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Original Research Article

Changes in central macular thickness after uneventful phacoemulsification in diabetics and non-diabetics using normothermic and hypothermic balanced salt solution in a tertiary care hospital in Tamil Nadu

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Abstract

Background: Central macular thickness (CMT) may undergo significant changes after cataract surgery, particularly in diabetic individuals. The temperature of balanced salt solution (BSS) used during phacoemulsification may influence postoperative inflammatory response and macular changes.
Aim and Objective: To assess and compare the central macular thickness (CMT) in diabetic and non-diabetic patients undergoing phacoemulsification using normothermic and hypothermic BSS.
Materials and Methods: The study consisted of 140 participants divided equally into four groups of 35 each. Group 1 – NDMR: Nondiabetics who received room temperature BSS; Group 2 – NDMC: Nondiabetics who received cold BSS; Group 3 – DMR: Diabetics who received room temperature BSS; and Group 4 – DMC: Diabetics who received cold BSS. The cold BSS used was at a temperature of 4ºC and room temperature BSS used was normothermic and was in the range between 34 – 36ºC. CMT was measured pre and post-operatively using a spectral domain optical coherence tomography scan and compared.
Results: The CMT values were significantly different between the NDMR (non-diabetic patients receiving room temperature BSS) and NDMC (non-diabetic patients receiving cold [4ºC] BSS) consistently at POD 7, 28 and 42, with CMT being higher in those who were given room temperature BSS.
Conclusion: The incidence of cystoid macular edema is less in non-diabetics than diabetics who were subjected to hypothermic BSS.

Keywords: Balanced salt solution, Cold vs room temp irrigating solution, Diabetics, Central macular thickness, Phacoemulsification, Cystoid macular edema.

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1. Introduction

Cataract refers to the opacification or modification in the optical homogeneity of the lens entailing the anterior epithelium, capsule, cortex, or nucleus.[1] In phacoemulsification, the cataractous lens is disintegrated via a micro-incision of less than 3 mm, offering faster optical rehabilitation and regarded as the benchmark protocol for cataract management.[2]

Diabetes can influence ocular anatomy and cause diabetic retinopathy, metabolic cataract, punctate keratopathy, repetitive corneal breakdown, corneal edema, retarded wound recovery, as well as insistent epithelial deformities.[3] Diabetes affects phacoemulsification outcomes by slowing wound healing, raising infection risk, and causing more postoperative problems. Diabetic patients often face wound infections, poor healing, and abnormal scarring.[4] High blood sugar can worsen these issues by reducing new blood vessel growth and proper inflammation.[5] Corneal healing is often slower, and there is a greater risk of cell loss, which makes cataract surgery harder.[6] After surgery, diabetics have higher rates of cystoid macular edema, capsule clouding, and eye infections. Many need added treatments, like injections to manage swelling.[7]

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Macular edema delineates retinal fluid agglomeration in the macula due to a disintegration of the blood-retinal barrier resulting in egress of the fluid from perifoveal capillaries. This leakage causes pooling of fluid in the retina, deforming the architecture of the photoreceptors and potentially causing loss of central vision. It may occur after cataract surgery and present with diminution of visual acuity and disfigured central vision.[8] It is often self-resolving, but a small proportion of people develop chronic persistent macular edema leading to cystoid macular edema (CME).[9]

Cystoid macular edema is a common cause of vision loss after cataract surgery. It often happens if the capsule breaks during the operation or if conditions like diabetes, uveitis, retinal vein blockages, or epiretinal membranes are present. Swelling forms in the retina, which thickens and affects vision.[10] Balanced salt solution (BSS) keeps eye tissues healthy during surgery. Newer studies show that cooler BSS may lower inflammation by reducing cytokine release and heat damage. There's still not enough research comparing warm and cool BSS on retinal swelling, especially for people with diabetes.[11]

Macular edema is assessed and monitored using optical coherence tomography (OCT), which allows accurate measurement of central macular thickness and provides valuable insight into subtle changes in the macular profile post-surgery.[12] Recent research has begun to explore the role of thermal modulation during intraocular procedures as a means of improving surgical outcomes. Lowering the temperature of intraocular solutions may help in stabilizing retinal metabolic activity, reducing cellular stress responses, and enhancing recovery of the blood-retinal barrier.[13] Additionally, cold irrigation has been hypothesized to influence the release of prostaglandins and other mediators involved in postoperative inflammation, especially in patients with a predisposing metabolic state like diabetes.[14]

Intraocular surgery is a precise process, as the eye leaves little room for error. Any mistake or misjudgement can damage delicate tissues and may lead to permanent loss of vision. Because of these risks, it's always important to keep improving surgical methods, equipment and medicines used in eye operations. Accordingly, this study aims to measure and compare the central macular thickness in both diabetic and non-diabetic patients who undergo phacoemulsification. The research looks at the effects of using cold BSS vs room temperature BSS. To date, there have been very little published studies directly comparing the effect of BSS temperature on the eyes of diabetic and non-diabetic patients during phacoemulsification. This work seeks to address that gap, giving new information that could help improve patient care and surgical outcomes.

2. Objectives

1. To evaluate and uncover the differences in central macular thickness in diabetic and non-diabetic patients undergoing phacoemulsification in which each group was further divided and subjected to normothermic and hypothermic BSS as an irrigating solution.
2. To determine the role of temperature of balanced salt solution used intraoperatively has an influence over retinal parameters

3. Materials and Methods

This was a quasi-experimental study that was carried out in the Department of Ophthalmology at a single tertiary medical centre in Tamil Nadu during the period of 12 months (February 2024 to January 2025). The study began after obtaining the necessary approvals from the Institutional Ethical Committee. Adult patients who were willing for participation and provided valid consent and fulfilled the selection criteria were selected for this study. Inclusion criteria included patients over the age of 45 who were diagnosed with immature cataract and scheduled for uncomplicated phacoemulsification surgery with implantation of a posterior chamber intraocular lens. Exclusion criteria ruled out patients with any evidence of corneal dystrophy or existing retinal pathology. Those with a record of previous eye surgery, shallow anterior chamber or pseudoexfoliation syndrome were not considered. Additional exclusion factors comprised a diagnosis of glaucoma or uveitis, presence of presenile or juvenile cataract, and cases involving mature or hyper mature cataracts. Patients with a known history of complications during previous cataract procedures or any record of ocular trauma were also excluded from participation. These criteria were set to minimise confounding variables and enhance consistency across the study population.

The grouping for this study divided 140 participants into four equal groups of 35 each. Group 1 – NDMR: Nondiabetics who received room temperature BSS; Group 2 – NDMC: Nondiabetics who received cold BSS; Group 3 – DMR: Diabetics who received room temperature BSS; and Group 4 – DMC: Diabetics who received cold BSS. The cold BSS used was at a temperature of 4^{o}C and room temperature BSS used was normothermic and was in the range between 30 – 34^{o}C. The BSS temperature was cooled by refrigeration and maintaining it at the cold state until use. The normothermic BSS was checked for temperature and used directly from stock as a sterile unit. Proper safety methods were observed to prevent contamination. The surgeries were performed by a single phaco surgeon for all the participants. The central macular thickness of retina was assessed using Spectral domain Optical coherence tomography pre-operatively and in the 7th, 28th and 42nd post-operative days.

The statistical analysis was carried out with SPSS v.26 software. Appropriate statistical tests were used to compare the mean CMT values. Welch's ANOVA and T-test were used to assess significant differences (due to heteroscedasticity) between the CMT values during the measured period. Paired T Test was used to assess the change

in the mean CMT values between each recording. The findings were reported in the form of tables and figures.

4. Results

The study included a total of 140 participants, with the majority falling within the age range of 51–60 years (57.14%), followed by 61–70 years (32.86%). Females constituted a larger proportion of the study population (62.9%) compared to males (37.1%), maintaining an approximate 2:3 male-to-female ratio. Participants were equally distributed into four study groups: Non-Diabetic Room (NDMR), Non-Diabetic Cold (NDMC), Diabetic Room (DMR), and Diabetic Cold (DMC), with 35 individuals in each subgroup (**Table 1**).

Table 1: The sociodemographics of the participants

Groups	Sub-groups	Frequency	Percentage
Age group	50 & below	5	3.57%
	51 – 60	80	57.14%
	61 - 70	46	32.86%
	71 - 80	9	6.42%
	Total	140	100%
Gender	Male	52	37.1%
	Female	88	62.9%
	Total	140	100%
Study Groups	NDMR	35	25.0%
	NDMC	35	25.0%
	DMR	35	25.0%
	DMC	35	25.0%
	Total	140	100%

Table 2: Comparison of CMT between the study groups at planned intervals

Pre-op CMT					
		Mean (SD)	***p*-value**	**Mean (SD)**	***p*-value**
NDM	Room	224.63 ±17.01	.449	223.09 ±16.88	.772
	Cold	221.54 ±16.86			
DM	Room	221.74 ±17.54	.931	221.96 ±20.47	
	Cold	222.17 ±23.29			
POD 7 CMT					
		Mean (SD)	***p*-value**	**Mean (SD)**	***p*-value**
NDM	Room	224.40 ±16.52	.049*	220.64 ±16.07	1
	Cold	216.89 ±14.90			
DM	Room	221.46 ±17.97	.742	220.64 ±20.50	
	Cold	219.83 ±22.99			
POD 28 CMT					
		Mean (SD)	***p*-value**	**Mean (SD)**	***p*-value**
NDM	Room	232.94 ±15.16	.004*	227.44 ±16.41	.574
	Cold	221.94 ±15.95			
DM	Room	229.89 ±20.32	.827	229.30 ±22.17	
	Cold	228.71 ±24.16			
POD 42 CMT					
		Mean (SD)	***p*-value**	**Mean (SD)**	***p*-value**
NDM	Room	238.29 ±16.17	.006*	232.76 ±17.12	.453
	Cold	227.23 ±16.45			
DM	Room	236.09 ±19.16	.779	235.31 ±22.71	
	Cold	234.54 ±26.03			
Welch's ANOVA / T - Test; * Significant (p-value < 0.05)					

Table 2 shows us the comparison between the CMT recordings pre-op and post op of the study groups. There is a significant difference in the mean value of CMT between the cold and room temperature groups of non-DM group, NDMC and NDMR. The NDMC group had a lower mean CMT than the NDMR group in the post op period readings at 7th, 28th and 42nd PODs and the difference was significant. This implies that the central macular thickness which was not that different between the study participants before surgery, was noted to be significantly more in participants who were non-diabetic and were given room temperature BSS. The cold BSS seems to play a role in minimizing macular edema post phacoemulsification.

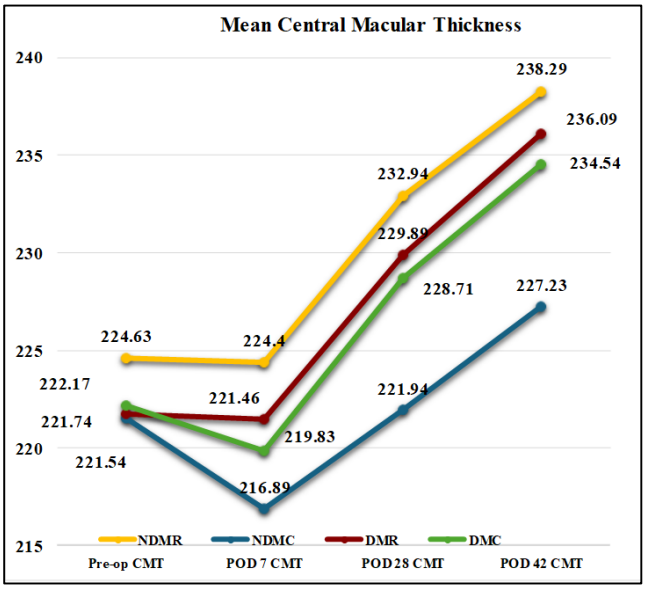

Figure 1: Comparison of CMT of the study groups

Though the graph in **Figure 1** shows a clear difference between the mean values noted amongst the groups, a significant difference was only recorded between the groups NDMR (yellow line) and NDMC (blue line).

Table 3: Comparison of CMT within the study groups at planned intervals

Groups	Pre-Op	POD 7	POD 28	POD 42
Non-DM Room		.799	< .001*	< .001*
Non-DM Cold		.001*	< .001*	< .001*
DM Room		.709	< .001*	< .001*
DM Cold		< .001*	< .001*	< .001*
Paired T - Test; * Significant (p-value < 0.05)				

Table 2 shows the differences between the same group over time before and after phacoemulsification. We see that the increase noted (**Figure 1**) in the mean CMT values in all the study groups after POD 7 was found to be significant. A decrease in the mean CMT values seen in NDMC and DMC between pre-op and POD 7 was also significant implying a role played by cold BSS on CMT post-operatively. While we note a significant decrease in mean CMT values immediately after surgery among those who were given cold BSS, we don't see that on those for whom room temperature BSS was used (insignificant p-value for NDMR & DMR). This is evident of the reduction in CMT caused by the cold BSS post phacoemulsification procedure.

5. Discussion

Analysis of the CMT values across the study groups showed no detectable differences in the pre-operative period, including when comparing diabetic and non-diabetic participants. This finding matches earlier work by Akkaya S et al, who also found similar CMT measurements between these groups before surgery.[15] The data suggest that diabetic status alone does not affect pre-operative CMT, at least within the measured population. The analysis pointed out significant differences only in the non-diabetics between the room and cold BSS. POD 7, NDMR - 224.40 ±16.52, NDMC - 216.89 ±14.90, p-value = .049; at POD 28, NDMR - 232.94 ±15.16; NDMC - 221.94 ±15.95, p-value = .004; at POD 42, NDMR - 238.29 ±16.17, NDMC - 227.23 ±16.45, p-value = .006. This finding was also shared by Meduri A et al., in which they suggested that cold BSS can control post-operative macular thickening.[16]

There was a marked reduction in CMT among participants within DMC and NDMC groups who received cold balanced salt solution during their surgery. This initial decrease was statistically significant. In the period following surgery, however, a steady increase in CMT values occurred within these groups, and this rise also reached statistical significance. The data suggest that cold BSS affects the immediate post-operative CMT, producing a short-term reduction.

From post-operative day 7 onwards, both diabetic and non-diabetic groups—whether treated with cold or room temperature BSS—showed a sustained and significant increase in CMT. While the hypothermic (cold) BSS groups continued to record lower CMT values compared to those receiving room temperature BSS, the difference between these groups however was not large enough to be considered statistically significant. These findings indicate a limited and temporary benefit associated with cold BSS in reducing early macular swelling.

These trends are consistent with previous reports that highlight a transient effect of temperature-modified BSS on macular thickness. While some may expect prolonged benefit from hypothermic irrigation, our data do not support a lasting difference. This suggests the influence of cold BSS is restricted mainly to the immediate post-operative period.

The mechanism behind the use of cold BSS during ocular surgeries is not exactly known and current clinical practice doesn't support that.[17] However, there is a credibility that it may help reduce macular edema by minimizing thermal damage to retinal tissues, as also evidenced by a prospective randomized study by Meduri A et al. When cold BSS is introduced into the eye, it creates a temperature gradient that can shock retinal tissues, but this effect may be beneficial in reducing postoperative macular thickening.[18]

Ikegami Y et al. observed that the increase in retinal thickness continued for three months after surgery, yet their data showed no significant difference between diabetic and non-diabetic groups.[19] In line with this, Shafi M et al. reported significant shifts between preoperative and postoperative central macular thickness (CMT) but similarly found no meaningful difference tied to diabetic status.[20] Degenring F R et al., however, identified significant differences between diabetic (DM) and non-diabetic (NDM) groups at postoperative day 28 in their study, though our data do not reflect such findings, as our groups showed comparable outcomes to this finding.[21]

Romero-Aroca P likewise highlighted that the association between diabetes and cataract is growing stronger, which aligns with rising global diabetes rates. After routine cataract surgery, cystoid macular oedema (CME) remains a recognised risk that may lead to reduced visual outcomes for some patients.[22] This risk is an important factor in postsurgical follow-up and patient counselling, especially as the prevalence of diabetes keeps rising among the Indian population for decades.[23,24]

Further research supports these findings, as shown in the work of Hayashi K et al. focused on the frequency of macular oedema in patients following phacoemulsification, comparing those with diabetic retinopathy to those without and concluded that individuals with diabetes were more likely to develop macular oedema, and that these changes were more marked in eyes with existing diabetic retinopathy.[25] These results add to the evidence suggesting a clear association between diabetes and a higher risk of macular complications after cataract surgery. While some clinicians suggest that careful monitoring can reduce these risks, the data highlight the need for heightened vigilance in diabetic patients.

6. Strengths

1. All the surgeries were performed by the same specialist under similar conditions.
2. The study focused on an area under Ophthalmology surgery that has received less attention from previous research.

7. Limitations

1. A larger sample size would have strengthened the data and supported more reliable subgroup analysis, as outliers would have less effect, and patterns would appear more clearly.

While bigger studies need more resources, the gains in data quality and insight are significant.

8. Conclusion

This study examined how the temperature of balanced salt solution (BSS) affects eyes with and without diabetes during phacoemulsification. The analysis compared outcomes for patients who received room temperature BSS with those who had cold BSS. Results showed a clear difference in central macular thickness (CMT) among non-diabetic patients. Those given room temperature BSS developed a higher CMT during the post-operative period, a finding that remained consistent at each time point measured. In contrast, diabetic patients showed no significant difference in CMT whether they received cold or room temperature BSS.

Evidence from this study suggest that hypothermic BSS has a protective effect, limiting acute increases in macular thickness and lowering the risk of cystoid macular oedema after surgery. However, diabetic eyes remain at higher risk for complications, regardless of BSS temperature. For this reason, increased post-operative monitoring and support are recommended for diabetic patients to address their greater susceptibility to adverse outcomes. These findings support the use of cold BSS for non-diabetics but highlight the ongoing need for special care in diabetic cases.

9. Source of Funding

No funding.

10. Conflict of Interest

Nil.

11. Ethical Approval

IHEC-I/3595/25.

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