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CLINICAL STUDY

The conjunctival bacterial pattern of diabetics undergoing cataract surgery

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Abstract

Purpose **To ascertain the conjunctival bacterial pattern of diabetics undergoing cataract operation to reduce the risk of postoperative endophthalmitis (PE).**

Methods **An observational retrospective study of the conjunctival bacteria of consecutive patients undergoing cataract surgery from July 2005 to November 2008. Records of patients having eye surgical prophylaxis in the 6 months before the culture and those patients having cataract operation combined with other surgical procedures were excluded. Aerobic and microaerobic cultures were carried out. Dade-Behring panels were used for bacterial identification. The database containing the isolated bacteria was linked to another Access database containing demographic and clinical data such as diabetes presence and baseline blood glucose and creatinine levels. The conjunctival bacteria of diabetics were compared with those of the non-diabetics. Epidat 3.1 program was used for statistical calculations.**

Results **From 5922 selected patients, 1325 (22.37%) knew they were diabetics (higher prevalence than expected). Among self-reported non-diabetics, 900 (15.2%) could be 'unknown' diabetics; another 274 had an impaired renal function; and 3423 non-diabetics joined the control group. Diabetics have a significantly higher prevalence of *Staphylococcus aureus*, *Enterococci*, certain *Streptococci*, and *Klebsiella* sp. than non-diabetics. Diabetics and non-diabetics having a blood creatinine level above 105.2 μmol/l had an increased conjunctival bacterial prevalence; these groups had a higher mean age and men predominated.**

Conclusions **Diabetics have a conjunctival flora pattern whose increased bacteria are a predominant cause of many diabetic infections. An abnormally high blood creatinine level is an indicator of increased conjunctival colonisation in diabetics and non-diabetics.**

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Keywords: diabetic conjunctival bacteria; diabetics cataract surgery; conjunctival bacterial pattern; diabetic complications

Introduction

The visual outcome of diabetic patients after postoperative endophthalmitis (PE) is worse than that of non-diabetics.[1–3] In developed countries, there is the threat of an epidemic growth of diabetes prevalence,[4–6] in particular in the elderly; only in the US estimates,[4] about 25% of people over 60 years of age will be diabetic (22.6 million people) in the year 2031. In fact, 21.6% of adults older than 65 years had diabetes in the US National Health and Nutrition Examination Survey 1999–2002.[7] This age range is also the lifetime period when most patients need to be operated on for cataracts.[2,8,9] This potential quantity of patients threatened with a poor visual acuity is a reason for preventing diabetics from PE. But, in addition, among the huge quantity of patients undergoing cataract operation, an increased PE incidence has often been associated with diabetes;[10–14] however, not many studies have been carried out to assess this fact and its causes.

Thus, the proportion of diabetics operated on for cataract in the Endophthalmitis study of the European Society of Cataract and Refractive Surgeons[15] is unpublished. Although diabetics were included in this study,[15] some of the

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diabetics could be excluded following their exclusion criteria,[16] such as the existence of certain ocular and skin infections. This outstanding study[15,17] has stated that certain prophylaxes are capable of reducing the PE incidence after cataract surgery significantly. But, in another study[18] with a similar prophylaxis and a less restrictive inclusion criteria of the patients, a wider bacterial spectrum was isolated from their PE cases.[19] Other studies of cataract operations carried out in outpatient surgical units[20,21] generated a PE incidence as low as in the mentioned studies[17,18] without using intracameral antibiotics; but possibly the health status of the patients operated on in outpatient units is better than in a tertiary hospital.

Probably, many of the patients operated on for cataracts do no need any prophylaxis, but, at the moment, we cannot identify them. Nevertheless, we can identify patients with an increased risk of PE. Thus, the aim of this study is to ascertain whether the conjunctival flora of diabetic patients undergoing cataract surgery present some peculiarity that could offer some explanation for the often found association of diabetes and PE, apart from the known susceptibility of diabetics with retinopathy for having posterior capsular rupture during the cataract operation,[22] as not many of these surgical complications become a PE case.[15] For this purpose, we compare the conjunctival bacteria of diabetics and non-diabetics who underwent cataract operation in our tertiary referral hospital.

Materials and methods

Study design

A retrospective observational study of consecutive cases of patients registered in the Laboratory database from 11 July 2005 to 3 November 2008 to have a routine conjunctival culture carried out before their cataract surgery. This database contains the clinical record numbers and demographic data of the patients, the identification, origin and collecting date of the samples, and the results of the microbiological isolations. Every patient undergoing their first cataract operation in our hospital has a preoperative examination carried out, consisting of a thorax X-ray, a basic clinical analysis, a conjunctival bacterial culture, and a clinical evaluation for anaesthetic and surgical purposes (the appointments of this culture and clinical evaluation being on the same day and as close as possible to the scheduled cataract operation date). In this evaluation, performed by the Internist of our Ophthalmic Institute, an Access database is generated, which contains the clinical record number, the surgical procedure indication, the evaluation date, the demographic data and existence of diabetes or not, the kind of diabetes, and the updated baseline blood glucose and creatinine levels, among many other data. As a rule, patients admitted for cataract operations in our hospital and having coexisting dacryocystitis, pterygium, or eyelid closure disturbances are scheduled for the corrections of these coexisting local problems in a separate procedure before the cataract surgery.

The Internal Medicine database was linked to the above mentioned Laboratory database after applying the following exclusion criteria: (i) The Laboratory records of any subsequent cataract operations after the first study record were excluded to avoid the effect of any previous prophylaxis on the conjunctival flora. (ii) Patients having combined surgical procedures of cataract phacoemulsification with trabeculectomy or pars plana vitrectomy were excluded, because of the difficulty of collecting these patients' samples in the same conditions as in the planned cataract surgeries.

Diabetic and non-diabetic definition criteria: the diabetic condition was self-reported by the patient and the non-diabetic theoretical status. The kind of diabetes was typified by the Internist, based on the updated data and the patient history disease, when it was possible. For classifying the non-diabetic patients, the updated blood glucose level was taken into account because of the impossibility of checking whether an unexpected baseline blood glucose level higher than the upper limit of our normal reference value, 6.05 mmol/l (110 mg per 100 ml), for a non-diabetic patient was true or false. In addition, self-reported non-diabetics having a blood creatinine level $>105.2\,\mu$mol/l (1.19 mg per100 ml) were studied as a separate group, in order to ensure that false non-diabetics with renal dysfunction did not join the non-diabetic group (in our country, about 23% of the patients suffering from advanced chronic kidney insufficiency are diabetics[23,24]). For these reasons, only self-reported non-diabetics having the baseline glucose and creatinine blood levels below the upper limit of our normal reference values were considered for the non-diabetic control group.

Microbiological methods

The specimen collection and the culture technique were described elsewhere.[19,25] The identification of the isolated bacteria was performed as follows: for rapid growing and non-exigent bacteria, Dade-Behring identification panels were used (for *Staphylococci* and *Enterococci*, panel PC23; for Gram-negative rods, panels PC38 and PUC37). These panels were automatically read and recorded in the AutoScan4 microbiological system (Siemens Healthcare Systems, Barcelona, Spain). When <5 colony-forming units of a particular coagulase-negative *Staphylococcus* were isolated, the panel PC23 was used for identification, only if the fermentation mannitol test was positive. The identification of *Haemophilus*, *Neisseria*, and

Moraxella was carried out with the HNID Dade-Behring panel. *Streptococci*, *Propionibacteria*, *Corynebacteria*, and other Gram-positive rods were identified by their growing characteristics and their macroscopic and microscopic morphology; *Streptococcus pneumoniae* was differentiated by the optochin disc.

Analysis of the results

In the AutoScan4 microbiological system, a Laboratory data text file was generated, which was exported to a Microsoft Access database (version 2003). This Laboratory database was linked to the Access Internal Medicine database through the clinical record number of the patients. By means of the Access utilities, patients' records were selected according to the inclusion criteria study. The frequencies of diabetic and non-diabetic patient groups, the mean age of these patient groups, and the isolated conjunctival bacteria of each group were also obtained with the Access program utilities. The isolated bacteria were grouped in order to try to reach a number of bacteria sufficient for making statistical comparisons. The Epidat program 3.1 version (produced by the Pan American Health Organization, Washington, DC, USA and the Consejería de Sanidad de la Junta de Galicia, La Coruña, Spain; http://dxsp.sergas.es), was used for (i) calculating the 95% confidence interval (CI) of the bacterial group percentages in the whole sample of patients. (ii) Comparing the mean age and the percentage of men and women of the non-diabetics control group with that of each of the following groups: self-reported non-diabetics who had a blood creatinine level $>105.2\,\mu$mol/l; self-reported non-diabetics who had a baseline glycaemia >6.05 mmol/l; diabetics maintaining a creatinine level below $106\,\mu$mol/l; those diabetics having a probable renal dysfunction; those identified as type I diabetics; those identified as type II diabetics; those diabetics that we were unable to classify; and those of the whole self-reported diabetics group; also, comparing the mean age of the men and the women of every group of patients in Table 1. (iii) Comparing the conjunctival bacterial percentages of the whole self-reported non-diabetics group with those of the whole self-reported diabetic group. In addition, the conjunctival bacterial percentages of the non-diabetic control group were compared with those of the different groups of diabetics and non-diabetics listed above.

Results

A total of 5922 patients were selected from the linked database according to the inclusion criteria of the study;

Table 1 Comparison of percentages of men and women of the control group and their mean age with each of the following groups of patients

Data for both sexes	*Self-reported non-diabetics*			*Self-reported diabetics*			*Self-reported classified diabetics*		
	Control group	*With blood creatinine >105.2 μmol/l*	*With fasting glycaemia >6.05 mmol/l*	*All diabetics*	*With blood creatinine <106 μmol/l*	*With blood creatinine >105.2 μmol/l*	*Diabetics type I*	*Diabetics type II*	*Non-classified*
Patients count	3423	362	900	1325	1138	187	191	1067	67
Men count	1460	250	471	594	487	107	79	482	33
Men %	42.65	69.06[a]	52.33[a]	44.83	42.79	57.22[a]	41.36	45.17	49.25
Men mean age	71.70	76.65[b]	73.07[c]	72.65[d]	72.18	74.78[c]	70.43	73.02	72.61
Men age range	(10–95)	(45–95)	(43–97)	(35–93)	(39–91)	(35–93)	(35–89)	(41–92)	(49–93)
Men age SD	11.135	8.093	8.531	8.513	8.245	9.390	10.209	8.147	8.785
Difference to the control group mean age (years)		−4.95	−1.37	−0.95	−1.10	−3.08	1.27	−1.32	−0.91
Women %	57.35	30.99	47.67	55.17	57.21	42.78	58.64	54.83	50.75
Women mean age	73.94	80.71[b]	76.49[b]	74.72[d]	74.61	75.60	71.86[c]	75.29[b]	74.38
Women age range	(19–98)	(59–96)	(38–95)	(42–94)	(42–94)	(50–91)	(47–94)	(42–94)	(60–86)
Women age SD	9.249	7.403	7.433	7.324	7.245	7.933	8.017	7.119	6.305
Difference to the control group mean age (years)		−6.77	−2.55	−0.78	−0.67	−1.66	2.08	−1.35	−0.44
Sexes mean age difference	−2.24[e]	−4.06[e]	−3.42[e]	−2.07[e]	−2.43[e]	−0.82	−1.43	−2.27[e]	−1.77

SD, standard deviation.
[a]These percentages of men were significantly higher than that of the control group, $P<0.001$.
[b]These mean ages were significantly higher than that of the control group, $P<0.001$.
[c]These mean ages were significantly higher than that of the control group, $P<0.01$; except for the diabetic women type I, which is lower than in the control group.
[d]These mean ages were significantly higher than that of the control group, $P<0.05$.
[e]These mean age differences between men and women were significant $P<0.001$, although women were older than men in every group.
In addition, the mean age of men and women were compared for every group.

the mean age of these patients was 73. 66 years, with a standard deviation (SD) of 9.40, in a range from 10 to 98. In all, 3214 (54.27%) of them were women, and 1325 of the patients said that they were diabetic (22.37%); among those diabetics, 191 were identified as type I, 1067 as type II, and 67 were unclassified. The self-reported non-diabetics accounted for 4597 patients; of those, 3423 presented a baseline blood glucose level lower than 6.11 mmol/l and a blood creatinine level below 106 μmol/l (these being the control group); 900 of those self-reported non-diabetics (15.2% of the total sample of patients) who had a fasting glycaemia above 6.05 mmol/l could be diabetics without knowing it; and 362 self-reported non-diabetics had a blood creatinine level >105.2 μmol/l.

In Table 1, the frequency of both sexes, the mean age, the SD, and the range of age of each of the study groups of patients are shown. The significant higher proportion of men in the diabetic and non-diabetic groups with an impaired renal function should be noted, as well as the significant increased age of these two groups of patients, whether men or women, with respect to the control group. Women were older than men in every group, but statistical significance was only found in those groups containing >361 patients. The diabetics type I was the sole group of patients with a mean age lower than the control group.

In Table 2, the whole patients' conjunctival bacterial frequency and their CI percentages of every bacterial group are given, as well as the frequency of these bacteria in the whole self-reported diabetic and non-diabetic groups. There are eight groups of conjunctival bacterial colonisers of the diabetic patient group outside the CI of the bacterial percentages of the whole 5922 patients studied. From these eight bacterial groups, four turnd out to be statistically higher than those for the whole self-reported non-diabetic, which are *Staphylococcus aureus, Enterococci*, *Streptococci* (except *S. pneumoniae)*, and *Klebsiella* sp.

Table 3 shows the comparison of the control group's conjunctival bacterial percentages with those of the following groups: the self-reported non-diabetics having a fasting glycaemia >6.05 mmol/l; the self-reported non-diabetics having a blood creatinine level >105.2 μmol/l; the diabetic patients who had a blood creatinine level <106 μmol/l; and the diabetics having a creatinine level >105.2 μmol/l. In this table, both groups of diabetics and non-diabetics having an impaired renal

Table 2 Frequency of bacteria isolated in all the studied patients and the comparison between self-reported diabetics and non-diabetics

Bacteria isolated	*5922 patients included in the study*				*4597 self-reported non-diabetics*		*1325 self-reported diabetics*		*Comparison of diabetics and non-diabetics*
	Frequency	*%*	*CI of the %*[a]		*Frequency*	*%*	*Frequency*	*%*	P-*value*
Staphylococcus aureus	576	9.73	8.96	10.50	420	9.14	156	11.77[b]	**0.005**[c]
CNS	5171	87.32	86.46	88.17	4014	87.32	1158	87.40	0.977
Enterococcus sp.	127	2.15	1.77	2.52	87	1.89	40	3.02[b]	**0.017**[c]
Bacillus sp.	37	0.63	0.42	0.83	25	0.54	12	0.91[b]	0.202
Corynebacterium xerosis	2771	46.79	45.51	48.07	2153	46.84	618	46.64	0.926
Other diphtheric bacilli	617	10.42	9.63	11.21	471	10.25	146	11.02	0.447
Propionibacterium sp.	1485	25.08	23.96	26.19	1169	25.43	316	23.85	0.257
Other Gram-positive rods	33	0.56	0.36	0.76	25	0.54	8	0.60	0.961
Haemophilus sp.	191	3.23	2.77	3.68	146	3.18	45	3.40	0.755
Gram-negative Diplococci	220	3.72	3.23	4.21	160	3.48	60	4.53[b]	0.090
Streptococcus pneumoniae	192	3.24	2.78	3.70	154	3.35	38	2.87	0.433
Other *Streptococci*	986	16.65	15.69	17.61	741	16.12	245	18.49[b]	**0.046**[c]
Citrobacter sp.	13	0.22	0.09	0.35	9	0.20	4	0.30	0.694
Enterobacter sp.	23	0.39	0.22	0.56	20	0.44	3	0.23	0.409
Escherichia sp.	8	0.14	0.03	0.24	4	0.09	4	0.30[b]	0.147
Klebsiella sp.	16	0.27	0.13	0.41	6	0.13	10	0.75[b]	**0.000**[c]
Morganella morganii	44	0.74	0.52	0.97	33	0.72	11	0.83	0.812
Proteus sp.	101	1.71	1.37	2.04	83	1.81	18	1.36	0.324
Serratia sp.	10	0.17	0.06	0.28	9	0.20	1	0.08	0.576
Pseudomonas sp.	33	0.56	0.36	0.76	25	0.54	8	0.60	0.961
Other Gram-negative rods	47	0.79	0.56	1.03	32	0.70	15	1.13[b]	0.162
Sterile cultures	377	6.37	5.74	7.00	306	6.66	71	5.36[d]	0.101

CNS, coagulase-negative *Staphylococci*.
[a]Confidence intervals, with 95% security, of the percentage of organisms isolated in all the studied patients.
[b]Frequency outside the confidence intervals of the percentage of isolated organisms in the 5922 studied patients.
[c]Groups of bacteria isolated with a significantly high frequency in diabetic patients.
[d]Group of sterile cultures with a significantly low frequency in diabetic patients.

Table 3 Comparison of the non-diabetic control group conjunctival bacterial prevalence with that of each of the following groups: non-diabetics with creatinine >105.2 μmol/l, non-diabetic with glucose >6.05 mmol/l, diabetics with creatinine <106 μmol/l, and diabetics with creatinine >105.2 μmol/l

Groups of patients	*4597 Self-reported non-diabetics*								*1325 Self-reported diabetics*					
	Control group[a]		*With blood creatinine >105.2 μmol/l*			*With fasting glycaemia >6.05 mmol/l*			*With blood creatinine <106 μmol/l*			*With blood creatinine >105.2 μmol/l*		
Patients in each group	*3423*	*%*	*362*	*%*	*P-value*	*900*	*%*	*P-value*	*1138*	*%*	*P-value*	*187*	*%*	*P-value*
Staphylococcus aureus	303	8.85	49	13.54[b]	0.005	79	8.78	0.997	127	11.16[b]	0.025	29	15.51[b]	0.003
CNS	2925	85.45	328	90.61[b]	0.009	840	93.33[b]	0.000	983	86.38	0.468	175	93.58[b]	0.003
Enterococcus sp.	67	1.96	3	0.83	0.190	18	2.00	0.958	34	2.99	0.054	6	3.21	0.359
Bacillus sp.	19	0.56	2	0.55	0.715	4	0.44	0.882	8	0.70	0.734	4	2.14[b]	0.029
Corynebacterium xerosis	1588	46.39	161	44.48	0.522	446	49.56	0.098	543	47.72	0.459	75	40.11	0.109
Other diphtheric bacilli	316	9.23	63	17.40[b]	0.000	104	11.56[b]	0.042	126	11.07	0.078	20	10.70	0.588
Propionibacterium sp.	846	24.72	113	31.22[b]	0.008	241	26.78	0.220	266	23.37	0.383	50	26.74	0.592
Other Gram-positive rods	20	0.58	1	0.28	0.705	4	0.44	0.802	8	0.70	0.822	0	0.00	0.588
Haemophilus sp.	103	3.01	16	4.42	0.192	28	3.11	0.960	37	3.25	0.756	8	4.28	0.447
Gram-negative Diplococci	109	3.18	21	5.80[b]	0.014	33	3.67	0.537	50	4.39	0.067	10	5.35	0.161
Streptococcus pneumoniae	111	3.24	16	4.42	0.303	32	3.56	0.717	34	2.99	0.743	4	2.14	0.533
Other *Streptococci*	538	15.72	72	19.89[b]	0.048	142	15.78	0.994	214	18.81[b]	0.017	31	16.58	0.833
Citrobacter sp.	4	0.12	3	0.83[b]	0.019	3	0.33	0.331	4	0.35	0.219	0	0.00	0.509
Enterobacter	17	0.50	0	0.00	0.352	3	0.33	0.714	3	0.26	0.440	0	0.00	0.676
Escherichia sp.	3	0.09	1	0.28	0.842	0	0.00	0.859	3	0.26	0.344	1	0.54	0.509
Klebsiella sp.	4	0.12	1	0.28	0.974	1	0.11	0.613	8	0.70[b]	0.003	2	1.07[b]	0.028
Morganella morganii	21	0.61	4	1.10	0.449	8	0.89	0.502	11	0.97	0.302	0	0.00	0.924
Proteus sp.	62	1.81	8	2.21	0.741	15	1.67	0.881	16	1.41	0.434	2	1.07	0.643
Serratia sp.	7	0.20	1	0.28	0.750	1	0.11	0.885	1	0.09	0.685	0	0.00	0.815
Pseudomonas sp.	16	0.47	6	1.66[b]	0.014	7	0.78	0.378	7	0.62	0.713	1	0.54	0.676
Other Gram-negative rods	26	0.76	2	0.55	0.909	4	0.44	0.431	15	1.32	0.122	0	0.00	0.452
Sterile cultures	252	7.36	11	3.04[c]	0.003	44	4.89[c]	0.011	60	5.27[c]	0.019	11	5.88	0.540

CNS, coagulase-negative *Staphylococci*.

[a]Those self-reported non-diabetic patients having a blood creatinine level <106 μmol/l and a blood glucose level <6.1 mmol/l.

[b]Percentages of conjunctival bacteria significantly higher than those in the control group.

[c]Percentages of conjunctival bacteria significantly lower than those in the control group.

Table 4 Comparison of the non-diabetic control group conjunctival bacteria prevalence with that of each of the following diabetic groups: type I, type II, unclassified diabetics, and the whole group of diabetic patients

Groups of patients	*Control group*[a]		*Diabetics type I*			*Diabetics type II*			*Unclassified diabetics*			*Total of diabetics*		
Patients in each group	*3423*	*%*	*191*	*%*	P-*value*	*1067*	*%*	P-*value*	*67*	*%*	P-*value*	*1325*	*%*	P-*value*
Staphylococcus aureus	303	8.85	25	13.09	0.064	122	11.43[b]	0.014	9	13.43	0.278	156	11.77[b]	0.003
CNS	2925	85.45	148	77.49[c]	0.004	954	89.41[b]	0.001	56	83.58	0.799	1158	87.40	0.092
Enterococcus sp.	67	1.96	5	2.62	0.712	32	3.00[b]	0.057	3	4.48	0.309	40	3.02[b]	0.036
Bacillus sp.	19	0.56	2	1.05	0.703	9	0.84	0.411	1	1.49	0.850	12	0.91	0.252
Corynebacterium xerosis	1588	46.39	85	44.50	0.664	505	47.33	0.617	28	41.79	0.532	618	46.64	0.903
Other diphtheric bacilli	316	9.23	14	7.33	0.448	121	11.34[b]	0.049	11	16.42	0.074	146	11.02	0.070
Propionibacterium sp.	846	24.72	53	27.75	0.391	245	22.96	0.261	18	26.87	0.794	316	23.85	0.559
Other Gram-positive rods	20	0.58	0	0.00	0.577	7	0.66	0.970	1	1.49	0.877	8	0.60	0.895
Haemophilus sp.	103	3.01	5	2.62	0.928	38	3.56	0.422	2	2.99	0.727	45	3.40	0.552
Gram-negative Diplococci	109	3.18	6	3.14	0.858	50	4.69[b]	0.026	4	5.97	0.354	60	4.53[b]	0.031
Streptococcus pneumoniae	111	3.24	7	3.67	0.912	30	2.81	0.546	1	1.49	0.649	38	2.87	0.568
Other *Streptococci*	538	15.72	29	15.18	0.924	203	19.03[b]	0.013	13	19.40	0.516	245	18.49[b]	0.023
Citrobacter sp.	4	0.12	0	0.00	0.519	3	0.28	0.457	1	1.49	0.188	4	0.30	0.317
Enterobacter	17	0.50	0	0.00	0.665	3	0.28	0.510	0	0.00	0.758	3	0.23	0.298
Escherichia sp.	3	0.09	0	0.00	0.378	4	0.38	0.103	0	0.00	0.063	4	0.30	0.192
Klebsiella sp.	4	0.12	2	1.05	0.031	8	0.75[b]	0.002	0	0.00	0.123	10	0.75[b]	0.001
Morganella morganii	21	0.61	1	0.52	0.747	9	0.84	0.555	1	1.49	0.904	11	0.83	0.535
Proteus sp.	62	1.81	1	0.52	0.299	17	1.59	0.734	0	0.00	0.519	18	1.36	0.336
Serratia sp.	7	0.20	0	0.00	0.826	1	0.09	0.739	0	0.00	0.313	1	0.08	0.563
Pseudomonas sp.	16	0.47	1	0.52	0.665	7	0.66	0.612	0	0.00	0.725	8	0.60	0.714
Other Gram-negative rods	26	0.76	3	1.57	0.420	12	1.13	0.345	0	0.00	0.999	15	1.13	0.285
Sterile cultures	252	7.36	15	7.85[b]	0.045	51	4.78[c]	0.004	5	7.46	0.838	71	5.36[c]	0.017

CNS, coagulase-negative *Staphylococci*.
[a]Those self-reported non-diabetic patients having a blood creatinine level $<106\,\mu$mol/l and a blood glucose level <6.11 mmol/l.
[b]Percentages of conjunctival bacteria significantly higher than those in the control group.
[c]Percentages of conjunctival bacteria significantly lower than those in the control group.

function exhibited a significantly higher percentage of *S. aureus* and other *Staphylococci*. In the two groups of diabetics, the *S. aureus* and *Klebsiella* sp. prevalence are significantly higher than those in the non-diabetics control group.

In Table 4, the conjunctival bacterial percentages of the non-diabetic control group were compared with those of the following groups: diabetics type I, diabetics type II, unclassified diabetics, and all the self-reported diabetics. Diabetics types I and II coincided in having a higher prevalence of *S. aureus* and *Klebsiella* sp., and a significantly lower prevalence of sterile cultures, compared with those in the control group, although the *S. aureus* prevalence of diabetics type I did not reach statistical significance.

In Table 5, the proportion of non-diabetics and different kinds of diabetics who had an impaired renal function when they underwent cataract surgery is shown.

Table 5 Proportion of patients with impaired renal function undergoing cataract operation

Groups of patients	*Number of patients*	*Patients with creatinine* $>105.2\,\mu$*mol/l*	
Diabetics type I	191	43	22.51 (%)
Diabetics type II	1067	128	12.00 (%)
Unclassified diabetics	67	16	23.88 (%)
Self-reported non- diabetics	4597	362	7.87 (%)
Total of patients	5922	549	9.27 (%)

Discussion

To our knowledge, this study provides the biggest sample of patients ever described for studying the conjunctival bacterial pattern in diabetics. The prevalence of the 900 self-reported non-diabetics (15.2% of the total sample of patients) excluded from the control group because of the uncertainty that they could be 'unknown' diabetics, is a result consistent with the prevalence of 'unknown' diabetics in our country.[24,26] The 22.37% of our patients who knew that they were diabetics when they underwent cataract operation in our hospital is a higher prevalence of 'known' diabetes than the national prevalence average of our country, as it was at the beginning of the last decade.[24,26] In two studies carried

out at about the same time, the prevalence of diabetics undergoing cataract surgery was about 11% in the United Kingdom[2] and 20% in New Zealand;[27] but this difference is probable due to ethnic characteristics.[26] Our patients' increased prevalence could be due to the following reasons. First, the proportion of elderly patients in this study is bigger than that in the above mentioned Spanish studies, and an increase in age was associated with the risk of being diabetic everywhere.[4–7,24,26] Second, there could be a concentration of diabetic patients with a poor health status in a tertiary referral hospital as ours. Third, the predicted worldwide tendency of an increasingly serious diabetes epidemic could have already been affecting our country's diabetes prevalence.

The conjunctival bacterial pattern of our diabetics presents the peculiarity of having an increased prevalence of *S. aureus*, *Klebsiella* sp., *Enterococci*, and *Streptococci* α-haemolytic different from *S. pneumoniae* with respect to the non-diabetics conjunctival bacteria (Tables 2 and 4). This peculiarity was even detected by comparing the self-reported information of the patients as diabetics or non-diabetics (Table 2). However, the two most consistent of these results is the higher prevalence of *S. aureus* and *Klebsiella* sp., found even in those diabetics with a normal blood creatinine level or when the number of patients was smaller, as in diabetics type I or those diabetics with an abnormally high blood creatinine level (Tables 2–4). The *Enterococci* prevalence is higher in all the diabetic groups with respect to the control group; but only when the total group of diabetics is compared, a statistical significance is obtained (Tables 2 and 4). The higher prevalence of *Streptococci* (except *S. pneumoniae*) of the diabetics reached statistical significance in some of the groups, but its distribution among groups is not so persistent (Tables 2–4).

In one of the two small-sized studies published on the diabetics conjunctival bacteria,[28,29] an increased prevalence of *S. aureus* was only found in diabetics type II, although the number of patients studied by Bilen *et al*[28] was small (17 diabetics type I, 66 diabetics type II, and 50 control subjects). But only an increased prevalence of SCN was found in the other one,[29] which only studies the flora of diabetics with retinopathy. This second study[29] used certain exclusion criteria for their patients, such as any sign of external ocular infection or inflammation, which we did not use. In addition, their patients were younger (mean age 67 years) than ours (mean age 73 years), which could condition their flora prevalence.[9]

Undoubtedly, the great number of patients contained in our sample allows us to identify this diabetic bacterial pattern, although the prevalence of the affected bacteria is not strikingly high. However, our big sample of patients also allows us to differentiate the influence of diabetes on the conjunctival bacterial flora from other factors affecting the prevalence of these flora. In a previous study from our hospital,[9] advanced age and male sex increased the conjunctival bacterial prevalence; in this study, this effect is also shown (Tables 1 and 3). But, in addition, the groups of patients having a predominance of men and a higher mean age, both diabetics and non-diabetics, also had a blood creatinine level above the normal level, which indicates that the conjunctival bacterial prevalence is also altered in the patients with a suspected impaired renal function (Tables 1 and 3). In particular, the higher conjunctival prevalence of *S. aureus* in those patients with a high creatinine level is congruent with the well-known likelihood of diabetics and non-diabetics suffering from nephropathy of being nasal carriers of this bacterium[30,31] and having other infections as a consequence of this carriage.[32] This fact reinforced the reliability of the association of an increased conjunctival *S. aureus* colonisation with a suspected renal lesion in our patients who are diabetic or not.

The prevalence of diabetic nephropathy varies among studies,[23,24,26,33–35] but there is some agreement as regard to recognising its determinant factors, such as increased blood pressure,[33–36] increased glycosylated haemoglobin,[33,35,36] increased blood creatinine,[33,34] male sex,[33,34] and a previous retinopathy.[33,34] The prevalence of retinopathy also varies among studies,[24,26,34,35,37] and its development is mainly associated with the duration of the diabetes,[35,37] among other determinant factors. We did not find a fixed rule in the diabetes follow-up studies for the appearance and coincidence of these two diabetic complications.[34,35,37] However, the concomitance of nephropathy and retinopathy represents a worse state in the diabetes progression.[34,35] This fact indicates that, apart from the risk of diabetics with retinopathy having a higher rate of posterior capsule rupture during the cataract operations[22] (a surgical complication associated with an increased incidence of PE[15,18]), diabetics with renal function impairment have a potential increased risk of bacterial contamination during that operation. In our study, 14.11% of the self-reported diabetics had an abnormally high blood creatinine level; among those, the proportion in the diabetics type I group is higher than that in the type II group (Table 5). But 7.87% of the self-reported non-diabetics also presented a suspected renal dysfunction, although we do not know what part of them were unknown diabetics. On the basis of our results, 9.27% of the patients with a suspected renal dysfunction had an increased conjunctival bacterial prevalence (Table 5).

On the other hand, a gradual *S. aureus* conjunctival colonisation (8.78, 11.16, and 15.51%) could be seen in the three groups of differentiated diabetics that could represent three different stages of the diabetes (Table 3). (i) Patients who recently became diabetics (part of those self-reported non-diabetics with a high fasting glycaemia); (ii) diabetics with a normal blood creatinine level; (iii) diabetics with a suspected renal function impairment. The progressive colonisation by *Klebsiella* sp. and *Enterococci* in the three groups of diabetics follows the same behaviour as the *S. aureus* colonisation (Table 3), despite their lower prevalence on the conjunctiva. This progressive colonisation suggests us the possibility that there exists a group of diabetics with a higher conjunctival bacterial load because of the personal development of their disease, which could explain the different risk of PE attributed to diabetes in patients operated on for cataracts. Another point to underline among our data for assessing the diabetic conjunctival bacterial pattern is the fact that patients in the control group had similar sex distribution and mean age to those diabetics with a normal blood creatinine level (Table 1). Therefore, the bacterial pattern of those diabetics cannot be attributed to these two conditions.

However, what is more surprising from our study is to note that diabetes has been described as being a risk for different infections caused by the same bacteria that we have found more prevalent on diabetics' conjunctiva. For instance, bacteraemia caused by *S. aureus*,[38,39] *Enterococci*,[40] and *Klebsiella sp.*;[41,42] hepatic abscess and fascial space infection of the head and neck and soft tissue due to *Klebsiella pneumoniae*.[43,44] In particular, the association of *K. pneumoniae* and bloodstream infections of diabetics was described in a recent study,[42] in which diabetics had a 4.4-fold higher risk of bloodstream infections than non-diabetics. The repetition of this diabetic bacterial pattern led us to suppose that diabetes provides certain conditions that encourage this bacterial colonisation.

In conclusion, ophthalmic surgeons should be aware that some diabetics have a higher risk of contamination with *S. aureus*, *Enterococci*, *Klebsiella sp.*, and certain *Streptococci* during the cataract surgery compared with the non-diabetics. Among these bacteria, *Enterococci* present a high antibiotic resistance pattern,[19,45] and this resistance is on the increase in *S. aureus*.[32,46] An advanced age and an abnormally high blood creatinine level are also associated with an increased conjunctival bacterial colonisation in diabetics and non-diabetics; these two simple figures could be reliable indicators of the contamination risk.

Summary

What was known before

- Among the huge quantity of patients undergoing cataract operation, an increased postoperative endophthalmitis incidence has often been associated with diabetes, but not always.
- The visual outcome of diabetic patients after postoperative endophthalmitis is worse than that of non-diabetics.
- There is the threat of an epidemic growth of diabetes prevalence, in particular in the elderly.
- It was known that patients with chronic illness are heavily colonised with potential pathogens.
- The conjunctival flora is the main cause of intraocular contamination during the cataract surgery.
- There was very little knowledge of the conjunctival bacterial flora of diabetic patients undergoing cataract operation.

What this study adds

- To assess the conjunctival bacterial pattern of diabetics, in a big sample of consecutive patients undergoing cataract surgery, which consists on having an increased prevalence of *Staphylococcus aureus*, *Enterococci*, *Klebsiella* sp., and certain *Streptococci*.
- To differentiate the conjunctival bacterial flora of diabetics type I and type II and that of those diabetics and non-diabetics having an impaired renal function. Given also is the distribution of age and sex for each of these groups.
- To associate the impaired renal function with an increase of the conjunctival bacterial flora. We have found a simple indicator of this association, which is a serum creatinine level $>105.2\,\mu$mol/l.

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