AN EVALUATION OF CONTACT LENS DISINFECTION

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Introduction

The pharmacist has a vital role to play in assuring safe contact lens wear. Other then the contact lens practitioner, the pharmacist is the only person who can supply lens care materials and provide counselling based on scientific knowledge.

Corneal infections are the most dreaded complications associated with lens wear. Lenses are highly liable to become contaminated with harmful pathogenic organisms particularly during handling. Moreover, contact lens wearers run an increased risk of ocular infections due to interference with normal tears washout mechanisms. A satisfactory means of disinfecting lenses is therefore a basic requirement.

Disinfection procedures are particularly troublesome with flexible (hydrophilic) lenses. These lenses are able to absorb and bind antimicrobial preservatives such that a 'charged' lens may cause severe irritation and toxicity when placed on to the eye. To minimize these risks, preservative agents are required to be used in as low a concentration as possible. The antimicrobial performance of these solutions may therefore be limited (Phillips, 1985).

The aim of this project is to review the use of various contact lenses after-care products, with special reference to disinfection systems. An investigation was carried out whereby the antimicrobial efficacy of a selection of branded contact lens disinfecting solutions was evaluated.

Methodology

The test procedures used were obtained and modified from the Medical Guidelines (1985) of the Food and Drug Administration of the USA and also from the Department of Health and Social Security (1982) of the UK.

Escherichia coli, Staphylococcus auereus, Pseudomonas aeruginosa, Staphylococcus epidermidis and Candida albicans were used as test organisms. A standard inoculum of 10^6 organisms per ml was placed in a sample of a contact lens disinfecting solution and samples taken at various time intervals. These samples were serially diluted in sterile saline and cultured on tryptone soya agar plates. Colony counts were performed after an incubation period of 18 hours at 37°C.

Results

Table 1 displays the results obtained simply in the context of growth, or absence of growth, of micro-organisms. From this table, several preliminary observations can be made.

1. In the case of rigid contact lens disinfecting solutions, micro-organisms were generally inhibited only within 30 minutes. Because of this, it was not possible to work out the D-values for these solutions in the majority of cases.

2. In sharp contrast to this, growth was recorded for solutions intended for flexible lenses, in all the five times intervals. However, a decrease in the viable count with time was generally evident and the effectiveness of these solutions was further evaluated by determination of D-values, Safety Factors and Solution Powers.

The **D-value (Decimal reduction time)** is the time required to kill one log of cells of the original population (assuming first order kinetics). It is a means of assessing the activity of a particular solution against specific micro-organisms. The D-value was calculated by linear regression of data from the combined results of at least two experimental trials. The range of D-values obtained (Table 2) is from less than 1 minute, up to 248.8 minutes (4.2 hours).

Specification of the D-values alone is insufficient to gauge solution performance **clinically** since on a clinical scale, disinfection procedures are independent of both the **size of the initial inoculum** and the **duration of exposure** to the disinfecting solution. Allowance for the latter variable may be achieved by the calculation of a safety factor.

The **Safety Factor (SF)** is the minimum recommended disinfection time divided by the safe kill time (9D). The Safety Factor (Table 3) is a ratio that can be made use of to compare the disinfecting systems studied with each other and also to fail or pass a particular solution.

EFFECTIVENESS OF DISINFECTION SYSTEMS IN TERMS OF MICROBIAL GROWTH OR NON-GROWTH									
TIME (minutes)	MICRO ORGANISM	TEST SOLUTIONS							
		for rigid (hydrophobic) lenses			for flexible (hydrophilic) lenses				
		A	B	C	D	E	F	G	H
0	E. coli	+	+	-	+	+	+	+	+
	S. aure	+	+	+	+	+	+	+	+
	P. aeru	+	+	-	+	+	+	+	+
	S. epid	+	-	+	+	+	+	+	+
	C. albi	+	+	+	+	+	+	+	+
15	E. coli	-	-	-	+	+	+	+	-
	S. aure	-	-	+	+	+	+	+	-
	P. aeru	+	+	-	+	+	+	+	-
	S. epid	-	-	+	+	+	+	+	-
	C. albi	+	+	+	+	+	+	+	+
30	E. coli	-	-	-	+	+	+	+	-
	S. aure	-	-	+	+	+	+	+	-
	P. aeru	+	-	-	+	+	+	+	-
	S. epid	-	-	-	+	+	+	+	-
	C. albi	+	+	-	+	+	+	+	+
45	E. coli	-	-	-	+	+	+	+	-
	S. aure	-	-	-	+	+	+	+	-
	P. aeru	-	-	-	+	+	+	+	-
	S. epid	-	-	-	+	+	+	+	-
	C. albi	-	+	-	+	+	+	+	+
60	E. coli	-	-	-	+	+	+	+	-
	S. aure	-	-	-	+	+	+	+	-
	P. aeru	-	-	-	+	+	+	+	-
	S. epid	-	-	-	+	+	+	+	-
	C. albi	-	+	-	+	+	+	+	-

Key: A Complete Care B Total C Contactasoak D Conservante
E Aerotab F Hydrocare G Hydrosoak H 10-10

D - VALUES FOR CHEMICAL DISINFECTION SYSTEMS FOR USE WITH FLEXIBLE (HYDROPHILIC) CONTACT LENSES.

D - value (minutes)	Safe Kill Time [9D] (hours)	Trials	Test Microorganism	Solution
<1	<0.15	2	E. coli	10 10 (Ciba)
<1	<0.15	2	S. aure	10 10 (Ciba)
<1	<0.15	2	P. aeru	10 10 (Ciba)
<1	<0.15	2	S. epid	10 10 (Ciba)
5.00	0.75	2	C. albi	10 10 (Ciba)
34.1	5.12	4	P. aeru	CONSERVANTE (Ciba)
35.3	5.30	4	P. aeru	HYDROSOAK (Ciba)
35.3	5.30	4	C. albi	TOTAL (Allergan)*
39.0	5.82	2	E. coli	HYDROSOAK (Ciba)
43.5	6.53	2	S. epid	HYDROSOAK (Ciba)
49.5	7.43	2	S. aure	AEROTAB (Sauflon)
54.8	8.22	2	S. aure	HYDROCARE (Allergan)
60.0	9.00	2	S. aure	HYDROSOAK (Ciba)
60.5	9.08	2	E. coli	CONSERVANTE (Ciba)
67.4	10.1	2	S. epid	CONSERVANTE (Ciba)
85.2	12.8	2	P. aeru	HYDROCARE (Allergan)
88.0	13.2	4	S. aure	CONSERVANTE (Ciba)
103.4	15.5	2	S. epid	HYDROCARE (Allergan)
134.8	20.2	2	P. aeru	AEROTAB (Sauflon)
157.5	23.6	2	C. albi	HYDROCARE (Allergan)
200.4	30.0	2	C. albi	CONSERVANTE (Ciba)
206.1	30.9	4	C. albi	HYDROSOAK (Ciba)
208.9	31.3	2	S. epid	AEROTAB (Sauflon)
208.9	31.3	2	C. albi	AEROTAB (Sauflon)
236.1	35.4	2	E. coli	AEROTAB (Sauflon)
248.8	37.3	4	E. coli	HYDROCARE (Allergan)

* for use with rigid (hydrophobic) lenses

If the Safety Factor is equal to or **greater than one** (exposure time equals or exceeds Safe Kill Time), the system can be considered as '**safe**' under these test conditions. However, if the Safety Factor is **less than one** (exposure time is less than Safe Kill Time), the system may be considered '**unsafe**' under the same test conditions.

SAFETY FACTORS

Test organisms	Test solutions					
	10 10	HYDROSOAK	HYDROCARE	CONSERVANTE	AEROTAB	TOTAL
E. coli	1.10	1.03	0.11	0.70	0.01	nd
S. aure	1.10	0.70	0.50	0.45	0.07	nd
P. aeru	1.10	1.13	0.30	1.17	0.02	nd
S. epid	1.10	0.92	0.30	0.60	0.02	nd
C. albi	0.25	0.20	0.17	0.20	0.02	1.13

nd--not determined

If the Safety Factor is equal to or **greater than one** (exposure time equals or exceeds Safe Kill Time), the system can be considered as '**safe**' under these test conditions. However, if the Safety Factor is **less than one** (exposure time is less than Safe Kill Time), the system is considered to be '**unsafe**' under the same test conditions.

The **Power** of a solution (Table 4) is the minimum recommended disinfection time divided by the largest D-value obtained for that particular solution. It is yet another way for classifying the disinfection systems according to their microbiological effectiveness. However, unlike the safety factor, the solution 'power' is more standardized because it is independent of the size of the initial inoculum used. Therefore the solution power is of more significance when it comes to cross-comparison of results between different sources.

POWER OF SOLUTION			
SOLUTION	MINIMUM RECOMMENDED DISINFECTION TIME (minutes)	LARGEST D -VALUE FOR SOLUTION (minutes)	POWER OF SOLUTION
for flexible lenses			
10 10 (Ciba)	10.0	5.00	2.0
CONSERVANTE(Ciba)	360	200.4	1.8
HYDROSOAK(Ciba))	360	206.1	1.7
HYDROCARE (Allergan)	240	248.8	1.0
AEROTAB (Sauflon)	30.0	236.1	0.1
for rigid lenses			
TOTAL (Allergan)	360	35.30	10.2

The results obtained are discussed and analyzed in the discussion below.

The results obtained in this investigation compare well with results from other sources (Marques et al., 1991; Grant 1988). However it should be pointed out that the inoculum used of 10^6 (which was adopted by the FDA and DHSS simply to facilitate the calculation of results) is unrealistically high. Moreover, the test micro-organisms were obtained from patient samples (more resistant) from the Department of Microbiology at St Luke's Hospital and no type cultures were actually used. Thus, the testing conditions applied here are an attempt at an extreme case of the actual conditions of use.

Conclusion

Solutions for use with rigid contact lenses

All of the 3 solutions tested were able to inactivate the five test micro-organisms within the minimum allowed action time (6 hours). These solutions are very effective, being able to kill the initial inoculum in not more than 45 minutes, on nearly all occasions.

None of the solutions was able to satisfy the test conditions. Of those tested, the most effective, as indicated by their safety factors (SFs) and solution powers (SPs) are:

10-10 (3% hydrogen peroxide)	(SF 0.25/SP 2.0)
Conservante (0.025%EDTA/0.001% thiomersal/ 0.005% chlorhexidine)	(SF 0.20/SP 1.8)
Hydrosoak (0.128% EDTA/0.0025% thiomersal/ 0.0025% chlorhexidine)	(SF 0.20/SP 1.7)

The remaining two soaking solutions, which exhibit the poorest antimicrobial properties are:

Hydrocare (0.03% alkyltriethanol ammonium chloride/0.002% thiomersal)	(SF 0.11/SP 1.0)
Aerotab (0.0016% halazone)	(SF 0.01/SP 0.1)

Besides the use of a 'powerful' solution, patient compliance with the proper conditions of use of the system is equally important. This is because cleaning prior to the disinfection procedure can reduce the number of micro-organisms on the lens by about 3-4 logs (Houlsby et al., 1984). This in turn would result in shortening of the safe kill time, with a considerable improvement in the safety factor of the contact lens disinfecting solution.

References

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