



The Microbiological Profile of Bicanalicular Silicone Tubes Placed During External Dacryocystorhinostomy

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Abstract

Objectives: To identify microbiological growth on bicanalicular silicone tubes (BST) placed during dacryocystorhinostomy (DCR) surgery and to analyze the association between culture results and surgical outcomes and BST removal time.

Materials and Methods: A total of 80 lacrimal drainage systems of 68 patients who had external DCR with bicanalicular silicone intubation were included the study. Twenty-five tubes (31.3%) were removed up to 8 weeks, 28 tubes (35.0%) were removed between 9 and 11 weeks, and the remaining 27 tubes (33.7%) were removed 12 weeks or more after surgery. The tubes were transferred to Stuart medium and sent for microbiologic examination. The disc diffusion method was used to determine antibiotic resistance.

Results: Culture positivity was observed for 96.2% of the tubes. Among a total of 109 isolates, 63 were gram-positive bacteria (57.8%), 37 were gram-negative bacteria (34%), and 9 were fungi (8.2%). The most commonly isolated gram-positive and gram-negative bacteria were *Staphylococcus aureus* (66.6%) and *Enterobacter* spp. (29.7%), respectively. Penicillin, clindamycin, erythromycin, and tetracycline resistances were higher among gram-positive pathogens. Cephalothin, amoxicillin-clavulanic acid, and ampicillin resistances were higher among gram-negative pathogens. There was no significant difference in terms of the microbiological profile between the three groups of removed tubes. *Haemophilus influenzae* was isolated at a significantly higher rate in patients with surgical failure ($p=0.04$).

Conclusion: Although a variety of agents were isolated from removed BST, gram-positive organisms were more frequent than gram-negatives and fungi. *S. aureus* and *Enterobacter* were the most common gram-positive and gram-negative isolates. Later BST removal was associated with the isolation of significantly more bacterial strains per tube. There was no correlation between multiple infections and surgical failure. *H. influenzae* was more common in failed DCR cases.

Keywords: Bicanalicular silicone tube, external dacryocystorhinostomy, microbiology, nasolacrimal duct obstruction

Introduction

External dacryocystorhinostomy (DCR) is the gold standard therapeutic procedure for nasolacrimal duct obstruction (NLDO). Bicanalicular silicone tube intubation has been widely used in DCR surgery since its introduction by Gibbs in 1967.^{1,2} However, the benefit of bicanalicular silicone tube intubation in DCR surgery remains controversial.^{3,4,5} Kim et al.⁶ reported that silicone intubation improves surgical success rate, whereas Allen and Berlin⁷ asserted that it has a negative impact on primary DCR surgery.

Choung and Khwarg⁸ conducted a study and suggested that patients with primary NLDO who have large lacrimal sacs, intact canalicular systems, and wide nasal cavities do not require tube placement during external DCR. Consequently, common indications for bicanalicular silicone tube intubation in DCR are revision surgeries, common canalicular stenosis, fibrotic lacrimal sac, and inadequate anastomosis of lacrimal sac and nasal mucosal flap.^{9,10} The most frequent complications considered to be related with silicone tube intubation are punctal slitting and peripunctal granuloma formation, canalicular laceration, tube

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displacement or loss, chronic nasal or conjunctival irritation, and corneal abrasion.¹¹

Microbiological growth over the silicone tubes and its effect on surgical outcomes has been analyzed in a few studies. Although Ali et al.¹² reported that the organisms isolated from silicone tubes did not influence the success rate of DCR, Kim et al.¹³ found that the rate of *Pseudomonas aeruginosa* infection was significantly higher in those with final surgical failure.

In this study, we aimed to identify the microbiological profile and antibiotic resistance of agents colonizing silicone tubes removed after DCR. We also analyzed the relationship between the culture results and surgical outcomes and tube removal time.

Materials and Methods

This study was a retrospective observational case series and included a total of 80 eyes of 68 adult patients who underwent external DCR surgery and silicone tube intubation in Ankara University Faculty of Medicine Ophthalmology Department. The study protocol was approved by the Ethics Committee of Ankara University of Medical Sciences and was carried out in accordance with the ethical guidelines of the Declaration of Helsinki. Thirteen of the patients were men (19.1%) and 55 were women (80.9%). The mean age of the participants was 55.1 years (± 13.9 , range 30-82 years). The number of patients with bilateral involvement was 12 (17.6%). Fifteen patients had diabetes mellitus (22%), one patient had scleroderma (1.4%), and one patient had history chemotherapy because of breast carcinoma (1.4%). Eight eyes (10%) had history of acute dacryocystitis and 12 eyes (15%) had history of chronic dacryocystitis before the operation. Patients using systemic and topical antibiotics prior to surgery were not included in the study. NLDO was confirmed using lacrimal irrigation before surgery. The otolaryngology department was consulted to detect the presence of intranasal pathologies before surgery. Thirteen eyes (16.2%) underwent revision and 67 eyes (83.8%) underwent primary external DCR surgery by a single surgeon (M.B.H.). The indications for silicone intubation were recurrent NLDO, common canalicular obstruction, fibrotic lacrimal sac, or inadequate lacrimal or nasal mucosal flaps for successful anastomosis.

Bicanalicular tubes were planned to be removed at 8 to 12 weeks after surgery. The tubes were removed through the nasal cavity using aseptic precautions and transferred to Stuart medium. Gram staining was performed first for all the collected samples. All the samples were cultured on blood agar, eosin methylene blue (EMB) agar, and chocolate agar and in brain-heart infusion broth for isolation of aerobic or facultative anaerobic bacteria. Chocolate, blood and EMB agars were incubated at 37°C in a 5%-10% CO₂ atmosphere for 24-72 hours. For the differentiation of fungal isolates, Sabouraud dextrose agar was incubated at both 25°C and 37°C for 7 days and contained chloramphenicol. The disk diffusion method was used to determine the antibiotic resistance profile of all

bacterial isolates using European Committee on Antimicrobial Susceptibility Testing guidelines.

Statistical Analysis

Categorical variables were compared using chi-square or Fisher's exact test as appropriate. Survival analyses on categorical variables were performed using the Kaplan-Meier method and significant differences between groups were identified using the log-rank test. P-values less than 0.05 were considered to be statistically significant. Statistical analyses were performed using SPSS (Statistical Package for Social Sciences; version 11.5).

Results

The mean follow-up period after the surgery was 8.7 months (± 9.5 , range 2-60 months). The overall success rate was 80%; the success rate for primary DCR was 85.1% and for revision DCR was 53.9% ($p=0.04$). The mean time to reocclusion of the nasolacrimal passage was 4.4 months (± 3 , range 1 to 11 months). The mean time for the bicanalicular tube removal was 12.2 weeks (± 5.7 range: 6-32 weeks).

Microorganisms were isolated from 77 tubes (96.2%). There was no microbiological growth on 3 silicone tubes (3.8%). A total of 109 isolates were identified. Of these, 63 were gram-positive bacteria (57.8%), 37 were gram-negative bacteria (34%), and the remaining 9 were fungi (8.2%) (Table 1). Of all 80 tubes, 39 had single bacterial species growth (48.8%), 25 had two bacterial species growth (31.3%), and 12 had three bacterial species growth (15%). There was no correlation between multiple growth and surgical failure ($p=0.09$). We grouped the tube removal times into three categories: up to 8 weeks after surgery (25 tubes, 31.3%), 9 to 11 weeks after surgery (28 tubes, 35%), and 12 weeks or more after surgery (27 tubes, 33.7%). There was no significant difference between these three groups in terms of microbiological profile or surgical outcomes. However, later tube removal was associated with a higher number of bacterial strains isolated for each tube. Triple bacterial growth was more common in tubes that remained 12 weeks or more compared to the tubes removed before 12 weeks ($p=0.04$).

Among the gram-positive organisms, *Staphylococcus aureus* was the most common isolate (66.6%), followed by *Corynebacterium* species (22.2%). The most common antibiotic resistances for *S. aureus* and coagulase-negative staphylococci (CNS) were penicillin and erythromycin. The rate of methicillin resistance among all *Staphylococcus* spp. was 18.75%. The most common antibiotic resistances for *Corynebacterium* spp. were penicillin and clindamycin. In general, gram-positive bacteria were more sensitive to gentamicin and cefotaxime (Table 2).

The most common gram-negative organisms were *Enterobacter* spp. (29.7%), *Haemophilus influenzae* (21.6%), and *P. aeruginosa* (18.9%). The most common antibiotic resistance was to ampicillin and cephalotin for *Enterobacter* spp., trimethoprim-sulfamethoxazole and cefuroxime for *H. influenzae*, and imipenem for *P. aeruginosa*. The rate of extended-spectrum beta-lactamase resistance among *Enterobacteriaceae*

was 12.5%. As a whole, gram-negative bacteria were more sensitive to imipenem and aztreonam (Table 3).

Yeasts (7.5%) were more commonly isolated than molds (5%). The most common fungi found in specimens were *Fusarium* species (44.4%), followed by *Aspergillus niger* (33.3%) and *Candida albicans* (22.2%). Molds were more commonly isolated in patients older than 65 years of age (p=0.03).

Among all isolated agents, *Enterobacter* spp. growth showed a significant correlation with diabetes mellitus (p=0.03). However, there was no difference in surgical outcomes. Success rate and microbiologic profile were similar in the patients with and without history of dacryocystitis. There was no statistically significant difference in terms of microbiological isolates of bicanalicular silicone tubes between revision and primary cases.

We compared the surgical failure with the growth of each infectious agent and found that *H. influenzae* was isolated more

in patients with surgical failure (p=0.04). Four of the 9 patients with *H. influenzae* isolated in culture had surgical failure (44.4%) (Table 4).

Discussion

The normal flora of the human conjunctiva is diverse and mostly consists of gram-positive bacteria. CNS is the most commonly isolated group of bacteria, detected in up to 100% of positive conjunctival cultures taken from patients preoperatively, with *Staphylococcus epidermis* the predominant species. Other organisms commonly constituting the ocular flora are *Propionibacterium*, *Corynebacterium* spp., *P. aeruginosa*, and *H. influenzae*.^{14,15} The normal nasal flora also includes *Corynebacterium*, *Streptococcus*, *Acinetobacter*, *Proteus*, *Mycoplasma* spp. and *Escherichia coli*. From the nasopharynx, *H. influenzae*, *Streptococcus pneumoniae*, *Streptococcus pyogenes*,

Table 1. Summary of microbiological growth in removed silicone tubes (n=80)

	No growth, n=3 (3.8%)	One bacterial sp., n=39 (48.8%)				Two bacterial spp., n=25 (31.3%)	Three bacterial spp., n=12 (15%)	Fungal growth, n=9 (11.25%)					
		Gram-positive only, n=29 (36.3%)		Gram-negative only, n=10 (12.5%)				Yeast, n=6 (7.5%)		Mold, n=4 (5%)			
Female	2	23	p=0.5	9	p=0.3	20	p=0.08	12	p=0.08	6	p=0.3	4	p=0.4
Male	1	6		1		5		0		0		0	
Age <65 years	3	22	p=0.4	7	p=0.7	16	p=0.4	9	p=0.7	6	p=0.1	1	p=0.03
Age >65 years	0	7		3		9		3		0		3	
Tube removal ≤8 weeks (n=25)	1	10	p=0.3	6	p=0.2	8	p=0.8	0	p=0.04	1	p=0.2	1	p=0.8
Tube removal 9-11 weeks (n=28)	1	12		1		8		5		3		2	
Tube removal >12 weeks (n=27)	1	7		3		9		7		2		1	

Table 2. Antibiotic resistance of gram-positive isolates (n=63)

	<i>Staphylococcus aureus</i> , n=42 (66.6%)	Coagulase-negative staphylococci, n=11 (17.4%)	<i>Streptococcus pneumoniae</i> , n=9 (9.5%)	<i>Corynebacterium</i> spp. n=14 (22.2%)
Penicillin	92.8%	81.8%	0	14.3%
Clindamycin	11.9%	5.4%	0	28.6%
Erythromycin	14.2%	72.7%	0	7.1%
Tetracycline	7.0%	45.4%	0	21.4%
Cephalothin	4.7%	45.4%	0	0
Amoxicillin-clavulanic acid	4.7%	45.4%	0	7.1%
Ceftriaxone	0	0	0	7.1%
Trimethoprim-sulfamethoxazole	0	9.0%	0	7.1%
Mupirocin	2.3%	9.0%	0	0
Rifampicin	4.7%	9.0%	0	7.1%
Ciprofloxacin	4.7%	36.3%	0	7.1%
Gentamicin	2.3%	0	0	7.1%
Fusidic acid	0	36.3%	0	0
Cefotaxime	0	9.0%	0	0
Susceptible to all antibiotics	7%	18.1%	100%	64.2%

Table 3. Antibiotic resistance of gram-negative isolates (n=37)

	<i>Haemophilus influenzae</i> , n=8 (21.6%)	<i>Pseudomonas aeruginosa</i> , n=7 (18.9%)	<i>Stenotrophomonas maltophilia</i> , n=5 (13.5%)	<i>Escherichia coli</i> , n=2 (5.4%)	<i>Klebsiella</i> spp., n=3 (8.1)	<i>Enterobacter</i> spp., n=11 (29.7%)	<i>Citrobacter koseri</i> , n=2 (5.4%)	<i>Proteus</i> spp., n=1 (2.7%)	<i>Serratia</i> spp., n=2 (5.4%)	<i>Pantoea agglomerans</i> , n=2 (5.4%)	<i>Morexella</i> spp., n=3 (8.1%)
Cephalorhin	0	0	0	50%	0	81.8%	0	0	50%	0	0
Amoxicillin-clavulanic acid	0	14.2%	0	50%	0	63.6%	0	0	100%	0	0
Trimethoprim-sulfamethoxazole	12.5%	0	20%	50%	33%	0	0	0	0	0	0
Gentamicin	0	14.2%	0	50%	33%	0	0	0	0	0	0
Imipenem	0	28.2%	0	0	0	0	0	0	0	0	0
Levofloxacin	0	0	20%	50%	0	0	0	0	0	0	0
Aztreonam	0	14.2%	0	0	0	0	0	0	0	0	0
Ampicillin	0	14.2%	0	100%	100%*	81.8%	100%*	0	50%	50%	100%
Ceftazidime	0	0	40%	0	0	0	0	0	0	0	0
Tigecycline	0	0	0	0	0	0	0	0	50%	0	0
Cefuroxime	12.5%	0	0	0	0	0	0	0	0	0	0
Susceptible to all antibiotics	75%	71.4%	40%	0	0	9.1%	0	100%	0	50%	0

and *Neisseria meningitides* can be isolated. Among the fungal flora, *Aspergillus*, *Cladosporium*, *Penicillium*, and *Alternaria* genera has been isolated from the noses of healthy adults.^{16,17}

Kim et al.¹³ identified the microbiologic profile of 39 silicone tubes placed during DCR in the Korean population and determined that 94.9% of the tubes had microbiological growth. They isolated gram-positive bacteria from 73.1%, gram-negative bacteria from 23.1%, and fungi from 3.8% of the tubes. *S. aureus* was the most common gram-positive isolate (73.9%), *P. aeruginosa* was the most common gram-negative isolate (12.8%), and *Aspergillus* (5.4%) and *Fusarium* (5.4%) were the most common fungi.¹³

Ali et al.¹² analyzed 50 silicone tubes retrieved after DCR in the Indian population and microbiological growth was noted in 88% of all stents cultured. They reported that fungal isolates were cultured from significant number (60%) of stents and the most common fungi was *Aspergillus* (66.6%). Gram-negative bacteria (54.5%) were more common than gram-positive bacteria (45.5%). The most common strains among the gram-negative and gram-positive bacteria were *P. aeruginosa* (27%) and *S. aureus* (18%), respectively. Gram-positive organisms were commonly sensitive to cephalosporins and vancomycin, whereas gram-negative organisms were sensitive to quinolones and aminoglycosides.¹²

Nemati et al.¹⁸ included 72 eyes in a study conducted in the Iranian population and reported culture positivity in 66.4% of the tubes. They identified gram-positive agents in 62%, fungi in 48.6%, and gram-negative agents in 20% of the tubes. *Staphylococcus epidermidis* (36.4%), *Aspergillus fumigatus* (47.64%), and *Enterobacter aerogenes* (29.8%) were the most common bacterial and fungal species isolated from the tubes cultured. Of the antibiotics studied, the highest antibiotic resistance rates were to ceftazolin and cloxacillin.¹⁸

Goel et al.¹⁹ conducted a similar study in the Nepalese population and reported 100% positivity in cultures of 24 silicone tubes. Of the total isolates, gram-positive bacteria were found in 66.6% and gram-negative bacteria in 33.3% of the tubes, while no fungi were isolated. The most common gram-positive isolate was *S. aureus* (50%) and the most common gram-negative isolate was *E. coli* (20.8%).¹⁹

In our study, there was 96.2% culture positivity from 80 bicanalicular silicone tubes. A total of 109 agents were isolated, of which 57.8% were gram-positive bacteria, 34% were gram-negative bacteria, and 8.2% were fungi. *S. aureus* was the most common gram-positive organism (66.6%), *Enterobacter* spp. was the most common gram-negative organism (29.7%), and *Fusarium* species were the most common fungi (44.4%) in the Turkish population. Among the gram-positive pathogens, resistance to penicillin, clindamycin, erythromycin, and tetracycline was more common. Among gram-negative pathogens, resistance to

Table 4. Factors potentially associated with surgical outcome

	Success, n=64 (80.0%)	Failure, n=16 (20.0%)	P values
Age (years), mean ± SD	53.2 (±3.4)	54.7 (±4.7)	p=0.080
Primary DCR (n=67)	57 (85.1%)	10 (14.9%)	p=0.040
Revision DCR (n=13)	7 (53.9%)	6 (46.1%)	
Acute dacryocystitis (n=8)	5 (62.5%)	3 (37.5%)	p=0.200
Chronic dacryocystitis (n=12)	8 (66.4%)	4 (33.3%)	p=0.197
Diabetes mellitus (n=15)	7 (66.4%)	5 (33.3%)	p=0.601
<i>Haemophilus influenzae</i> isolation (n=9)	5 (55.6%)	4 (44.4%)	p=0.004
<i>Pseudomonas aeruginosa</i> isolation (n=7)	4 (57.1%)	3 (42.9%)	p=0.166
Fungi isolation (n=9)	3 (33.3%)	p=0.261	p=0.261

SD: Standard deviation, DCR: Dacryocystorhinostomy

cephalotin, amoxicillin-clavulanic acid, and ampicillin was more common. Generally, gram-positives were more sensitive to gentamicin and cefotaxime and gram-negatives were more sensitive to imipenem and aztreonam.

The high prevalence of fungal growth in the studies by Ali et al.¹² and Nemati et al.¹⁸ might be related to a tropical and moist climate, as the climate is drier in Turkey than South India and the Iranian coast of the Caspian Sea. Increased *Enterobacter* spp. among our isolates may be linked to the low socioeconomic profile of the patients and poor hygiene habits. Similarly to our results, Nemati et al.¹⁸ and Goel et al.¹⁹ reported high rates of enteric floral growth among the gram-negative isolates obtained from silicone tubes.

Charalampidou et al.²⁰ compared surgical outcomes according to the timing of silicone tube removal. They removed 52.3% of the silicone tubes in 8-16 weeks, 13.3% before 8 weeks, and 34.4% after 16 weeks. They suggested that the timing of silicone tube removal after external DCR does not affect the long-term outcome of surgery. We grouped tube removal time into three categories: up to 8 weeks after surgery (31.3%), 9 to 11 weeks after surgery (35%), and 12 weeks or more after surgery (33.7%). There was no significant difference in terms of the microbiological profile and success rate between the three groups. As a result, the timing of the tube removal may be determined according to patient characteristics or surgeon preference.

Cultures should include the distal part of the silicone tubes. Becker²¹ compared the results of cultures of the proximal and distal segments of silicone tubes after external DCR and found that the proximal tube segments were culture positive in 28% and the distal tube segments were culture positive in 89% of lacrimal systems. Nearly all (91%) of the proximal tube cultures were either negative or grew different organisms than the distal segment cultures.²¹

The organisms isolated were not associated with the success rate of DCR in the studies by Ali et al.¹² and Goel

et al.¹⁹ However, Kim et al.¹³ reported that surgical failure and revision surgeries were associated with *Pseudomonas* infection. In our study, *H. influenzae* growth was associated with surgical failure, although we were unable to determine the exact relationship between the surgical failure and *H. influenzae* growth. Likewise, Kim et al.¹³ could not explain the impact of *P. aeruginosa* growth on surgical failure. *H. influenzae* and *P. aeruginosa* are both biofilm-producing pathogens and silicone tubes aggravate their adherence. *H. influenzae* and *P. aeruginosa* also produce immunoglobulin A protease, an important virulence factor, to eliminate tear film immune defense and increase colonization. Silicone tubes coated with antibiotic, antiseptic, nano-silver, or cationic polymers may reduce biofilm formation and bacterial adhesion.²² Histopathologic studies are essential for better understanding the mechanism by which these agents contribute to surgical failure.

Conclusion

In conclusion, *S. aureus* and *Enterobacter* spp. were the most commonly isolated gram-positive and gram-negative bacteria, respectively. The timing of silicone tube removal did not affect surgical outcomes. Tubes removed at or after 12 weeks were more likely to culture three bacterial strain than tubes removed before 12 weeks. *H. influenzae* was associated with unfavorable surgical outcomes. Supportive investigations are needed to gain knowledge and a better understanding of the variables effecting surgical outcomes.

Ethics

Ethics Committee Approval: Ankara University Faculty of Medicine Clinical Research Ethics Committee (source no: 05-397-19).

Peer-review: Externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: B.M.H., Concept: G.Ö., B.M.H., Design: G.Ö., B.M.H., Analysis or Interpretation: G.Ö., Literature Search: G.Ö., B.M.H., D.G., Writing: G.Ö.

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