Effect of capsular tension ring on optical and multifunctional lens position outcomes: a systematic review and a Meta-analysis

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Abstract

AIM: To evaluate the effect of capsular tension rings with multifunctional lens position and optical outcomes.

METHODS: We defined multifunctional lens more than improve vision, but also restore visual quality. Search of PubMed, EMBASE, Cochrane Library, Scopus for English-language articles published up to November 11, 2020. Randomized controlled trials and comparative prospective clinical trials were selected. Data extraction was completed by independent pairs of reviewers. Risk of bias was evaluated using the Cochrane Collaboration risk of bias tool for RCTs and select items from the Newcastle-Ottawa Scale for comparative prospective clinical trials.

RESULTS: a total of 5 randomized controlled trials and 6 prospective comparative clinical trials were included. Evaluating 1099 eyes of implantation intraocular lens. Capsular tension ring was helpful associated in un-corrected distance visual acuity (SMD: 0.54, 95%CI=0.15 to 0.94, P=0.829) in 1st month. Contrary to 1st month, no show positive effect in 3rd month un-corrected distance visual acuity (SMD: -0.30, 95%CI=-0.70 to -0.10, P=0.311), corrected distance visual acuity (SMD: 0.02, 95%CI=-0.78 to 0.81, P<0.001), sphere (SMD: 0.44, 95%CI=-0.43 to 1.31, P<0.001), cylinder (SMD: -0.12, 95%CI=-0.36 to 0.13, P=0.262), and spherical equivalent (SMD: 0.41, 95%CI=0.13 to 0.69, P=0.084). Our study also revealed low correlation between capsular tension ring and postoperative optical outcome with un-corrected distance visual acuity (SMD: 0.43, 95%CI=-0.69 to 1.56, P=0.001), corrected distance visual acuity (SMD: -0.11, 95%CI=-0.43 to 0.20, P=0.56), sphere (SMD: -0.26, 95%CI=-1.18 to 0.66, P=0.005), cylinder (SMD: 0.10, 95%CI=-0.39 to 0.59, P=0.075), spherical equivalent (SMD: 0.22, 95%CI=-0.10 to 0.54, P=0.849) in 6th month. The position of intraocular lens co-implantation with capsular tension ring was no significantly difference in 1st week with lens decentration (SMD: -0.34, 95%CI=-1.19 to 0.51, P=0.038) and tilt (SMD: -1.00, 95%CI=-2.19 to 0.19, P=0.007), but capsular tension ring is helpful to prevent lens tilt in 1st month (SMD: -0.67, 95%CI=-1.08 to 0.27, P=0.323). In 3rd month, no significant difference between two groups in lens rotation (SMD: -0.51, 95%CI=-1.71 to 0.69, P<0.001).

CONCLUSION: The correlation is low between capsular tension ring and postoperative optical outcomes and lens position, based on small numbers of studies in a short range of follow-up.

Introduction

Lens misalignment is a major factor responsible for suboptimal visual outcomes after intraocular lens implantation[1]. Perfect centration of the multifocal lens is crucial to their optimum optical functioning and prevent the problems related to intraocular lens decentration and tilt[2]. Capsular tension rings play a role in the stability and position of the multifocal lens and may prevent intraocular lens rotation caused by capsular bag contraction, thus providing good centration[3]. But some studies proved using capsular tension ring had no significant effect on refractive stability[4]. Variety of multifunctional intraocular lens has to add the element of refractive correction and the ability for patients to higher visual quality.

In this systematic review and meta-analysis, we aim to combine all published capsular tension rings co-implantation multifunctional intraocular lens clinical trials to evaluate the effects of capsular tension rings on optical outcomes and position of multifunctional of intraocular lens across un-corrected distance visual acuity, corrected distance visual acuity, sphere, cylinder, spherical equivalent, de-centration of the lens, the tilt of intraocular lens.

Materials And Methods

This Meta-analysis was performed under the Preferred Reporting Items for Systematic Review and Meta-Analysis Statement[5].

Cochrane Library, PubMed and EMBASE database were systematically researched to screen all relevant studies published up to November 11, 2020. Mesh terms was no retrieved, intraocular lens, capsular tension ring, and capsular tension rings were searched as free terms. Additional potential articles were screened by reference lists of selected studies.

Selection criteria

1. study that lens implantation includes cataract surgery.

2. prospective comparative clinical trials, or randomized controlled trials.
3. with capsular tension ring as the experimental group, without capsular tension ring as control.

Excluded criteria

1. Retrospective studies.
2. Studies not evaluated optical outcomes and multifunctional lens positions.
3. Do not have control group studies.
4. The publications were abstracts, reviews, editorials, corresponding letters, comments.

Data Extraction and Quality Assessment

Data extraction was completed by independent pairs of reviewers (Tangshou Xie, Xi Liu). Extracted the following data: general characteristics (the first author, publication year, region of study), clinical outcomes (un-corrected distance visual acuity, corrected distance visual acuity, sphere, cylinder, spherical equivalent), and lens position (de-centration, tilt, rotation). The discrepancy was resolved through discussion or consultation with a third reviewer (Xiuyun Li). Risk of bias was evaluated using the Cochrane Collaboration risk of bias tool for randomized controlled trials and select items from the Newcastle-Ottawa Scale for comparative prospective clinical trials. Newcastle-Ottawa Scale score ≥ 6 were considered as high quality.

Statistical Analysis

Heterogeneity between trials was tested by Chi-square and I^2 statistics tests. $P < 0.1$ and $I^2 > 50\%$ indicated significant heterogeneity between studies, and then the random-effect model was used; otherwise, a fixed-effects model was adopted.

A standardized mean difference (SMD) for continuous variables and corresponding 95% confidence intervals (CIs) were estimated as a measure of effect size. Egger's test was used to assess the possible publication bias for continuous variables, $p < 0.05$ was considered to be statistically significant. Meta-analysis was conducted by Stata 14.0 software (STATA Corporation, College Station, TX, USA).

Results

Descriptions of Studies

The strategy of this Meta-analysis followed the literature research (Figure 1). 5 randomized controlled trials[6-10] and 6 comparative prospective clinical trials[4, 11-15] were included. 4 articles implanted Toric lens, 1 article implanted Chiron Vision IOL, 1 article implanted AcrySof IOL, 1 article implanted Acri.Lisa 366D IOL, 1 article implanted multifocal Lentis Mplus LS-312 IOL, 1 article implanted Tecnis ZCB00, 1 article implanted acrylic IOL, 1 article implanted POD FT lens,

Table 1 shows the characteristics of optical outcomes in selected trials

Table 1 characteristics of optical outcomes in selected trials(M±SD) ^[1]											
Author/deadline	UDVA(logMAR)		CDVA(logMAR)		sphere(D ^[2])		cylinder(D)		SE(D)		
	CTR ^[3]	+IOL ^[4]	IOL	CTR+IOL	IOL	CTR+IOL	IOL	CTR+IOL	IOL	CTR+IOL	IOL
park/1 st month	0.11±0.02		0.10±0.02	0.05±0.01	0.03±0.01	0.01±0.10	-0.07±0.10	-0.45±0.11	-0.40±0.11	-0.21±0.11	-0.29±0.11
park/3 rd month	0.09±0.02		0.10±0.02	0.03±0.01	0.02±0.01	0.07±0.10	-0.07±0.10	-0.48±0.10	-0.42±0.10	-0.17±0.10	-0.27±0.10
Rastogi/1 st month	0.25±0.08		0.20±0.09	unclear	unclear	unclear	unclear	unclear	unclear	unclear	unclear
Rastogi/3 rd month	0.20±0.11		0.21±0.10	unclear	unclear	unclear	unclear	unclear	unclear	unclear	unclear
Alió /3 rd month	0.19±0.28		0.15±0.21	0.02±0.06	0.05±0.1	-0.16±1.01	-0.01±0.64	0.53±0.46	0.45±0.71	-0.1±1.06	-0.23±0.75
Hahn/3 rd month	unclear		unclear	0.02±0.04	0.03±0.07	unclear	unclear	0.59±0.49	0.64±0.48	unclear	unclear
Nistad /3 rd month	unclear		unclear	unclear	unclear	unclear	unclear	unclear	unclear	0.331±0.461	0.123±0.442
Nistad /3 rd month	unclear		unclear	unclear	unclear	unclear	unclear	unclear	unclear	-0.016±0.037	-0.09±0.39
Weber/3 rd month	unclear		unclear	unclear	unclear	-1.11±0.76	-1.24±0.75	0.82 ±0.76	0.89 ±0.65	-0.70 ±0.58	-0.81 ±0.81
Zhao/6 th month	unclear		unclear	unclear	unclear	unclear	unclear	-0.50±0.25	-	unclear	unclear
Alió /6 th month	0.13±0.02		0.11±0.02	0.01±0.08	0.02±0.01	0.12±0.55	0.53±0.58	-0.59±0.52	1.25±0.33 -0.53±0.51	-0.18± 0.6	-0.31 ± 0.45
Vokrojová /6 th month	0.09±0.14		0.11±0.13	0.04±0.07	0.04±0.07	0.38±0.80	0.23±0.57	-0.45±0.77	-0.36±0.40	0.15 ± 0.57	0.05 ± 0.52

[1] mean standard deviation

[2] diopter

[3] Capsular Tension Ring group

[4] Intraocular lens group

Table 2 shows the characteristics of the lens position in the selected trials.

Table 2 characteristics of the lens position in the selected trials

Author/deadline	decentration(mm)		tilt(degree)		rotation(degree)	
	CTR+IOL	IOL	CTR+IOL	IOL	CTR+IOL	IOL
park/1 week	0.38±0.16	0.49±0.11	2.22±0.46	3.14±0.65	unclear	unclear
park/1 month	0.43±0.15	0.53±0.14	2.36±0.50	2.91±0.67	unclear	unclear
Alió/1week	0.26±0.18	0.25±0.11	2.30±1.34	2.99±1.89	unclear	unclear
Alió/1month	0.28±0.18	0.24±0.13	2.1±1.63	2.91±1.54	unclear	unclear
Hahn/3 month	unclear	unclear	unclear	unclear	2.07±2.09	1.92±1.82
Rastogi/3month	unclear	unclear	unclear	unclear	1.85±1.72	4.02±2.04

Table 3 shows the quality of randomized controlled trials by Cochrane Collaboration Risk of BiasTool.

Table 3 assessment of randomized controlled trials

Year	region	Sequence Generation	Allocation Concealment	Blindness of Participants	Imcomplete Outcome Data	Selective Outcome Reporting	Other Bias
2012	Sapin	yes	yes	unkonwn	yes	no	yes
2015	Austria	yes	yes	yes	yes	no	no
2020	India	unkonwn	unkonwn	unkonwn	yes	no	no
2019	Germany	unkonwn	unkonwn	unkonwn	unkonwn	no	unkonwn
2016	Korea	yes	yes	yes	yes	no	no

Table 4 shows the Newcastle-Ottawa Scale score of prospective comparative of clinical trials.

Table 4 quality assessment of prospective comparative of clinical trials

author	region	published year	type of trial	Newcastle-Ottawa-Scale		
				selection	comparability	outcome
Zhao	China	2016	PCCT ^[5]	□□	□□	□□
Lee	Korea	2002	PCCT	□□□	□□	□□
Alió	Spain	2008	PCCT	□□□	□□	□□
Vokrojová	Czech	2020	PCCT	□□□	□□	□□
Nistad	Sweden	2017	PCCT	□□	□□	□□
Cheon	Korea	2000	PCCT	□□□	□□	□□

[5] prospective comparative of clinical trials

Postoperative Optical Outcomes

Un-corrected distance visual acuity

Four trials[8, 10, 13, 14] were pooled. We analysis the subgroup data by follow-up time with a random-effect model. In the 1st month, capsular tension ring group have better performance (SMD: 0.54, 95%CI = 0.15 to 0.94, P = 0.829); 3rd month (SMD: -0.30, 95%CI = -0.70 to -0.10, P = 0.311) and 6th month (SMD: 0.43, 95%CI = -0.69 to 1.56, P = 0.001) show do difference in two groups.(Figure2)

Corrected distance visual acuity

Five trials[6, 9, 10, 13, 14] were pooled. Analysis mode is random-effect model, define subgroup by follow-up time. Only one trial recorded the data of 1st month so we cannot get the synthesis result. No significant difference of two groups in 3rd month (SMD: 0.02, 95%CI = -0.78 to 0.81, P<0.001) and 6th month (SMD: -0.11, 95%CI = -0.43 to 0.20, P = 0.56). (Figure 3)

Sphere

Five studies[6, 7, 10, 13, 14] were pooled, and just one trial record the outcomes in 1st month, so we failure to analysis. Analysis mode is a random-effect model, define subgroup by follow-up time. Experiment group show no positive effect in 3rd month (SMD: 0.44, 95%CI = -0.43 to 1.31, P<0.001) and 6th month (SMD: -0.26, 95%CI = -1.18 to 0.66, P = 0.005). (Figure 4)

Cylinder

Analysis mode is a random-effect model, define subgroup by follow-up time. Seven trials[6, 7, 9-11, 13, 14] were included. We just analysis the 3rd month and 6th month statistics because of only one trial record the data, which this trial shows no benefit in the capsular tension ring group. No difference found between two groups in 3rd month (SMD: -0.12, 95%CI = -0.36 to 0.13, P = 0.262) and 6th month (SMD: 0.10, 95%CI = -0.39 to 0.59, P = 0.075). (Figure 5)

Sphere equivalent

Five trials[4, 6, 10, 13, 14] were analysis with the random-effect model by the subgroup of follow-up time. We analysis outcomes of 3rd and 6th month, just because of only one trial record the sphere equivalent data. In 3rd month (SMD: 0.41, 95%CI = 0.13 to 0.69, P = 0.084), experimental group show positive effect, but no benefit in 6th month (SMD: 0.22, 95%CI = -0.10 to 0.54, P = 0.849). (Figure6)

Position of lens

Just two trials[12, 15] were pooled to analysis with lens de-centration and tilt. We only synthesis statistics of 1st week and 1st month. Analysis mode is the random-effect model, define subgroup by follow-up time.

In de-centration of lens, capsular tension rings group show low relationship compare to control group in 1st week (SMD: -0.34 , 95%CI = -1.19 to 0.51 , $P = 0.038$) and 1st month (SMD: -0.20 , 95%CI = -1.12 to 0.73 , $P = 0.023$). (Figure 7) In lens tilt analysis, 1st week (SMD: -1.00 , 95%CI = -2.19 to 0.19 , $P = 0.007$) show capsular tension ring is useless to prevent lens tilt, but in 1st month (SMD: -0.67 , 95%CI = -1.08 to 0.27 , $P = 0.323$), the capsular tension ring is helpful. Because of a small sample and short range of follow-up, the result should assess carefully. (Figure 8) Only two randomized controlled trials[8, 9] of small sample size reported the data of lens rotation in 3rd month. The result is no significant difference between two groups, the result should assess carefully. (SMD: -0.51 , 95%CI = -1.71 to 0.69 , $P < 0.001$). (Figure 9)

Publication Bias

Egger's test showed no significant difference in optical outcomes ($P = 0.084$), (Figure10) but indicated significant publication bias in lens position ($P = 0.005$). (Figure 11)

Discussion

This Meta-analysis, based on 5 randomized controlled trials and 6 comparative prospective clinical trials, shows that capsular tension rings have no significant effect in intraocular lens with un-corrected distance visual acuity, corrected distance visual acuity, sphere, cylinder, and spherical equivalent.

Our analysis confirms the capsular tension rings have un-sufficient effect in the intraocular lens in 3rd month, and 6th month with optical outcomes, in 1st month, without sufficient data, we only prove the same result with un-corrective distance visual acuity. Boomer and Jackson found no statistical significance refractive errors in small case-controlled series in 2006 [16]. Another study showed that capsular tension rings have no benefit in the optical quality in pseudophakic eyes[17]. These are consistent with our analysis. A randomized controlled trial of 60 eyes demonstrated that capsular tension rings co-implantation with diffractive multifocal intraocular lens reduce the ocular wavefront error[18].

We just pooled 2 prospective comparative clinical trials in short-range with small samples ($n=140$) on monitor lens position by decentration and tilt. Results of the analysis show capsular tension ring group($n=70$) less degree of lens tilt only in 1st month, alternately, the degree of lens decentration and tilt are no significant difference in 1st week and 1st month. Monitor 360 days on 60eyes ($n=60$), a randomized controlled trials showed no benefits in decentration and tilt of co-implantation capsular tension rings group($n=30$) [18]. By synthesis two small sample randomized controlled trials ($n=189$), we only analyzed the toric intraocular lens rotation and shows no significant difference between two groups on 3rd month. A study reported 6 cases of high myopia with more than 20 degrees of postoperative rotation[19]. One important step using the toric intraocular lens is complete to remove the bed of ophthalmic visco-surgical device that lies beneath the implanted intraocular lens along with removing the ophthalmic visco-surgical device anterior the intraocular lens[20].

Thus, this Meta-analysis originally focuses on the optical and lens position outcomes of capsular tension rings in the pseudophakic eyes. The capsular tension ring is a PMMA open-ring device implantation to enhance capsular bag and avoid shrinkage, and the diameter of capsular tension ring is greater than the capsular diameter in physiological condition, in our knowledge, after intraocular lens implantation, the capsular bag is bigger diameter and flatter shape. In this situation, the capsular bag is more unstable and easier waggle with or without capsular tension ring.

A cross-sectional study ($n=196$ eyes) shows pars plana vitrectomy and short axial length was associated with greater intraocular lens tilt, whereas longer axial length, thicker lens, and overlarge capsulorhexis contribute greater intraocular lens decentration[21]. Another study also shows similar results either multifocal or monofocal lens[22]. Our study reveals optical outcomes have a low correlation to lens decentration and tilt with capsular tension rings in 1st month postoperatively. According to this, flatter capsular bag and synchysis maybe the main reason for lens decentration and tilt.

Limits

This meta-analysis pooled randomized controlled trials and prospective comparative clinical trials may introduce unavoidable bias. The definition of multifunctional is one of bias of results. All studies assessed in short term effectiveness and follow-up time was different among studies. Species of lens are not identical in included trials. Egger's test suggested the presence of a potential publication bias, a language bias, inflated estimates by a flawed methodologic design in smaller studies, and/or a lack of publication of small trials with opposite results. The sample size of selected studies was relatively small, which still need more long term, multicenter, randomized prospective trials to find the effect of capsular tension rings in lens position and optical outcome.

Conclusion

Based on short term clinical outcomes, capsular tension rings have a low relationship in optical outcome and lens position, meanwhile, this conclusion based on small samples.

Declarations

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Figures

PRISMA 2009 Flow Diagram

Figure 1

PRISMA flow diagram

Figure 2

Forest plot of UDVA(logMAR). Legends: UDVA: Un-corrected Distance Visual Acuity

Figure 3

Forest plot of CDVA(logMAR). Legends: UDVA: Corrected Distance Visual Acuity

Figure 4

Forest plot of Sphere(D). Legends: D: Diopter

Figure 5

Forest plot of Cylinder(D). Legends: D: Diopter

Figure 6

Forest plot of SE(D). Legends: SE: Spherical Equivalent, D: Diopter

Figure 7

Forest plot of IOL decentration (mm). Legends: mm: millimeter

Figure 8

Forest plot of IOL tilt (D). Legends: IOL: Intraocular Lens, D: Degree

Figure 9

Forest plot of IOL rotation (D). Legends: IOL: Intraocular Lens, D: Degree

Figure 10

Publication bias of optical outcomes. Legends: A: Un-corrected Distance Visual Acuity, B: Corrected Distance Visual Acuity, C: Sphere, D: Cylinder, E: Spherical Equivalent

Figure 11

Publication bias of IOL position. Legends: A: decentration, B: tilt, C: rotation

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