Original Article

A system review and meta-analysis of the treatment of acute angle-closure glaucoma under optical coherence tomography

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Background: A meta-analysis was conducted to investigate the value of treatment-related indicators of acute angle-closure glaucoma (AACG) based on optical coherence tomography (OCT) to evaluate the curative effect.

Methods: Articles on the treatment of AACG in clinical research of OCT published from January 2010 to June 2020 were retrieved from the PubMed, Web of Science, and Spring databases. RevMan 5.3 software was used for the meta-analysis of the relevant data. The angle opening distance (AOD), trabecular-iris space area (TISA), angle recess area (ARA), anterior chamber depth (ACD), anterior chamber width (ACW), anterior chamber area (ACA), anterior chamber volume (ACV), lens vault (LV), iris thickness 750 (IT750), intraocular pressure (IOP), and pupil diameter (PD) values were observed and compared before and after the treatment.

Results: A total of 12 articles were included in the meta-analysis. The results indicated that patients' ACD, I-Area, IOP, and PD values were lower after treatment than before treatment [mean deviation (MD): –0.32, 0.12, –0.04, 13.55, 0.30; 95% confidential interval (CI): –0.55 to –0.08, 0.04 to 0.1, –0.09 to 0.01, 4.71 to 22.39, 0.09 to 0.529; Z=2.66, 3.06, 1.39, 3, 2.75, and P=0.008, 0.002, 0.16, 0.003, 0.006, respectively]. The ACA, ACV, ARA, AOD750, and TISA500 values were higher after treatment than before treatment (MD: –3.22, –2.90, –0.03, –0.05, –0.01; 95% CI: –5.07 to –1.38, –5.44 to –0.36, –0.05 to –0.02, –0.08 to –0.03, –0.02 to –0.01; Z=3.42, 2.24, 4.10, 4.41, 7.77, and P=0.0006, 0.03, <0.0001, <0.0001, and <0.0001, respectively). The ACW, LV, I-Curve, IT750, AOD500, and TISA750 values showed little change (MD: 0.01, 0.05, 0.075, 0.05, –0.07, 0.02; 95% CI: –0.04 to 0.05, –0.01 to 0.11, 0 to 0.15, –0.08 to 0.17, –0.16 to 0.02, –0.03 to 0.07; Z=0.29, 1.65, 1.85, 0.72, 1.49, 0.79, and P=0.77, 0.10, 0.06, 0.47, 0.14, 0.43, respectively).

Discussion: The different indicators were not compared with the control group in this study, but it still could provide a reference for the selection of OCT diagnostic parameters before and after the treatment of AACG in the future.

Keywords: Optical coherence tomography (OCT); acute angle-closure glaucoma (AACG); meta-analysis

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Introduction

Glaucoma is the second most common blind eye disease in the world. It is mainly caused by damage to retinal ganglion cells and axons, which leads to depressed atrophy of the optic disc and characteristic changes in visual fields (1). Glaucoma is also one of the main blind eye diseases in China. Twenty percent of blindness is caused by glaucoma, and vision cannot be recovered after blindness. At present, the prevalence of primary angle-closure glaucoma, which

accounts for 79.60–86.13% of glaucoma cases, is 1.79% in China. Acute angle-closure glaucoma (AACG) is the main type of glaucoma (1.1%) in the Asian population (2). Optical coherence tomography (OCT) is widely used in the diagnosis and treatment of glaucoma because of its real-time, high-resolution, non-invasive, and safe characteristics (3). OCT uses light instead of ultrasound, and can reach a resolution of 8 μm, increasing the understanding of the structure and function of the omentum (4). Currently, the main mechanism of blindness caused by glaucoma is believed to be the apoptosis of retinal ganglion cells. A decrease in the number of ganglion cells leads to the thinning of the thickness of the retinal nerve fiber layer. OCT can measure the thickness of the retinal nerve fiber layer (5).

If a state of high intraocular pressure (IOP) continues, it can cause extensive adhesions in the angle of the chamber, serious damage to the trabecular meshwork filtering function, and damage to the optic nerve, resulting in irreparable vision loss. Thus, the key to treating AACG attacks is to control the IOP and open the angle as soon as possible to save the visual function (6). The treatment methods of AACG mainly include drug and surgical treatments. Drug treatments mainly include miotic agents, β-receptor antagonists, carbonic anhydrase inhibitors, and hypertonic agents (7). Drugs can lower IOP, shrink the pupils, and open the angle, reducing tissue damage (8). Surgical therapy is the main method of glaucoma treatment, and mainly includes laser peripheral iridoplasty (LPI), filtering surgery, and trabeculectomy (Trab) (9). These methods have been applied in the clinical treatment of AACG patients, but the curative effects are inaccurate, and the effects on indicators are different; thus, further study is required.

In summary, the current therapeutic efficacy of AACG based on OCT is still controversial. We conducted a meta-analysis to examine the therapeutic effects of OCT-based AACG and provide a reliable reference for clinical treatment. We present the following article in accordance with the PRISMA reporting checklist (available at http://dx.doi.org/10.21037/apm-21-1054).

Methods

Data inclusion

Patients with primary AACG monocular attacks were selected as the research objects. The types of publications included articles on retrospective controlled studies and prospective cohort studies. The treatment methods detailed in the AACG publications included drug and surgical treatments. The surgical treatment mainly included surgery peripheral iridectomy (SPI), LPI, phacoemulsification, Trab, and cyclocryotherapy. The data included the author, year of publication, country, number of subjects (i.e., number of eyes), age of subjects, treatment methods, and observation indicators.

Inclusion and exclusion criteria

Publications were included if they met the following inclusion criteria: (I) was a SCI paper on a clinical trial published from January 2010 to June 2020 with original data; (II) included an analysis of the therapeutic efficacy of AACG based on OCT; (III) included records of basic information of patients' age, gender, and treatment methods in detail; and (IV) compared the angle opening distance (AOD), trabecular-iris space area (TISA), angle recess area (ARA), anterior chamber depth (ACD), anterior chamber width (ACW), anterior chamber area (ACA), anterior chamber volume (ACV), lens vault (LV), iris thickness 750 (IT750), AOD500, AOD750, TISA500, TISA750, IOP, and pupil diameter (PD) before and after the treatment. Publications were excluded if they met any of the following exclusion criteria: (I) was a duplicate document; (II) was a literature review; (III) was a non-English document; (IV) the original data was unavailable; (V) was a single case report; (VI) was an animal experiment study; (VII) did not include indicator data; and/or (VIII) did not include treatment methods.

Document retrieval strategy

The PubMed (2010–6/2020), Nature (2010–6/2020), Web of Science (2010–6/2020), Spring (2010–6/2020), and Science Direct (2010–6/2020) databases were searched using the keywords "optical coherence tomography", "acute angle-closure glaucoma", "metastasis", "treatment", "surgery", "operation", and "meta-analysis", which were connected with "or" or "and". Clinical studies of OCT-based AACG treatments published in the current search period were searched. All keywords were freely combined and then searched. Documents were confirmed based on the relevance of the searched content. The confirmed documents were tracked using the search engines such as Web of Science, PubMed, and Google Scholar. In addition, the documents and the latest research progress related to the treatment of AACG patients were retrieved and

consulted.

Document screening and data extraction

In this study, two investigators independently screened all the relevant documents and extracted the research indicators. If there was any disagreement between the two investigators, a third investigator was asked for a ruling after the differences in the extraction results had been discussed. Finally, the Cochrane Evaluation Manual 4.2.6 was used to evaluate the included documents. The evaluation criteria included whether the surgical method was correct and clear, whether the research results were clear, and whether the intention-to-treat analysis method was applied to the results. The included documents were categorized into three levels (low deviation, moderate deviation, and high deviation). The documents were initially screened by reading the title. If any data was missing, an attempt was made to contact the original author to supplement the data. Next, the abstract and full text were read to determine whether the publication should be included. For the selected study, information on all available variables were extracted and entered into a Microsoft Excel database. The following content was extracted from the publications: (I) basic information: article title, first author, year of publication, journal published, research type, start time and deadline; (II) research objects: the number of samples, the age and gender ratio of the research objects; (III) evaluation method: statistics and analysis of the main indicators before and after treatment; and (IV) observation indicators: AOD, TISA, ARA, ACD, ACW, ACV, ACA, LV, IT750, AOD500, AOD750, TISA500, TISA750, IOP, and PD.

Statistical methods

All data were analyzed using STATA 12.0 software (Stata Corporation, College Station, TX, USA). To determine the heterogeneity of the results, Cochran's chi-square test was adopted to evaluate (test level: α=0.1), and heterogeneity size was quantitatively analyzed using I^2. A combination of methods was selected depending on the heterogeneity test results. If P>0.1 and $I^2 \leq 50\%$, the heterogeneity of the included studies was small, and the fixed-effects model (FEM) was adopted. If P≤0.1 and $I^2>50\%$, the included studies were heterogeneous, and the source of heterogeneity required further analysis to eliminate heterogeneity as much as possible. After the influence of heterogeneity was eliminated, a meta-analysis was performed using the random-effects model (REM). The measurement data were expressed as mean deviation (MD) and standard deviation (SD), and each effect size was given with its point estimate and 95% confidential interval (CI). If necessary, the MD and SD could be estimated based on the available median and CI or range. Sensitivity was analyzed by excluding the study with the lowest quality score. The meta-analysis was performed according to the time sequence of publications to evaluate the stability of the effect size (test level: α=0.05).

Results

Document screening process and results

A search of "optical coherence tomography", "acute angle-closure glaucoma", "metastasis", "treatment", "surgery", "operation", and "meta-analysis" in the PubMed, Web of Science, Spring, Nature, and Science Direct databases retrieved 326 English-language documents published between January 2010 and June 2020. Among them, 175 articles were retrieved from the PubMed database, 85 from the Web of Science database, 17 from the Spring database, 10 from the Nature database, 28 from the Science Direct database, and 11 from the referenced publications and reviews. After deleting duplicate documents using Endnote X8 software, 126 documents remained. After reading each title, abstract, and text to exclude any unqualified documents, such as reviews, conference papers, case analyses, and risk-factor assessments, 24 documents met the primary screening requirements. After further intensive reading of the documents, 12 with no original data and uncontrolled studies were excluded. Thus, 12 documents were finally included in the analysis. Specific information about these documents is shown in *Table 1*. The results of the risk of bias evaluation of the included articles were shown in *Figures 1,2*. All studies scored 7–10 points in the NOS bias risk evaluation of 0–10, indicating that they were high-quality articles.

Comparison of ACW values

AACG patients' ACW values in 6 documents before and after treatment were compared statistically in the meta-analysis (see *Figure 3*). There was no obvious heterogeneity in the changes in patients' ACW values before and after treatment with different methods (I^2=0 and P=0.91). The REM analysis showed no statistical difference in patients' ACW values before and after treatment with different

Table 1 Basic information of included documents

Documents	Country	Type	Number of cases (number of eyes)	Males (cases)	Females (cases)	Treatment method
Sng [2016] (10)	Singapore	Prospective comparative study	30	9	21	Drug/ALPI
Mokbel [2020] (11)	Egypt	Retrospective comparative study	34	12	22	LPI/ultrasonic phacoemulsification
Li [2011] (12)	China	Retrospective comparative study	37	6	31	SPI
Park [2014] (13)	Korea	Prospective comparative study	17			LPI
Moghimi [2018] (14)	Canada	Prospective comparative study	42	13	29	SPI
Sng [2014] (15)	Singapore	Prospective comparative study	31	11	20	LPI
Moghimi [2016] (16)	Canada	Prospective comparative study	52	37	15	ALPI
Yin [2018] (17)	China	Prospective comparative study	26	12	14	Trab
Shao [2015] (18)	China	Retrospective comparative study	43	19	24	Phacectomy
Lee [2014] (19)	Korea	Prospective comparative study	36	14	22	SPI
Atalay [2016] (20)	Singapore	Retrospective comparative study	53	17	36	ALPI
Moghimi [2015] (21)	US	Prospective comparative study	46	19	27	Ultrasonic phacoemulsification

ALPI, argon laser peripheral iridoplasty; LPI, laser peripheral iridoplasty; SPI, surgery peripheral iridectomy; Trab, trabeculectomy.

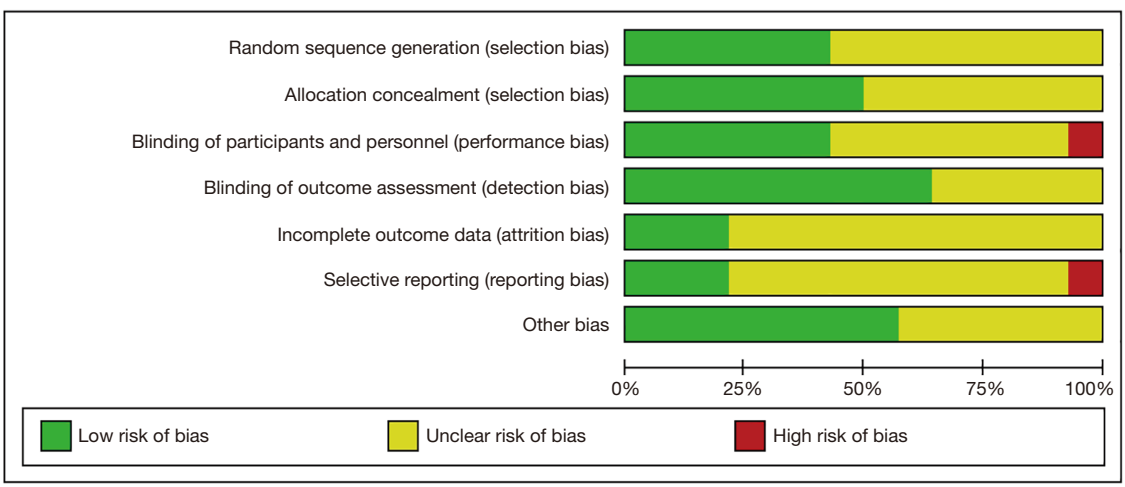

Figure 1 The risk bias assessment of articles included in the meta-analysis.

methods (MD: 0.01, 95% CI: –0.04 to 0.05; Z=0.29, and P=0.77).

Comparison of ACD values

A statistical analysis of AACG patients' ACD values before and after treatment in 6 articles (see *Figure 4*) showed that the changes in patients' ACD values before and after treatment with different methods were observably heterogeneous (I^2=99% and P<0.00001). The REM analysis results revealed that patients' ACD values after treatment with different methods were much lower than

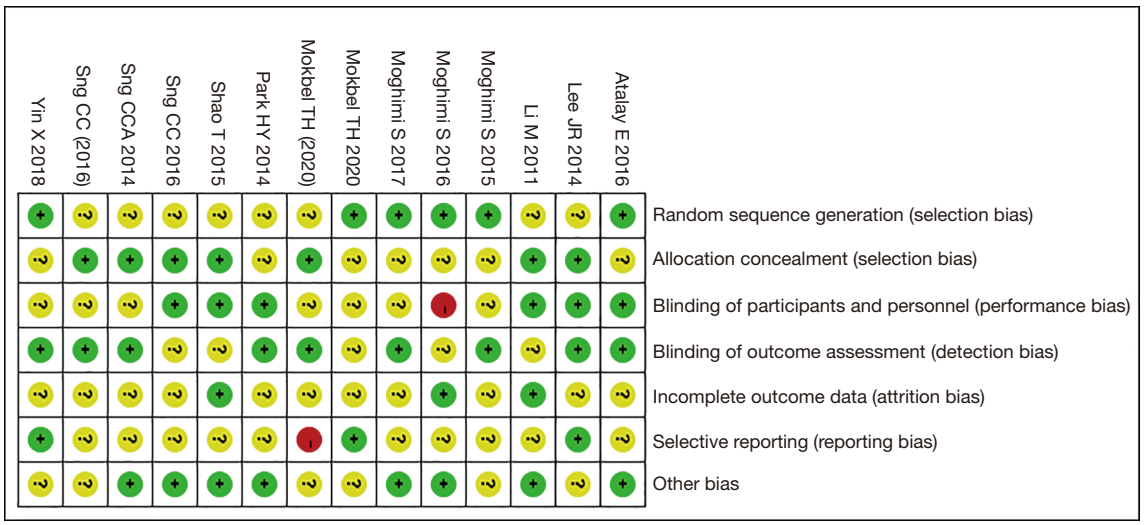

Figure 2 Bar chart of risk bias assessment of articles included in the meta-analysis.

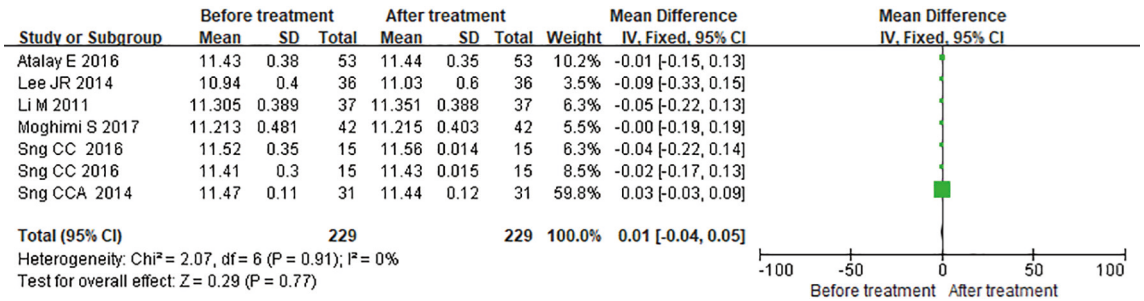

Figure 3 Comparison of ACW values. ACW, anterior chamber width; SD, standard deviation; CI, confidential interval.

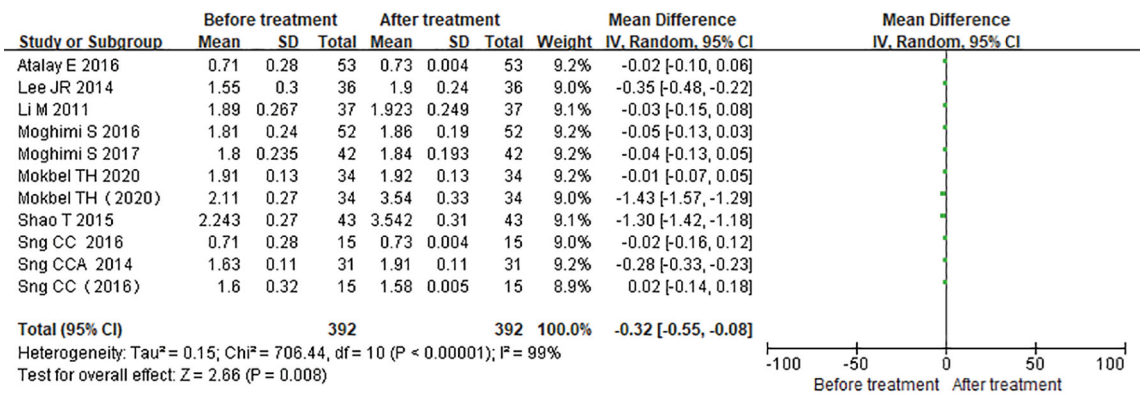

Figure 4 Comparison of ACD values. ACD, anterior chamber depth; SD, standard deviation; CI, confidential interval.

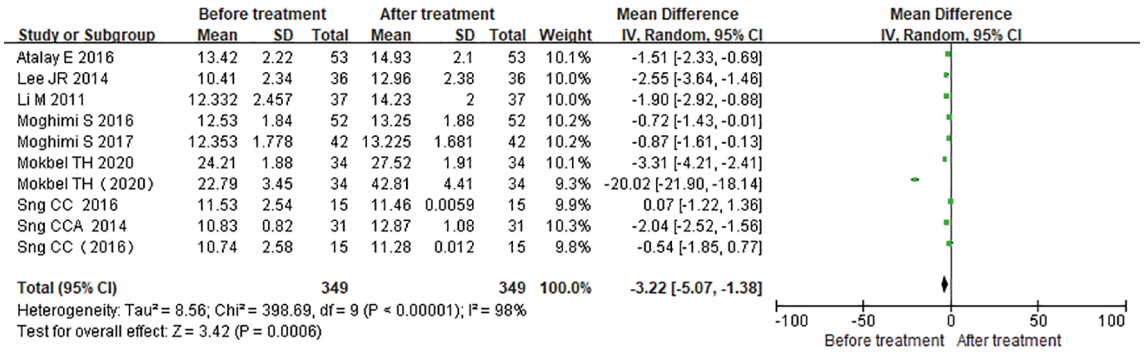

Figure 5 Comparison of ACA values. ACA, anterior chamber area; SD, standard deviation; CI, confidential interval.

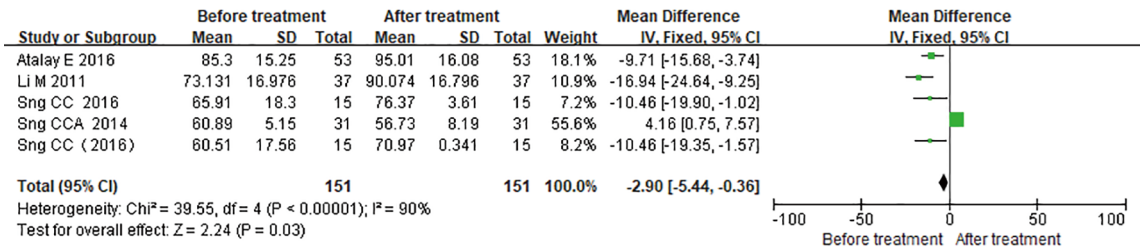

Figure 6 Comparison of ACV values. ACV, anterior chamber volume; SD, standard deviation; CI, confidential interval.

those before treatment; the difference was statistically significant (MD: –0.32, 95% CI: –0.55 to –0.08; Z=2.66, and P=0.008).

Comparison of ACA values

A statistical analysis of AACG patients' ACA values before and after treatment in 8 documents (see *Figure 5*) showed significant heterogeneity (I^2=98% and P<0.00001). The REM analysis results suggested that patients' ACA values after treatment with different methods was significantly higher than patients' ACA values before treatment (MD: –3.22, 95% CI: –5.07 to –1.38; Z=3.42, and P=0.0006).

Comparison of ACV values

As *Figure 6* shown, a statistical analysis of AACG patients' ACV values before and after treatment in 4 documents revealed that the changes in the ACV values of patients treated with different methods were heterogeneous (I^2=90% and P<0.00001). The REM analysis results indicated that patients' ACV values were higher after treatment with different methods than before treatment (MD: –2.90, 95% CI: –5.44 to –0.36; Z=2.24, and P=0.03).

Comparison of ARA values

The ARA values of AACG patients before and after treatment in 3 documents were analyzed and compared statistically; the results are set out in *Figure 7*. No obvious heterogeneity was found in the changes in the ARA values of patients treated with different methods (I^2=55% and P=0.11); thus, a REM analysis was adopted. The result showed that patients had higher ARA values after treatment than before treatment; the difference was statistically significant (MD: –0.03, 95% CI: –0.05 to –0.02; Z=4.10, and P<0.0001).

Comparison of LV values

The LV values of AACG patients before and after treatment in 6 documents were analyzed and compared statistically; the results are set out in *Figure 8*. There was remarkable heterogeneity in the changes in LV values of patients treated with different methods (I^2=62% and P=0.01). The REM results revealed no significant

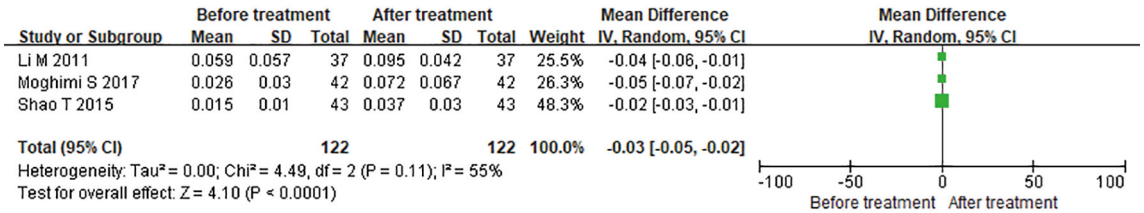

Figure 7 Comparison of ARA values. ARA, angle recess area; SD, standard deviation; CI, confidential interval.

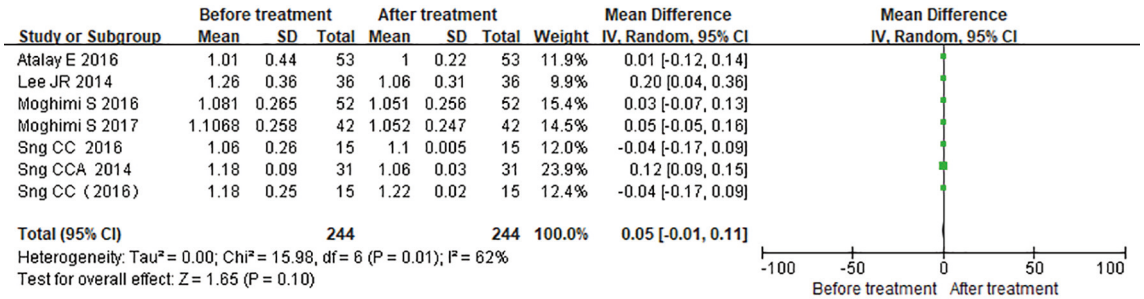

Figure 8 Comparison of LV values. LV, lens vault; SD, standard deviation; CI, confidential interval.

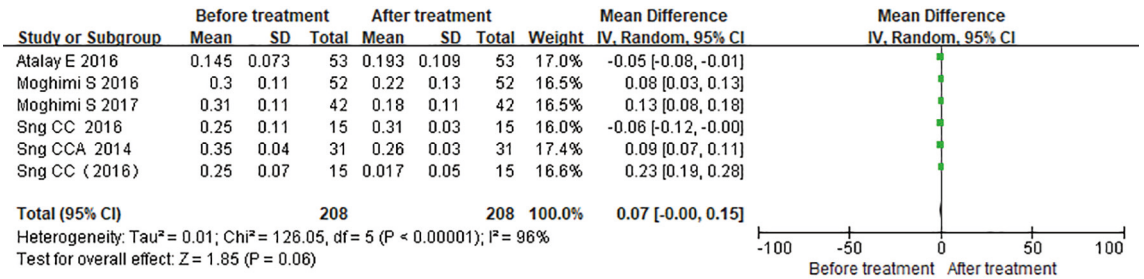

Figure 9 Comparison of I-Curve values. SD, standard deviation; CI, confidential interval.

difference in the LV values of patients treated with different treatment methods (MD: 0.05, 95% CI: –0.01 to 0.11; Z=1.65, and P=0.10).

Comparison of I-Curve values

The I-Curve values of AACG patients before and after treatment in 6 documents were analyzed and compared statistically; the results are set out in *Figure 9*. There was remarkable heterogeneity in the changes in the I-Curve values of patients treated with different methods (I^2=96% and P<0.00001). The REM results revealed no visible difference in the I-Curve values of patients treated with different methods (MD: 0.075, 95% CI: 0 to 0.15; Z=1.85, and P=0.06).

Comparison of I-Area values

As *Figure 10* shown, a statistical analysis of AACG patients' I-Area values before and after treatment in 5 documents showed visible heterogeneity in the changes in the I-Area values of patients treated with different methods (I^2=96% and P<0.00001); thus, a REM analysis was adopted. The results showed that the I-Area values of patients after different treatment methods were much lower than the I-Area values of patients before treatment; the difference between the two was significant (MD: 0.12, 95% CI: 0.04 to 0.19; Z=3.06, and P=0.002).

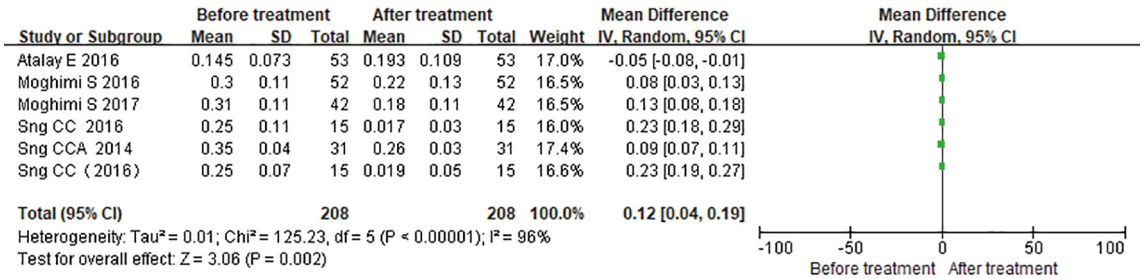

Figure 10 Comparison of I-Area values. SD, standard deviation; CI, confidential interval.

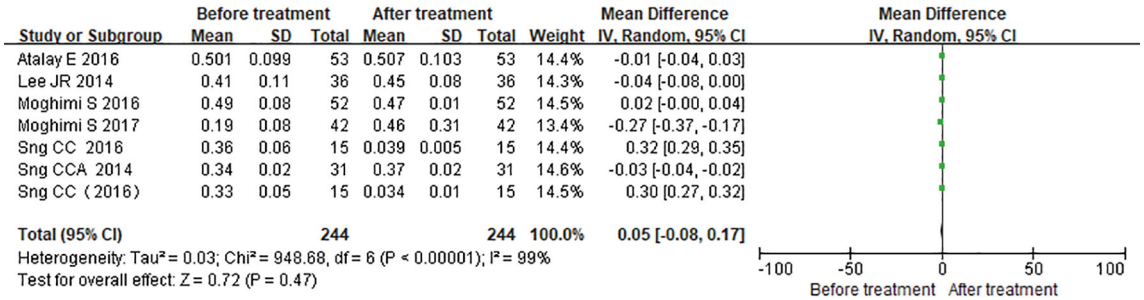

Figure 11 Comparison of IT750 values. IT, iris thickness; SD, standard deviation; CI, confidential interval.

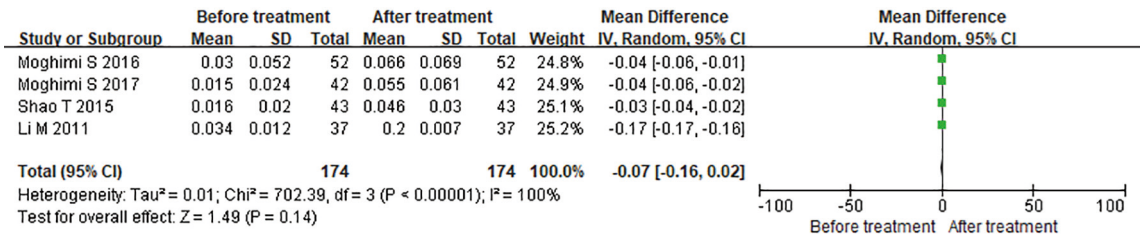

Figure 12 Comparison of AOD500 values. AOD, angle opening distance; SD, standard deviation; CI, confidential interval.

Comparison of IT750 values

As *Figure 11* shown, AACG patients' IT750 values before and after treatment in 5 documents showed great heterogeneity for patients treated with different methods (I^2=99% and P<0.00001). The REM results indicated that there was no great difference in the IT750 values of patients before and after different treatments (MD: 0.05, 95% CI: –0.08 to 0.17; Z=0.72, and P=0.47).

Comparison of AOD500 values

AACG patients' AOD500 values before and after treatment in 4 documents were analyzed and compared; the results are illustrated in *Figure 12*. The heterogeneity in the changes in the AOD500 values of patients before and after treatment with different methods was very visible (I^2=100% and P<0.00001). A standard error of the mean (SEM) analysis showed no difference in patients' AOD500 values before and after treatment with different methods (MD: –0.07, 95% CI: –0.16 to 0.02; Z=1.49, and P=0.14).

Comparison of AOD750 values

AACG patients' AOD750 values before and after treatment in 4 documents were analyzed and compared; the results are illustrated in *Figure 13*. The results showed that the

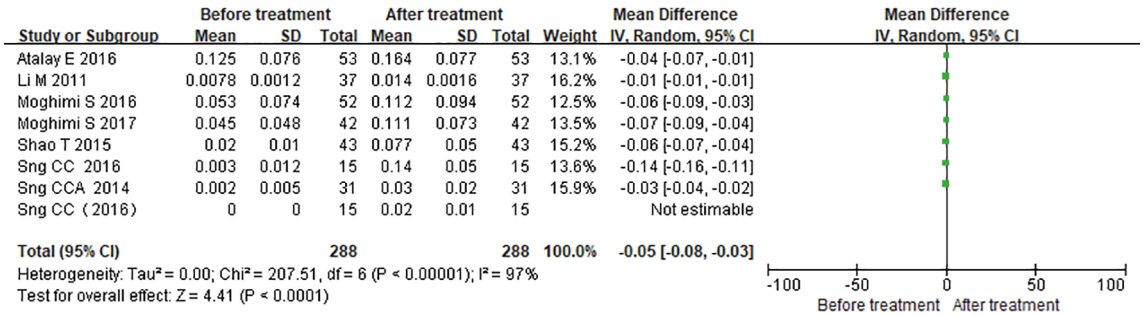

Figure 13 Comparison of AOD750 values. AOD, angle opening distance; SD, standard deviation; CI, confidential interval.

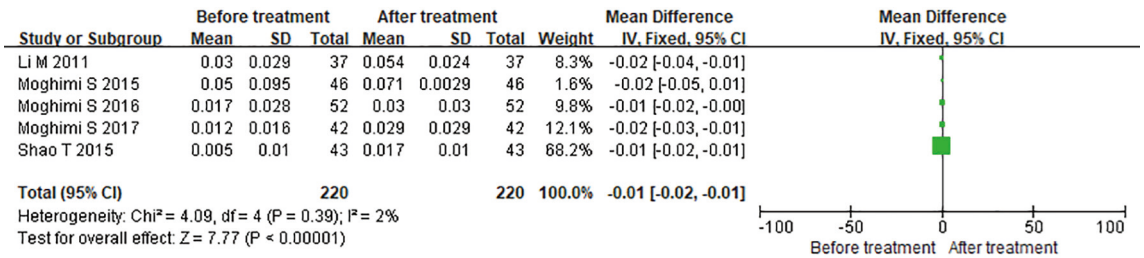

Figure 14 Comparison of TISA500 values. TISA, trabecular-iris space area; SD, standard deviation; CI, confidential interval.

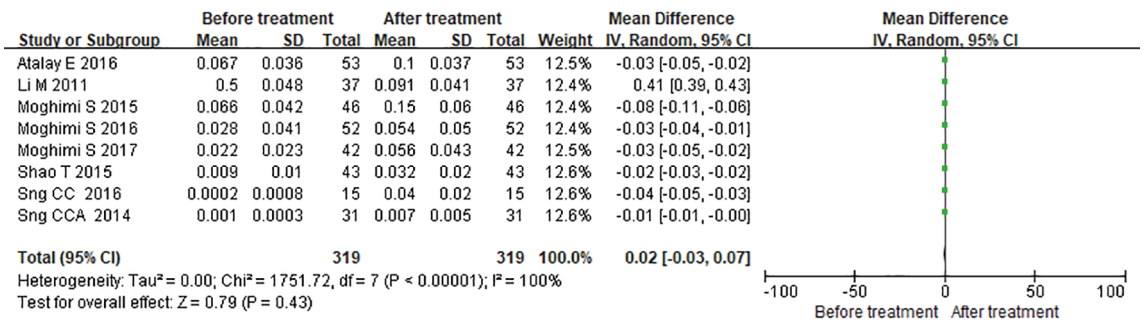

Figure 15 Comparison of TISA750 values. TISA, trabecular-iris space area; SD, standard deviation; CI, confidential interval.

heterogeneity in the changes in patients' AOD750 values before and after treatment with different methods was very visible (I^2=97% and P<0.00001). A SEM analysis showed that patients' AOD750 values were obviously higher after treatment with different methods than before treatment (MD: –0.05, 95% CI: –0.08 to 0.03; Z=4.41, and P<0.0001).

Comparison of TISA500 values

As *Figure 14* shown, the statistical analysis of AACG patients' TISA500 values before and after treatment in 5 documents revealed no notable heterogeneity in the changes in AACG patients' TISA500 treated with different methods (I^2=2% and P=0.39). The REM results showed that patients' TISA500 values after treatment with various methods increased significantly (MD: –0.01, 95% CI: –0.02 to –0.01; Z=7.77, and P<0.0001).

Comparison of TISA750 values

AACG patients' TISA750 values before and after treatment in 8 articles (see *Figure 15*) were compared, and obvious

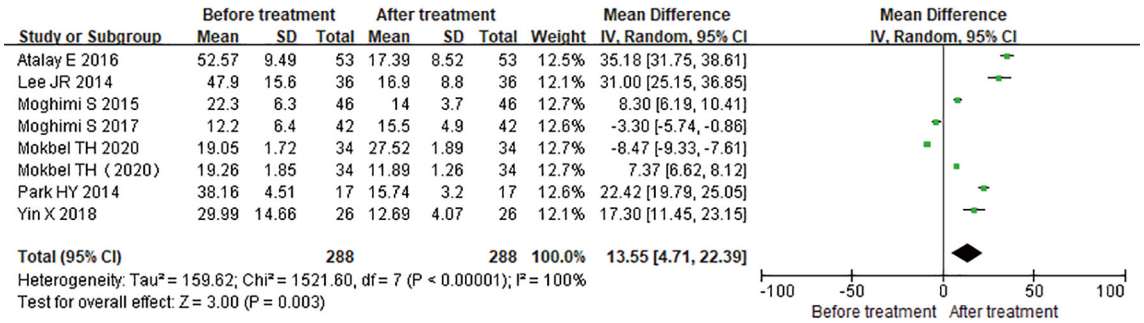

Figure 16 Comparison of IOP values. IOP, intraocular pressure; SD, standard deviation; CI, confidential interval.

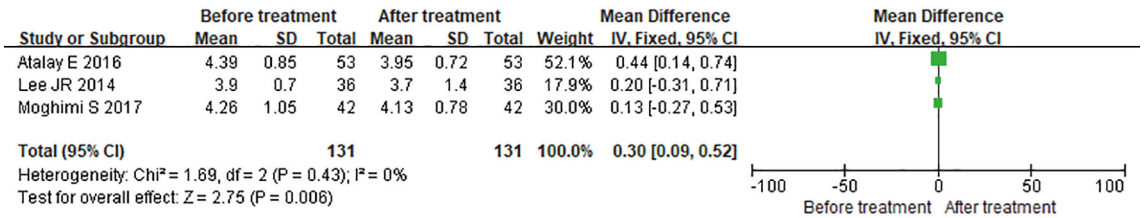

Figure 17 Comparison of PD values. PD, pupil diameter; SD, standard deviation; CI, confidential interval.

heterogeneity was found for patients treated with different methods (I^2=100% and P<0.0001). The REM results revealed a statistical difference in patients' TISA750 values after treatment with different methods compared to those before treatment (MD: 0.02, 95% CI: –0.03 to 0.07; Z=0.79, and P=0.43).

Comparison of IOP values

A statistical analysis of AACG patients' IOP values before and after treatment in 8 documents (*Figure 16*) revealed great heterogeneity in the IOP values of patients treated with different methods (I^2=100% and P<0.0001); thus, a REM analysis was adopted. The results showed that patients' IOP values were much lower after different treatments than before treatment, and the difference was significant (MD: 13.55, 95% CI: 4.71 to 22.39; Z=3, and P=0.003).

Comparison of PD values

A statistical analysis of AACG patients' PD values before and after treatment in 3 documents (see *Figure 17*) revealed great heterogeneity (I^2=0 and P=0.43); thus, a REM analysis was adopted. The results showed that patients' PD values after treatment with different methods decreased significantly compared with those before treatment, showing statistically obvious difference (MD: 0.30, 95% CI: 0.09 to 0.529; Z=2.75, and P=0.006).

Discussion

AACG is an eye disease characterized by a sharp increase in IOP accompanied by corresponding symptoms and changes in the anterior segment of the eye. It is more common in elderly people aged over 50 years than younger people, and is more common in women than men. The ratio AACG among males and females is about 1:2. AACG is often accompanied by hyperopia, and the onset in both eyes can occur sequentially or simultaneously (22). Emotional agitation, dim light, local, or systemic application of anticholinergic drugs can cause pupil dilation and induce this disease (23). Prolonged reading, pain, and fatigue are also common causes of AACG (24). Simple peripheral iris resection is an intraocular drainage surgery that mainly aims to reduce IOP. However, this surgical method is not suitable for with features such as ciliary hypertrophy, anterior, and/or iris root hypertrophy, and an anterior attachment point, as it fails to solve the continued closure of the angle of the chamber and the continued rise of IOP (25). Trab is a classic

anti-glaucoma surgery method. It is suitable for patients with ADC ≥180° and patients with loss or decline of trabecular meshwork function. The effect of lowering IOP is good, but the incidence of postoperative complications is high (26). OCT can directly image the lens, the measured lens thickness, and the relative position of the lens more objectively (27).

In this study, 12 clinical studies on OCT-based AACG treatments were included in a meta-analysis to analyze changes in OCT detection–related indicators before and after treatment with different treatment methods. The results showed that patients' values of ACD, I-Area, IOP, and PD after treatment were lower than those before treatment, and the values of ACA, ACV, ARA, AOD750, and TISA500 were more elevated after treatment than before treatment. In addition, there were no obvious changes in ACW, LV, I-Curve, IT750, AOD50, and TISA750 values before and after treatment. These results indicate that different treatment methods had little effects on changes in ACW, LV, I-Curve, IT750, AOD50, and TISA750 values after treatment.

Conclusions

In this study, meta-analysis was adopted to analyze the application of OCT in the treatment of AACG. The changes in OCT detection indicators before and after treatment were compared with those of different treatment methods to analyze the changes in related parameters of the OCT-based AACG. The results showed that the ACD, I-Area, IOP, PD, ACA, ACV, ARA, AOD750, and TISA500 values of patients with AACG treated with different methods had significant changes compared with those before treatment. However, the values of ACW, LV, I-Curve, IT750, AOD50, and TISA750 were not different from those before treatment. It should be noted that this study had some shortcomings. Notably, it failed to compare different methods and indicators with a control group. However, the results of this study still provide a reliable theoretical basis for the evaluation on OCT-based AACG treatments.

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Footnote

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