ASSOCIATION BETWEEN REFRACTIVE ERROR PROFILES AMONG PATIENTS WITH DIFFERENT TYPES OF CATARACT

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ABSTRACT

Purpose: *To evaluate the association between cataract morphology (nuclear, cortical, and posterior subcapsular) and refractive error profiles, and to assess preoperative and postoperative refractive shifts following cataract surgery.*
Methods: *A prospective cross-sectional study was conducted on 80 patients (44 males, 36 females; mean age 63.0 ± 9.18 years) undergoing cataract surgery. Comprehensive ophthalmic evaluation included visual acuity assessment, objective and subjective refraction, slit-lamp examination, and cataract grading using the LOCS III classification. Preoperative and one-month postoperative refractive outcomes were analyzed.*
Results: *Nuclear cataract was the most prevalent subtype (43.8%), followed by posterior subcapsular cataract (28.8%) and cortical cataract (27.5%). Data analysis was performed using IBM SPSS Statistics Version 23 (IBM Corp., Armonk, NY, USA). A statistically significant myopic shift was observed preoperatively in myopic patients ($p = 0.012$), consistent with index myopia. Postoperatively, myopic patients demonstrated a significant hyperopic shift toward emmetropia ($p < 0.001$), while hyperopic patients showed a significant myopic shift ($p < 0.001$). Consistent refractive neutralization was achieved across all cataract morphologies.*
Conclusion: *Cataract morphology, particularly nuclear sclerosis, is associated with characteristic preoperative refractive shifts. Modern cataract surgery with appropriate IOL power calculation effectively neutralizes refractive errors, achieving predictable refractive outcomes regardless of cataract type.*

Keywords: *Nuclear cataract, cortical cataract, posterior subcapsular cataract, index myopia, refractive shift, intraocular lens.*

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INTRODUCTION

One of the biggest causes of visual impairment in the world is cataracts, which are caused by clouding of the naturally clear lens of the eye. [5] This condition can take many different forms, including nuclear sclerosis, which involves the hardening and yellowing of the central nucleus and often induces index myopia. Cortical cataracts are characterized by spoke-like opacities forming in the lens cortex, while posterior subcapsular cataracts (PSC) develop directly in front of the posterior capsule, presenting as granular-like opacities that significantly impact visual clarity. [6]

Blurred vision is caused by refractive errors, which happen when the eye cannot correctly focus light onto the retina. Myopia, which is generally caused by an excessively large eyeball or a steep cornea, is a condition in which light concentrates in front of the retina rather than directly on it, usually allowing for clear near vision but blurring distant objects. Conversely, in hyperopic eyes, light focuses behind the retina, a condition often caused by an eyeball that is too short or a cornea that is too flat. [3]

The relationship between refractive errors and cataract development is complex, with distinct patterns observed for different cataract types. Myopia is strongly associated with nuclear and posterior subcapsular cataracts; in the case of nuclear cataracts, the relationship is bidirectional, as the cataract itself can induce an index myopic shift. [9] For posterior subcapsular cataracts (PSC), myopia acts as a pre-existing risk factor, where early-onset and high degrees of myopia increase susceptibility. [1] While the link to cortical cataracts is less clear though high myopia may be associated with all types.[1] The relationship between hyperopia and cataract development presents a contrasting picture. Hyperopia is more commonly linked to cortical cataracts, potentially due to biomechanical stress from increased accommodative effort during presbyopia. [10]

The transition from pre-operative to post-operative status involves immediate refractive changes as the cataractous lens is removed. During this process, a predictable shift occurs where myopic eyes tend to shift in a hyperopic direction, while hyperopic eyes conversely tend to shift toward a myopic state, ultimately moving both toward the desired point of neutralization.[12]

METHODOLOGY

A prospective cross-sectional study was conducted at Eye Hospital, involving 80 patients aged above 40 years who were scheduled for cataract surgery. Ethical clearance was obtained from the Institutional Review Board, and informed consent was secured from all participants prior to inclusion.

Inclusion criteria comprised patients diagnosed with nuclear, cortical, or posterior subcapsular (PSC) cataracts who had a documented history of spectacle use for 10–15 years and a stable prescription for at least 4–5 years. Both myopic and hyperopic patients were included. Patients with glaucoma, diabetic retinopathy, maculopathy, or active ocular infections were excluded.

All participants underwent comprehensive ophthalmic evaluation, including unaided and best-corrected visual acuity assessment using Snellen's chart for distance and N notation chart for near, objective and subjective refraction, slit-lamp biomicroscopy, and fundus examination. Cataract grading was performed using the Lens Opacities Classification System III (LOCS III).

Postoperative assessment was conducted one month following surgery and included subjective refraction and visual acuity evaluation.

RESULTS

Statistical analysis: Data analysis was performed using IBM SPSS Statistics Version 23 (IBM Corp., Armonk, NY, USA). The sample size was calculated using the Cochran formula based on an expected prevalence of 5% ($p = 0.05$) with a 5% margin of error at a 95% confidence level. The initial estimated sample size was 73 subjects. After accounting for a 10% non-response rate, the final sample size was determined to be 79 participants.

The normality of continuous variables was assessed using the Kolmogorov–Smirnov test. Data were expressed as mean ± standard deviation (SD). For normally distributed data, paired samples t-test was used to compare preoperative and postoperative refractive values. For non-normally distributed data, the Wilcoxon signed-rank test was applied. A p-value < 0.05 was considered statistically significant.

Refractive error was expressed as spherical equivalent (SE) in Diopters (D).

A total of 80 participants were included (mean age 63.0 ± 9.18 years; range 41–83 years). Males constituted 55% (n = 44) and females 45% (n = 36). The baseline mean spherical equivalent was -0.79 ± 2.69 D.

Nuclear cataract was the most prevalent subtype (43.8%, n = 35), followed by posterior subcapsular cataract (PSC) (28.8%, n = 23) and cortical cataract (27.5%, n = 22). Nuclear cataracts were predominantly Grade 4 (52.4%), cortical cataracts were most commonly Grade 3 (54.5%), and PSC cases were mainly Grades 3 and 4 (41.7% each).

Preoperative Refractive Changes

Among myopic patients (n = 44), a statistically significant myopic shift was observed from a mean initial refraction of -2.87 D to -3.48 D preoperatively ($p = 0.012$).

Subgroup analysis showed:

- Nuclear cataract: -3.17 D to -3.89 D ($p = 0.093$)
- Cortical cataract: -2.60 D to -3.37 D ($p = 0.066$)

• PSC: -2.58 D to -2.84 D (p = 0.552)
Although nuclear and cortical subgroups demonstrated greater myopic shifts, these did not reach statistical significance.
Among hyperopic patients (n = 36), mean refraction shifted from +1.75 D to +1.34 D preoperatively; however, this change was not statistically significant.

Postoperative Refractive Outcomes
At one-month follow-up, significant refractive neutralization was observed across all groups.
In the myopic cohort, mean SE improved from -3.48 D preoperatively to -0.23 D postoperatively ($p < 0.001$), indicating a significant hyperopic shift toward emmetropia.
Similarly, in hyperopic patients, mean SE changed from +1.34 D to -0.18 D ($p < 0.001$), demonstrating a significant myopic shift toward emmetropia.
Subgroup analysis confirmed consistent postoperative refractive improvement across nuclear, cortical, and PSC cataracts, with statistically significant shifts observed in all categories.

DISCUSSION

Preoperative Refractive Changes and Index Myopia
The present study demonstrated a statistically significant myopic shift in the overall myopic cohort prior to surgery ($p = 0.012$). This finding is consistent with previously reported evidence that nuclear cataracts induce a progressive increase in the refractive index of the crystalline lens, resulting in index myopia. Studies by Hashemi et al. and Pesudovs et al. have similarly reported a significant association between nuclear sclerosis and myopic refractive shifts.
Although subgroup analysis of nuclear and cortical cataracts did not reach statistical significance, the observed numerical trend toward increasing myopia supports the known physiological mechanism of nuclear hardening and lens densification. The lack of statistical significance in these subgroups may be attributed to relatively smaller sample sizes rather than absence of a true refractive effect.

In contrast, posterior subcapsular cataracts (PSC) demonstrated minimal preoperative refractive alteration. This aligns with the understanding that PSC primarily affects visual quality through light scatter rather than significantly altering the refractive index of the lens.
Among hyperopic patients, a mild preoperative myopic shift was observed; however, it was not statistically significant. This suggests that cataract-induced refractive alterations in hyperopic individuals may be less predictable and influenced by additional biometric factors.

Postoperative Refractive Neutralization
One of the most significant findings of this study was the highly predictable postoperative refractive correction achieved across all groups.
Myopic patients demonstrated a significant hyperopic shift toward emmetropia following surgery ($p < 0.001$), indicating successful neutralization of both axial and lens-induced myopia. Similarly, hyperopic patients experienced a significant myopic shift toward emmetropia ($p < 0.001$), confirming the precision of modern intraocular lens (IOL) power calculation formulas and surgical techniques.
Importantly, this pattern of refractive normalization was consistent across nuclear, cortical, and PSC subtypes. These findings reinforce previous large-scale registry data and population-based studies that report high predictability of postoperative refractive outcomes when appropriate biometry and IOL calculation methods are employed.

CLINICAL SIGNIFICANCE

1. **Clinical Predictability**: This study provides evidence that modern cataract surgery achieves highly predictable refractive neutralization ($p < 0.001$) regardless of the initial cataract morphology, including nuclear, cortical, and posterior subcapsular (PSC) types.
2. **Morphology-Specific Trends**: While many studies focus on general outcomes, this research quantifies specific preoperative shifts, showing that nuclear cataracts (43.8% of the cohort) exhibit the strongest numerical trend toward index myopia.
3. **Surgical Planning Insights**: The findings underscore the importance of understanding how different cataract subtypes, particularly nuclear sclerosis, alter preoperative refractive profiles to improve patient counseling and surgical expectations.

STUDY LIMITATIONS

This study has certain limitations. The sample size was moderate and derived from a single tertiary eye care center, which may limit the generalizability of the findings to broader populations. The follow-up period was limited to one month postoperatively, and longer-term refractive stability was not evaluated. Additionally, axial length and other biometric parameters were not independently analyzed in relation to refractive shifts, which may further influence postoperative outcomes. Future multicentric studies with larger sample sizes and extended follow-up are recommended to validate these findings.

CONCLUSION

This study demonstrates a significant association between cataract morphology and preoperative refractive profiles, particularly in nuclear cataracts where a myopic shift was commonly observed. Although preoperative refractive alterations varied among cataract subtypes, nuclear sclerosis showed the strongest tendency toward index myopia. Cataract surgery with appropriate intraocular lens power calculation resulted in highly predictable refractive neutralization across all cataract types. Myopic patients consistently exhibited a postoperative hyperopic shift toward emmetropia, while hyperopic patients demonstrated a significant myopic shift, achieving near-emmetropic outcomes. These findings highlight the importance of understanding cataract-related refractive changes for accurate preoperative counseling and optimal surgical planning.

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