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Comparative study of the effects of laser peripheral iridotomy and cataract surgery on anterior chamber angle parameters in primary angle closure suspect patients

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ABSTRACT

Introduction Prophylactic laser peripheral iridotomy (LPI) and cataract surgery are considered the primary treatments for primary angle closure suspect (PACS) as they have proven effectiveness in widening the iridocorneal angle and addressing the underlying anatomical issues associated with this condition. The objective of this study is to compare the impact of LPI and cataract surgery on anterior chamber angle parameters, aiming to fill the existing research gap.

Methodology A prospective comparative study was conducted, involving 76 eyes of 61 patients. The study focused on patients diagnosed with PACSs and early cataract. The patients received treatment either through LPI or cataract surgery. Comprehensive eye examination was performed, including gonioscopy and anterior segment parameters were measured using anterior segment ocular coherence tomography (ASOCT). Follow-up examinations were conducted at 1 week and 1 month after the procedures, which included ASOCT and gonioscopy performed during the 1-month follow-up.

Results All anterior chamber angle parameters increased significantly after treatment in both groups, including trabecular iris angle (TIA), angle opening distance at 250, 500 and 750 µm (AOD 250, AOD500, AOD750), trabecular iris surface area at 500 and 750 µm (TISA500, TISA750) and angle recess area at 500 and 750 µm from scleral spur (ARA500, ARA750) ($p<0.05$ for all). Moreover, all these parameters were greater after cataract surgery than after LPI ($p<0.05$ for all).

Conclusion Compared with LPI, cataract extraction resulted in a wider anterior chamber angle. Moreover, no residual angle closure was observed after cataract extraction, which could morphologically prevent the progress of angle closure. Thus, cataract extraction is superior to LPI in PACSs with early cataract in widening the anterior chamber angle.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Both laser peripheral iridotomy (LPI) and lens extraction have proven to be successful in the treatment of primary angle closure suspects (PACSs).

WHAT THIS STUDY ADDS

⇒ In PACS patients with early cataracts, early intervention through cataract surgery is more effective in opening the anterior chamber angle compared with LPI.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Clinicians may contemplate opting for early cataract surgery instead of LPI in PACS patients who have early cataracts.

INTRODUCTION

Primary angle closure glaucoma (PACG) is one of the leading causes of blindness worldwide.[1–4] In various population-based studies, primary angle closure suspect (PACS) has been found to have a much higher prevalence than that of primary angle closure (PAC) or PACG.[5]

First-line treatment for PACS includes a prophylactic laser peripheral iridotomy (LPI), which creates an alternative route for the aqueous to pass from the posterior chamber to the anterior chamber, thus preventing acute angle closure attack.[6] Various studies have shown LPI to be effective enough to widen the iridocorneal angle in eyes with angle closure.[6–8] Similarly, there have been a number of studies that support cataract extraction to be equally effective as LPI in correcting the anatomic pathology in PACS.[9 10] Cataract surgery helps by eliminating the thick anteriorly positioned lens which is considered to be the principle primary pathology in PACS.[10–12]

Clinically, one can appreciate the effect of LPI or cataract surgery on the anterior chamber angles by static gonioscopy, which is cheap, readily available and reliable. One

major disadvantage, however, is its wide subjective variance. Lately, clinicians are shifting to a more objective evaluation technique of the anterior chamber angle using anterior segment optical coherence tomography (ASOCT).

Since the anatomical basis of angle closure diseases is primarily based on the morphology of anterior chamber angle, it is meaningful to document changes in anterior segment parameters after treatment with LPI or cataract surgery.[13] There is limited research comparing the differences between the two procedures viz LPI and cataract extraction. The current study aims to address this gap in the literature by comparing the changes in anterior chamber angle parameters following LPI and cataract surgery. By investigating the differences between the two procedures, this study may provide valuable insights into the optimal management of patients.

METHODOLOGY

This is a prospective comparative study conducted in Reiyukai Eiko Masunaga eye hospital in Banepa, Nepal, from 1 January 2022 to 31 December 2022.

Patients who were diagnosed with PACS and early cataract were included in the study. Early cataract was defined as a cataract in which there is a minimal-to-mild opacification in the nuclear, cortical and posterior subcapsular regions, graded as 1 or 2 in the Lens Opacities Classification System II, or a combination thereof.[14]

Patients with evidence of a previous acute episode of angle closure, PACG, ocular hypertension, corneal abnormalities and cataract obscuring posterior segment examination, prior intraocular surgery or those who were unwilling to enrol in the study were excluded from the study.

The patients were recommended either LPI or cataract surgery, depending on their best-corrected visual acuity (BCVA). Individuals with LogMar BCVA better than 0.3 were advised to undergo LPI, while those with LogMar BCVA worse than 0.2 were advised to undergo cataract surgery.

All patients underwent detailed eye examination which included logMAR visual acuity, intraocular pressure (IOP) measurement by Goldmann applanation tonometry (Haag-Streit), slit-lamp biomicroscopy (Model BQ 900, Haag-Streit) and stereoscopic optic disc examination with a 90 D lens (Volk Optical). In every patient, gonioscopy was performed by an ophthalmologist (glaucoma specialist) in a semidarkened room with the minimum possible slit-lamp illumination, using a Sussman four-mirror gonioscopy lens. The angles were graded according to the Shaffer's classification.[15] An eye with PACS was defined as the posterior pigmented trabecular meshwork (PTM) could not be seen for ≥180° on static gonioscopy, without elevation of IOP, PAS or optic neuropathy.[6]

ASOCT (Spectral domain 3D OCT-2000, Topcon) was performed and anterior segment parameters were measured in all cases by an experienced optometrist. A high-resolution image that displayed a distinct view of the iridocorneal angle and the scleral spur guaranteeing precise measurements of the angle parameters was selected. The scleral spur was identified as a curved or V-shaped structure perpendicular to the cornea within the iridocorneal angle. Since this is a critical step in our study, the identification of the angle structures including the spur was solely done by an experienced glaucoma specialist.

Angle parameters including angle opening distance at 250, 500 and 750 µm from the scleral spur (AOD250, AOD500, AOD750), trabecular iris angle (TIA), trabecular iris surface area at 500 and 750 µm (TISA500, TISA750) and angle recess area at 500 and 750 µm from scleral spur (ARA500, ARA750) were measured by the calliper provided in the ASOCT software (online supplemental figures 1–7).

AOD250, AOD500 or AOD750 was the distance, measured perpendicular to the cornea, from the inner face of the cornea at 250, 500 or 750 mm from the scleral spur to the anterior surface of the iris. TIA was the angle formed by the two intersections of the cornea and iris, with the iris recess serving as the apex and the line perpendicular to the cornea 500 m away from the scleral spur. AOD500 or AOD750, line perpendicular to sclera at scleral spur, posterior corneoscleral surface and anterior surface of iris made up TISA, which was a trapezoidal surface area.[16] ARA was the region between two points where the iris and cornea converge on a line perpendicular to the cornea, 500 and 750 m from the scleral spur, respectively.

Patients undergoing neodymium yttrium–aluminium–garnet (Nd-YAG) PI received 1% pilocarpine 1 drop every 10 min for three times. YAG laser lens was used in all patients. A single 5–6 mJ pulse was delivered to the temporal quadrant and repeated until patency was achieved. After the YAG PI, patients were prescribed with 'ofloxacin and dexamethasone' combination eyedrop four times a day for 1 week. A drop of timolol (0.5%) was instilled in every eye undergoing YAG PI after the procedure. The patients were examined at 1-week and 1-month follow-up. At 1-month follow-up, gonioscopy and ASOCT were recorded.

Cataract surgery was performed following the same standard phacoemulsification procedures under topical anaesthesia. A foldable, posterior chamber intraocular lens was implanted after phacoemulsification. Postoperative treatment included topical prednisolone acetate 1%, ofloxacin 0.3% and carboxymethyl cellulose every 2 hours during the daytime for 1 week. The drops were then tapered in a period of 1 month. All participants underwent routine follow-up at 1 day, 1 week and 4 weeks after treatment. Postoperative ASOCT and gonioscopy were conducted at 1-month follow-up.

The minimal clinically important difference was defined as a significant change in the median value of gonioscopy grading, as per the Schaffer's grading

Table 1 Demographic and clinical parameters of patients

Variables	Yttrium–aluminium–garnet laser peripheral iridotomy	Cataract surgery	P value
Age ($\bar{x}$±SD)	65.93±5.31 years	63.7±6.43 years	0.051
Males, n,%	16 (48.4%)	18 (64.2%)	>0.05
Right eye, n,%	19 (48.7%)	19 (51.3%)	>0.05
Best-corrected visual acuity ($\bar{x}$±SD)	0.42±0.29	0.29±0.20	0.26

system, with an increase of at least one grade observed during the 1-month follow-up after the procedure.

Statistical analysis

Data entry was done in Microsoft Excel 2014. The data was then imported to STATA V.17.0 software, which was used for data cleaning and analysis. The test for normality was done using Shapiro-Wilk test. For Gaussian distribution, data were expressed in terms of mean and SD and compared using t-test (paired/independent). If data were not normally distributed, median and IQR were calculated and compared using Wilcoxon-signed rank test or Mann-Whitney U test. A p value of <0.05% was considered to be statistically significant. CI used for the tests was 95%.

RESULTS

In total, 39 eyes of 33 patients were enrolled in the LPI group and 37 eyes of 28 patients were included in the cataract surgery group. This was done as per patients' choice after full explanation of the two procedures. Table 1 showed the baseline demographics. There were no statistically significant differences observed between the two groups at baseline. No postoperative complications occurred in either of the groups at the end of the 4-week follow-up.

As shown in table 2, the baseline anterior segment parameters were compared between the groups (p>0.05 for all). All anterior chamber angle parameters increased significantly after treatment in both groups, including TIA, AOD500, AOD750, TISA500, TISA750, ARA500 and ARA750 (p<0.05 for all). Moreover, all these parameters were greater after cataract extraction than after LPI (p<0.05 for all).

After LPI, the median Shaffer grade increased from 1 to 2; after cataract surgery, the median Shaffer grade increased from 1 to 4 in all quadrants. Thus, the minimum clinically significant difference was achieved in both the groups. Although both LPI and cataract surgery significantly increased the angle width as measured with Shaffer grade (p<0.05 for both), angles were much wider after cataract surgery than after LPI (p<0.05) (table 3). In the cataract surgery group, all quadrants in all of the subjects (100%) had open angles after operation. However, after LPI, 12 eyes (30.76%) had residual angle closure in ≥2 quadrants and 22 eyes (56.4%) had ≥1 quadrant closed.

DISCUSSION

This study introduces an approach by comparing the effects of LPI and cataract surgery on anterior chamber angle parameters in PACS patients. To the best of our knowledge, this is the first study in Nepal to directly compare these two treatment modalities in PACS patients and evaluate their impact on angle parameters. By doing so, we aimed to provide valuable insights into the management of PACS patients and assist clinicians in making informed decisions regarding the most appropriate intervention. By emphasising the comparative analysis of LPI and cataract surgery specifically in PACS patients, the study presents a unique contribution to the existing literature and addresses a gap in knowledge regarding the optimal treatment approach for this specific patient population.

The results of our study showed significant changes in anterior chamber angle parameters following both LPI and cataract surgery. When two groups were compared, cataract surgery was found to be superior to LPI in opening the anterior chamber angle.

Our findings are consistent with previous studies that have reported significant changes in anterior chamber angle parameters viz TIA, AOD250, AOD500, AOD750, TIA, TISA500, TISA750, ARA500 and ARA750 following LPI and cataract surgery. However, we observed some differences in the magnitude and pattern of these changes, which could have important clinical implications. In studies conducted by How *et al* and Zebardast *et al*, LPI was found to significantly increase the anterior chamber depth and angle opening distance.[8 17] Similarly, in a study by Man *et al*, cataract surgery was found to significantly increase the anterior chamber depth and angle opening distance.[18] However, Yan *et al* have found lens extraction to be more superior to LPI in widening the angle parameters.[13]

In addition, Azuara-Blanco *et al* conducted a comprehensive study involving multiple medical centres, using randomisation and control groups, to evaluate the effectiveness, safety and cost-effectiveness of clear-lens extraction as compared with LPI in individuals newly diagnosed with primary angle closure. The results of this trial presented strong evidence indicating that opting for clear-lens extraction initially leads to improved clinical outcomes and better patient-reported experiences.[19]

In our study, the grade of the gonioscopic angle was in agreement with the ASOCT findings, indicating that both

Table 2 Comparison of anterior segment angle parameters before and after yttrium–aluminium–garnet laser peripheral iridotomy and cataract surgery

Anterior chamber angle parameters	Laser peripheral iridotomy ($\bar{X}$ ± SD)	Cataract extraction ($\bar{X}$ ± SD)	P value
Trabecular iris angle (°)			
Pre surgery	10.53±2.25	9.7±2.09	0.18
Post surgery	19.37±3.67	39.55±3.66	0.00
P value	<0.05	<0.05	
AOD 250 (mm)			
Pre surgery	0.225±0.008	0.222±0.007	0.34
Post surgery	0.237±0.004	0.413±0.014	0.00
P value	<0.05	<0.05	
AOD 500 (µm)			
Pre surgery	0.257±0.008	0.275±0.059	0.94
Post surgery	0.303±0.008	0.504±0.005	0.00
P value	<0.05	<0.05	
AOD 750 (µm)			
Pre surgery	0.376±0.013	0.371±0.008	0.99
Post surgery	0.408±0.058	0.600±0.023	0.00
P value	<0.05	<0.05	
TISA 500 (mm^2)			
Pre surgery	0.084±0.14	0.122±0.13	0.32
Post surgery	0.127±0.02	0.496±0.09	0.00
P value	<0.05	<0.05	
TISA 750 (mm^2)			
Pre surgery	0.15±0.07	0.18±0.07	0.36
Post surgery	0.19±0.15	0.70±0.03	0.00
P value	<0.05	<0.05	
ARA 500 (mm^2)			
Pre surgery	0.17±0.07	0.20±0.07	0.87
Post surgery	0.20±0.06	0.62±0.09	0.00
P value	<0.05	<0.05	
ARA 750 (mm^2)			
Pre surgery	0.23±0.10	0.28±0.07	0.34
Post surgery	0.24±0.06	0.83±0.03	0.00
P value	<0.05	<0.05	

AOD, Angle opening distance; ARA, Angle recess area; TISA, Trabecular iris surface area.

Table 3 Comparison of gonioscopy before and after laser peripheral iridotomy and cataract surgery

	Angle width, median of Shaffer grade		
	Pre procedure	Post procedure	P value
Laser peripheral iridotomy	1	2	<0.05
Cataract surgery	1	4	<0.05

interventions were effective in considerably widening the angle. The changes in anterior chamber angle parameters that we observed in our study suggest that careful management of patients undergoing LPI or cataract surgery is warranted to minimise the risk of complications such as angle closure glaucoma.

In this study, after LPI, about 12 eyes (30.76%) eyes still had a residual angle closure in at least 2 quadrants and 22 eyes (56.4%) had appositional angle closure in at least 1 quadrant. Among the 72 PACS patients who received LPI as part of the Liwan Eye Study, it was observed that 14 patients (19.4%) still had angle closure remaining

after a 2-week period.[20] Another research where 46 PACS eyes were treated with LPI, 23.9% of the patients had persistent angle closure was 23.9%.[21] Moreover, Lee *et al* and Jiang *et al* have observed an increasing proportion of angle closure after LPI over time.[22 23] Baskaran *et al* also reported that a significant 81.8% of eyes still had gonioscopic residual angle closure (PTM not visible for at least 2 quadrants) 1 year after LPI in PACS patients.[24]

The study has several limitations that need to be acknowledged. First, a randomised design was not employed. Instead, patients were allotted to LPI or cataract surgery depending on the visual acuity. Additionally, the inclusion of patients with clear lenses for lens extraction in the study was not feasible. This decision was influenced by moral considerations and the low probability of patients in this specific region choosing clear lens extraction as a viable treatment option.

Furthermore, the measurement of ASOCT was performed manually due to the unavailability of the latest software in our facility. As a result, there is a potential for subjective variation if this study were to be replicated.

CONCLUSION

Our study revealed that performing cataract surgery on patients with PACS was more effective than LPI in widening the anterior chamber angle. While both treatments led to a significant increase in angle width, LPI resulted in residual angle closure in 30.76% of eyes, while all patients who received cataract surgery had open angles in all 4 quadrants. These findings suggest that early cataract surgery may be more beneficial than LPI for PACS patients and provide compelling evidence for future prospective randomised studies on this topic.

Contributors SP1 and SS conceptualised, designed and drafted the manuscript. RA helped with data collection. DM, RS and PS helped with review and editing. SP2 contributed with data analysis. SP1 is the guarantor of the study.

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Competing interests None declared.

Patient consent for publication Consent obtained directly from patient(s).

Ethics approval This study involves human participants and was approved by the local ethical committee of Reiyukai Eye Hospital, REMEH 07/22. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data may be obtained from a third party and are not publicly available.

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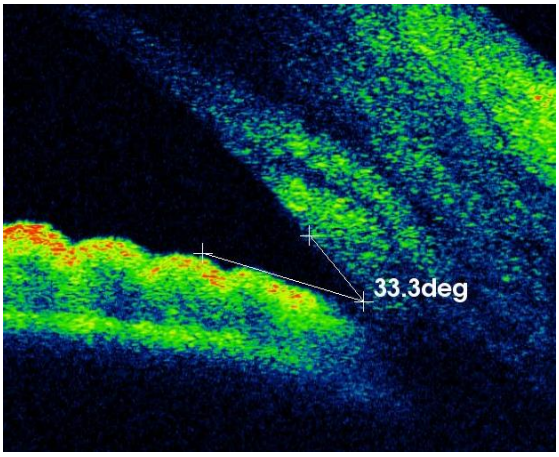
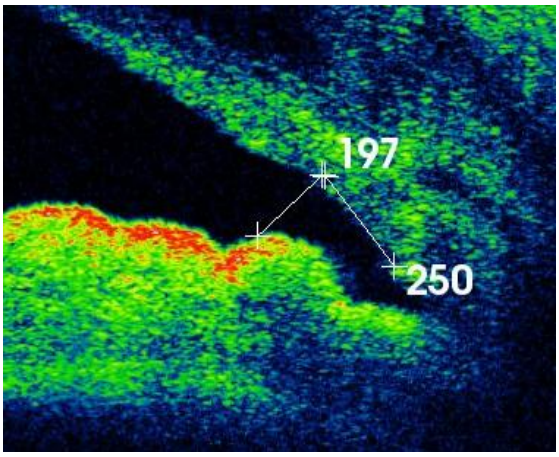
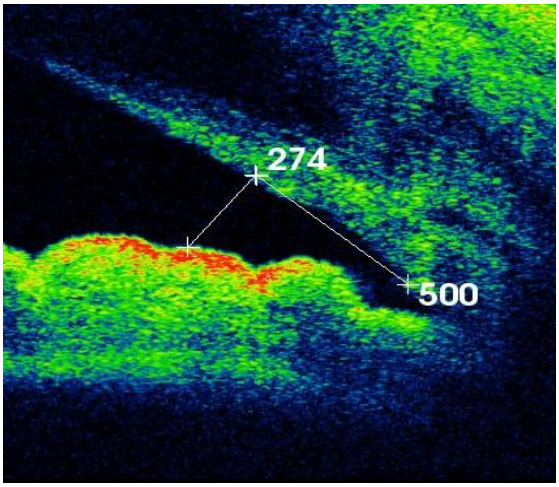


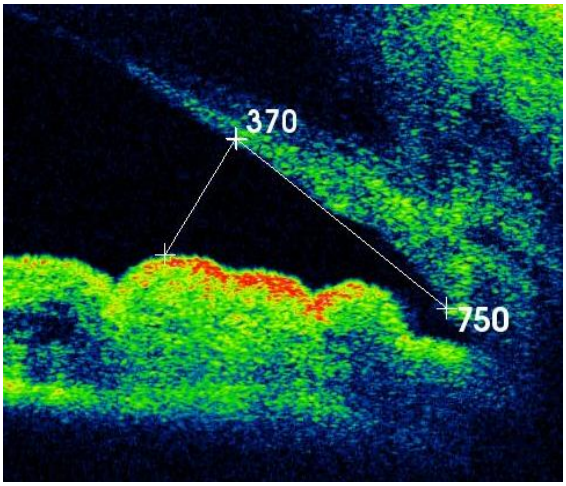
Supplementary Figure 1: Trabecular iris angle (TIA)



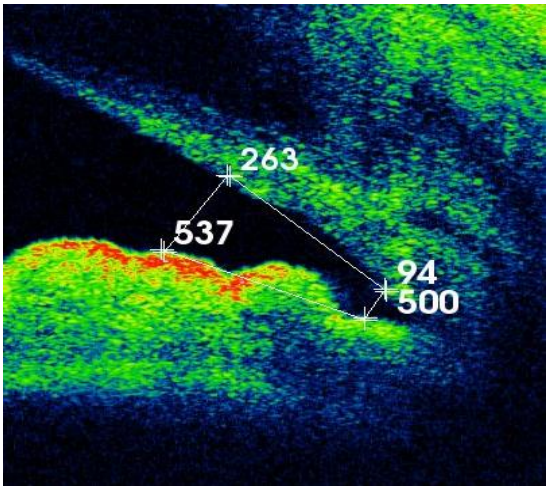
Supplementary Figure 2: Angle Opening distance at 250µm (AOD 250)



Supplementary Figure 3: Angle Opening distance at 500µm (AOD 500)



Supplementary Figure 4: Angle Opening distance at 750µm (AOD 750)



Supplementary Figure 5 Trabecular iris surface area at 500 µm (TISA 500)

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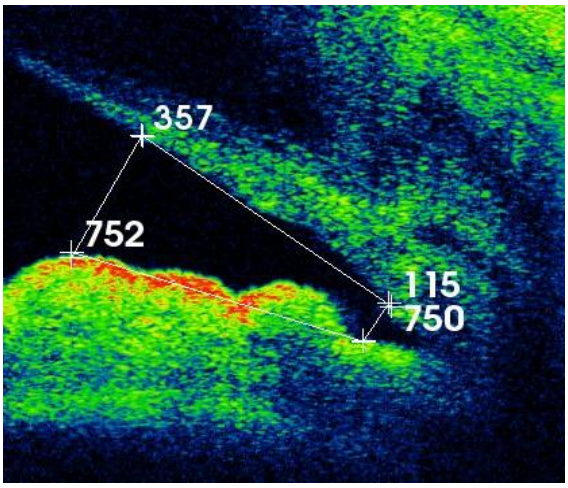
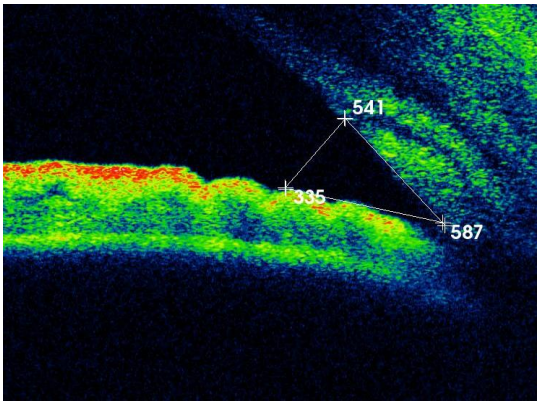


Supplementary Figure 6 Trabecular iris surface area at 750 µm (TISA 750)



Supplementary Figure 7 Angle recess area at 500 µm (ARA 500)