

Acute Surgical vs. Non-surgical Management for Ocular and Peri-ocular Burns: Oculoplastic Systematic Review and Meta-analysis Kevin M. Klifto, PharmD; Ala Elhelali, PhD; Caresse F. Gurno, BA, BS; Stella M. Seal, MLS; Mohammed Asif, MD; C. Scott Hultman, MD, MBA

ABSTRACT

Summary

Burn related injury to the face involving the structures of the eyes, eyelids, eyelashes, and/or eyebrows could result in multiple reconstructive procedures to improve functional and cosmetic outcomes, and correct complications following poor acute phase management. This systematic review and metaanalysis compared 272 surgical to 535 non-surgical interventions within one month of patients suffering burn-related injuries to 465 eyes, 253 eyelids, 90 eyelashes, and 0 eyebrows and evaluated associated outcomes and complications. The PubMed, EMBASE, Cochrane Library, Web of Science, and Scopus databases were systematically and independently searched. Patient and clinical characteristics, surgical and medical interventions, outcomes and complications were recorded. Eight of the 14927 studies queried for this study were eligible for the systematic review and meta-analysis, with results from 33 of the possible 58 outcomes and complications using PRISMA and Cochrane guidelines. In conclusion, this systematic review and meta-analysis found that compared to non-surgical interventions, acute surgical interventions for ocular, eyelid, and/or eyelash burns were found to have greater visual acuity on follow-up, shorter epithelial defect diameters on follow-up, greater changes in epithelial diameters from baseline, smaller epithelial defect areas on follow-up, greater changes in epithelial defect areas from baseline, greater numbers of healed epithelial defects, more keratitis infections, and a greater reduction in limbal ischemia, possibility preventing the need of a future limbal stem cell transplantation.

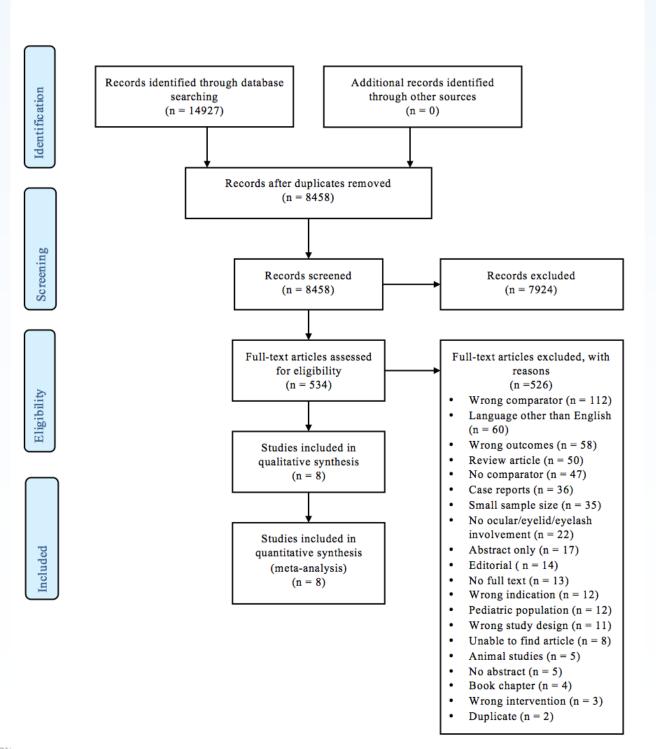
INTRODUCTION

Burn related injury to the face involving the structures of the eyes, eyelids, eyelashes, and/or eyebrows could result in multiple reconstructive procedures to improve functional and cosmetic outcomes, and correct complications following poor acute phase management. Burn injury to ocular structures requires patient transfer to specialized burn centers, where early evaluation by an oculoplastic surgeon may prevent long-term morbidity.¹ The majority of ocular burns do not require surgical interventions and rates of long-term morbidity have been reported as low as 4.5% with medical management alone. ²⁻⁴ Prior associated risk factors identified for surgical interventions after ocular burns have been deep eyelid burns, flame burns, increasing severity of corneal injuries, periorbital edema, visual loss on presentation, and keratitis.²

This new systematic review and meta-analysis compared surgical to nonsurgical interventions within one month of patients suffering burn-related injuries to the eyes, eyelids, eyelashes, and/or eyebrows. This review is an attempt to organize the literature to create a uniform set of data for clinical interpretation and management to optimize outcomes and minimize complications. Based on peer-reviewed literature, it was hypothesized that early surgical interventions for severe burn-related injury to the eye, eyelid, eyelash, and/or eyebrow would result in better patient-related outcomes and lower risks of complications, compared to non-surgical interventions alone.

MATERIAL AND METHODS

Figure 1. PRISMA flow chart summarizes the results of the screening process and final article selections.

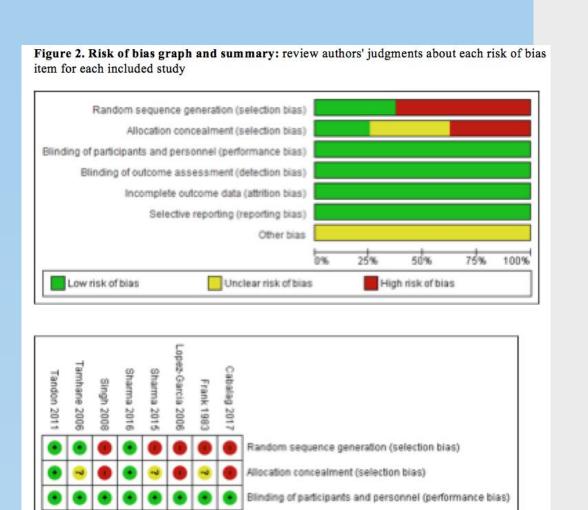


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RESULTS

•Results and Risk of Bias of Individual Studies

Table 1 summarizes the years, study designs, sample sizes, burn etiologies, group characteristics, burn depth classifications, outcomes, and complications assessed by each individual study from the 8 articles included in our study. Tables 2-3 summarize the details for outcomes and complications of interest assessed for each individual study. All seven risks of bias domains were assessed for each study using the Cochrane risk of bias tool (Figure 2).



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🕒 🕒 🕒 🕒 🕒 🕒 🕒 🕒 Incomplete outcome data (attrition bias)

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🔫 🔫 🤜 🔫 号 号 Other bias

Study Selection and Characteristics

The search resulted in 14927 citations; after removing 6469 duplicates, 8458 unique citations remained. Following title/abstract review, 534 articles were eligible for full-text review. Following full-text review, 8 articles were eligible and included in the systematic review (Table 1). ^{2,14-20} All 8 articles were eligible for final data extraction and meta-analysis (Figure 1).

The 8 studies included in the systematic review were published from 1983 through 2017 (Table 1). A total of 465 eyes, 253 eyelids, 90 eyelashes and 0 eyebrows were reported in 271 males and 102 females evaluated within one month of burn-related injury. Surgery was performed in 182/465 eyes, 75/253 eyelids, and 15/90 eyelashes. These 272 surgical cases were compared to 535 non-surgical cases. The most reported anatomical structure was the eye (7/8 studies), $^{2,15-20}$ surgical intervention was AMT (5/8 studies), ^{15-17,19,20} outcome was visual acuity on initial evaluation and at follow-up (5/8 studies), ^{15,16,18-20} and complication was corneal vascularization at follow-up (6/8 studies). ¹⁵⁻²⁰ The eyebrow was reported in 0/8 studies. There were three RCTs, ^{17,19,20} one prospective cohort, ¹⁵ and four retrospective cohort studies, ^{2,14,16,18} published in English. Five studies were performed in India, ¹⁶⁻²⁰ one in Spain, ¹⁵ one in Australia, ² and one in the United States.¹⁴

Classification of burns

The following data for eyelid and eyelash burns was totaled for burn depth: Surgery 3 SPT, ² 9 DPT, ² 5 FT, ² 32 DPT/FT. ^{2,14} No surgery: 60 DPT. ¹⁴ The following data for ocular burns was totaled after conversion of Roper-Hall to Dua's burn classification: Surgery: 17 Grade II, ^{18,20} 57 Grade III, ^{15-18,20} 9 Grade II/III, ¹⁹ 42 Grade IV, ^{15-17,20} 18 Grade V, ^{16,17,20} 11 Grade VI, ²⁰ 31 Grade IV/V/VI.^{18,19} No surgery: 17 Grade II, ^{18,20} 63 Grade III, ^{15-18,20}15 Grade II/III, ¹⁹ 22 Grade IV, ^{15-17,20} 14 Grade V, ^{16,17,20} 11 Grade VI, ²⁰ 29 Grade IV/V/VI.^{18,19}

uthor	Year	Design	Sample size	Etiology	Group Characteristics	Burn classification	Outcomes	Complications
ink et al.	1983	Retrospective cohort	92	•	 Eyelid surgery Eyelid no surgery 	• DPT • FT	•	 Corneal ulceration Vision loss Ectropian Eye perforation
mhane et al.	2005	Prospective, randomized trial	44	 Thermal Acid Alkali 	 Eye surgery Eye no surgery 	Dua's grade II-VI	 Visual acuity Pain Epithelial defect area Schirmer TBUT 	 Wound/ocular infection Symblepharon Corneal vascularization
pez-Garcia et	2006	Prospective cohort	24	 Alkali 	 Eye surgery Eye no surgery 	Dua's grade III, IV	 Visual acuity 	 Corneal ulceration Corneal vascularization
igh et al.	2008	Retrospective cohort	100	 Acid Alkali Chemical 	Eye surgeryEye no surgery	 Dua's grade II-VI 	Visual acuity Corneal haze	 Symblepharon Corneal vascularization
ndon et al.	2011	Prospective, randomized trial	153	 Thermal Acid Alkali 	 Eyelid surgery Eyelid no surgery Eye surgery Eye no surgery 	• Dua's grade II, III	 Time to management Visual acuity Corneal haze Epithelial defect area Time to epithelialization Limbal ischemia 	 Symblepharon Corneal vascularization
rma et al.	2015	Retrospective cohort	28	 Acid Alkali 	 Eye surgery Eye no surgery 	• Dua's grade III-V	 Time to management Visual acuity Corneal haze Epithelial defect diameter Epithelial defect area Schirmer TBUT Time to epithelialization Healed epithelial defect 	 Symblepharon Entropian Ectropian Corneal vascularization
ırma et al.	2016	Prospective, randomized trial	30	 Acid Alkali 	 Eye surgery Eye no surgery 	• Dua's grade III-V	Time to management Pain Corneal haze Epithelial defect diameter Epithelial defect area Schirmer TBUT Time to epithelialization Healed epithelial defect Limbal ischemia	 Symblepharon Corneal vascularization
alag et al.	2017	Retrospective cohort	326	 Thermal Chemical 	 Eyelid surgery Eyelid no surgery Eye surgery Eye no surgery Eyelash surgery Eyelash no surgery 	 SPT DPT FT Dua's grade I, II 	 %TBSA Time to management LOS Rate of intubation Inhalation injury 	 Wound/ocular infection Eyelid contracture Corneal ulceration Vision loss Ectropian

Surgical intervention Mean ages ranged from 18 to 41.8 years. Studies that reported sex had significantly more males (RR: 3.32, 95% CI: 1.18, 9.35, I² = 88%, p = 0.02).^{2,18-20} The most common surgery performed for acute ocular burns was AMT for 115 eyes in 5/8 studies, ¹⁵⁻ ^{17,19,20} followed by DALK for 50 eyes in 1/8 studies.¹⁸ The most common surgery for acute eyelid burns was a full-thickness skin graft for 44 eyelids in 2/8 studies, ^{14,17} followed by tarsorrhaphy for 16 eyelids in 2/8 studies, ^{14,17} and split-thickness skin grafts for 3 eyelids in 1/8 studies.² No surgical interventions were described for the acute management of eyelashes and eyebrows. Direct closure, CLAT, keratolimbal allograft transplantation, penetrating keratoplasty skin substitutes, and tissue flap techniques were not available with our criteria in the literature. Non-surgical intervention

Mean ages ranged from 16 to 40.5 years. Studies that reported sex had significantly more males (RR: 3.27, 95% CI: 1.34, 7.98, I² = 91%, p = 0.009).^{2,18-20} Medical interventions were provided to all patients for the management of acute burns. Medications included topical medications (corticosteroids prednisolone or dexamethasone, sodium ascorbate, sodium citrate, EDTA), $^{2,15-20}$ topical lubricants/irrigation (0.9% NaCl, lactated ringers solution, preservative-free drops), ^{2,15-20} topical antimicrobial (oxafloxacin, oxytetracycline, tetracycline, moxifloxacin), ^{2,15-20} topical antiglaucoma (timolol, homatropine, atropine), ^{2,15-20} oral medication (vitamin C), ¹⁶⁻²⁰ oral antimicrobial (doxycycline), ¹⁸ oral anti-glaucoma (acetazolamide) 15-17,19,20

Author Group

Frank Surgery

Surgery

et al.

et al.

SurgeryTandoSurgern et al.No

a et al.

Surgery Surgery No

Department of Plastic and Reconstructive Surgery, The Johns Hopkins University School of Medicine, Baltimore, MD

RESULTS

Normality				
3.6 TBUT Image: Description: 3.7 Time to Epithelialization: Image: Description: 3.8 Inside Ipithelial Defect Image: Description: 3.9 Limbal Lobenia (hours) Initial Image: Description: Image: Description: Image: Description: 3.9 Limbal Lobenia (hours) Initial Image: Description: Image: Description: Image: Description: Image: Description	IX 0.81 [0.54, 1.47]			
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Image: Display in the image in the imag	tcomes and complications in meta-analysis	8		
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3.5 Schirmer 3.5 Schirmer 3	6.57 (8.21, 1.74) -0.32 (-0.52, 0.38) -2 -3 0 1 2			
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The for overall effect $2 = 1.50$ ($P = 6.10$) 3.12 Symblepharon Follow-up Study or Sobgroup Friends Total Versity Total Weight N-4, Random, 955 (1) N-4, Random, 955 (2) N-4,	0.33 (0.04, 2.66) 1.66 (0.71, 1.58) 0.55 (0.26, 1.15)	100		
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$\frac{5 \operatorname{surgery}}{1 \operatorname{surgery}} = \frac{\operatorname{No Surgery}}{1 \operatorname{surgery}} = \frac{\operatorname{Risk}}{1 \operatorname{surgery}} = \frac{\operatorname{Ris}$	7.39 (6.40, 66.42)	300		
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$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Random, 95N Cl M-H, Random, 95N Cl 0.59 (0.11, 2.23) 0.77 (0.44, 1.35) 0.48 (0.28, 0.42) 0.39 (0.27, 0.55)	_		
Meansymetry: Tay' = 0.78; CM ² = 138.32; df = 6.07 < 0.0000(1); f = 9405 6.1 10 3.14 Corneal Vascularization Follow-up d to fit table) Dithelial Epithelial defect Time to epithelial Epithelial defect Time to epithelial Epithelial defect Time to epithelial Epithelial defect Time to epithelial Epithelial defect Chirmer TBUT Mathematical for the table Time to epithelial Epithelial defect Time to epithelial defect TBUT (s) Target of table Dithelial Schirmer TBUT (s) Time to epithelial Epithelial (s) Time to epithelial Epithelial (s) Time to epithelial (s) Time to (s) Time to (s) Time to (s)	0.52 (0.52, 1.64) 0.62 (0.64, 0.64) 1.60 (0.53, 1.06) 0.64 (0.32, 1.28)			
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	Table 3
Author	Group
Frank et al.	Surgery
	Surgery
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Tamhane et	Surgery
al.	No surg
Lopez-	Surgery
Garcia et	No surg
al.	
Singh et al.	Surgery
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Sharma et	Surgery
al.	No surg
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al.	No surg
Cabalag et	Surgery
al.	
	No Sur

	d to Non-surgical Management for Ac
	ion: Ocular, eyelid, eyelash, eyebrow bu
Settings: Inpatient	
Intervention: Surg	
Comparison: Med	lical management alone
	Illustrative comparative risks* (95%
	Assumed risk
	No Surgery Group
3.7 Visual	The mean visual acuity on follow-up
Acuity Follow-	ranged across control groups from 0.0
up	0.41
3.20 Change in	The mean change in epithelial area ran
Epithelial Area	across control groups from 26mm2 to
(mm ²)	48mm ²
3.24 Healed	Medium risk population
Epithelial Defect	758 per 1000
-	
3.26	Medium risk population
Wound/Ocular	0 per 1000
Infection	-
3.30	Medium risk population
Symblepharon	610 per 1000
Follow-up	
3.31 Ectropion	Medium risk population
Follow-up	67 per 1000
3.32 Corneal	Medium risk population
Vascularization	42 per 1000
	• • • • • •
*The basis for the a	ssumed risk (e.g. the median control gr
	roup and the relative effect of the interv
	erval; RR: Risk Ratio; SMD: Standard M
	Group grades of evidence
High quality: Furth	her research is very unlikely to change of
	Further research is likely to have an imp
Low quality: Furth	er research is very likely to have an imp
Very low quality:	We are very uncertain about the estimate
 Risk of bi 	ias
Inconsister	ency: heterogeneity > 50%
Indirectne	ess: low diversity of patient population
	on: small event size
Publication	on bias: small study effects

Patients having surgery for ocular, eyelid, and/or eyelash burns were found to have greater visual acuity on follow-up, shorter epithelial defect diameters on follow-up, greater changes in epithelial diameters from baseline, smaller epithelial defect areas on follow-up, greater changes in epithelial defect areas from baseline, greater numbers of healed epithelial defects, more keratitis infections, and a greater reduction in limbal ischemia, possibility preventing the need of a future limbal stem cell transplantation.

Res. 2017;38(2):71-77. 2010;31(6):911-917. using impression cytology. Cornea. 2006;25(8):908-913.

e	azo	olan	nde)	.15-17,	,19,20					3	3.14 Com	neal Vascular	rization F	ollow-up					
bl	e 2. A	cute su	irgical ar	nd non-si	urgical st	tudy oi	utcome	s (value	es roun	ded to	o fit ta	ble)							
	Sam ple size (n)	Surg ery	Time to manage ment (days)	Visual ac	uity	Pain (0	-10)	Corneal	haze	Epithe defect diame (mm)	elial t	Epithelial (area (mm ²)		Time to epithelial ization	Healed epithelial defect	Schirmer	TBUT (s)	Limbal ischem (hours)	ia
				I	F	I	F	I	F	Ι	F	Ι	F					I	F
у	22	FTG																	
y	10	FTG, T																	
,	60																		
у	20	AMT	2.5±1	0.02±0	0.3±4	8.8±2	2.5±0 .3					97±39				7±4	4±4		
,	24			0.1±0.2	0.6±0.4	8.6±2	5.5±1					61±47				8±4	5±4		
у	12	AMT		0.2±0.2	0.63±0. 2														
,	12			0.2±0.2	0.4± 0.2														
у	50	DAL K		0.3±0.6	0.4±0.2			3.7±0. 2	0.2±0 .5										
y	50			0.3±0	0.03±0. 5			3.7±0. 5	3.6±0 .5										
y y	38	AMT	5±12	0.1±0.3	0.3±1			3±2	1.3±3			47±80		27±52				4.5±3	
y	36		7±17	0.04±1	0.2±0.5			2.5±3	0.5±2			48±116		35±69				3±4	
y	38	AMT	7.5±12	0.005±0	0.014±0			1.5±3	2±3			114±99		41±65				9±4	
y	41		7.5±12	0.01±0	0.01±0			1.3±3	2.5±3			112±106		56±63				4.8±4	
y	18	AMT	7±3	0.03±0	0.5±0.4			2.3±1	0.4±1	7.7± 1	1.7±1	76±27	1±2	41±29	18	13.3±2	9.4±1		
,	20		6.6±2	0.03±0	0.3±0.3			2.4±1	1± 1	7.2± 2	3.2±2	54±22	6±5	57.8±29	17	13.7±1	8.6±1		
y	15	AMT	4±2			6.4±1	2.4±1	1.8±1	1±1	6±2	0.2±1	38±22	0.4±1	22±10	14	21.2±2	10.7±2	7±3	1.5±2
,	15		4.2±1			5.8±1	2.2±2	1.7±1	1.1±1	5.6± 2	2.6±1	33±20	6.8±8	567±15	10	18±4	10.3±4	6±3	3.7±3
у	49	STG, FTG, T	1±2																
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			1	. 1		DATE	7 1						~ 11/	4.1.1	0 122	F.C. 0.11.4	• •		

AMT: amniotic membrane transplantation, DALK: deep anterior lamellar keratoplasty, STG: split-thickness graft, FTG: full-thickness graft, T: tarsorrhaphy, I: Initial evaluation, F: follow-up

RESULTS

٨٥	uto suroi	ical and n	on-surgical st	tudy compl	igations								
. At	Sample	Surgery	Wound/ocular	Eyelid	Corneal	Vision loss	Symble	pharon	Entropian	Ectropian	Corneal yas	cularization	Eye perforation
	size (n)	Surgery	infection	contracture	ulceration	V 151011 1055	J	-	Enuopian	Leuopian	T Cornear vas		Lyc perioration
		ETC					1	F		7	1	F	0
	22 10	FTG T			/	0				4			0
		FTG, T				-							1
ery	60				5					4			0
	20	AMT	1				5	10			0	10	
ery	24	-	0				4	12			2	13	
	12	AMT			1							2	
ery	12				5							4	
	50	DALK						1				19	
ery	50							31				50	
	38	AMT					1	1			0	15	
ery	36						0	3			0	25	
	38	AMT					5	17			0	25	
ery	41						5	16			0	25	
	18	AMT						7	1	2	1	9	
ery	20							12	2	2	2	13	
	15	AMT						5				7	
ery	15							10				15	
	49	STG,	2	8	5	7				11			
		FTG, T											
ery	277		0	0	3	10				0			

iotic membrane transplantation, DALK: deep anterior lamellar keratoplasty, STG: split-thickness graft, FTG: full-thickness sorrhaphy, I: initial evaluation, F: follow-up

Table 4. Summary of Findings al Compared to Non-surgical Management for Acute Ocular, Eyelid, Eyelash, and/or Eyebrow Burns

Instrative comparative risks* (95% CI) ssumed risk Corresponding risk o Surgery Group Surgery Group he mean visual acuity on follow-up The mean visual acuity on follow-up in the inged across control groups from 0.01 to The mean visual acuity on follow-up in the A1 higher) he mean change in epithelial area ranged The mean change in epithelial area in the cross control groups from 26mm² to The mean change in epithelial area in the 8mm² 1.37 higher (0.4 to 2.34 higher) Iedium risk population 925 per 1000 (773 to 1000) (773 to 1000)	(95% CI) SMD 0.44 (0.07 to 0.81) SMD 1.37 (0.40 to 2.34) RR 1.22 (1.02 to 1.46)	Participants (studies) 262 (4 studies) 68 (2 studies) 68 (2 studies)	Quality of the evidence (GRADE) $\oplus \oplus \ominus \ominus$ Low ^{1, 2,3,4} $\oplus \oplus \ominus \ominus$ Low ^{1, 2,3}	
he mean visual acuity on follow-up The mean visual acuity on follow-up in the inged across control groups from 0.01 to The mean visual acuity on follow-up in the intervention groups was 0.44 higher (0.07 to 0.81 higher) he mean change in epithelial area ranged The mean change in epithelial area in the cross control groups from 26mm² to The mean change in epithelial area in the Bmm² The mean visual acuity on follow-up in the Iedium risk population 925 per 1000 (773 to 1000) (773 to 1000)	SMD 0.44 (0.07 to 0.81) SMD 1.37 (0.40 to 2.34) RR 1.22	(studies) 262 (4 studies) 68 (2 studies) 68	 ⊕⊕⊖⊖ Low^{1, 2,3,4} ⊕⊕⊖⊖ Low^{1, 2,3} ⊕⊕⊖⊖ 	
nged across control groups from 0.01 to intervention groups was 0.44 higher (0.07 to 0.81 higher) he mean change in epithelial area ranged gross control groups from 26mm² to The mean change in epithelial area in the intervention groups was 1.37 higher (0.4 to 2.34 higher) tedium risk population 925 per 1000 (773 to 1000) tedium risk population 925 per 1000 (773 to 1000)	(0.07 to 0.81) SMD 1.37 (0.40 to 2.34) RR 1.22	(4 studies) 68 (2 studies) 68	Low ^{1, 2,3,4}	
41 higher) ne mean change in epithelial area ranged The mean change in epithelial area in the ross control groups from 26mm² to The mean change in epithelial area in the mm² intervention groups was 1.37 higher (0.4 to 2.34 edium risk population 925 per 1000 (773 to 1000) (773 to 1000)	SMD 1.37 (0.40 to 2.34) RR 1.22	68 (2 studies) 68		
ross control groups from 26mm ² to intervention groups was 1.37 higher (0.4 to 2.34 higher) edium risk population 8 per 1000 edium risk population edium risk population	(0.40 to 2.34) RR 1.22	(2 studies)	Low ^{1. 2.3} ⊕⊕⊝⊝	
mm ² higher) edium risk population 925 per 1000 (773 to 1000) (773 to 1000)	RR 1.22	68	000	
925 per 1000 925 per 1000 (773 to 1000) (773 to 1000)				
(773 to 1000) edium risk population	(1.02 to 1.46)	(2 studies)	Low ^{1, 2,3}	1
edium risk population				
	RR 11.17	173	$\Theta \Theta \Theta \Theta$	
per 1000 0 per 1000	1.28 to 597.85)	(2 studies)	Moderate ^{1,3}	
(0 to 0)				
edium risk population	RR 0.55	312	$\Theta \Theta \Theta \Theta$	
0 per 1000 336 per 1000	(0.26 to 1.15)	(5 studies)	Moderate ^{2,3}	
(159 to 701)				
edium risk population	RR 7.30	259	0000	
per 1000 487 per 1000	(0.80 to 66.42)	(3 studies)	Low ^{1, 2,4}	
(53 to 1000)				
edium risk population	RR 0.64	336	$\Theta \Theta \Theta \Theta$	
2 per 1000 17 per 1000	(0.32 to 1.28)	(6 studies)	Moderate ^{2, 3}	
(3 to 105) med risk (e.g. the median control group risk across studies) is provided in footnotes. The correspon				

research is very unlikely to change our confidence in the estimate of effect.

ther research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. esearch is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

CONCLUSION

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