



Comparison of visual acuity between phacoemulsification and extracapsular cataract extraction: a systematic review and meta-analysis

AiLing Li^{1#}, Qiongmin He^{2#}, Lijuan Wei³, Yingying Chen³, Shuxiong He², Qiongzhang Zhang², Yijie Yan³

¹Ward I, Hainan Eye Hospital and Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Haikou, China;

²Department of Ophthalmology, Qionghai Jianping Hospital, Qionghai, China; ³Department of Ophthalmology, Hainan General Hospital (Hainan Affiliated Hospital of Hainan Medical University), Haikou, China

Contributions: (I) Conception and design: A Li; (II) Administrative support: Y Yan; (III) Provision of study materials or patients: Q He; (IV) Collection and assembly of data: L Wei; (V) Data analysis and interpretation: Y Chen; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work and should be considered as co-first authors.

Correspondence to: Yijie Yan. Department of Ophthalmology, Hainan General Hospital (Hainan Affiliated Hospital of Hainan Medical University), Haikou 570311, China. Email: yanyijie11@163.com.

Background: Surgical treatment is the primary intervention for cataracts. Extracapsular cataract extraction (ECCE) is a routine surgery for cataracts, phacoemulsification (PE) is another procedure with a small incision and injury area. This study investigated the comparison of the effects of these two procedures on the patient's visual acuity.

Methods: Embase, PubMed, Cochrane Library, and SpringerLink databases were searched from January 2000 to August 2021 to obtain randomized controlled trial (RCT) studies of PE and ECCE procedures for cataract in English. After the initial screening, Revman 5.4 software was used for the meta-analysis.

Results: This meta-analysis included a total of eight articles with 1,015 affected eyes. The results showed that the rate of good final visual acuity in the PE group was higher than that in the ECCE group [odds ratio (OR) =2.94, 95% confidence interval (CI): 2.17–3.99, P<0.00001], the incidence of vitreous Loss during PE surgery was lower than that in ECCE surgery (OR =0.16, 95% CI: 0.04–0.64, P=0.01), as was the incidence of capsular tear (OR =0.29, 95% CI: 0.10–0.85, P=0.02), the incidence of capsule opacification after surgery (OR =0.20, 95% CI: 0.08–0.53, P=0.001), and the incidence of cystoid macular edema after surgery (OR =0.16, 95% CI: 0.04–0.74, P=0.02).

Discussion: Compared with ECCE, PE demonstrates an improvement in postoperative visual acuity and has fewer complications for cataract patients.

Keywords: Cataract; extracapsular cataract extraction (ECCE); phacoemulsification (PE); meta-analysis

Submitted Nov 23, 2021. Accepted for publication Dec 30, 2021.

doi: 10.21037/apm-21-3633

View this article at: <https://dx.doi.org/10.21037/apm-21-3633>

Introduction

Cataract is a common ophthalmic disease in individuals over 50 years of age. Patients acquire turbidity due to lens protein degeneration caused by natural aging, heredity, nutritional deficiency, immune and metabolic system

abnormalities, trauma, poisoning, or radiation, resulting in decreased visual acuity and, in severe cases, blindness (1). Surgical procedures have become the primary treatment for cataracts, and intraocular lens (IOL) placement after cataract extraction can correct refractive errors and restore the patient's vision to a satisfactory state (2). Extracapsular

cataract extraction (ECCE) is a routine surgery requiring suturing and a large incision (3). With the development of medical technology, phacoemulsification (PE) is now widely used and has become the treatment of choice for cataract in developed countries due to its short operation time, small incision and injury area, and rapid postoperative recovery (4). However, despite the advanced technology of PE, the associated costs of the procedure are higher than ECCE, and its use in developing countries remains limited. Therefore, it remains meaningful to study the effect contrast between PE and ECCE (5,6). A meta-analysis by de Silva *et al.* in 2014 (7) included 11 randomized controlled trials (RCTs) with a total of 1,228 participants to compare the surgical effects of PE and ECCE. However, the studies included in their meta-analysis were mostly dated and of low quality, so their conclusions are of limited value. In this study, high-quality RCTs were included for meta-analysis to further investigate the comparison between PE and ECCE surgery. We present the following article in accordance with the PRISMA reporting checklist (available at <https://apm.amegroups.com/article/view/10.21037/apm-21-3633/rc>).

Methods

Criteria for literature inclusion

Type of study

Only RCTs published in English and with single or multicenter distributions were included. Case-control and cohort studies, case reports, controlled clinical trials (CCTs), or quasi-randomized studies were excluded.

Participants

All patients had cataracts caused by natural aging. Cataracts caused by trauma, poison, diabetes, and partial or complete subluxation of the lens were excluded, as were patients with vitreous in the current chamber.

Intervention type

The patients underwent PE or ECCE to remove the cataract, and posterior chamber IOL implantation was performed after the surgery. Included studies were required to report data comparing the two procedures (PE and ECCE). Studies that reported additional data concerning manual small-incision cataract surgery (MSICS) were included, but the additional data was excluded from the final analysis.

Outcome indicators

Primary indicators

Postoperative visual acuity: the proportion of patients who obtained good vision (as defined by visual acuity >6/12).

Secondary indicators

Intraoperative complications: the proportion of zonular dialysis, vitreous loss, capsular tear, or central corneal edema occurring during surgery.

Postoperative complications: the incidence of postoperative posterior capsule opacification, high astigmatism, or cystoid macular edema.

Follow-up duration

Studies reported the follow-up duration from one to 6 months were included.

Search strategy and literature screening

Electronic retrieval

Embase (January 2000 to August 2021), PubMed (January 2000 to August 2021), Cochrane Library (August 2021), and SpringerLink (January 2000 to August 2021) databases were searched for RCTs published after 2000 and in the English language.

Keyword matching

A keyword search was conducted with the following keywords: [phacoemulsification/PE] AND [extracapsular cataract extraction/ECCE] OR [cataract].

Literature screening

Two researchers independently conducted an initial screening of the identified studies by reading the titles and abstracts. Duplicate and unqualified studies were excluded. If the two researchers had a different opinion regarding any study, a third researcher was consulted for discussion until consensus was reached.

Data extraction

Two researchers independently extracted the data and read the full text of each article. Any missing information was obtained by contacting the corresponding author in the original study. The extracted information was recorded in an Excel spreadsheet. After completion, a cross-check

was performed of the two researchers' records, and any inconsistencies were discussed and finalized. The extracted contents included:

- (I) Basic information of the study: title, author, mailing address, name of publication, and publication date;
- (II) Basic characteristics of the study: inclusion and exclusion criteria, total sample size, number of groups, and number of samples in each group;
- (III) Basic characteristics of the participants: age, gender ratio, and duration of illness;
- (IV) Characteristics of the interventions: the different intervention methods used in different groups and the follow-up time;
- (V) Outcome indicators: the number of cases of visual acuity improvement before and after surgery, and type and proportion of complications.

Literature bias and evaluation analysis

The risk of bias for the RCT studies was assessed according to the Cochrane Handbook for Systematic Reviews of Interventions and expressed as high, low, or unclear. We classified the literature according to class A, B and C. Class A: all of the 6 aspects, including random method, distribution concealment, blind method, data integrity, selective reporting and other bias were well implemented. Class B: any one or more aspect partially met the criteria. Class C: any one or more of them were not well implemented.

Statistical analysis

The odds ratio (OR) and 95% confidence interval (CI) were used to evaluate dichotomous variables (rate of good postoperative visual acuity, proportion of intraoperative complications, and proportion of postoperative complications), and the forest plot was used to display the results.

Integrity and consistency of analysis

For patients with only one eye diseased, we assigned them to the different surgery types; for patients with two eyes diseased, the study needed to specify whether both eyes were assigned to the same group at the same time. We made every effort to avoid the situation where two eyes from one individual were assigned to different surgical methods.

Handling of data loss

Cases lost to follow-up were required to be described in

detail in the studies, and should be counted during the analysis.

Heterogeneity assessment

The I^2 statistic and Q test were used to assess heterogeneity. An I^2 value >50% or a P value <0.1 indicated statistically significant heterogeneity.

Publication bias analysis

Funnel plots were used to represent publication bias.

Data synthesis

RevMan 5.4 software (Cochrane Collaboration) was used as the analysis tool for this study.

Heterogeneity survey

Heterogeneity was investigated using subgroup analysis.

Sensitivity analysis

For analyses without significant heterogeneity, fixed-effects and random-effects models were used. If there was no significant difference, we considered that the sensitivity was good.

Results

Literature search results and screening process

Figure 1 shows the results of the literature search and the screening process.

Basic characteristics of the included studies

Eight RCTs were included in our study, with a total of 1,015 affected eyes. The youngest patient was 49 years old, and the oldest was 92 years old. The grouped sample sizes ranged from 33 to 146. The studies were conducted in several countries, including Greece, Brazil, Malaysia, China, Kashmir, Pakistan, and Nigeria. The basic characteristics of the studies are shown in Table 1.

Assessment of risk of bias

We used the Cochrane Handbook for Systematic Reviews of Interventions to evaluate the studies included in this meta-analysis. All studies described the method of random sequence grouping. Except for one study (8), all other studies described the allocation concealment method and only one study (9) failed to mention the blinding method.

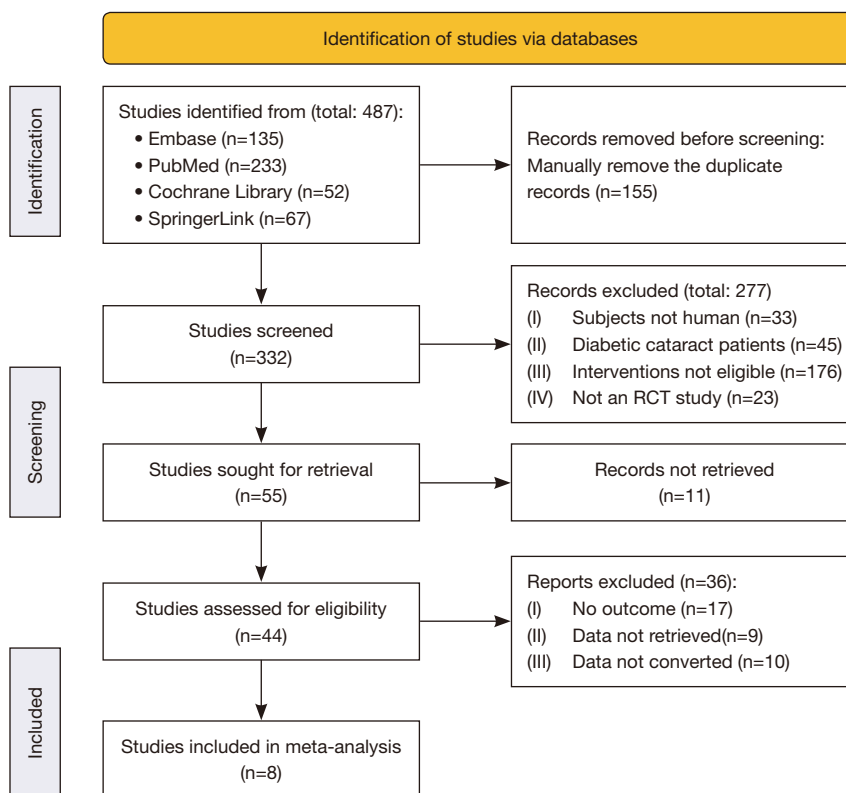


Figure 1 Literature screening flow chart.

All studies detailed dropout cases. No selective reporting or other biases were found, as shown in *Table 2*.

Intervention effect

Visual acuity outcome

All studies described the proportion of best-corrected visual acuity. The rate of good vision was defined as corrected visual acuity at 6/6 or above. Of the total number of eyes, 445 were included in the PE group, and 219 were included in the ECCE group. The results showed that the rate of good final visual acuity in the PE group was higher than that in the ECCE group (OR =2.94, 95% CI: 2.17–3.99, $P < 0.00001$). There was no significant heterogeneity between the studies ($I^2 = 17\%$, $P = 0.30$), as shown in *Figure 2*.

The eight studies were further divided into four subgroups according to their geographical region: Europe, Asia, Africa, and America. The results showed that there was no statistically significant heterogeneity among the internal subgroups. The rate of good vision in the PE group was higher than that in the ECCE group, indicating that the results were not related to race or regional distribution.

Intraoperative complications

The results of the main intraoperative complications are listed in *Table 3*. The proportion of vitreous prolapse and capsular tear in PE surgery was lower than that in ECCE surgery. There was no significant difference in the proportion of other complications, such as zonular dialysis and central corneal edema.

Postoperative complications

Table 4 lists the results of the main postoperative complications. The proportion of capsule opacification and cystoid macular edema after PE surgery was lower than that after ECCE surgery, and there was no significant difference in the proportion of other complications such as high astigmatism.

Sensitivity analysis

For the analysis in *Figure 2*, a random-effects model was used (OR =2.98, 95% CI: 2.12–4.17, $P < 0.00001$), which did not differ significantly from the results of the fixed-effects model, so the stability of the analysis was judged as good.

Table 1 Basic study information, patient characteristics, surgical method, follow-up period, and outcome indicators

Author	Region	Group	Number of affected eyes	Age (years)	Follow-up time (weeks)	Outcome indicators
Katsimpris JM 2004, (8)	Greece	PE	47	77.0±5.3	10	(I) (II) (III)
		ECCE	47	75.5±6.0		
Thevi T 2014, (9)	Malaysia	PE	146	–	14	(I) (II) (III)
		ECCE	33	–		
Mendonça PT 2014, (10)	Brazil	PE	30	68±8.4	5	(I) (IV)
		ECCE	30	67±8.0		
Osita ME 2012, (11)	Malaysia	PE	48	65.0±9.62	8	(I)
		ECCE	30	63.4±12.13		
Jiang T 2011, (12)	China	PE	114	–	6	(I)
		ECCE	35	–		
Abdulsalam S 2015, (13)	Nigeria	PE	117	62.1±7.6	12	(I)
		ECCE	108	63.3±7.8		
Ahmad CN 2011, (14)	Pakistan	PE	50	58.52	8	(I) (III)
		ECCE	50	57.12		
Khan S 2014, (15)	Kashmir	PE	65	–	12	(I) (III)
		ECCE	65	–		

Outcome indicators: (I) best-corrected visual acuity; (II) intraoperative complications; (III) postoperative complications; (IV) quality of life. PE, phacoemulsification; ECCE, extracapsular extraction.

Table 2 Risk of bias and quality assessment based on the Cochrane Handbook for Systematic Reviews of Interventions

Study	Random sequence generation	Classification hiding	Blind method	Data integrity	Optional reporting	Other Bias	Class
Katsimpris JM 2004, (8)	Low	Unclear	Low	Low	Low	Low	B
Thevi T 2014, (9)	Low	Low	Unclear	Low	Low	Low	B
Mendonça PT 2014, (10)	Low	Low	Low	Low	Low	Low	A
Osita ME 2012, (11)	Low	Low	Low	Low	Low	Low	A
Jiang T 2011, (12)	Low	Low	Low	Low	Low	Low	A
Abdulsalam S 2015, (13)	Low	Low	Low	Low	Low	Low	A
Ahmad CN 2011, (14)	Low	Low	Low	Low	Low	Low	A
Khan S 2014, (15)	Low	Low	Low	Low	Low	Low	A

Analysis of publication bias

As shown in *Figure 3*, the funnel plot indicated that the distribution of the eight articles was basically symmetrical without significant publication bias.

Discussion

Summary of study results

Since Dr. Kelman's 1967 invention of the PE technique

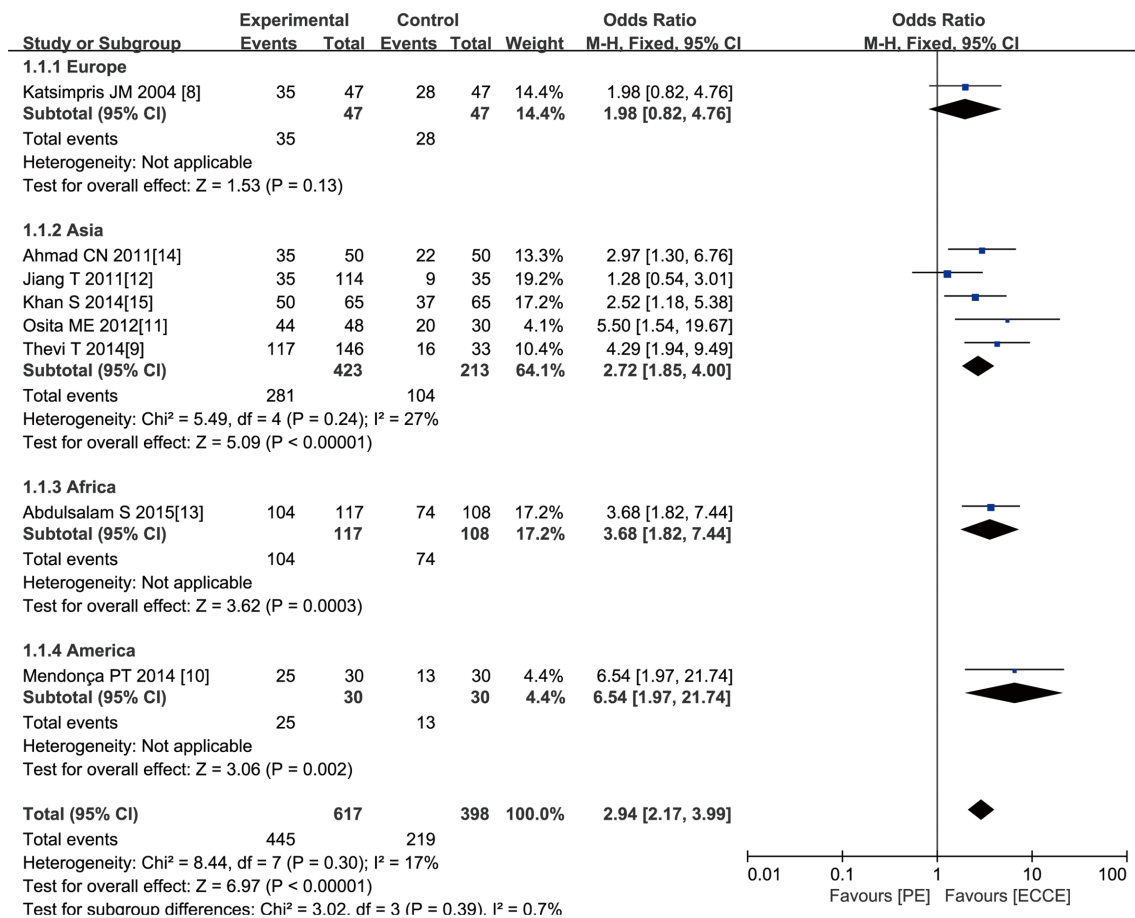


Figure 2 Comparison of good visual acuity rate in the ECCE and PE groups. ECCE, extracapsular cataract extraction; PE, phacoemulsification; M-H, Mantel-Haenszel; CI, confidence interval.

Table 3 Comparison of intraoperative complications

Complications	Eyes	Study num	Statistical method	Effect estimate	P value
Zonular dialysis	273	2	Odds ratio (M-H, random, 95% CI)	0.17 (0.01–2.54)	0.20
Vitreous loss	273	2	Odds ratio (M-H, fixed, 95% CI)	0.16 (0.04–0.64)	0.01
Capsular tear	403	3	Odds ratio (M-H, fixed, 95% CI)	0.29 (0.10–0.85)	0.02
Central corneal edema	273	2	Odds ratio (M-H, random, 95% CI)	0.34 (0.02–4.79)	0.42

M-H, Mantel-Haenszel test; CI, confidence interval.

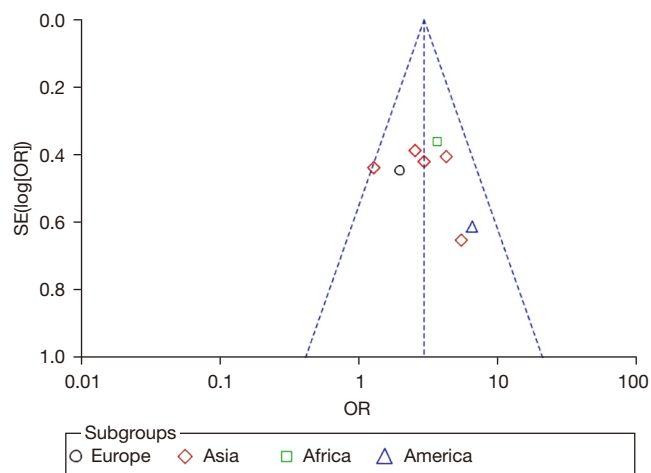
in the United States, it has undergone many years of improvement and development in clinical practice. It is now a universally well-recognized and advanced surgical method. The procedure involves placing a probe into the eye chamber through a small incision, breaking the turbid lens into chyle and suctioning it out, and then implanting the IOL to allow the patient to regain visual acuity (16,17).

PE surgery is characterized by a small incision and a short operation time. A previous study (12) recorded the operation time of PE and found that surgery was completed within 15 minutes for 53.5% of patients and within 30 minutes for 95.6% of patients, indicating that surgery was completed within 30 minutes for most patients. Since PE surgery has better control, postoperative visual acuity recovery is better.

Table 4 Comparison of postoperative complications

Factors	Number of participating patients	Number of studies	Statistical method	Effect estimate	P value
Posterior capsule opacification	403	3	Odds ratio (M-H, fixed, 95% CI)	0.20 (0.08–0.53)	0.001
High astigmatism	273	2	Odds ratio (M-H, fixed, 95% CI)	0.29 (0.05–1.85)	0.19
Cystoid macular edema	273	2	Odds ratio (M-H, fixed, 95% CI)	0.16 (0.04–0.74)	0.02

M-H, Mantel-Haenszel test; CI, confidence interval.

**Figure 3** Funnel plot analysis. OR, odds ratio; SE, standard error.

In the present meta-analysis, a total of 1,015 affected eyes in eight articles were included, and those with corrected visual acuity of 6/6 or more were considered to have good visual acuity correction. The meta-analysis results showed that PE surgery had better visual acuity compared with ECCE surgery. The study also compared intraoperative and postoperative complications. The proportion of complications, such as vitreous prolapse, capsule tear, capsule opacification, and cystoid macular edema during and after PE, was lower than that of ECCE, suggesting that PE had fewer complications.

Comparison with other studies

The results of de Silva *et al.* (7) showed that compared with ECCE surgery, PE surgery had a lower incidence of complications and better postoperative visual acuity, consistent with the present study results.

Moulick *et al.* (18) compared possible complications of posterior capsular opacification in PE, ECCE, and MSICS and showed that the incidence of posterior capsular

opacification was lower in the PE and MSICS procedures than in ECCE, which was also consistent with the results of this study.

In this study, because only a few articles reported the incidence of ocular hypertension, these results were not included in the analysis. However, a previous study (8) reported that the incidence of early postoperative ocular hypertension after PE surgery was 8.4%, in contrast to 29.8% after ECCE surgery. This significantly smaller incidence of ocular hypertension after PE compared with ECCE is consistent with the results of Pal *et al.* (19).

Although the intraoperative and postoperative complications of PE surgery are less than those of ECCE surgery, there were still a small number of complications happened, such as posterior capsule opacification, elevated intraocular pressure, corneal edema and retinal detachment. Posterior capsule opacification can be corrected by laser. Elevated intraocular pressure is a common phenomenon after surgery and generally recovers itself. The probability of corneal edema and retinal detachment is low and can also be corrected by surgery. Therefore, the safety of PE operation is good (20).

Nevertheless, despite the technical advantages of the PE procedure over other procedures, its cost is higher. In a study conducted by Kara *et al.* (21), the mean operative cost for 101 patients who received PE surgery was US\$587.71, while the mean operative cost for 104 patients who received ECCE surgery was US\$341.21. Hence the ECCE procedure is still preferred in low-income populations.

Quality of evidence and possible bias

In this study, the random sequence generation and blinding methods were described in detail. Only one study failed to mention the allocation concealment method (8), and another did not report the blinding method (9). All of the RCTs provided detailed descriptions of the dropout cases during follow-up. Therefore, the risk of bias in the

literature was small, and the sensitivity analysis showed that the results were stable. The publication bias analysis showed that there was no significant publication bias. However, a limitation of the present study was that too few studies included details of complications, which compromised the quality of this evidence. The comparison of complications between the two surgical methods requires further investigation.

Conclusions

In summary, PE cataract extraction shows better postoperative visual acuity improvement and fewer complications than ECCE. Since the cost of surgery was not analyzed in this study, this topic will require further exploration by using more high-quality RCT studies in clinical practice.

Acknowledgments

Funding: This project was supported by Hainan Province Clinical Medical Center.

Footnote

Reporting Checklist: The authors have completed the PRISMA reporting checklist. Available at <https://apm.amegroups.com/article/view/10.21037/apm-21-3633/rc>

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <https://apm.amegroups.com/article/view/10.21037/apm-21-3633/coif>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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- (English Language Editor: D. Fitzgerald)

Cite this article as: Li A, He Q, Wei L, Chen Y, He S, Zhang Q, Yan Y. Comparison of visual acuity between phacoemulsification and extracapsular cataract extraction: a systematic review and meta-analysis. *Ann Palliat Med* 2022;11(2):551-559. doi: 10.21037/apm-21-3633