LITERATURE REVIEW

Comparison of Clinical Outcomes between Phacoemulsification and Laser Peripheral Iridotomy in the Spectrum of Primary Angle Closure Diseases of the Eye

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ABSTRACT

Background: To compare clinical outcome between phacoemulsification and laser peripheral iridotomy in the spectrum of primary angle closure eyes.
Methods: A literature review of databases were retrieved online through Pub-med, Clinical Key, and Science Direct, using keywords of 'primary angle closure', 'primary angle closure glaucoma', and 'acute primary angle closure'. In addition, all literatures involving the use of laser peripheral iridotomy (LPI) or phacoemulsification as a treatment in PAC diseases were included. Publications and journals before the year 2000 were excluded.
Results: There were 18 articles that fulfilled our inclusion criteria. All of the studies showed a decrease in IOP following cataract extraction or LPI, compared to baseline. This study also showed that the phacoemulsification group gave a significantly larger angle width increment when compare to LPI. When directly compared between phaco to LPI, the number of topical glaucoma medication was more decreased in the phaco group, meanwhile the need for additional glaucoma surgery was higher in the LPI group.
Conclusion: Phacoemulsification with posterior chamber lens implantation is more effective procedure than LPI in lowering IOP and preventing IOP rise in long term follow up in PAC diseases. That surgery will reduce the number of additional glaucoma medication and further glaucoma filtering surgery. Despite of superiority in phacoemulsification treatment, LPI is still the mainstay of initial treatment, especially in PAC eye diseases without cataract.

Keywords: spectrum of primary angle closure eye disease, phacoemulsification, laser peripheral iridotomy, angle width

Primary angle closure glaucoma (PACG) is one of the leading causes of bilateral blindness worldwide, in which 4 million people are bilaterally permanent blind.[1,2] Primary angle closure (PAC) of the eye consists of a spectrum of diseases, ranging from primary angle closure suspect (PACS), primary angle closure (PAC), acute primary angle closure (APAC) and PACG.[3,4] Pupillary block has been suggested as a major cause

of PAC and laser peripheral iridotomy (LPI) has been used widely for treating acute or chronic angle closure.[5,6] However, despite its initial success, up to half of cases in PAC eyes had persistent raised intraocular pressure (IOP) subsequently.[7,8] Several studies has suggested that poor IOP control post LPI due to crystalline lens which has an important role in the angle configuration, by pushing the peripheral iris anteriorly which will narrow the anterior angle.[8,9,10] Nongpiur et al[11] stated that a greater lens vault increases the risk of angle closure by 48 times compared with a smaller lens vault. Increasing lens thickness and forward movement of the lens related to advancing age explain why PACG is typically found in elderly population. Cataract extraction with posterior chamber intraocular (PC-IOL) implantation is predicted to affect IOP reduction in the spectrum of PAC diseases of the eye.[12] This potential effective treatment of phacoemulsification+IOL will change the structure of the angle, thus likely reducing the progression of these diseases.[13] The aim of this literature review is to compare the efficacy of phacoemulsification+IOL to LPI in the management of PAC diseases.

MATERIALS AND METHODS

A literature review of databases were retrieved online through Pub-Med, Clinical Key, and Science Direct, using keywords of 'primary angle closure', 'primary angle closure glaucoma', and 'acute primary angle closure'. In addition, all literatures involving the use of laser peripheral iridotomy or phacoemulsification as a treatment in PAC diseases were included. Publications and journals before the year 2000 were excluded, and also articles that were not published in English and that could not be accessed in full-text.

Inclusion criteria were all articles that reported the efficacy (outcome) of phacoemulsification+IOL and LPI treatment in PAC diseases. All studies that met the inclusion and exclusion criteria were rated

Table 1. Characteristic data of the reviewed articles

No	Author	Year	Study Design	Level of Evidence	Subject (eyes)	Mean Age (years)	Diagnosis	Type of Treatment
1	Lam DS et al[14]	2008	Prospective randomized controlled trial	II	31 31	72.3±7.3 (phaco) 69.0±7.8 (LPI)	APAC	Phaco or LPI
2	Hata H et al[15]	2008	Prospective, non-randomized comparative trial	III	50	75.8±7.2 (phaco) 72.1±6.5 (LPI)	PAC and PACG	Phaco or LPI
3	Nonaka A et al[10]	2006	Retrospective case series	IV	31	71.5±8.1	PAC and PACG	Phaco
4	Cumba RJ et al[6]	2013	Retrospective case series	IV	25 30 24	64.6±12.5	PACS PAC PACG	LPI
5	Yan-yun C et al[9]	2011	Prospective interventional study	III	21 81 55	60.43±6.38 60.14±7.13 64.49±7.80	PACS PAC PACG	LPI
6	K Lei et al[16]	2009	Prospective interventional study	III	15	66.0±5.7	PAC	LPI
7	Liu CJ et al[13]	2006	Prospective interventional study	III	32 28	74.9±7.0 72.8±6.7	PACG, PAC and PACS	Phaco
8	Esmaeili A et al[17]	2013	Prospective interventional study	III	48	57.04±8.65	PACS	LPI
9	Santos AD et al[18]	2015	Prospective randomized controlled trial	II	30	N/A	PAC and PACG	Phaco or LPI
10	Tin A et al[19]	2001	Retrospective case series	IV	111	63.7	APAC	LPI
11	Jacobi PC et al[20]	2002	Prospective, non-randomized comparative trial	III	43 32	64.8±7.2	APAC	Phaco or iridectomy
12	Hayashi K et al[12]	2001	Prospective, non-randomized comparative trial	III	74	73.4±7.3 73.5±7.9	PACG POAG	Phaco
13	Chen MJ et al[21]	2008	Retrospective case series	IV	130	71.8±6.8	PACG	LPI
14	Alipanahi R et al[22]	2011	Prospective interventional study	III	244	64.60±9.49	PACG APAC	LPI
15	Kondo T et al[23]	2005	Prospective interventional study	III	13	70.6±7.5	PAC and PACG	Phaco

Table 2. Intraocular pressure changes following cataract extraction or LPI

No	Author	Subject (eyes)	Diagnosis	Treatment	Mean IOP at baseline (mmHg)	Follow Up Time	Mean IOP at Last Follow Up (mmHg)	Mean IOP Reduction (mmHg)
1	Lam DS et al[14]	62	APAC	Phaco or LPI	15.8±1.3 15.7±1.4	18 months	12.6±1.9 15.0±3.4	3.2 0.7
2	Hata H et al[15]	50	PAC and PACG	Phaco or LPI	14.8±4.2 15.5±4.1	6 months	10.8±1.6 14.7±4.7	4.0 0.8
3	Nonaka A et al[10]	31	PAC and PACG	Phaco	19.3±4.1	3 months	14.8±3.0	4.5
4	Cumba RJ et al[6]	25 30 24	PACS PAC PACG	LPI	16.0±3.0 22.0±5.7 21.6±6.7	60 months	14.0±6.1 18.3±3.0 15.0	2.0 3.7 6.6
5	Yan-yun C et al[9]	21 81 55	PACS PAC PACG	LPI	16.25±4.82 22.17±10.03 27.77±12.47	18 months	15.24±2.13 16.18±2.28 18.82±4.28	1.01 5.99 8.95
6	K Lei et al[16]	15	PAC	LPI	17.8±3.3	20.2±2.7 days	15.9±3.1	1.9
7	Liu CJ et al[13]	32 28	PACG PAC and PACS	Phaco	14.3±3.6 14.4±3.7	3 months	12.2±3.1 11.3±3.8	2.1 3.1
8	Santos AD et al[18]	30	PAC and PACG	Phaco or LPI	19.93±8.30 15.07±3.26	31.13±4.97 months	14.53±1.51 14.87±2.19	5.4 0.2
9	Jacobi PC et al[20]	43 32	APAC	Phaco or iridectomy	40.5±7.6 39.7±7.8	6 months	17.8±3.4 20.1±4.2	22.7 19.6
10	Hayashi K et al[12]	74	PACG POAG	Phaco	21.4±3.9 20.7±5.4	24 months	14.5±2.6 15.2±3.8	6.9 5.5
11	Alipanahi R et al[22]	244	PACG APAC	LPI	57.17±14.94	21.59±12.37 months	17.34±8.82	39.9
12	Kondo T et al[23]	13	PAC and PACG	Phaco	18.2±4.1	3 months	14.3±2.7	3.9

according to the level of evidence developed by Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence (I-V). The data was divided into basic characteristics and the outcomes. The information data based on author, year of publication, level of evidence were noted. Outcomes included the mean of IOP reduction from baseline to last follow up, angle width changes, the number of additional anti-glaucoma medication, the number of eyes requiring additional glaucoma surgery and complications.

RESULTS

There were 18 articles that fulfilled our inclusion criteria. Three articles were excluded because the full text could not be accessed and in total 15 articles were reviewed for this study

Based on the study design, 2 studies were randomized controlled trials (level of evidence II) and the others were prospective non-randomized trial or retrospective case series with the level of evidence of III. The number of eyes in the articles ranged from 13 to 244 eyes, with an age distribution of 57 to 76 years old, and a follow-up of 20 days to 60 months (Table 1).

In all eligible studies, the glaucoma surgeons performed cataract extraction by phacoemulsification with IOL. Two studies compared the final result of IOP after phaco and LPI in PAC diseases. Their studies reported that in phacoemulsification groups, the range of mean initial IOP before procedure was 14.3 to 21.4 mmHg, while in the LPI groups the IOP was higher (range 15.5 to 27.77 mmHg). After the procedures, the range of mean IOP in phacoemulsification groups were reduced to 10.8-14.53 mmHg, while in LPI groups, to 14.3-18.82 mmHg. All of the studies showed a decrease in IOP following cataract extraction or LPI, compared to baseline (Table 2).

There were 5 studies that assessed the angle width changes before and after the intervention of cataract surgery or LPI.[6,13,14,17,18] All of them used Shaffer grading systems, while in the study done by Santos et al[18], a Pentacam Scheimpflug camera was used. The studies revealed that in the phaco group, angle width increased significantly from 0.28 to 2.10. In LPI groups, the range was also increased, from 0.4 to 0.73. However,

Table 3. Angle width change after treatment

No	Author	Subject (eyes)	Treatment	Angle Width before Intervention (degrees)	Follow Up Time	Angle Width at Last Follow Up (degrees)
1	Lam DS et al[14]	62	Phaco or LPI	0.28±0.64 0.40±0.55	18 months	2.10±0.76 0.73±0.64
2	Cumba RJ et al[6]	79	LPI	0: 11.4% 10: 22.8% 20: 63.3% 30: 2.5%	60 months	Deepened by: 0^o: 32.9% 10^o: 49.4% $\geq 20^o$: 17.8%
3	Liu CJ et al[13]	60	Phaco	0.3±0.50	3 months	Increased, not mentioned spesifically
4	Esmaili A et al[17]	48	LPI	Superior: 1.33±0.47 Inferior: 1.79±0.50 Nasal: 1.50±0.50 Temporal: 1.50±0.50	1 hour	Superior: 1.87±0.39 Inferior: 2.35±0.56 Nasal: 1.94±0.24 Temporal: 2.00±0.29
5	Santos AD et al[18]	30	Phaco or LPI	24.85±6.42 22.40±4.39	31.13±4.97 months	43.98±8.71 23.05±3.06

in comparing the two groups (phaco vs LPI), it was shown that the phacoemulsification group gave a significantly larger angle width increment during follow-up of 3, 6, 12, and 18 months (p value <0.0001) (Table 3).

Out of 15 studies, 8 studies reported the number of topical anti-glaucoma medications needed after both interventions (Table 4). Out of these studies, it was noted that there was a decrement of glaucoma medication, except in the study by Cumba et al[6]. Lam et al[14] and Liu et al[13] even showed that there were nearly no medication given at the last follow up after phacoemulsification and the IOP was significantly controlled well. In studies by Lam et al[14], Hata et al[15], and Santos et al[18] that directly compared phaco to LPI, the number of topical glaucoma medication was more decreased in the phaco group (Table 4).

Table 5 shows the need for additional glaucoma surgery, which was higher in the LPI group. Only in the study by Santos et al[18] stated that none of the 15 eyes who underwent LPI required glaucoma surgery during follow up. Meanwhile, Jacobi et al[20] in his study stated those whose eyes underwent phacoemulsification still needed glaucoma surgery in 4.6%.

DISCUSSION

The result of our literature review regarding the management of PAC diseases showed that phacoemulsification has a superior final result compared to LPI in terms of IOP reduction, angle width increment, number of glaucoma medications, and need for additional glaucoma surgery.

Laser peripheral iridotomy (LPI) has been widely accepted as one of the first-line treatment for PAC diseases as well as the

Table 4. Number of additional topical antiglaucoma medication given after intervention

No	Author	Intervention	No. Drugs Before Intervention	Follow Up Time	No. Drugs After Intervention
1	Lam DS et al[14]	Phaco or LPI	0.39±0.61 0.42±0.85	18 months	0.03±0.18 0.90±1.14
2	Hata H et al+15	Phaco or LPI	0.41±0.75 0.52±0.67	6 months	0 0.24±0.44
3	Cumba RJ et al[6]	LPI	0.75±0.98	60 months	1.45±0.95
4	Liu CJ et al[13]	Phaco	1.93±1.13 (PACG) 0.57±0.92 (PAC)	3 months	0.83±0.13 0±0.02
5	Santos AD et al[18]	Phaco or LPI	1.67±1.18 0.6±1.12	31.13±4.97 months	0.93±0.59 0.40±0.83
6	Jacobi PC et al[20]	Phaco or iridectomy	Not mentioned	6 months	0.18±0.45 0.45±0.62
7	Hayashi K et al[14]	Phaco	1.30±0.22	24 months	0.60±0.10

Table 5. Number of eyes needed additional glaucoma surgery

No	Author	Intervention	Subject (eyes)	No. of eyes need additional glaucoma surgery
1	Cumba RJ et al[6]	LPI	70	23 (29.1%)
2	Hayashi K et al[14]	Phaco	74	0 (0%)
3	Chen MJ et al[21]	LPI	130	33 (25.4%)
4	Hata H et al[15]	Phaco or	27	0 (0%)
		LPI	23	0 (0%)
5	Tin A et al[19]	LPI	111	36 (32.4%)
6	Liu CJ et al[13]	Phaco	60	0 (0%)
7	Kondo T et al[23]	Phaco	13	0 (0%)
8	Yan-yun C et al[9]	LPI	158	32 (20.2%)
9	Jacobi PC et al[20]	Phaco	43	2 (4.6%)
10	Alipanahi R et al[22]	LPI	244	55 (22.54%)
11	Santos AD et al[18]	Phaco or	15	0 (0%)
		LPI	15	0 (0%)

treatment of choice for fellow eyes of a person having an acute primary angle closure.[5,6,7] The purpose of LPI treatment is directed to eliminate the pupillary block, as one of the major mechanism in angle closure and preventive treatment option in eliminating the risk of acute glaucoma attacks. By performing LPI, a hole in the peripheral iris allows aqueous humor to flow directly from the posterior chamber to the anterior chamber, relieving the pupillary block. This causes an equalization of the pressure gradient across the iris, thus allowing the iris to flatten and root iris pulled posteriorly away from the peripheral angle.[5] As a result, an LPI is expected to reduce IOP; however, if the IOP remains elevated, glaucoma medication is to be given to the patients followed by surgery if necessary. Usually, years after LPI, the IOP will increase regardless the glaucoma medication given.[8,9] This management sequence is applied in general for PAC diseases without cataract.

One mechanism in pupillary block is due to an apposition between the lens surface and the pupillary margin.[11] Since the lens plays a role in the pathogenesis of angle closure, lens extraction would be expected to widen the angle structure. Lens extraction will reduce the lens volume, and resolve pupillary block through deepening the anterior chamber and relieving the crowding of the angle.[10,12] Moreover, lens extraction also attenuates the plateau iris mechanism by repositioning the ciliary process into a more posterior location. Study by Gunning et al[24] revealed a significant reduction of PAS following cataract surgery alone, without goniosynechiolysis. Lens extraction may be preferable as the treatment of PACG at an early stage, because of the ability to relieve angle closure by attenuating multiple causative factors, such as pupillary block, increased lens vault, iris thickness, and plateau iris.

A quantitative study of angle configuration using ultrasound biomicroscope (UBM) revealed that lens extraction has a more potent effect than iridotomy on deepening of the anterior chamber and widening of the angle. This result was also consistent with the study by Hayashi et al[12] that used an ultrasound biomicroscopy and Scheimpflug videophotography. This effect is true even for eyes with plateau iris syndrome. The effect of lowering the IOP may also occur by improvement of the aqueous outflow facility through other mechanisms.

When dealing with PAC diseases post-iridotomy, more residual angle closure exists; thus cataract extraction may be critical, since repeated appositional closure may compromise the remaining trabecular outflow or increase the extent of synechial closure.[23] It should also be noted that in cases of PAC diseases that underwent cataract surgery, less additional glaucoma medication were needed compared to eyes that underwent LPI.[14,15,18,20] In other words, the IOP was better controlled by cataract extraction. This intervention has more benefit in avoiding adverse effects of glaucoma medications and cost related to the additional medications.

The most common complication associated with cataract surgery were corneal edema and fibrinous inflammation reaction; but these complications resolves within days with the help of topical steroid. However, LPI is an even less invasive procedure and consequently associated with lower incidence of complications, thus it is still recommended for initial treatment in managing PAC diseases without cataract and in early stages of PAC diseases. When cataract

already exists, early phacoemulsification is suggested as the primary treatment.

CONCLUSION

Phacoemulsification with posterior chamber lens implantation is a safe and more effective procedure than LPI in lowering IOP and preventing IOP rise in long term follow up in PAC diseases. The cataract extraction surgery will reduce the number of additional glaucoma medication and further glaucoma filtering surgery. However, taking into account, the feasibility and safety of LPI results that LPI is still recommended as an initial treatment for these blinding diseases.

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