Eye (2006), 1–10

www.nature.com/eye

CLINICAL STUDY

Influence of intraocular lens material on the development of acute endophthalmitis after cataract surgery?

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Abstract

Purpose **To investigate the causal relationship between acute postoperative endophthalmitis (POE) after cataract surgery and the biomaterial properties of the intraocular lens (IOLs) implanted.**
Methods **This retrospective cohort study included all patients who had undergone cataract surgery with IOL implantation at the Lyon Croix-Rousse University Hospital between 1st January 1994 and 31st December 2004. Details respecting the type of IOL implanted (material and manufacturer) were meticulously recorded. The number of patients presenting with POE within 6 weeks of cataract surgery was documented together with their medical characteristics. These data were then compared, and Fisher's exact test was used to establish the significance of any apparent associations.**
Results **Eight of the 5837 eyes manifested acute POE (0.14%). Seven of these were composed of polymethylmethacrylate (PMMA) and one of heparinized PMMA. Patients with PMMA IOLs carried a higher risk of developing POE than did those implanted with either heparinized PMMA ($P = 0.001$), hydrophilic acrylic, or hydrophobic acrylic IOLs ($P = 0.002$).**
Conclusions **The incidence of acute POE after cataract surgery in our hospital is similar to that currently reported for other institutions in developed countries. Our results add further evidence that IOL material and type are factors contributing to the risk to develop an acute POE after cataract surgery, and that PMMA IOLs may be associated with an increased risk of POE.**

Eye advance online publication, 15 September 2006; doi:10.1038/sj.eye.6702544

Keywords: endophthalmitis; cataract surgery; intraocular lens material; biomaterial

Introduction

Acute postoperative endophthalmitis (POE) is still one of the most serious complications of cataract surgery.[1] Indeed, bacteria are sometimes postoperatively present within the aqueous humour without inducing this condition.[2] Precisely why bacteria induce POE after cataract surgery is not entirely understood. The risk of its development may be influenced by several factors, above all by bacterial adherence to the intraocular lens (IOLs).[2–4] The ability of an organism to adhere to the IOL surface is believed to be associated with a risk of infection at the implantation site.[5–8] Obviously, bacterial adhesion to an IOL will be influenced by the properties of the biomaterial employed, such as its chemical composition, surface roughness, hydrophilicity, and surface electric charge.[2,4,9,10] A causal relationship between bacterial adhesion to IOLs and POE was first demonstrated for the material polypropylene.

Epidemiological data relating to this supposed relationship are scarce and have provided conflicting results for some IOL materials.[11–18] The present retrospective cohort study was conducted with a view to throwing further light on the association between IOL material and type and the risk of developing POE.

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Received: 16 November 2005
Accepted in revised form: 5 July 2006

This study received no funding, and the authors had no financial or proprietary interest in it

Materials and methods

All patients who had undergone extracapsular cataract extraction or phacoemulsification with IOL implantation at a single centre (Croix-Rousse Hospital, University of Lyon, France) between 1st January 1994 and 31st December 2004 were included in this cohort. The IOL type implanted was classified according to its biomaterial composition into one of the five categories: polymethylmethacrylate (PMMA), heparinized PMMA, silicone, hydrophilic acrylic, and hydrophobic acrylic. Fluorine PMMA was not used. Rigid (PMMA and heparinized PMMA) IOLs with an optic diameter of 5.5–6.5 were used as the IOLs of choice in cases without complications before 2000. Small-incision cataract surgery using foldable IOLs has been performed as standard of care since 2000.

Our standard technique for phacoemulsification consists of a three-step incision at the limbal sclera (sclerocorneal phacoemulsification) associated with a clear corneal paracenteses. Scleral tunnels are always constructed in the superior quadrant. Rarely, clear corneal incisions (corneal phacoemulsification) have to be performed, with the incisions also always in the superior quadrant. In all cases, the wounds are sutured using a 10-0 nylon suture, to guarantee perfect closure of the wound. All patients are given a single dose of oral ofloxacine 2 h before surgery, if no contraindication is found. Use of topical 5% povidone-iodine and careful draping of the eyelids are systematically performed in any case, and additionally, a subconjunctival aminoglycoside injection was placed at the end of surgery until 2001. Intracameral or systemic antibiotics were never applied prior to or during surgery. All patients receive topical antibiotic and dexamethasone after surgery during 1 month.

Cases of POE are usually identified at the Lyon Croix-Rousse University Hospital in a prospective manner by the Department of Infectious Diseases. Patients presenting with acute POE within 6 weeks of cataract surgery were diagnosed according to criteria established by the Endophthalmitis Vitrectomy Study (EVS) Group.[19] POE was defined either as an impairment of visual acuity (6/12 or worse) or as a manifestation of pain, hypopion, or significant clouding of the anterior chamber or vitreous after cataract surgery. The medical characteristics of the patients with acute POE were documented, with particular attention being paid to recognized risk factors (ie, diabetes mellitus, chronic obstructive-airway disease, immunosuppressive therapy, long-term steroid treatment, glaucoma treatment, lid-margin disease, previous intraocular surgery, disruption of the capsular barrier, loss of vitreous, and postoperative wound abnormalities).[11,16] After 1997 (but not before), aliquots of aqueous humour or vitreous were routinely withdrawn from patients with POE for laboratory testing, and the condition was managed according to guidelines established by the EVS Group.[19]

All statistical analyses were carried out using SPSS version 12.0 (SPSS Inc., Chicago, IL, USA) or SAS version 8.2 (SAS Institute Inc., Cary, NC, USA) packages. The incidence of acute POE and the exact 95% confidence interval were estimated according to a Poisson distribution. When applicable, odds ratios and 95% confidence intervals were used to assess the influence of each IOL material on the occurrence of POE. Fisher's exact test was used to compare the incidence rates associated with the different IOL materials, with the time of surgery, and the surgical technique (extracapsular cataract extraction *vs* phacoemulsification). Bonferoni corrections were made for the multiple comparisons before concluding that differences were statistically significant.

Results

Between 1st January 1994 and 31st December 2004 (11 years), 5837 IOLs were implanted during cataract surgery in our department, 4907 during phacoemulsification, and 930 during extracapsular cataract extraction. The medical characteristics from patients developing POE may be depicted from Table 1. The IOLs, which were manufactured by various companies (Table 2), composed of five different biomaterials: 5% of silicone, 14% of PMMA, 20% of hydrophilic acrylic, 20% of hydrophobic acrylic, and 41% of heparinized PMMA.

Eight cases (two females and six males) of acute POE were registered within 6 weeks of cataract surgery (Tables 1 and 2), which represented an overall incidence of 0.14% (95% confidence interval: 0.06–0.27%) during the 11-year study period. The median age of the POE patients was 62.5 years (range: 47–88 years). The median time elapsing between cataract surgery and the diagnosis of POE was 8 days (range: 4–16 days). Seven of the eight patients underwent phacoemulsification (7/4907; 0.14%) and one other extracapsular cataract extraction (1/930; 0.11%; Table 1). Two patients had a history of prostate adenocarcinoma and one had undergone topical treatment for glaucoma. None of these POE patients presented with either diabetes mellitus, chronic obstructive-airway disease, lid-margin disease, disruption of the capsular barrier, loss of vitreous, or postoperative wound abnormalities, and none of them had undergone either immunosuppressive therapy, long-term steroid treatment, or previous intraocular surgery. All patients were given a single dose of oral ofloxacine

Table 1 Medical characteristics of patients with POE

Patient no.	*Age (years)/ gender*	*Medical history*	*Ophthalmic history*	*Preop. VA*	*Year of surgery*	*Type of surgery*	*Location of incision*	*IOL*	*Duration of surgery (min)*	*Time to presentation for POE (days)*	*VA at presentation for POE*	*AC/vitreous tapping*	*Organism*	*Final VA*
1	88.1/M	Prostate adenocarcinoma, hypertension	—	20/100	1994	Corneal phaco	Superior	PMMA	20	4	LP	No	NA	LP
2	60.6/F	—	—	20/50	1996	Sclerocorneal phaco	Superior	PMMA	21	16	20/200	No	NA	20/25
3	52/M	—	—	20/200	1996	Sclerocorneal phaco	Superior	PMMA	25	8	CF	No	NA	20/40
4	46.4/M	—	Glaucoma treatment	20/100	1996	Sclerocorneal phaco	Superior	PMMA	15	8	20/400	No	NA	20/40
5	81.6/M	Prostate adenocarcinoma, periarthritis	—	20/50	1997	Sclerocorneal phaco	Superior	PMMA	18	5	20/400	Yes	Technical failure	20/30
6	66.8/M	—	Pterygium	20/50	1998	ECCE	NA	HSM PMMA	80	12	20/200	Yes	Coag neg staph	20/40
7	69.5/M	—	—	20/80	2001	Sclerocorneal phaco	Superior	PMMA	45	6	CF	Yes	Coag neg staph	20/100
8	48.3/F	—	—	20/200	2001	Sclerocorneal phaco	Superior	PMMA	30	10	20/400	Yes	No growth	20/60

A wound abnormality was not observed in any of the POE cases, all of which had been sutured at the end of surgery. A disruption of the capsular barrier or loss of vitreous was not observed in any of the POE cases.

ECCE = extracapsular cataract extraction; phaco = phacoemulsification; corneal phaco = clear corneal incision; sclerocorneal phaco = limbal scleral incision; NA = not applicable; VA = visual acuity; AC = anterior chamber; LP = light projection; CF = counting fingers; coag neg staph = coagulase-negative staphylococci.

Table 2 Numerical distribution of the five different IOL materials implanted in relation to the incidences of POE

	No. of IOLs implanted (%)	*No. of cases of POE*	*Incidence of POE (%)*	P-*value (Fisher's exact test)*
PMMA	833 (14.3)	7	0.84	
Heparinized PMMA	2362 (40.5)	1	0.04	0.001
Silicone	316 (5.4)	0	0	0.20
Hydrophilic acrylic	1186 (20.3)	0	0	0.002
Hydrophobic acrylic	1140 (19.5)	0	0	0.002
Total	5837 (100)	8	0.137	

Fisher's exact test was used to compare the incidence of POE in the PMMA group with that in the other four material groups.
PMMA = polymethylmethacrylate.
The following IOL models were most commonly used: 911A, Opsia Saphir and Vision Chip 2 (PMMA) from Pharmacia and Bausch & Lomb; 722C, 728C and 812C; heparinized PMMA from Pharmacia; SI40NB (silicone) from AMO; Akreos adapt, Akreos disc, and Visacryl (hydrophilic acrylic) from Bausch & Lomb and Staar; MA60BM, MA50BM, and AR40 (hydrophobic acrylic) from Alcon and AMO.

2 h before surgery. Only four of the eight patients had been subjected to tapping of the anterior chamber or vitreous. POE had been triggered predominantly by Gram-positive bacteria (Table 1). A final visual acuity $\geq 20/40$ was achieved in five of the eight patients.

In the eight POE patients, seven of the IOLs were composed of PMMA and the other one of heparinized PMMA (Table 2). The impact of IOL material on acute POE was significant (global Fisher's exact test: $P = 0.00007$). Patients with PMMA IOLs carried a statistically higher risk of developing POE than did those implanted with either hydrophilic acrylic, hydrophobic acrylic, or heparinized PMMA IOLs (odds ratio: 0.05; 95% confidence interval: 0.01–0.41) (Table 2). The cataract surgery technique (ie, phacoemulsification or extracapsular cataract extraction) had no significant influence on the development of POE ($P = 1$). Between 1994 and 1997, extracapsular cataract extraction was performed more frequently (79%) than phacoemulsification (Figure 1); hence, rigid IOLs were implanted more often (96%) than foldable ones (Table 3) and thus rigid IOL implantation was not due to the presence of surgical complications in this series. Between 1998 and 2004, phacoemulsification was performed more commonly (88%) than extracapsular cataract extraction; hence, foldable IOLs were implanted more frequently (57%) than rigid ones. However, the incidences of POE occurring within these two periods did not differ significantly from each other and actually depended of the nature of the IOL implanted (Fisher's exact test including Bonferoni's correction: $P = 0.018$; but Fisher's exact test after adjusting for the IOL type implanted: $P = 0.74$).

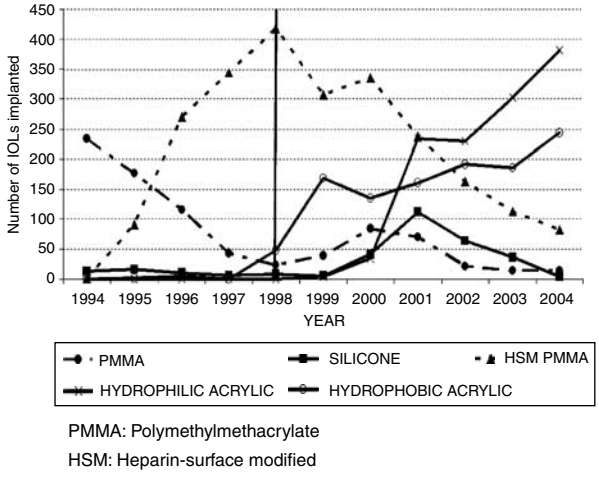

Figure 1 Numerical distribution of the five different IOL materials implanted between 1994 and 2004.

Table 3 Numerical distribution and incidences of POE, of the five different intraocular lens materials, and of the two different types of cataract-extraction technique between the periods 1994–1997 and 1998–2004

Number of (%)	*1994–1997*	*1998–2004*	*Total*
Endophthalmitis	5 (0.38)	3 (0.07)	8 (0.14)
Cataract extraction	1326 (22.7)	4511 (77.3)	5837 (100)
Extracapsular	739 (79)	191 (21)	930 (100)
Phacoemulsification	587 (12)	4320 (88)	5837 (100)
PMMA	570 (68)	263 (32)	833 (100)
Heparinized PMMA	705 (30)	1657 (70)	2362 (100)
Silicone	45 (14)	271 (86)	316 (100)
Hydrophilic acrylic	0 (0)	1186 (100)	1186 (100)
Hydrophobic acrylic	6 (0.5)	1134 (99.5)	1140 (100)

PMMA = polymethylmethacrylate.

Discussion

The present retrospective study affords evidence that the IOL material is correlated to the risk of acute POE after cataract surgery. Since POE is a rare complication of cataract surgery, large reference samples are necessary to establish reliable results. Hence, epidemiological data relating to the impact of IOL materials on the

development of POE are scarce, and available data have provided contradictory results regarding the contribution of IOL materials.[11–18]

Nevertheless, there is a general agreement on a qualitative level that the IOL material and its surface composition are linked to bacterial adhesion and the risk to develop POE (Table 4). There is some evidence that polypropylene haptics support bacterial adherence to the IOL. Dilly and Sellors[5] and Raskin *et al*[20] have shown that bacteria are more prone to adhere to polypropylene haptics than either to PMMA haptics[20] or to the PMMA optical component,[5,20] both *in vitro*[5,20] and in explants derived from patients with recurrent episodes of intraocular inflammation.[5] And in an earlier epidemiological study, Raskin *et al*[20] demonstrated polypropylene haptics to be a significant risk factor in the development of POE (risk ratio: 4.5; $P<0.007$). Lastly, a recent epidemiological retrospective case–control study demonstrated that silicone IOLs with polypropylene haptics could be a significant risk factor for the development of POE (relative risk: 21; $P=0.013$) in comparison to silicone IOLs with PMMA haptics.[14] Adding to this, we observed that patients with PMMA IOLs carried a higher risk of developing POE than did those implanted with either heparinized PMMA, hydrophilic acrylic, or hydrophobic acrylic IOLs. Silicone IOLs were implanted in only 5% of the patient population; hence, data relating to this material lacked statistical power. Consistent to our results, Montan *et al*[11] have demonstrated that patients implanted with heparinized PMMA IOLs are better protected against POE than are those with either PMMA ($P=0.002$) or silicone IOLs ($P=0.04$). However, in a more recent study,[12] the same authors demonstrated the risk of developing POE to be lower in patients with acrylic IOLs than in those with either silicone ($P=0.014$), PMMA ($P=0.001$), or hydrogel IOLs ($P=0.001$), whereas the risk difference between acrylic IOLs and heparinized PMMA IOLs was not significant ($P=0.06$). The lower risk of POE associated with heparinized PMMA IOLs was attributed by Montan *et al*[11] to the biocompatible, hydrophilic surface properties of the heparin coating. This is supported by *in vitro* data (Table 4).[3,28–34]

Many of the discrepant results published so far may be derived from the retrospective nature of most clinical studies. A quantitative analysis of any single study might therefore misweight the study findings. In order to provide an overview over the existing studies and to give the reader space for an own weighting of the pertaining results, we have therefore displayed the most important findings from published clinical (Table 5a) and *in vitro* studies (Table 5b) in a qualitative manner instead of discussing the single studies.

In the current study, the incidence of endophthalmitis in the PMMA group (0.84% or 7/833 cases) is rather high compared to other reports (0.16% or 15/9453 cases and 0.06% or 5/7873 cases).[12,17] This is probably explained by the difference in the number of patients included. Nevertheless, even if the current study involved less patients, it is noteworthy that the number of patients included per group, that is, with PMMA (833 cases), hydrophilic acrylic (1186 cases), and hydrophobic acrylic (1140 cases), was comparable. Therefore, our study is probably strong enough to allow to read out on a qualitative basis a tendency that heparinized PMMA IOLs have a lower risk, that is, 20-fold lower risk of endophthalmitis (0.04% or 1/2362 cases), compared to PMMA (0.84%) and actually a similarly low risk compared to acrylic lenses.

Also in the context of our results, the findings of Nagaki *et al*[15] may be worth mentioning: cataract patients were randomized into three groups. In the first, a hydrophobic acrylic IOL was implanted through a temporal corneal incision; in the second, the same type of IOL was implanted via a superior sclerocorneal incision; and in the third, a silicone IOL was implanted via the latter route. The incidence of POE was higher in the first group than in the other two. This finding indicates that a temporal corneal incision may heighten the risk of POE developing, but that hydrophobic acrylic and silicone IOLs silicone do not have a differential impact on its manifestation. In the present series of patients, the incision was systematically made at the 12 o'clock position, with the conjunctiva covering the wound postoperatively. Hence, we can exclude the influence of incision site (Table 1). Moreover, the cataract-extraction technique probably had no influence on the incidence of POE; hence, several studies have reported a reduction in the incidence of POE following the change from intra- to extracapsular extraction,[11] but no further reduction in incidence has been reported following the change from extracapsular extraction to phacoemulsification (Table 4).[21–23]

Rigid IOLs require a wound enlargement to 5.5–6.5 mm, which could possibly result in a higher chance of wound leakage and thereby increase the risk of POE. Moreover, Mayer *et al*[24] reported that injectable IOLs were less likely to cause POE because rigid lenses may be contaminated by contact with conjunctiva upon insertion.[24] Nevertheless, among the rigid IOLs group, we demonstrated a significant higher risk of POE with PMMA than with heparinized PMMA, proving that wound's size is not the main aetiological factor in this series and that biomaterial seems on the contrary to be the most important one.

We are aware of the limitations of our study, which namely lie in its retrospective nature and the relative

Table 4 Factors with influence on the risk to develop POE after cataract surgery

Factor assessed for their influence on the risk to develop POE	*Author (reference)*	*Year of publication*	*Impact on bacterial adhesion and the risk of POE*
IOL material	Own results	2006	PMMA > heparinized PMMA, silicone, or acrylic
	Montan *et al*[11]	1998	PMMA and silicone > heparinized PMMA
	Montan *et al*[12]	2002	PMMA, silicone, and hydrogel > acrylic
	Wejde *et al*[18]	2005	Silicone > heparinized PMMA heparinized PMMA > acrylic
	Wejde *et al*[17]	2005	Silicone = heparinized PMMA = acrylic = PMMA = hydrogel
	Nagaki *et al*[15]	2003	Silicone = hydrophobic acrylic
	Wong and Chee[16]	2004	Silicone > PMMA = acrylic
	Cusumano *et al*[30]	1994	Silicone > hydrogel > PMMA[a]
	Ng *et al*[29]	1996	PMMA > hydrogel[a]
	Pinna *et al*[28]	2000	Acrylic > PMMA[a]
	Garcia-Saenz *et al*[3]	2000	Slime-positive bacteria adhere best to acrylic IOLs, and slime-negative ones to PMMA[a]
Polypropylene haptics	Menikoff *et al*[13]	1991	PMMA with polypropylene haptics > PMMA
	Raskin *et al*[20]	1993	PMMA with polypropylene haptics > PMMA[a]
	Dilly and Sellors[5]	1989	PMMA with polypropylene haptics > PMMA
	Agrawal *et al*[31]	1997	PMMA with polypropylene haptics > PMMA[a]
	Bainbridge *et al*[14]	1998	Silicone IOL with polypropylene haptics > PMMA
	Garcia-Saenz *et al*[3]	2000	Polypropylene > PMMA[a]
Other IOL surface composition and treatment	Schmidt *et al*[32]	1998	Surface smoothing reduces POE risk[a]
	Kienast *et al*[27]	2006	Dynasilan surface modification reduces POE risk[a]
	Garcia-Saenz *et al*[3]	2000	Surface hydrophobic composition interacts with the infectious agents[a]
	Schmidt *et al*[32]	1998	Hydrophobic interactions of the IOL with the bacterial surface composition and properties[a]
Cataract surgical technique	Own results	2006	Phaco = ECCE
	Wejde *et al*[18]	2005	Phaco < ECCE
	Semmens *et al*[21]	2003	Phaco = ICCE = ECCE
	Li *et al*[22]	2004	Phaco = ICCE = ECCE
	Somani *et al*[23]	1997	Phaco = ECCE
	Wong *et al*[26]	2004	Phaco > ECCE
	Mayer *et al*[24]	2003	Phaco < ECCE
Wound configuration	Nagaki *et al*[15]	2003	Temporal > superior incision
	Montan *et al*[11]	1998	Wound abnormalities
Posterior capsule damage	Menikoff *et al*[13]	1991	Increased POE risk after capsular rupture
	Wong and Chee[25]	2004	Increased POE risk after capsular rupture
Age	Li *et al*[22]	2004	Elder age (> 80 years) associated with increased POE risk
Bacterial properties	Kienast *et al*[27]	2006	SE adhesion to IOL better than that of *Propionibacterium acnes*[a]
	Wong and Chee[25]	2004	No bacterial growth < coagulase-negative staphylococci < other bacteria
	Garcia-Saenz *et al*[3]	2000	Slime-positive and -negative bacteria prefer different IOL surface composition[a]
	Pinna *et al*[34]	2000	ICA locus presence (= slime-positive bacteria) is crucial for bacterial adhesion to a distinct IOL surface[a]

Not all studies do provide consistent findings.
[a]Results of *in vitro* studies.
IOL = intraocular lens; POE = postoperative endophthalmitis; SE = *Staphylococcus epidermidis*; phaco = phacoemulsification; ICCE = intracapsular cataract extraction; ECCE = extracapsular cataract extraction; PMMA = polymethylmethacrylate; ICA = intercellular adhesion.

Table 5a Overview over the most relevant findings in clinical settings reporting on the risks of POE and factors possibly influencing incidences or outcomes

Author (reference)	*Year*	*Aim*	*Design*	*Observation period*	*Denominator (n)*	*Events (%)*	*Outcomes*
Current series	2006	Influence of IOL material on the development of POE	Retrospective case series	1994–2004	5837	8 (0.14)	PMMA compared to heparinized PMMA and acrylic IOL associated with an increased risk of POE (estimated RR 20)
Montan *et al*[11]	1998	Influence of surgical technique on POE	Retrospective case–control study	1990–1993	22 091	57 (0.26)	Immunosuppressive therapy Wound abnormality IOL without heparinized surface
Montan *et al*[12]	2002	Morbidity of POE	Prospective population-based survey	1998	54 666	58 (0.11)	57% Gram-positive bacteria POE risk lower for acrylic than for hydrogel or PMMA IOLs
Wejde[17]	2005	Epidemiology of POE	Prospective population-based survey	3 years	188 951	112 (0.06)	85% Gram-positive bacteria POE risk decreased with intracameral cefuroxime
Wejde *et al*[18]	2005	Risk factors for POE	Retrospective case–control series	1994–2000	46 292	60 (0.13)	Lower risk after intracameral cefuroxime POE risk lower after phaco than after ECCE or ICCE POE risk higher for silicone than for heparinized PMMA IOLs
Semmens *et al*[21]	2003	Trend in the incidence rate of POE	Retrospective case series	1980–1998	94 653	188 (0.22)	POE rate unchanged despite changes in surgical technique and patient age
Li *et al*[22]	2004	Risk factors for POE	Retrospective case series	1980–2000	117 083	210 (0.18)	No difference in POE incidence rates between surgical techniques Increased risk for patients >80 years
Ng *et al*[26]	2005	Predictive factors for a poor functional outcome	Retrospective population-based study	1980–2000	NA	213	No use of systemic antibiotics (OR 3.9; 95% CI 1.2–12.4) Growth of organisms other than coagulase-negative *Staphylococcus* (OR 9.8; 95% CI 2.8–34.1)
Wong and Chee[16]	2004	Risk factors for POE in Asia	Retrospective case–control series	NA	NA	34	Increased risk for silicone IOLs (OR 5.1; 95% CI 1.2–21.6) Increased risk after capsular rupture (OR 20.9; 95% CI 2.3–187.9)

Table 5a (Continued)

Author (reference)	*Year*	*Aim*	*Design*	*Observation period*	*Denominator (n)*	*Events (%)*	*Outcomes*
Wong and Chee[25]	2004	Incidence, risk factors and clinical outcome of POE	Prospective case series	1996–2001	44 803	34 (0.76)	Risk association with phaco (RR 1.9; 95% CI 0.9–3.9) Risk association with posterior capsule rupture (RR 8.0; 95% CI 3.1–20.7)
Nagaki *et al*[15]	2003	Influence of the incision site in small incision phaco	Prospective multicenter observational case series	1998–2001	11 595	15 (0.13)	Increased risk of POE with temporal incision (RR 4.6) No influence of silicone material
Mayer *et al*[24]	2003	Incidence of POE related to surgical technique	Retrospective case series	10-year period	NA	NA	POE risk lower for phaco than for ECCE POE risk lower for injectable than for rigid IOLs
Bainbridge *et al*[14]	1998	Association of 3-piece silicone polypropylene IOL and POE	Retrospective case series	NA	772	6 (0.78)	Increased POE risk for three-piece silicone compared to PMMA IOL (RR 20.1)
Somani *et al*[23]	1997	Predisposing surgery and VA after POE	Retrospective case series	1989–1996	NA	164	Microbial growth in 99/164 (60%) Incidences of POE comparable for phaco and ECCE
EVS Group[19]	1995	Role of immediate vitrectomy and systemic antibiotics in POE	Prospective randomized multicenter	NA	NA	420	No influence of systemic antibiotics on VA or media clarity Vitrectomy better than biopsy if VA light perception only (three-fold probability of a final VA of 20/40)
Menikoff *et al*[13]	1991	Risk factors for POE	Retrospective case control	1988–1990	24 105	54 (0.22)	Capsular rupture (RR 13.7) Polypropylene haptics (RR 4.5) compared to PMMA
Agrawal *et al*[31]	1997	Influence of IOL type on bacterial contamination of the anterior chamber	Prospective case series	NA	156	28 (17.9)	Anterior chamber contamination rate 2.5-fold higher for polypropylene haptics as compared to PMMA

ICA = intercellular adhesion; IOL = intraocular lens; POE = postoperative endophthalmitis; SE = *Staphylococcus epidermidis*; phaco = phacoemulsification; ICCE = intracapsular cataract extraction; ECCE = extracapsular cataract extraction; PMMA = polymethylmethacrylate; NA = not applicable.

Table 5b Overview over some findings from *in vitro* cultural studies reporting on risk modification for POE

Author (reference)	*Year*	*Aim*	*Outcomes*
Kienast *et al*[27]	2006	Influence of surface modification with dynasilan on the development of POE	Dynasilan surface modification reduces adhesion of SE and *Propionibacterium acnes* by 40–60% independent of the IOL material (PMMA, hydrogel, silicone)
Garcia-Saenz *et al*[3]	2000	Influence of slime production of SE on bacterial adhesion to different IOLs	Slime-negative SE adhere to all IOL materials at a lower level than slime-positive ones Slime-negative SE adhere best to PMMA, worst to hydrogel. Slime-positive SE adhere best to polypropylene and acryl, worst to PMMA No difference between rigid and foldable IOLs Individual bacterial isolates and IOL materials influence bacterial load
Pinna *et al*[28]	2000	Comparison of bacterial adhesion to PMMA and acrylic IOLs	Bacterial adhesion is stronger to acrylic than to PMMA IOLs
Pinna *et al*[34]	2000	Influence of ICA locus (responsible for slime production) on adherence to acrylic IOLs	ICA locus crucial for bacterial adhesion to the IOL surface
Schmidt *et al*[32]	1998	Influence of surface modification on bacterial adhesiveness	Surface smoothing and heparin coating reduce bacterial adherence Hydrophobic interactions may play a crucial role depending on the bacterial surface composition and properties
Abu el-Asrar *et al*[33]	1997	Influence of heparin coating on adhesion of SE	Heparin surface modification reduces bacterial adhesion to the IOL In contrast, antibiotics in the washing solution do not significantly impair bacterial adhesion
Raskin *et al*[20]	1993	Adherence of SE to polypropylene haptics and three-piece PMMA	Increased risk of bacterial adhesion for polypropylene haptics as compared to PMMA (RR 2.0)

ICA = intercellular adhesion; IOL = intraocular lens; POE = postoperative endophthalmitis; SE = *Staphylococcus epidermidis*; PMMA = polymethylmethacrylate.

limited number of patients included. Therefore, the conclusions drawn from our results have to be interpreted with care. On the other hand, we feel that reporting these data may be worthwhile because the incidence of POE is so low that at a later point, a pooling of published data could virtually contribute to understand the contradictory results and to find a more reliable answer in which direction to focus with future large multicentre studies. The strength of this retrospective investigation lies in its single-centre design, which guaranties tight control and uniformity of diagnostic criteria and surgical techniques.

In summary, we gathered further evidence that the risk to develop an acute POE after cataract surgery is associated to the lens material and type used and may be increased with the use of PMMA IOLs. Several factors possibly add to this increased risk, with the IOL material obviously being according to published and own findings beyond the more relevant ones. Nevertheless, a substantial number of operating technique-dependent variables and systemic risk factors will have to be addressed in a prospective multivariate analysis before the actual role of IOL material in POE development can definitively be assessed.

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