT.

Exclusion Criteria

Patients with other complications that could affect corneal state (e.g. severe liver or kidney dysfunction, glaucoma, iritis, or eye injury)

Data Extraction

The patients data were extracted from the selected studies via a standard form: first author, country (province), year of publication, age of patient, sex of patient, follow up duration, quality control, and preoperative diabetes condition.

The measurement of corneal properties included corneal endothelial cell density (ECD), corneal endothelial hexagon percentage (HC%), Most of the studies only reported the absolute values of the outcomes at a preoperative baseline and postoperative time points. The mean and standard deviation outcomes of the corneal changes were calculated.

For situations when the selected study included multiple groups, a group-combining method **[9]** was applied. If there were more than two groups to combine, the strategy was to repeat this method sequentially (i.e. combine group 1 and group 2 to create group 1 + 2, and then combine group 1 + 2 and group 3 to create group 1 + 2 + 3, and so on).

Study Quality Assessment

The quality of included trials was assessed by R.O. and J.B. using the Newcastle-Ottawa Scale (NOS) **[10]**, which was modified to fit our study design: 0-3 stars indicate poor study quality, 4-6 stars indicate acceptable study quality, and 7-9 stars indicate good study quality. In the event of disagreements, consensus was reached by discussion.

The study was done according to the ethical board of King Abdulaziz university.

Meta-Analysis

The results of the present study were analyzed by meta-analysis proportions which was performed with Stats Direct statistical software version (Version 3.0.0, Stats Direct Ltd, Cheshire UK) [11]. Individual study proportions were assessed at 95 % confidence interval (CI) as well as the pooled effect. Test for heterogeneity was performed for all the

proportions based on Cohran's Q and degree of inconsistency (I2) [12].

In all the summary or pooled analysis, random effect model was adopted over fixed effect model due to the presence of heterogeneity resulting from variations of effects from individual studies confirmed by $I2 > 0$ %. For all computations, statistical significance was set at $p < 0.05$. We conducted sub-analyses for the periods within which studies were published (1995–2002, 2003–2009 and 2010–2015-2017), among diverse population sub-groups.

RESULTS

Initially, a total of 779 articles were identified (711 from scientific literature and 8 publications manually searched in other journals). After elimination of duplicates, screening titles and abstracts, 132 papers were found irrelevant and excluded. Agreement between investigators on abstract selection was high (κ=0.88, $p<0.001$). Full texts of the remaining 215 papers were scrutinized for eligibility, among which 84 were again excluded. Overall, only 9 papers were found eligible; hence they were included in the meta-analysis. **Figure 1**

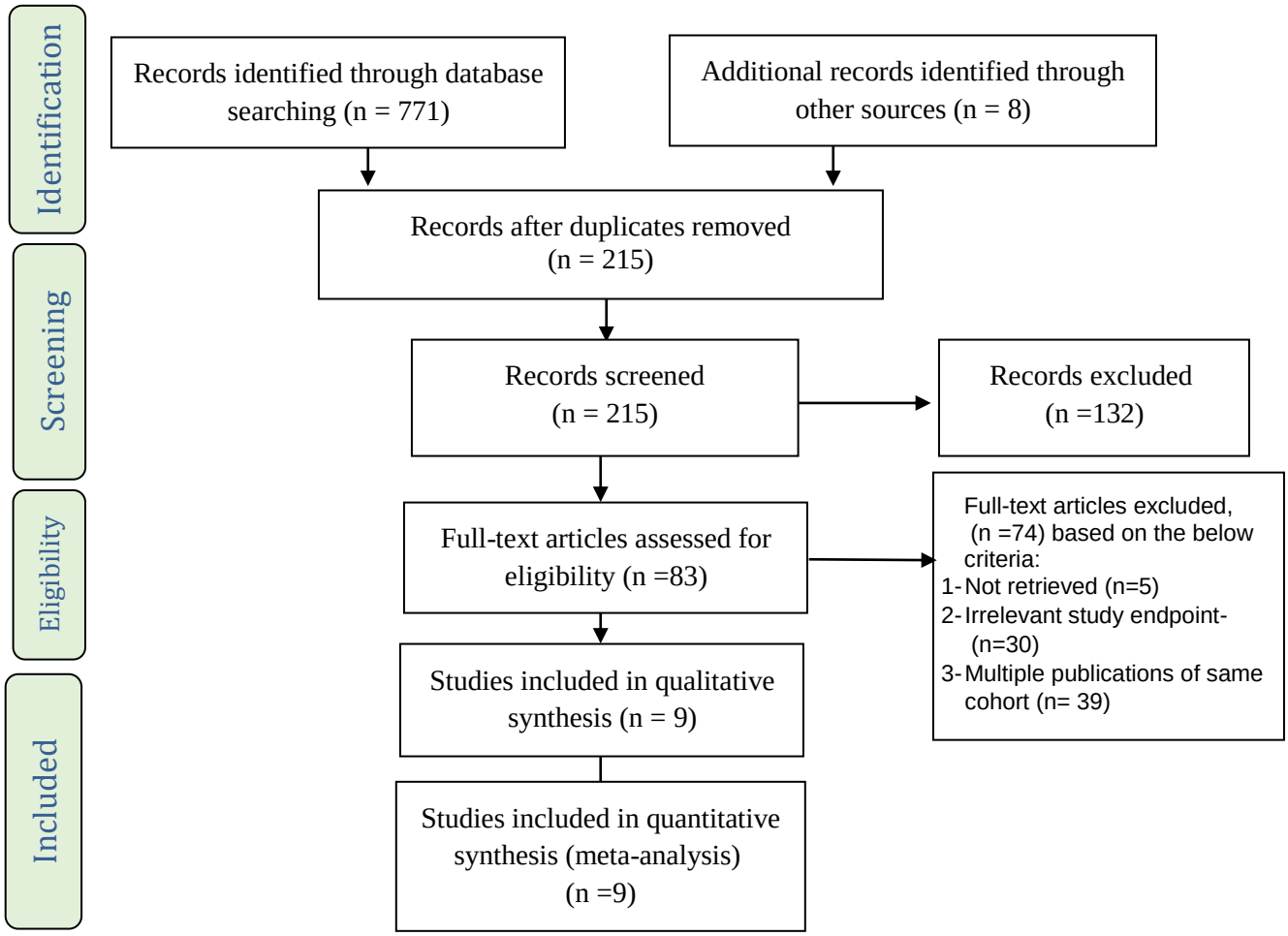

Figure 1: PRISMA flow diagram showing the selection criteria of assessed the studies [13].

A total of 9 prospective studies including 1923 eyes (941 in the non-diabetic group and 982 in the diabetic group) were identified. Age group ranged from 50 t0 85 for normal individuals versus 50 to 83 in DM patients.

The characteristics of the included studies are shown in Table 1**.**

Table 1: baseline characteristics of the included studies

Authors	Publication year	Study Location	Study design	Age (year/SD, range)		No. of eyes Gender (M/F)	
				Normal	DM	Normal	DM
Wu et al. [14]	2008	China Hainan	Prospective controlled study	65.6 (52–82)	66.8 (50–84)	33/31	26/24
Wu et al. [15]	2010	China Shaanxi	Prospective controlled study	50–80	50–80	31	28
Yang et al. [16]	2011	China Guangzhou	Prospective controlled study	68.1 (50–84)	67.8 (51–83)	33/32	34/41
Hugod et al. [17]	2011	Denmark	Prospective controlled study	75.4 (9.3)	75.6 (8.6)	30	30
Zhao et al. [18]	2013	China Shandong	Prospective controlled study	64.8 (55–83)	63.2 (52–80)	24/26	26/24
Zhu et al. [19]	2014	China Beijing	Prospective controlled study	60–80	60–80	16/17	15/20
Yan et al. [20]	2014	China Guizhou	Prospective controlled study	69.6 (55–85)	65.6 (52–82)	30/32	51/46
Misra et al. [21]	2015	New Zealand	Prospective cohort study	74.4 ±7.4	71.2 ±7.6	23	28
Li *et al.* [22]	2016	China Hainan	Prospective controlled study	65.1 ±12.3	64.6 ±12.5	106/84	101/85

Table 2: clinical presentation of patients enrolled in the included studies

Authors	Age (year/SD, range)		No. of eyes Gender (M/F)		Follow up duration	Diabetes condition	Quality control (NOS)
	Normal	DM	Normal	DM			
Wu et al. [14]	65.6 (52–82)	66.8 (50–84)	33/31	26/24	3 months	NA	8
Wu et al. [15]	50–80	50–80	31	28	3 months	Diabetic course < 12a	7
Yang et al. [16]	68.1 (50–84)	67.8 (51–83)	33/32	34/41	3 months	Blood glucose < 6. 6–10 mmol/L Duration (1–17 years)	8
Hugod et al. [17]	75.4 (9.3)	75.6 (8.6)	30	30	3 months	HbA1c% (7.08 (1.43))	8
Zhao et al. [18]	64.8 (55–83)	63.2 (52–80)	24/26	26/24	3 months	NA	8
Zhu et al. [19]	60–80	60–80	16/17	15/20	1 month	Blood glucose < 8.3 mmol/L, diabetic course > 5a	8
Yan et al. [20]	69.6 (55–85)	65.6 (52–82)	30/32	51/46	3 months	Diabetic course > 10a, Diabetic course < 10a	8
Misra et al. [21]	74.4 (7.4)	71.2 (7.6)	23	28	6 months	Duration (11.54 years) HbA1c% (DM: nDM 7.5:5.7, P < 0.001)	8
Li *et al.* [22]	65.1 (12.3)	64.6 (12.5)	106/84	101/85	3 months	NA	7

Meta-analysis of the outcomes

1. Endothelial cell density

There were nine studies reporting the outcome of ECD. The analysis was made at 1 day, 1 week, 1 month, and 3 months postoperatively. It was found that diabetic patients have a significantly lower ECD at preoperative and all postoperative time points than the non-diabetic group:

- 1 day postoperative: WMD = −130.85, 95% CI: −156.1 to −105.60, P < 0.001
- 1 week postoperative: WMD = −194.14, 95% CI: −271.4 to −116.87, P < 0.001
- 1 month postoperative: WMD = −193.09, 95% CI: −269.3 to −116.87, P < 0.001
- 3 months postoperative: WMD−230.87, 95% CI: −284.33 to −177.4, P < 0.001

Moreover, the percentage of the loss of ECD (ECL%, difference between preoperative and postoperative), which was calculated from equations was also evaluated to see the effect caused by phacoemulsification. There are significant differences in ECL% at all postoperative times for the DM group compared to the non-DM group

- 1 day postoperative: WMD = −130.85, 95% CI: −156.1 to −105.60, P < 0.001
- 1 week postoperative: WMD = 3.33, 95% CI: 2.51 to 4.15, P < 0.001
- 1 month postoperative: WMD = 3.93, 95% CI: 1.97 to 5.89, P < 0.001
- 3 months postoperative: WMD =4.83, 95% CI: 1.69 to 7.97, P = 0.003

Table 3: meta-analysis outcomes of the included studies presenting corneal endothelial cell density (ECD) change after phacoemulsification in diabetic and non-diabetic patients

Intervals	ECD	ECL% (ECD loss % between preoperative and postoperative)
1 day	WMD = −130.85, 95% CI: −156.1 to −105.60, P < 0.001	WMD = 3.54, 95% CI: 1.63 to 5.44, P < 0.001
1 Week	WMD = −194.14, 95% CI: −271.4 to −116.87, P < 0.001	3.33, 95% CI: 2.51 to 4.15, P < 0.001
1 Month	WMD =−193.09, 95% CI: −269.3 to −116.87, P < 0.001	WMD = 3.93, 95% CI: 1.97 to 5.89, P < 0.001
3 Month	WMD = −230.87, 95% CI: −284.33 to −177.4, P < 0.001	WMD =4.83, 95% CI: 1.69 to 7.97, P = 0.003

2.Hexagonal cell percentage

The 9 studies reported the outcome of hexagonal cells. The analysis was also made at 1 day, 1 week, 1 month, and 3 months postoperatively. It was revealed that diabetic patients have a significantly smaller HC% at preoperative and all postoperative time points (all: P < 0.001) and a significantly larger HC% loss (difference of preoperative and postoperative) at all postoperative times (P < 0.001) compared to the non-DM group.

DISCUSSION

The results of the present meta-analysis provided robust evidence that the effect of phacoemulsification on corneal changes in diabetics is greater compared to non-diabetics. For the changes between the preoperative and postoperative state, significant differences were identified in ECL% and HC% loss at 1 day, 1 week, 1 month, and 3 months postoperatively, in dCCT% at 1 month postoperatively, and in dCV at 1 week and 1 month postoperatively between the two groups. We observed that Aged ―related cataract patients with diabetes mellitus were much more poor tolerability on cataract phacoemulsification surgery. Compared with senile cataract patients, the corneal endothelium injury was more serious and the velocity and validity of recovery were lower comparatively.

Goebbels and Spitznas [23] performed fluorophotometry of the corneal endothelium before and 4 days, 3 weeks, and 6 weeks after phacoemulsification and intraocular lens implantation, and endothelial permeability was evaluated in the presence or absence of diabetes mellitus. Endothelial permeability did not differ

between the diabetic and nondiabetic groups before operation, markedly increased in both groups 4 days after operation, and recovered 3 weeks after operation in the nondiabetic group but 6 weeks after operation in the diabetic group. This result was consistent with the delayed recovery of endothelial function in the cornea of diabetic patients after cataract surgery observed in the present investigation . On the other hand, Furuse et al. [24] compared the endothelial cell density, coefficient of variation, and endothelial cell loss 3, 6, and 12 months after extracapsular cataract extraction and intraocular lens implantation between patients with and without diabetic mellitus . They observed endothelial cell density decreases of 10% to 20% in both groups, without noticeable differences. This variation in findings between their study and ours could be because extracapsular cataract extraction is more invasive to the cornea than phacoemulsification and masks diabetes mellitus– associated differences.

The percentage of hexagonal cells decreased after 1 day and was slightly lower in the diabetic group than in the non-diabetic group at each measurement point. The coefficient of variation slightly increased 1 day after operation, but did not significantly differ between the 2 groups. The corneal endothelium, once decreased, does not proliferate, and the defects are covered by stretching, extension, and transfer of the residual corneal endothelium [25].Although we considered that the coefficient of variation and percentage of hexagonal cells can be considered indexes of the repair mechanism, no marked difference was observed in either variable between the diabetic and nondiabetic groups in this study.

Several other studies have indicated that the endothelium of diabetic patients might be more vulnerable to surgical traumas compared with that of nondiabetic individuals. Morikubo *et al.* [26] compared corneal thickness and morphology in 93 eyes in patients with type 2 diabetes with 93 eyes in patients without diabetes before and 1 day, 1 week, and 1 month after phacoemulsification. Compared with the nondiabetic group, the eyes of patients with diabetes showed more changes in corneal endothelial cells because of cataract surgery and a delay in the postoperative recovery of the corneal edema. However, this study was hampered by a short observation period. Endothelial cell reorganization did not stabilize earlier than 3 months after cataract surgery, and thus measurements 1 month postoperatively will not give a true statement of final corneal changes after cataract surgery [27]. Hugod *et al.* [28] also reported a significantly greater loss of corneal endothelial cells in the diabetic group under good glycemic control, compared with the nondiabetic group, 3 months after phacoemulsification. The morphological changes in the endothelial cells in patients with well-controlled diabetes were not reflected in impaired function, as judged by CCT. Mathew *et al*. [29] also found that the diabetic endothelium was under greater metabolic stress and had less functional reserve after manual small incision cataract surgery compared with the normal corneal endothelium.

Briefly, the normal corneal endothelium plays a key role in keeping the cornea moist and transparent as well as maintaining integrity to prevent stromal swelling. Tight apical junctions on the endothelial cells function as physical barriers. The movement of water outward from the corneal stroma into the anterior chamber is increased due to ion pumps in the endothelial cells. Thus, corneal edema can be caused by a breakdown of either the anatomical barrier or the pump function of the corneal endothelial cells, representing an increase in CCT. This effect depends on the pathology insults of DM [30] and the severity of the physical trauma.

Visual acuity

In addition to the changes in the cornea, visual rehabilitation is still the top concern for patients undergoing phacoemulsification. Best corrected visual acuity (BCVA) is one of the best parameters for evaluating the quality and efficiency of a surgical technique. Although CCT values were significantly different between the two groups after phacoemulsification, there was no difference in visual acuity in the long-term comparison as reported [31] However, the BCVA of the non-diabetic group was better at 1 week postoperatively[31] , indicating that the diabetic achieve worse vision recovery, which is consistent with the CCT results. Eventually, patients in both groups had better postoperative visual acuity at the end of the follow-up period, which indicates that phacoemulsification should be considered as a safe procedure for cataract extraction in the diabetic.

Therefore, more efforts and focus need to be in place by the surgeon to minimize surgical trauma, especially for the diabetic. Thus, to reach this, phaco-power near the cornea must be avoided.

A viscoelastic agent could be generously used to cushion the endothelium as well.

CONCLUSION

The injury of corneal endothelial cells after phacoemulsification in diabetic cataract patients is by far more serious compared to those with simple cataract.

Moreover, aged －related cataract patients with diabetes mellitus manifested much more poor tolerability on cataract phacoemulsification surgery versus senile cataract patients, the corneal endothelium injury was more grave and the velocity and validity of recovery were lower as well.

REFERENCES

1. **Shaw JE, Sicree RA, Zimmet PZ(2010):** Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes research and clinical practice,87(1):4-14.
2. **Benson W(1992):** Cataract surgery and diabetic retinopathy.Current Opinion in Ophthalmology, 3(3):396–400.
3. **Ederer F, Hiller R and Taylor H(1981):**Senile lens changes and diabetes in two population studies. American Journal of Ophthalmology, 91(3):381–395.
4. **Pollreisz A, Schmidt-Erfurth U(2010):** Diabetic cataract—pathogenesis, epidemiology and treatment. Journal of ophthalmology, 17:2010.
5. **Herse PR(1988):** A review of manifestations of diabetes mellitus in the anterior eye and cornea. Am J Optom Physiol Opt ., 65 :224-230.
6. **Hugod M, Storr-Paulsen A, Norregaard JC, Nicolini J, Larsen AB, Thulesen J(201):** Corneal endothelial cell changes associated with cataract surgery in patients with type 2 diabetes mellitus. Cornea , 30 :749-753.
7. **Yee RW, Matsuda M, Schultz RO, Edelhauser HF(1985):** Changes in the normal corneal endothelial cellular pattern as a function of age. Curr Eye Res.,4 :671-678.
8. **Mathew PT, David S, Thomas N(2011):** Endothelial cell loss and central corneal thickness in patients with and without diabetes after manual small incision cataract surgery. Cornea , 30 :424-428
9. **Higgins j ,Green S(2011):** Cochrane Handbook for Systematic Reviews of Interventions. training.cochrane.org/handbook
10. **Wells GA, Shea B, O'connell D, Peterson J, Welch V, Losos M, Tugwell P(2013):** The Newcastle-Ottawa Scale (NOS) for assessing the quality if nonrandomized studies in meta-analyses. http://www. ohri. ca/programs/clinical_epidemiology/oxford. htm
11. **StatsDirect.** Proportion Meta-analysis http://www.statsdirect.com/help/default.htm#meta_analysis/proportion.htm.
12. **Higgins JPT, Thompson SG, Deeks JJ, Altman DG(2003):** Measuring inconsistency in meta-analyses. Br Med J., 327(7414):557–60.
13. **Moher D, Liberati A, Tetzlaff J, Altman DG (2009):**Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med., 6(7):45-49.
14. **Wu Z, Zhong J, Mai S *et al.*(2008):** Influence of cataract phacoemulsification on corneal endothelial cells in diabetes. International Journal of Ophthalmology, 8: 1908–1909 .
15. **Wu L, Zhang L, Wang C andYang X(2010):**Study on corneal endothelial cells after phacoemulsification in diabetic cataract. International Journal of Ophthalmology, 10: 1290–1293 .
16. **Yang R (2011):** The influence of phacoemulsification on corneal endothelial cells at varying blood glucose levels. Eye science ,26:91–95.
17. **Hugod M (2011):** Corneal endothelial cell changes associated with cataract surgery in patients with type 2 diabetes mellitus. Cornea,30: 749–753.
18. **Zhao C (2013):** Changes of corneal endothelium in diabetes patients after cataract phacoemulsification surgery by confocal microscopy. International Eye Science, 13: 876–879 .
19. **Zhu N, Zhang Z and Hao X (2014):**Influence of phacoemulsification on corneal endothelial cell of cataract patients with diabetes or hypertension. International Eye Science, 14: 480–483 .
20. **Yan A and Chen F(2014):** Phacoemulsification on corneal endothelium cells in diabetic patients with different disease duration. International Eye Science, 14: 1786–1789 .
21. **Misra S, Goh Y, Patel D *et al.*(2015):**Corneal microstructural changes in nerve fiber, endothelial and epithelial density after cataract surgery in patients with diabetes mellitus. Cornea, 34: 177–181 .
22. **Li M, Fu X and Yang W(2016):** Effect and risk factors for corneal endothelial cells after phacoemulsification in diabetic cataract patients. International Eye Science, 16: 1048–1051 .
23. **Goebbels M, Spitznas M(1991):** Endothelial barrier function after phacoemulsification: a comparison between diabetic and non-diabetic patients. Graefes Arch Clin Exp Ophthalmol,229:254-257
24. **Furuse N, Hayasaka S, Yamamoto Y, Setogawa T(1990):** Corneal endothelial changes after posterior chamber intraocular lens implantation in patients with or without diabetes mellitus. Br J Ophthalmol.,74:258-260.
25. **Matsuda M, Sawa M, Edelhauser HF, Bartels SP, Neufeld AH, Kenyon KR(1985):** Cellular migration and morphology in corneal endothelial wound repair. Invest Ophthalmol Vis Sci., 26:443-449

26. **Morikubo S, Takamura Y, Kubo E, Tsuzuki S, Akagi Y(2004):** Corneal changes after small-incision cataract surgery in patients with diabetes mellitus. Arch Ophthalmol ., 122 :966-969.
27. **Rao GN, Shaw EL, Arthur E, Aquavella JV(1978):** Morphological appearance of the healing corneal endothelium. Arch Ophthalmol .,96:2027-2030.
28. **Hugod M, Storr-Paulsen A, Norregaard JC, Nicolini J, Larsen AB, Thulesen J(2011):** Corneal endothelial cell changes associated with cataract surgery in patients with type 2 diabetes mellitus. Cornea , 30 :749-753.
29. **Mathew PT, David S, Thomas N(2011):** Endothelial cell loss and central corneal thickness in patients with and without diabetes after manual small incision cataract surgery. Cornea , 30 :424-428
30. **Lee J, Lee J, Choi H, Oum B and Cho B(2005):** Corneal endothelial cell change after phacoemulsification relative to the severity of diabetic retinopathy. *Journal of cataract and refractive surgery*, 31: 742–749.
31. **Wang B, Li J, Wang Y *et al.*(2013):**Clinical effect analysis of phacoemulsification on cataract patients with diabetes mellitus. *International Eye Science*, 13: 1163–1166 .