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Original Research Article

EARLY VERSUS LATE CAPSULAR TENSION RING PLACEMENT DURING PHACOEMULSIFICATION IN ZONULAR WEAKNESS: A COMPARATIVE STUDY

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ABSTRACT

Background: Zonular weakness increases the risk of complications during phacoemulsification. Capsular tension rings (CTR) stabilize the capsular bag, but the optimal timing of insertion remains unclear. This study compared early versus late CTR insertion in eyes with mild to moderate zonular weakness. **Materials and Methods:** Fifty eyes undergoing phacoemulsification were divided into two groups: early CTR insertion (Group A, n = 25) after capsulorrhexis and hydrodissection, and late CTR insertion (Group B, n = 25) after nucleus removal. Intraoperative capsular stability, cortical aspiration difficulty, posterior capsular rupture, postoperative BCVA, IOL positioning, and complications were recorded. **Results:** Mean age was similar between groups (Group A: 61.4 ± 7.2 years; Group B: 62.1 ± 6.9 years). Capsular instability occurred in 3 eyes (12%) in Group A versus 8 eyes (32%) in Group B. Posterior capsular rupture occurred in 1 eye (4%) in Group A and 3 eyes (12%) in Group B. Cortical aspiration was slightly more difficult in early CTR cases (6 eyes, 24%) compared to late insertion (2 eyes, 8%). Postoperatively, BCVA ≥6/9 was achieved in 21 eyes (84%) in Group A and 19 eyes (76%) in Group B. Mild IOL decentration occurred in 1 eye (4%) in Group A and 4 eyes (16%) in Group B. No significant complications were observed. **Conclusion:** Early CTR insertion enhances capsular stability, reduces the risk of posterior capsular rupture and IOL decentration, and ensures excellent visual outcomes. The slightly increased difficulty in cortical aspiration is manageable. Early CTR placement is recommended in eyes with zonular weakness.

INTRODUCTION

Successful phacoemulsification depends on adequate zonular support to maintain capsular bag stability. In eyes with zonular weakness, stability is compromised, increasing the risk of intraoperative complications such as capsular bag instability, posterior capsular rupture, vitreous loss, and postoperative IOL decentration. These factors make cataract surgery technically demanding and may adversely affect surgical and visual outcomes.

Capsular tension rings (CTR) provide circumferential equatorial support by redistributing zonular forces, thereby improving capsular stability and IOL centration in eyes with mild to moderate zonular weakness. Although the benefits of CTR are established, the optimal timing of insertion remains debated.

Early CTR insertion, performed after capsulorrhexis and hydrodissection, may enhance capsular stability throughout surgery and reduce stress on weakened zonules. However, early placement may interfere with nucleus rotation and cortical aspiration. Conversely, late CTR insertion after nucleus removal can facilitate cortical cleanup but may leave the capsular bag inadequately supported during nucleus manipulation.

Given these contrasting considerations and the lack of consensus, this study aimed to compare early versus late CTR placement during phacoemulsification, focusing on intraoperative safety, surgical ease, and postoperative outcomes.

MATERIALS AND METHODS

This hospital-based comparative study was conducted in the Department of Ophthalmology at Santhiram Medical College and General Hospital, Nandyal, over a period of 4 months. Fifty eyes of adult patients with senile cataract and mild to

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moderate zonular weakness undergoing phacoemulsification were included.

Patients were allocated into groups based on intraoperative CTR insertion timing: early CTR insertion (Group A, n = 25) after capsulorrhexis and hydrodissection, and late CTR insertion (Group B, n = 25) after nucleus removal. Mild to moderate zonular weakness was defined as zonular dialysis involving up to 3–4 clock hours or generalized zonular laxity. Patients with severe zonular dialysis (>6 clock hours), lens subluxation, traumatic cataract, prior intraocular surgery, advanced pseudoexfoliation with significant phacodonesis, corneal pathology affecting vision, or posterior segment diseases limiting visual recovery were excluded.

All surgeries were performed by experienced surgeons using standard phacoemulsification techniques. The capsulorrhexis size ranged between 5–5.5 mm, followed by hydrodissection. Nucleus removal was performed with phacoemulsification using a direct phaco chop technique. CTRs (standard design) were inserted according to group allocation. Cortical aspiration and IOL implantation were carried out in all cases using standard procedures.

Intraoperative parameters included capsular stability, nucleus manipulation, cortical aspiration difficulty, and complications. Postoperative assessment included BCVA, IOL centration, and complications during follow-up. The study adhered to the Declaration of Helsinki, and Institutional Ethics Committee approval was obtained.

RESULTS

Fifty eyes of 50 patients were included in the study, with 25 eyes in each group. Mean age and sex distribution were comparable between the two groups. The detailed distribution of participants by group is summarized in Table 1. Laterality and baseline ocular comorbidities—including pseudoexfoliation, prior ocular surgery, and cataract density—were also comparable. Preoperative best-corrected visual acuity (BCVA) showed no significant difference between the groups ($p > 0.05$).

Table 1: Group-wise Demographics of Study Participants

Group	Number of Eyes	Mean Age (years ± SD)	Male (n)	Female (n)
Group A (Early CTR)	25	61.4 ± 7.2	14	11
Group B (Late CTR)	25	62.1 ± 6.9	15	10

Intraoperatively, capsular instability occurred in 3 eyes (12%) in Group A versus 8 eyes (32%) in Group B ($p = 0.04$). Posterior capsular rupture occurred in 1 eye (4%) in Group A and 3 eyes (12%) in Group B ($p = 0.28$). Cortical aspiration was slightly more challenging in Group A (6 eyes, 24%) compared to Group B (2 eyes, 8%; $p = 0.22$). Phacoemulsification energy and duration were comparable, and no adjunct devices were required.

Postoperatively, BCVA ≥6/9 was achieved in 21 eyes (84%) in Group A and 19 eyes (76%) in Group B ($p = 0.47$). Mild IOL decentration occurred in 1 eye (4%) in Group A and 4 eyes (16%) in Group B ($p = 0.17$). No significant postoperative inflammation, cystoid macular edema, posterior capsular opacification, or other complications were observed during follow-up (mean 6 months).

Figure 1 illustrates these intraoperative and postoperative outcomes, highlighting the differences between early and late CTR placement.

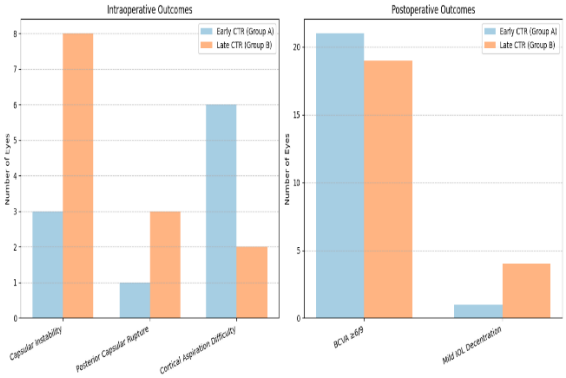

Figure 1: Comparison of intraoperative and postoperative outcomes between Early CTR (Group A) and Late CTR (Group B). Left panel: Intraoperative outcomes including capsular instability, posterior capsular rupture, and cortical aspiration difficulty. Right panel: Postoperative outcomes including the proportion of eyes achieving BCVA ≥6/9 and the incidence of mild IOL decentration. Early CTR insertion is associated with lower rates of capsular instability and posterior capsular rupture, slightly increased cortical aspiration difficulty, better visual outcomes, and reduced IOL decentration compared with late CTR insertion

DISCUSSION

Phacoemulsification in eyes with zonular weakness remains surgically challenging due to the increased risk of capsular instability, posterior capsular rupture, vitreous loss, and postoperative intraocular lens (IOL) decentration. Capsular tension rings (CTR) are

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well established for improving capsular bag stability by redistributing zonular forces; however, the optimal timing of CTR insertion continues to be debated. This study compared early versus late CTR placement during phacoemulsification in eyes with mild to moderate zonular weakness, focusing on intraoperative safety and postoperative outcomes.

The present study demonstrated that early CTR insertion, performed after capsulorrhexis and hydrodissection, resulted in significantly better intraoperative capsular stability compared to late insertion. Capsular instability was notably lower in the early CTR group, suggesting that early equatorial support helps minimize stress on compromised zonules during nucleus manipulation and phacoemulsification. This finding supports the concept that early stabilization reduces cumulative zonular stress throughout surgery, thereby decreasing the likelihood of capsular compromise.

Posterior capsular rupture occurred less frequently in the early CTR group, although the difference was not statistically significant. This trend is clinically relevant, as posterior capsular rupture is a major intraoperative complication that can adversely affect visual outcomes. Improved capsular support during nucleus removal in early CTR cases may contribute to this reduction, even if statistical significance was not achieved in the present sample size.

Cortical aspiration was found to be slightly more challenging in the early CTR group. This observation is consistent with the mechanical effect of the CTR exerting outward tension on the capsular equator, which can trap cortical fibers and necessitate careful aspiration technique. However, this increased difficulty did not translate into higher complication rates or poorer visual outcomes, indicating that with meticulous surgical technique, cortical cleanup remains manageable even with early CTR placement.

Postoperatively, both groups achieved excellent visual outcomes, with a high proportion of eyes attaining BCVA ≥6/9. However, mild IOL decentration was less frequent in the early CTR group, highlighting the long-term benefit of early capsular stabilization on IOL positioning. Proper centration is particularly important in eyes with zonular weakness, as late decentration can compromise visual quality and may necessitate secondary intervention.

The findings of this study are in agreement with previous reports suggesting that early CTR insertion enhances intraoperative safety and postoperative IOL centration in eyes with compromised zonules. While late CTR insertion may facilitate cortical aspiration, it leaves the capsular bag inadequately supported during critical stages of nucleus manipulation, potentially increasing the risk of instability.

The strengths of this study include comparable baseline characteristics between groups, standardized surgical technique, and focused evaluation of clinically relevant intraoperative and postoperative parameters. Limitations include the relatively small sample size, short-term follow-up, and subjective assessment of cortical aspiration difficulty. Larger, randomized studies with longer follow-up are warranted to further validate these findings and assess long-term capsular bag and IOL stability.

CONCLUSION

Early capsular tension ring insertion during phacoemulsification in eyes with mild to moderate zonular weakness provides superior intraoperative capsular stability, reduces the risk of posterior capsular rupture and intraocular lens decentration, and results in excellent postoperative visual outcomes. Although cortical aspiration may be slightly more challenging with early insertion, this is manageable with careful surgical technique and does not adversely affect final visual outcomes.

Conflict of Interest: The authors declare no financial interest or conflict of interest.

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