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Non-penetrating filtration surgery versus trabeculectomy in postoperative astigmatism: a meta-analysis

Xiangting Peng[1], Qiying Ling[1,2] and Xuanchu Duan[1,2,3,4*]

Abstract

Objective Trabeculectomy and non-penetrating trabecular surgery are common operations for glaucoma. This meta-analysis aims to compare the effect of trabeculectomy and non-penetrating trabecular surgery in postoperative astigmatism of patients with glaucoma.

Methods A systematic literature search was performed for studies comparing trabeculectomy and non-penetrating trabecular surgery in patients with glaucoma. The time frame for the search was from the time of construction to April 2024. There were no restrictions regarding study type or type of glaucoma. The endpoint was the surgically induced astigmatism assessed 6 months after operation. We conducted this meta-analysis following the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis).

Results Five eligible studies were included in this meta-analysis and presented data for 359 eyes with various types of glaucoma at different stages. The results revealed an increase in astigmatism in patients with glaucoma after trabeculectomy and non-penetrating trabecular surgery. Trabeculectomy had a higher incidence of astigmatism than in the non-penetrating trabecular surgery group at or around 6 months postoperatively, and the difference was statistically significant. (SMD = 0.40, 95% CI = 0.19 to 0.61, $P = 0.02$).

Conclusion Our results demonstrated that both trabeculectomy and non-penetrating trabecular surgery could increase astigmatism until 6 months after operation. Moreover, non-penetrating trabecular surgery group seems to have less influence on astigmatism.

Trial registration number CRD42024517708.

Keywords Trabeculectomy, Non-penetrating trabecular surgery, Astigmatism, Glaucoma, Meta-analysis

Introduction

Glaucoma is the second most common blinding disease of the eye, which is characterized by visual field defects and progressive optic nerve damage caused by elevated intraocular pressure (IOP). The number of patients with glaucoma is increasing year by year, and it is expected to reach 95.4 million worldwide in 2030 and 111.8 million in 2040 [1], which will bring a huge social and economic burden. Filtration surgery is indicated when medication and laser therapies are insufficient to control IOP, and when the rate of deterioration of visual

*Correspondence:
Xuanchu Duan
duanxchu@csu.edu.cn
[1] Aier Eye Hospital, Jinan University, Guangzhou, Guangdong Province, China
[2] Changsha Aier Eye Hospital, No.188 South Furong Road, Changsha, Hunan 410015, China
[3] Aier Glaucoma Institute, No.188 South Furong Road, Changsha, Hunan 410015, China
[4] Hunan Engineering Research Center for Glaucoma with Artificial Intelligence in Diagnosis and Application of New Materials, Changsha, Hunan 410015, China

function is rapid enough to damage the patient's quality of life [2]. Trabeculectomy (Trab) is considered as the gold standard. However, it is associated with significant postoperative complications such as hyphaema, shallow or flat anterior chamber, hypotony, choroidal detachment, and hypotony maculopathy leading to failure of glaucoma surgery [3]. To minimize these complications, non-penetrating trabecular surgery (NPTS) has been increasingly performed in recent years, including deep sclerectomy (DS), canaloplasty (CP), and viscocanalostomy (VCO), along with a combination of implants and antimetabolites [4].

With the continuous development of medical technology and newer equipment, glaucoma patients' expectations for surgical treatment are no longer satisfied with IOP reduction, but they also expect to have better vision to fulfill their life needs. Previous studies have found that surgically induced astigmatism (SIA) is an important factor that influences the quality of the vision and visual rehabilitation of patients with glaucoma [5]. However, different surgical procedures do not affect corneal astigmatism in the same way. Understanding and comparing the effects of Trab and NPTS in postoperative astigmatism may help to prevent or reduce the occurrence of astigmatism in the postoperative period. Few studies have directly compared the two operations. Consequently, this paper conducts a meta-analysis to evaluate the astigmatism after operation for glaucoma treatment.

Methods

We conducted this meta-analysis following the PRISMA 2020 reporting guideline (Table S1). Moreover, we registered this review protocol on the PROSPERO international prospective register of systematic reviews (PROSPERO registration number: CRD42024517708).

Search strategy

In this study, a computerized search of PubMed, Web of Science, Cochrane Library, and China National Knowledge Infrastructure was performed and literature on non-penetrating trabecular surgery and trabeculectomy in postoperative astigmatism of patients with glaucoma was searched. Search entries were adjusted according to the different databases. The time frame for the search was from the time of construction to April 2024.

The search strategy for PubMed was as follows: (((("Glaucoma"[Mesh]) OR (GLAUCOMA)) AND (("Trabeculectomy"[Mesh]) OR (Trabeculectomy))) AND (((((nonpenetrating glaucoma surgery) OR (non-penetrating trabecular surgery)) OR (deep sclerectomy)) OR (canaloplasty)) OR (viscocanalostomy))) AND (("Astigmatism"[Mesh]) OR (astigmatism)).

Study selection

Inclusion criteria

a) Study population: Adult glaucoma patients of all types;
b) Intervention and comparison: non-penetrating trabecular surgery versus trabeculectomy;
c) Study design: randomized controlled trials (RCTs) or cohort studies;
d) Outcome parameter: Astigmatism assessed 6 months after operation;
e) There were no restrictions on gender, ethnicity, or surgical history restrictions;

Exclusion criteria

a) Animal research, case reports, reviews, clinical trials without results, and abstract only
b) Articles with duplicated data;
c) Combined with other surgeries;
d) Without a control group;
e) Incomplete data on endpoint indicators that could not be statistically calculated.

Data extraction

The screening process was completed by two investigators independently (Xiangting Peng and Qiying Ling). The following data were extracted from each study: article characteristics (country, authors, publication year), study design (RCT, cohort study), interventions, participants' characteristics (number of eyes, age, type of glaucoma, baseline astigmatism), duration of follow-up, and astigmatism measurement. Any disagreements were resolved jointly by discussion.

Quality evaluation

Literature quality was evaluated using the Cochrane Handbook of Systematic Reviews of Interventions (version 5.1.0) for prospective controlled trials, and the Newcastle–Ottawa Scale (NOS) Literature Quality Assessment Scale for cohort and case–control studies.

Measurement outcome

To improve the validity of data evaluation, the outcome measure in this paper is the SIA assessed 6 months after operation. We used existing SIA data directly if they were available in the original study. If not, their

increase of astigmatism(astigmatismI), and standard deviation (SD) of the astigmatismI ($SD_{astigmatismI}$) were calculated using the following principles:

$$astigmatismI = astigmatism_{endpoint} - astigmatism_{baseline},$$

$$SD_{astigmatismI} = (SD^2{}_{baseline} + SD^2{}_{endpoint} - SD_{baseline} * SD_{endpoint})^{1/2}$$

Statistical analysis

The analysis was performed by RevMan 5.4 software and Stata 12.0 software. The Cochran Q test was used to test heterogeneity, and the fixed-effects model was used to analyze studies with good homogeneity, while the random-effects model was used to analyze studies with more obvious heterogeneity. AstigmatismI was a continuous variable, standardized mean difference (SMD) was used as the effect indicator, and $P<0.05$ was considered a statistically significant difference. In this study, literature was excluded from sensitivity analysis using the one-by-one exclusion method. The result of the meta-analysis is shown as a forest plot.

Results

Study characteristics and quality assessment

In all, 26 articles were initially identified through the search strategy described in the Methods section and 15 remained after duplicates were removed. After screening the titles and abstracts, 5 irrelevant studies were excluded. The remaining 10 papers were read in full, and 5 papers were finally included for META analysis based on the inclusion and exclusion criteria [6–10] (shown in Fig. 1). A total of 359 eyes were included in this study, which included 173 eyes in trabeculectomy group and 186 eyes in the NPTS group. The follow-up ranged from 6 to 12 months. The characteristics of the included studies are detailed in Table 1. The quality assessment is shown in Figs. 2, 3, and Table 2.

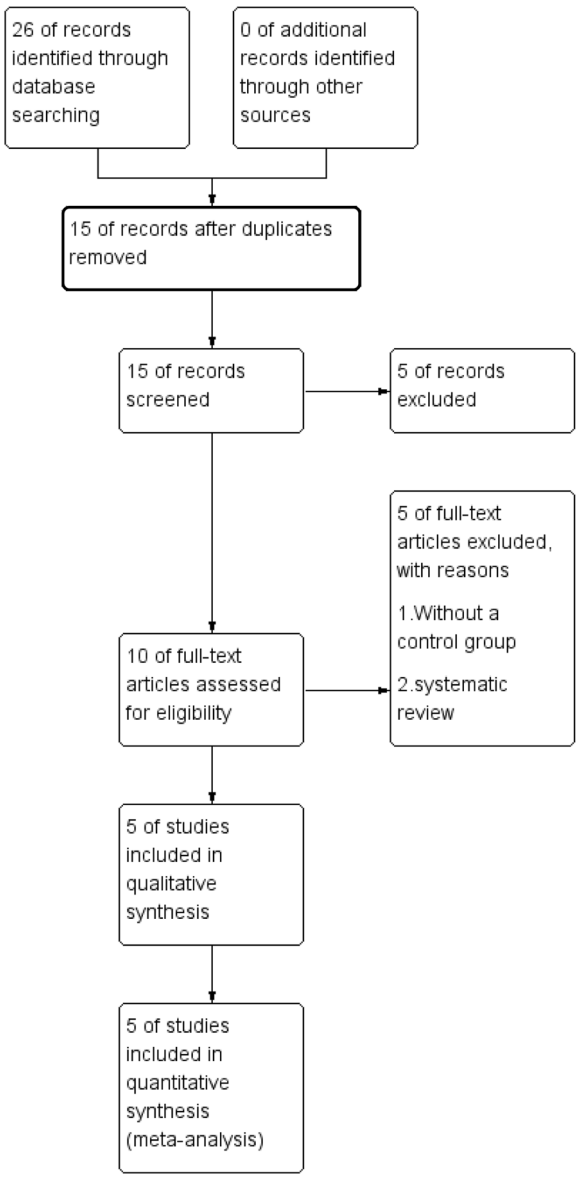

Fig. 1 Flow chart depicting the selection of included studies

Comparison of two operations for the change value of astigmatism at 6 months postoperatively

All five papers reported baseline astigmatism before surgery and astigmatism 6 months after operation. The original data showed that both Trab and NPTS resulted in an increase in astigmatism in patients with glaucoma after surgery. The amount of increase in astigmatism was greater in the Trab group than in the NPTS group at or around 6 months postoperatively, and the difference was statistically significant. (SMD = 0.40, 95% CI = 0.19 to 0.61, $P=0.02$); the test for heterogeneity showed that all were homogeneous studies ($I^2=66\%$, $P=0.02$) (Fig. 4).

Sensitivity analysis and assessment of reporting biases

To evaluate the stability and reliability of the results of the meta-analysis, the analysis was repeated after deleting each study in turn. Using the AstigmatismI as the analysis index and applying the fixed-effects model, the results showed that excluding any individual study did

Table 1 Baseline characteristics of included studies

Author/year	Egrilmez 2004 [6]	El-Saied 2014 [7]	Hong 2012 [8]	Jankowska 2018 [9]	Taruttis 2018 [10]
Research type	RCT	RCT	Cohort study	Cohort study	Cohort study
Type of glaucoma	OAG	POAG	POAG, secondary glaucoma	POAG, XFG	POAG, PXG
Samples	Trab: 11 eyes NPTS: 19 eyes	Trab: 60 eyes NPTS: 60 eyes	Trab: 6 eyes NPTS: 9 eyes	NPTS: 65 eyes Trab: 66 eyes	NPTS: 31 eyes Trab: 32 eyes
Follow-up time (m)	6	6	12	12	12
Outcome measure	Astigmatism assessed 6 months after operation	Astigmatism assessed 6 months after operation	Astigmatism assessed 6 months after operation	Astigmatism assessed 6 months after operation	Astigmatism assessed 6 months after operation

RCT randomized controlled trial, *OAG* open-angle glaucoma, *POAG* primary open angle glaucoma, *XFG* exfoliative glaucoma, *PXG* pseudoexfoliation glaucoma, *Trab* Trabeculectomy, *NPTS* non-penetrating trabecular surgery

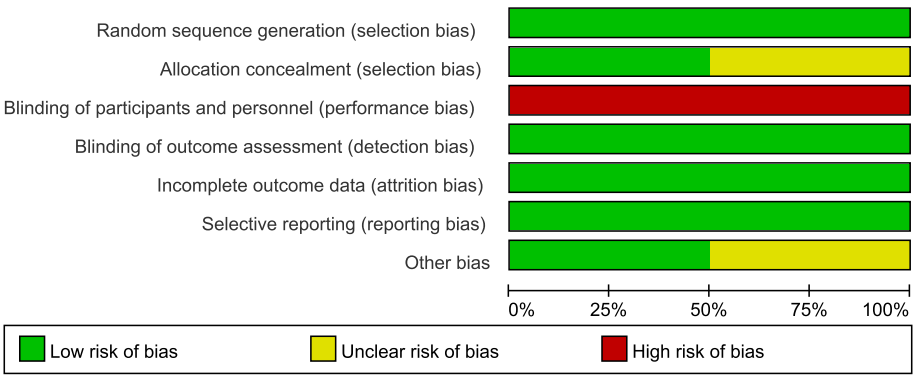

Fig. 2 Methodological quality graph: review authors' judgments about each methodological quality item presented as percentages across all included studies

not significantly alter the findings compared to those obtained before the exclusions. This indicates that the results of the current study are stable and credible. However, due to the small number of literature included in this study (less than 10), a publication bias analysis was not done.

Discussion

Glaucoma is an important public health concern. Its irreversibility and the demographic changes of an ageing population add to the problem. The reduction of IOP remains the backbone of glaucoma surgery. Therefore, most studies focus on comparing the intraocular pressure lowering between Trab and NPTS [11–13]. For patients with open angle glaucoma, the target intraocular pressure after the surgery usually needs to be kept quite low. Some studies showed that Trab lowers the IOP more than NPTS [14–16].

However, few studies have compared the astigmatism problem between the two glaucoma surgeries. SIA contributes to the factors behind patients complaining of reduction of vision after successful glaucoma surgery [17]. Therefore, it's important to have an accurate evaluation of astigmatism preoperatively and postoperatively.

Compared to trabeculectomy, the significant advantage of non-penetrating filtration surgery is that during the surgical procedure, the anterior chamber will not be directly opened and retains the thin Descemet membrane [18]. Therefore, early postoperative complications such as hypotony are rare. Moreover, there is less hyphema as peripheral iridectomy is not performed [19]. Theoretically, these benefits should shorten the patients' visual recovery period. In addition, the flap and sutures in Trab are positioned closer to the cornea, leading to a slight sinking of the unsupported corneal edge at the Trab opening, which results in more astigmatism than NPTS [20].

Several limitations should be acknowledged. (1) The 5 papers' definite inclusion/exclusion criteria were used, but the randomization techniques were not detailed. (2) The number of papers and sample sizes covered by the study might compromise the validity of the study. Therefore, more clinical studies are needed to support the conclusion of the study. (3) SIA is a vector, that not only has a magnitude but

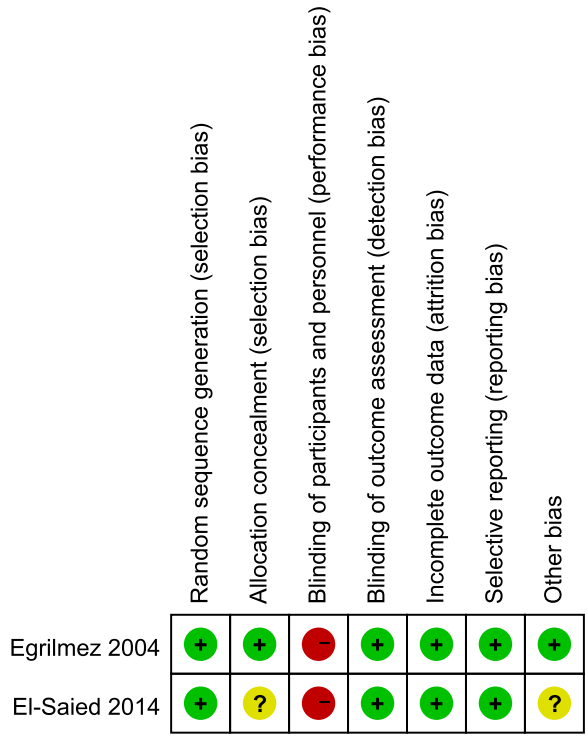

Fig. 3 Risk of bias summary: review authors' judgments about each risk of bias item for each included study

also has an axis, the calculation of its change should take the axial change into account [21]. However, one of the above studies only showed the magnitude, so we can only take a simple method, that is, to analyze the change of the magnitude of astigmatism, which is very easy to calculate but a little inaccurate. Vector analysis is widely regarded as the standard method for evaluating astigmatism. We recommend that future research standardize the calculation methods for surgically induced astigmatism to reduce methodological inconsistencies.

Conclusion

In summary, the result of this meta-analysis suggested that both NPTS and trabeculectomy could significantly induce astigmatism. Compared with the conventional trabeculectomy, Non-penetrating trabeculectomy induces less astigmatism at 6 months postoperatively. Further research is needed to investigate the specific effects and mechanisms of astigmatism induced by these two types of surgeries. The shortcomings associated with the two operations also await further improvement. Considering the small number of publications included, our results need to be interpreted with caution.

Table 2 Quality assessment of all included studies

Study	Type	Selection	Comparability	Outcome	Randomization	Masking	Accountability Quality of all patients	Quality (score)
RCT								
Egrilmez 2004 [6]					2	0	1	3
El-Saied 2014 [7]					2	0	1	3
Cohort study								
Hong 2012 [8]	Retrospective	4	1	1				6
Jankowska 2018 [9]	Prospective	4	2	2				8
Taruttis 2018 [10]	Retrospective	4	2	1				7

For RCTs, study scores ≥ 3 points were defined as high quality. For cohort studies, high-quality studies (score 8–9 points) and medium-quality studies (score 6–7 points) were included, while low-quality studies (score ≤ 5 points) were excluded

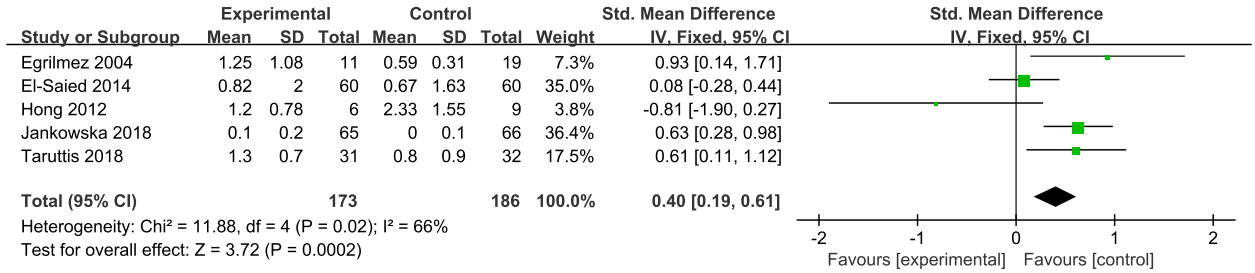

Fig. 4 Forest plot of comparison: trabeculectomy versus Non-penetrating filtration surgery, outcome: astigmatism at 6 months postoperatively

Abbreviations

IOP	Intraocular pressure
Trab	Trabeculectomy
NPTS	Non-penetrating trabecular surgery
DS	Deep sclerectomy
CP	Canaloplasty
VCO	Viscocanalostomy
SIA	Surgically induced astigmatism
AstigmatismI	Increase of astigmatism
Mesh	Medical subject headings
NOS	Newcastle–Ottawa Scale
$SD_{astigmatismI}$	Standard deviation of the astigmatismI
SMD	Standardized mean difference
RCT	Randomized controlled trial
OAG	Open-angle glaucoma
POAG	Primary open angle glaucoma
XFG	Exfoliative glaucoma
PXG	Pseudoexfoliation glaucoma

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12886-024-03651-y.

Supplementary Material 1.

Authors' contributions

Conception of the work were performed by Xuanchu Duan. Article evaluation were performed by Xiangting Peng and Qiying Ling. Data analysis were performed by Xiangting Peng. Results interpretation were performed by Xiangting Peng and Qiying Ling. Drafting the article were performed byXiangting Peng. Critical revision of the manuscript were performed by Xiangting Peng and Qiying Ling. Final approval of the manuscript: all the authors.

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Availability of data and materials

All data needed to evaluate the conclusions in the paper are present in the paper or the Supplementary Materials

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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