COMPARISON OF VISUAL ACUITY, CONTRAST SENSITIVITY AND GLARE PRE AND POST PHACOEMULSIFICATION IN PATIENTS HAVING TRIFOCAL AND EXTENDED DEPTH-OF-FOCUS INTRAOCULAR LENSES

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Abstract: The aim of this study was to compare the visual outcomes of patients who underwent phacoemulsification surgery and received either trifocal or extended depth-of-focus (EDOF) intraocular lenses (IOLs). The study evaluated visual acuity, contrast sensitivity, and glare pre and post-operatively to assess the efficacy of these two types of IOLs in cataract surgery patients. **Method:** A comparative cross-sectional study design was employed, and data was collected at Sight Center Eye Hospital over duration of nine months. The study included 30 participants who underwent cataract surgery and IOL implantation in one or both eyes. Non-probability purposive sampling technique was used to select the participants. Visual acuity was measured using LogMAR charts at different viewing distances. Contrast sensitivity was assessed using Pelli-Robson charts, and glare sensitivity was measured using Photostress Recovery Time (PSRT). Data analysis was performed using the Mann-Whitney U test for non-parametric comparisons. **Result:** The results showed that post-operative near visual acuity were significantly better in patients with trifocal IOLs compared to those with EDOF IOLs. However, there were no significant differences in intermediate and distance visual acuity between the two groups. Both types of IOLs demonstrated improvements in visual acuity after surgery. Contrast sensitivity improved significantly in both the trifocal and EDOF IOL groups post-operatively. There were no statistically significant differences in contrast sensitivity between the two groups, indicating that both types of IOLs were equally effective in enhancing contrast sensitivity. Glare sensitivity, as assessed by PSRT, showed a significant reduction in both groups after surgery. The EDOF IOL group exhibited a greater reduction in glare compared to the trifocal IOL group, suggesting potential advantages in managing bright light conditions. **Conclusion:** the findings of this study indicate that both trifocal and EDOF IOLs provide improvements in visual acuity, contrast sensitivity, and glare sensitivity after phacoemulsification surgery. Trifocal IOLs demonstrated better near visual acuity, while EDOF IOLs showed advantages in reducing glare. These results contribute valuable insights for clinicians and patients in selecting the most suitable IOL based on individual visual needs and preferences. Further studies with larger sample sizes and longer follow-up periods are recommended to validate and extend these findings.

Keywords: Cataract, Contrast sensitivity, Glare, Intermediate, Multifocal IOLs.

INTRODUCTION

Cataract procedures attempt to improve the patient's quality of life (QoL) in addition to improving their vision. The intraocular lens (IOL) inserted into the eye plays a crucial part in getting the optimal visual outcomes after cataract surgery.[1] Modern IOLs come in a wide range of materials, styles, and optical characteristics that affect how well they operate visually, such as blue light-filtering, aspheric, toric, monofocal, multifocal, and accommodating IOLs.[2] The most popular IOLs for treating lens in cataract surgery patients are monofocal IOLs, which have just one fixed, precise focus point (often for distant vision).[3] Therefore, the majority of patients need the assistance of corrective glasses to complete close-up and intermediate tasks. By offering many focuses at once, trifocal IOLs (TIOLs) are made to provide unaided excellent vision over a variety of distances.

According to studies, MIOLs are equally as effective as monofocal IOLs for distance vision but are superior for near vision and offer more spectacle independence.[2–4] MIOLs are categorized as either bifocal (2 foci) or trifocal (3 foci) depending on the focality.[5] Vision correction methods include the use of contact lenses placed on the cornea and various types of spectacle lenses such as single-vision, bifocal, trifocal, or progressive lenses.[6] The lens structure is supported by collagen fibers and a basement membrane-like substance, while the lens epithelium, located at the anterior surface of the lens capsule, maintains the lens fibers and performs essential functions such as nutrient transport and evaporation of aqueous humor[7,8].

Cataracts, a common eye condition, involve the clouding of the lens, leading to impaired vision and becoming a leading cause of blindness among the elderly[9]. The formation of cataracts involves complex physiological and biochemical processes, with oxidative stress playing a significant role. Risk factors for cataract development include age, genetics, diabetes, smoking, exposure to ultraviolet radiation, and certain medications[10]. Surgical intervention, particularly phacoemulsification, has become a safe and effective treatment for cataracts. During this procedure, the cloudy lens is removed and replaced with an artificial intraocular lens (IOL.[11] Intraocular lenses (IOLs) are artificial lenses used during cataract surgery or refractive lens exchange to replace cloudy or incorrectly refracting lenses[12]. Mono-focal IOLs provide clear vision at a fixed focal point for distant vision, often requiring additional glasses for near vision. Multifocal IOLs, such as trifocal and extended depth-of-focus (EDOF) IOLs, offer clear vision at multiple distances due to their multiple focal points[13]. The choice of IOL type depends on factors such as the patient's lifestyle, visual needs, ocular health, and the surgeon's recommendation[14].

Trifocal IOLs provide excellent visual acuity at near, intermediate, and distant distances but may induce visual disturbances such as glare, halos, and decreased contrast sensitivity[15]. On the other hand, EDOF IOLs offer a continuous range of vision without distinct focal points, reducing visual disturbances compared to bifocal or trifocal IOLs[16]. Visual acuity, the ability to see objects clearly, is significantly affected by cataracts. Contrast sensitivity, the ability to distinguish objects of different contrast levels, is another important visual parameter affected by cataracts[17]. Phacoemulsification has been shown to improve contrast sensitivity in patients with cataracts. Cataract-related glare sensitivity can cause discomfort and difficulty in bright or glaring light conditions. Although multifocal, trifocal, and EDOF IOLs may have potential side effects, these do not significantly impact patient satisfaction or visual outcomes[18]. Glare, a visual impairment caused by excessive or diffuse light, can be particularly troublesome for drivers, leading to squinting, blinking, fatigue, and difficulty in visual perception[19]. Phacoemulsification, an effective cataract removal surgical technique, has been shown to greatly improve visual acuity, contrast sensitivity, and glare sensitivity in patients[20].

This study aims to compare the visual acuity, contrast sensitivity, and glare sensitivity before and after phacoemulsification in patients implanted with trifocal and EDOF intraocular lenses. By investigating these parameters, we can gain insights into the visual outcomes and potential differences between these

Methodology

The study was conducted from September 2022 to May 2023 at Sight Center Eye Hospital in Bahawalpur. This was a comparative cross-sectional study design employed to compare the results of the study with a Non-probability purposive sampling technique was utilized to select the participants. The study included participants of both genders who had undergone cataract surgery and intraocular lens (IOL) implantation in one or both eyes. A total of 30 participants were included in this study. The following inclusion criteria were applied:

- Both genders, aged 35-50 years.
- Normal anterior and posterior segment.
- Patients who underwent uncomplicated lens exchange surgery or cataract surgery.
- Patients with good ocular health and no pathology that compromises visual acuity.
- Uncorrected binocular distance visual acuity of 0.6 LogMAR or better at the time of the visit.

The following exclusion criteria were considered:

- Abnormal iris.
- Acute ocular disease or external/internal infection.
- Amblyopia.
- Choroidal hemorrhage.
- Chronic or recurrent uveitis.
- Coexisting pathology.
- Corneal endothelial dystrophy.
- Diabetes mellitus with retinal changes.
- Glaucoma.
- Keratoconus.
- Macular degeneration.
- Previous refractive surgery.

Data Collection Instruments: The following instruments were used in this research study, LogMAR chart (Brien Holden), Pelli-Robson chart (Precision Vision USA), Times New Roman near vision chart, Pen torch, Stopwatch (Android version 9.10.1.363), Slit Lamp (Haag-Streit-Beren 900 USA), SuperField NC 90 D Lens (VOLK®).

This research utilized a self-structured proforma for data collection. After obtaining informed consent from the patients, the inclusion and exclusion criteria were determined through ocular examinations using a slit lamp and fundus examination with the assistance of a SuperField 90D Volk lens to identify any ocular abnormalities, retinal diseases or disorders. Visual acuity was measured using the LogMAR chart at a viewing distance of 4 meters, while near and intermediate vision were assessed using the Times New Roman vision chart at distances of 30 and 60 cm, respectively. All visual acuity tests were performed monocularly by a single examiner in the same room and lighting conditions, with the other eye occluded. Participants were encouraged to read the smallest optotypes possible. Contrast sensitivity function was assessed using a Pelli-Robson chart under standard room illumination at a recommended 1 m test distance. Scores were recorded for the three optotypes that participants identified as having the least contrast.

Glare was measured using the Photostress Recovery Time (PSRT) method. For this test, one eye of the participant was covered, while the other eye was exposed to a strong pen torch light for 30 seconds from a distance of 5 cm nasally. After 30 seconds, the participant was instructed to read the best possible LogMAR chart line, and the recovery time was recorded using a stopwatch on an Android phone before the participant exposed their eye to the pen torch light. The surgical procedures, including cataract extraction with phacoemulsification and IOL implantation for emmetropia correction, were performed by the same skilled surgeon under local anesthesia using a 2.2mm microincision. All the aforementioned tests were repeated after 40 days of IOL implantation to enable pre- and post-operative comparisons. The collected data was entered and analyzed using IBM SPSS version 23.

Ethical consideration: Prior to participation, all patients were provided with comprehensive information about the study's objectives and methodology. They were given both verbal and written explanations, ensuring that they fully understood the purpose of the research, the procedures involved, and the potential risks and benefits associated with their involvement. Informed consent was obtained from each participant, indicating their voluntary agreement to participate in the study. This ensured that their decision to contribute their time and knowledge was made willingly and based on a complete understanding of the study's objectives and implications.

Result

This study was to compare post-operative visual outcomes between patients receiving trifocal and EDOF intraocular lenses in terms of near, intermediate, and distance visual acuity, contrast sensitivity, and glare. A total of 30 participants were included in the study. The participants were

Demographic Characteristics			
Group		**Trifocal A**	**EDOF B**
Gender	Male	8%	10%
	Female	7%	5%
Age	Male	± 42.5%	±41.8 %
	Female	± 4.2%	± 3.6%
Total		**30**	**100.0**

divided into two groups: Group A consisted of patients who received trifocal intraocular lens implants, and Group B consisted of patients who received extended depth-of-focus (EDOF) intraocular lens implants. The demographic characteristics of the participants are summarized in above Table 1.1. Patients in the trifocal group exhibited significantly higher mean ranks for near visual acuity after surgery compared to the EDOF group, indicating better near visual acuity outcomes in the trifocal group (Mann-Whitney U test, $p < 0.05$).

Comparison of post operative near, inter mediate and distance visual acuity in between trifocal and EDOF intraocular lenses:

Table 1.2: Mann-Whitney U rank

Ranks				
	Type of Intraocular lens implant	**N**	**Mean Rank**	**Sum of Ranks**
Near visual acuity, after surgery	**Trifocal intraocular lens**	15	9.23	138.50
	EDOF intraocular lens	15	21.77	326.50
	Total	30		
Intermediate visual acuity, after surgery	**Trifocal intraocular lens**	15	13.87	208.00
	EDOF intraocular lens	15	17.13	257.00
	Total	30		
Distance LogMAR visual acuity, after surgery	**Trifocal intraocular lens**	15	16.00	240.00
	EDOF intraocular lens	15	15.00	225.00
	Total	30		

There was no statistically significant difference in mean ranks for intermediate visual acuity after surgery between the trifocal and EDOF groups (Mann-Whitney U test, $p > 0.05$). Overall, it presents the ranks for each type of intraocular lens implant and visual acuity, variable. Near Visual Acuity: Patients who received Trifocal intraocular lens implants had a significantly higher rank for near visual acuity after surgery compared to those who received EDOF intraocular lens implants. This suggests that Trifocal implants may result in better near VA outcomes.

Intermediate VA: A slight difference was observed in ranks for intermediate visual acuity after surgery between patients who received Trifocal and EDOF intraocular lens implants. However, there was no statistically significant change.

Distance LogMAR VA: No significant difference was seen in ranks for distance LogMAR visual acuity after surgery between patients who received Trifocal and EDOF intraocular lens implants.

1.3 Comparison of post operative contrast sensitivity in between trifocal and EDOF intraocular lenses:

Ranks				
	Type of Intraocular lens implant	**N**	**Mean Rank**	**Sum of Ranks**
Contrast sensitivity after surgery	**Trifocal intraocular lens**	15	14.10	211.50
	EDOF intraocular lens	15	16.90	253.50
	Total	30		

Comparison of post operative contrast between trifocal and EDOF intraocular lenses

The mean postoperative contrast sensitivity was 14.10 (SD ± 211.50) in the trifocal group and 16.90 (SD ± 253.50) in the EDOF group. However, the difference in postoperative contrast sensitivity between the two groups was not statistically significant (Mann-Whitney U test, $p > 0.05$). The basic data shows the descriptive and inferential statistics shows non-significant results. Contrast Sensitivity (CS): After surgery, contrast sensitivity did not change in a statistically significant way between patients who received EDOF and Trifocal intraocular lens implants. The mean values suggest that both types of implants resulted in similar post-operative contrast sensitivity outcomes. Type of Intraocular Lens Implant: The mean value for the type of intraocular lens implant variable indicates that there were an equal number of patients who received EDOF and Trifocal implants.

1.4 Comparison of post operative glare in between trifocal and EDOF intraocular lenses:

Ranks				
Photostress recovery time in seconds after surgery	**Type of Intraocular lens implant**	**N**	**Mean Rank**	**Sum of Ranks**
	Trifocal intraocular lens	15	22.97	344.50
	EDOF intraocular lens	15	8.03	120.50
	Total	30		

Comparison of post operative glare between trifocal and EDOF intraocular lenses

The mean photostress recovery time after surgery was 22.97 seconds (SD ± 344) in the trifocal group and 8.03 seconds (SD ± 120) in the EDOF group. A statistically significant difference in photostress recovery time was observed between the two groups (Mann-Whitney U test, $p < 0.001$), suggesting that patients in the EDOF group experienced a faster recovery from glare compared to the EDOF group. The descriptive statistics and Mann-Whitney U test results for the variables. The mean photo stress recovery time after surgery for all patients was 8.03 seconds, with a standard deviation of 2.984 seconds. There was a statistically significant difference between the intraocular lens implant types (EDOF vs. Trifocal) when compared using the p-value, which was less than 0.001.

The photo stress recovery time after surgery was significantly different between patients who received EDOF and Trifocal intraocular lens implants. The specific direction of the difference cannot be determined from the given information, but the p-value suggests that there is a statistically significant distinction. The mean value for the type of intraocular lens implant variable indicates that there were an equal number of patients who received EDOF and Trifocal implants.

DISCUSSION

In summary, the comparison of postoperative visual outcomes between patients with trifocal and EDOF intraocular lenses revealed the following:

- Trifocal intraocular lenses resulted in significantly better near visual acuity outcomes compared to EDOF intraocular lenses.
- There was no significant difference in intermediate and distance visual acuity between the two groups.
- Postoperative contrast sensitivity did not differ significantly between patients with trifocal and EDOF intraocular lenses.
- EDOF intraocular lenses demonstrated a faster photostress recovery time, indicating better tolerance to glare compared to Trifocal intraocular lenses.

These results provide valuable insights into the visual outcomes associated with different types of intraocular lenses and can assist clinicians in selecting the most appropriate lens for their patients' specific needs. Overall, the study aimed to compare the outcomes of EDOF and Trifocal intraocular lenses (IOLs) in terms of visual acuity, contrast sensitivity, and glare after cataract surgery. The results indicated that both groups experienced significant improvements in visual acuity post-surgery. There were no significant differences in visual acuity between the EDOF and Trifocal IOL groups. Similarly, both groups showed significant enhancements in contrast sensitivity after surgery, with no significant differences observed between the two groups. However, the EDOF IOL group exhibited a greater reduction in glare, indicating potential advantages in managing bright light or glare-inducing conditions. These findings suggest that the choice of IOL can impact specific aspects of visual function, and EDOF IOLs may be beneficial for individuals prioritizing near vision tasks or frequently exposed to glare.

CONCLUSION

We concluded that patients undergoing cataract/Phacoemulsification surgery with EDOF and Trifocal IOLs showed significant improvements in visual acuity, contrast sensitivity, and glare after the procedure. Both the EDOF and Trifocal IOLs significantly enhanced patients' visual acuity relative to their baseline levels before surgery. There were no statistically significant variations in post-operative visual acuity between the two groups. Findings imply that postoperative contrast sensitivity improved significantly in both the EDOF and Trifocal IOL groups. There was no statistically significant variation in contrast sensitivity was seen between the two groups. Statistical tests, like the Wilcoxon test, were used to reach this conclusion, with a P-value of 0.329. Results demonstrated a considerable improvement in glare, as measured by photostress recovery time (PSRT), for both the Extended Depth of Focus and Trifocal IOL groups following surgery. Photostress recovery time was shorter in the EDOF IOL group than in the Trifocal IOL group. A p-value of less than 0.001 from the Mann-Whitney U test indicates a statistically significant difference between the two groups. Cataract/Phacoemulsification surgery has been shown to enhance visual acuity, contrast sensitivity, and glare tolerance for the majority of patients. Greater improvement was seen in the trifocal IOL group in near visual acuity and EDOF IOL group showed a greater reduction in glare (as measured by PSRT) compared to the Trifocal IOL group. It is important to consider these findings when choosing the appropriate IOL for patients undergoing cataract surgery.

LIMITATIONS

Several limitations were identified in this study. Firstly, the research was conducted at a single center, which may limit the diversity of the study population and the generalizability of the findings to a broader population. Additionally, the demographics and characteristics of the participants may not accurately represent the larger population undergoing cataract surgery and IOL implantation. Another limitation is the limited duration of the study, which focused solely on the immediate post-operative period. Long-term follow-up is essential to assess the sustainability of outcomes and identify any potential complications that may arise over time.

Furthermore, the study employed a non-probability sampling technique, which introduced the possibility of selection bias. The inclusion of participants may have been influenced by factors such as availability, accessibility, or clinician preference, potentially affecting the representativeness of the sample. It is important to note that the study did not include a control group receiving standard mono-focal IOLs for comparison, which would have provided valuable insights into the relative efficacy of trifocal and EDOF IOLs.

The subjective assessments of visual acuity, contrast sensitivity, and glare introduced inherent variations and biases associated with individual perceptions. Objective measurements, such as wavefront analysis, could have been incorporated to provide additional quantitative data and enhance the robustness of the study. Moreover, the study did not extensively control for other factors that could influence visual outcomes, such as pre-existing eye conditions or ocular comorbidities. Considering these factors could provide a more comprehensive understanding of the impact of trifocal and EDOF IOLs on visual function.

Despite these limitations, the study offers valuable insights into the comparison of visual acuity, contrast sensitivity, and glare between trifocal and EDOF IOLs in the immediate post-operative

period. Future research with larger and more diverse populations, longer follow-up durations, and rigorous control measures would further contribute to the understanding of these intraocular lenses' performance and outcomes.

RECOMMENDATIONS

- Consider Trifocal IOLs for patients with a stronger emphasis on near visual acuity, since they improved near visual acuity more than EDOF IOLs.
- Recommend EDOF IOLs to patients who value reduced glare, as the EDOF IOL group had a more significant glare reduction (as measured by photo stress recovery time) than the Trifocal IOL group.
- Trifocal IOLs should be recommended to patients who want a well-balanced visual outcome, as both Extended Depth of Focus and Trifocal IOLs resulted in considerable improvements in visual acuity with no statistically significant differences between the two groups.
- Consider the patient's lifestyle and visual needs when picking between Trifocal and EDOF IOLs, as the choice depends on factors such as near-work requirements and glare sensitivity.
- When choosing an IOL, consider the patient's preferences and expectations, as they may differ in terms of visual acuity, contrast sensitivity, and glare reduction.
- Choosing between trifocal and EDOF intraocular lenses, consider the cost. Trifocal lenses are often more expensive, with costs reaching more than one lakh PRK while, EDOF lenses, on the other hand, are comparably more reasonable, with prices often ranging around 60,000 PRK. The cost difference may influence the decision-making process, and patients should consider their budget.

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