DEPOSIT FORMATION ON HYDROPHILIC LENSES

by

Joseph Kostesich
College of Optometry
Ferris State College
Big Rapids, Michigan 49307

TABLE OF CONTENTS

Deposit Formation On Hydrophilic Lenses

Since the introduction of hydrophilic contact lenses approximately nine years ago, deposits have remained a perplexing problem. They usually form on the anterior surface of the lens, causing a progressive decrease in visual acuity and possible ocular irritation and damage. Prior to the routine use of prophylactic surfactant cleaners and the enzyme cleaner, approximately 25 percent of the lenses dispensed required replacement due to deposit formation within the first four months of wear.[1]

Recent studies indicate the etiologies of these deposits to be proteinaceous,[2,4,5,22] ionic,[5,8,9,22] and muciodal[10,22]. It has also been documented that pathological conditions tend to increase the rate of deposit formation above that for similar normal eyes[11,12]. In order to understand these deposits, the many aspects of the lens, tear film, and routine lens care procedures must be examined.

All hydrophilic lenses have chemical ~~sights~~ sites which could be bound by charge molecules. The degree of binding is determined by the nature of the binding ~~sights~~ sites, and to what degree these sights sites are protected by other portions of the lens matrix. According to Cordrey[13], currently employed soft lenses can be categorized into three main groups. First, those derived from HEMA (2-hydroxyethyl methy methacrylate polymer; example, B & L Soft Lens®). Second, those using HEMA as one comonomer (example, Hydrocurve®). And third, those materials using the pyrriolidone ring instead of HEMA as the major unit (example, Sauflon®). All three categories contain a small amount of crosslinking agent, usually ethylene glycol dimethyacrylate. HEMA and its copolymers contain both ester and hydroxyl groups. Due to their electron charge, these groups are very reactive. The main function of the hydroxyl group is to attract and hold water. However, this charge can also attract ions and charged organic molecules, and lead to deposit formation. In the first group, there are many unbound and unprotected reactive ~~sights~~ sites. Therefore, the potential for binding charged particles is high. In the second group, many more of the ester and hydroxyl groups are bound in the matrix formation. This leaves fewer ~~sights~~ sites available for binding with tear components. Lenses with the pyrrolidone ring as their main component (group 3) have even fewer free binding ~~sights~~ sites, making deposits on this material the rarest of all.

The tear film of the normal human eye consists of three layers, lipid, aqueous, and mucin. The normal pH is 7.35, and the normal osmolarity is equivalent to 95 (0.95) percent sodium chloride. Included in the tear film are various ions, biochemicals, and proteins. By weight, the tear film is 2 percent solid, of which 0.2 - 0.6 percent is protein.[14] Further breakdown of tear protein is cited in the literature.[15] According to Holly[16], the tear film break-up time (B.U.T.) is decreased when a soft lens is placed on the eye. This, coupled with the fact that patients tend to blink less and incomplete blink while wearing contact lenses, results in a drying of the lens surface and possible deposit formation.[12] A very high correlation was found by Hathaway and Lowther between both B.U.T. (tear quality) and Schirmer test results (tear quantity) and deposit formation, whereas, no correlation was found between tear protein concentration and deposit formation.[17] Improperly designed or manufactured lenses can lead to a decreased B.U.T. or abnormal tear quantity, causing still further deposit formation.[12]

The third major area of concern is routine lens care. Of the two disinfecting systems currently available, lenses tend to last longer when using chemical as opposed to heat sterilization. According to Hill[18], this is due to improper lens cleaning before sterilization. Therefore, with heat disinfection, the remaining deposits most of which are proteinaceous in nature are baked onto the lens. Kleist[19] has reported that theoretically, the build up of calcium deposits on chemically disinfected lenses should be greater than on heat sterilized lenses since the heating process tends to prevent calcium deposition. However, calcium deposits are generally coated with protein, making them inaccessable to the heat disinfection system. He states these deposits may be hydroxyopatite (the thermodynamically stable phase of calcium phosphate in biological conditions). His study showed these deposits to be less prevalent than protein deposits, more prevalent with heat disinfection, and more prevalent on high plus lenses worn by aphakes. Until recently, the B & L salt tablet unpreserved saline regiment was widely utilized. When non-distilled water was used in saline preparation, deposits consisting of mucopolysaccharides, protein, and calcium were found.[19] Even if these deposits could be removed, they caused irrepairable damage since the lens matrix had been penetrated, distorting the optics.[20] Other deposits caused by improper handling and care include hair spray, hand cream or any other substance directly or indirectly transmitted to the lens. Normal cleaning procedures meet with little success on these deposits, and lens replacement becomes necessary if deposit severity warrants. Environmental deposit factors include pigment deposits from small foreign particles such as iron and tobacco smoke. As of yet, there is no known commercial product available for removal of these deposits. Finally, microorganisms can invade lenses, destroying the matrix. If not disinfected and removed, these organisms may attack the eye. As with all deposits in this category, prevention is the best way to avoid the irrepairable damage of the deposits.

The morphology of soft lens deposits has been classified by Lowther, Hathaway and co-workers.[20,23,24,25] They have identified and analyzed two major types of deposits. The first forms in about two weeks and is seen as small, white, discrete spots with crystaline "arms". These deposits may penetrate the lens surface. Calcium carbonate, sodium chloride, and a slight amount of protein and mucopolysaccharide make up the majority of these deposits. The second deposit has been described as uniform, diffuse and grainy. It is relatively slow developing (depending on patient handling) taking several months to develop. This was found to consist mainly of protein and mucopolyaccharides. According to Karageozian[2], the major component of tear protein responsible for lens binding is lysozyme. According to other investigators[7,26] the mucid and lipid fractions are responsible. Hathaway and Lowther[27], have shown that all organic protein fractions found in the normal tear film have the capability to form deposits. Kleist[19,22] is in general agreement with these investigators and has divided the deposits into twelve sub-classifications. Morgan[28] claimed to have found a positive correlation between serum cholesterol levels and deposits on hydrophilic lenses. This was refuted by Hill[29], who claimed a positive correlation between deposit formation and tear film cholesterol levels, not serum levels. As mentioned previously, both claims have been refuted by Hathaway and Lowther. They found a high correlation between tear quality and quantity, and deposit formation with no correlation among individual tear components and deposit formation.[17]

Currently, there are three major soft lens cleaning regiments commercially available. They are surfactants, oxidizing agents, and enzyme cleaners. The surfactants contain surface active agents, viscosity builders, preservatives, and buffering agents. Their ability to clean a lens depends on their ability to lower the surface tension between the lens and deposits. The surfactant should be of medium viscosity, clear, and high molecular weight. To be most effective, it should contain a nonionic polymeric detergent. Examples of this type of cleaner are Preflex® and Softmate®. It has been shown that once deposits are formed, surfactants do little to remove them.[12] Oxidizing agents are relatively harsh but effective cleaners. An example would be the Ren-O-Gel[R] system. These agents oxidize the tertiary structure of protein deposits, but do little or nothing to remove crystaline deposits. Due to the extreme pH changes required by this regiment, it should be restricted to in-office use only. The enzyme cleaners are the most gentle and effective system available for removing deposits. They hydrolyze peptide bonds in the protein deposits without affecting the lens matrix in any way. They are as effective as the oxidizing agents at removing deposits and not nearly as harsh. The procedure is simple and can be performed at home. According to Lowther and and Hathaway[30,31], both the oxidizing agents and the enzyme removed protein deposits, but were ineffective in removing crystaline deposits, gamma globulin, and glycoprotein. EDTA, a preservative in most soft lens solutions, is somewhat effective in preventing the deposition of calcium. This is helpful since calcium deposits may aid in protein and mucin deposition. Also, Welder[32] has found that thiol reagents break disulfide bonds. He has postulated this as a possible deposit removing mechanism. Allergan has already used this mechanism in their enzyme cleaner, since cysteine is used to stabilize the papain.

SURFACTANT CLEANERS: THEIR EFFECTIVENESS IN PREVENTING DEPOSIT FORMATION

Introduction:

Deposition of substances in the tear film on to the surface of hydrophilic lenses has been a major problem with this type of visual correction. It is of great expense to the patient in terms of lens replacement and costs for professional time. Likewise, the practitioner and lens manufacturer spend a lot of time and effort dealing with the problem.

There has been basically three approaches taken to prevent or overcome this problem. One is to have the patient clean the lens surface daily upon lens removal with saline solution and rubbing the lens. A second method is the use of a surfactant cleaner. Again, the lens is cleaned daily upon removal with the cleaner and rubbing. The third method is to use an enzyme cleaner which has a suggested use of approximately once a week to remove the build-up. This is accomplished by placing the lens in the enzymatic cleaner solution over night and cleaning by rubbing the lens with saline the next morning. Other in-office procedures performed by the practitioner are also available. The effectiveness of the enzymatic cleaner has been shown[30], however, the effectiveness of the surfactant cleaners have not.

Objective:

The objective of this study is to determine the relative efficacy of these surfactant cleaners.

Methods:

Patients of the College of Optometry clinic who were fitted with new hydrophilic lenses volunteered for the study. The fitting and follow-up care was done in the usual manner. Eighteen patients were given two different cleaners, one for the right eye and the other for the left. The enzymatic cleaner was not utilized in this study. The three solutions under study were Preflex®, Softmate®, and sterile, preserved saline. They were coded and dispensed such that neither the investigator nor the patient knew which cleaners they were using. All patients were identically instructed on lens handling and hygiene.

The lens condition was evaluated once a week for the first month of wear and every three months thereafter. Additional examinations were performed if the patient had difficulty or it was deemed necessary by the investigator.

The elapsed time between dispensing the lens, and first noticeable deposit formation using the bimicroscope was used as a measure of the relative efficacy of the various solutions. When deposits developed to the point of causing patient discomfort or decreased visual acuity, the patient was removed from the study.

Materials:

New, deposit and defect-free, B & L Softlens® lenses, AO Soft® lenses, and Hydrocurve II® lenses were used. All patients utilized either the Bausch and Lomb, Hydrocurve, or Burton Parsons heat disinfection unit.

Results:

The findings, shown in Table 1, reveal little correlation between deposit formation and the cleaning system utilized. When comparing the surfactant cleaners to the saline, 43 percent of the lenses showed less deposit on the surfactant cleaned lens, 28 percent showed equal deposits on both lenses, and almost 30 percent showed a greater degree of deposit formation on the surfactant cleaned lens. When comparing the two surfactant cleaners, they were found to perform equally well in 86 percent of the patients. An interesting sidelight is the variation in the amount of time required for deposit formation. Patient 9 took one week for deposits to form. Whereas, Patient 15, on the same cleaning regiment as Patient 9, still had not developed deposits in over five months of lens wear.

TABLE 1

Patient Number	Surfactant Cleaner: Preflex	Softmate	Preserved Saline	Length of Wear	Lens Type
1*	N/A		N/A	N/A	N/A
2	0	0		4 months	A
3	2	2		8 months	A
4	1		1	4 months	A
5		2	3	7 months	A
6	1 - 2		1	4 months	B
7	0	0		4 months	A
8	0	0		1 month	B
9	1 - 2	0		1 week	A
10		0	1	4 months	C
11		2	1	1 month	A
12	0	0		3 month	C
13	1		1	6 month	A
14		1	1	4 month	A
15	0	0		5 month	B
16**	N/A		N/A	N/A	N/A
17		0	1	3 month	A
18		0	0	1 month	C

Deposit Formation is denoted as: 0 no deposit
1 slightly deposited
2 moderately deposited
3 heavily deposited

Lens Type is denoted as: A -- B & L Softlens®
B -- AO Soft®
C -- Hydrocurve®

* Lens fit problems, therefore, discontinued

** Confused lenses, therefore, discontinued

Conclusion:

The findings in this initial study indicate that daily cleaning with saline alone is approximately as effective at preventing deposits as the commercially available surfactant cleaners. As was stated previously, none of these solutions are as effective at removing or preventing deposits as the enzyme system. Taking into account the cost factor, the results of this study raise serious doubts as to the usefulness of surfactant cleaners. A study should be performed where-by lenses are cleaned regularly with the enzyme cleaner, utilizing saline for daily cleaning in one eye and a surfactant cleaner in the other, to help determine the usefulness of surfactant cleaners.

REFRENCES

1. Arons, I.J., Soft lens coating, "Review of Optometry", pp: 35-83, April, 1978.

2. Karageozian, H.L., Chemical identity of opaque deposits on human worn hydrophilic lenses, "Allergan Report Series #92,"1974.

3. Koetting, R. A., Coping with coating- the most serious soft lens problem, "Opt. J. Review of Optom.", 4(4): pp 20-27, July, 1973.

4. Krezanoski, J. Z., Pharmaceutical aspects of cleaning and sterilizing flexable contact lenses, "The Ophthalmic Optician", 12: pp1035-1037, Oct. 14, 1972.

5. Lowther,G. E. and Hilbert,J. A., Deposits on hydrophilic lenses: differential appearance and clinical causes, "Am. J. Optom. & Physiol. Optics", 52 (10): pp 687-692, 1975.

6. Wiley,T. M., Discrete lens opacities on hydrophilic contact lenses, "Optometric Weekley", pp 34-34, July, 1975.

7. Doughman, Mobilia, Drago, Havner, Gavin, The nature of 'spots' on soft lenses, "Annals of Ophthal.", 7: (3), March, 1975.

8. Freiberg, J., Deposits of calcium carbonate and calcium phosphate on hydrophilic contact lenses, "International Contact Lens Clinic", pp: 63-70, May/June, 1977.

9. Winder, A.F., Ruben,M. and Sheraidah,G. A. K., Tear calcium levels and contact lens wear, "British J. of Ophthal.", pp: 539-543, 1977.

10. Stein, H.A., B.J. Slatt, Clinical impressions of hydrophilic lenses, "Canadian J. of Ophthal.", 8: pp 83-91, 1973.

11. Doughman, D. J., The nature of spots on soft lenses, "Contact Lens J.", 10,9, 1976.

12. Welder, F.C. and Riedhammer, T.M., Soft contact lenses: formation of deposits, Submitted for publication, date unknown.

13. Cordrey, P., Mechanism of protein binding to hydrogel lenses, "EYE 1, Contact Lenses (Manufacturing) Limited, (6), Sept, 1974.

14. Midler, B., The lacrimal apparatus, in Adler's Physiology of the Eye: Clinical Application, (R. A. Moses, ed.), 6th. Edition, C. V. Mosby Co., St. Louis, MO, USA (1975), pp 18-29.

15. Allensmith, M., Immunology of the tears, " Int. Ophth. Clinics,"13, 47, 1973.

16. Holly, F. J., Preocular tear film, "Contact and Interoc. Lens Med. J.", 4, pp134, 1978.

17. Hathaway, R. H., and Lowther, G. E., Factors influnencing the rate of deposit formation on hydrophilic lenses, "Aust. J. Optom.", 61 (92), pp 92-96, 1978.

18. Hill, J. F., A three eyed look at cold disinfection, "Contact Lens Forum", pp 21- 35, July, 1978.

19. Kleist, F. D., Appearance and nature of hydrophilic contact lens deposits - part 2: inorganic deposits, "International Contact Lens Clinic", pp 177-186, July/Aug., 1979.

20. Hilbert, J., Lowther, G. and King, J., Deposition of substances within hydrophilic lenses, "Amer. J. Optom. & Physio. Optics", 53, 51, 1976.

21. Ruben, M., Tripathi, R. C., and Winder, A. H., Calcium deposits as a cause of spoilation of hydrophilic soft contact lenses, " Brit. J. Ophthal." 59. pp 141- 148, 1975.

22. Kleist, F. D., Appearance and nature of hydrophilic contact lens deposits - part 1: protein and other organic deposits, "International Contact Lens Clinic", pp 120-129, May/ June, 1979.

23. Lowther, G. E., Hilbert, J. A., and King, J. E., Appearance of hydrophilic lens deposits, "International Contact Lens Clinic", 2, 30, 1975.

24. Lowther, G. E., and Hilbert, J. A., Deposits of hydrophilic lenses: differential appearance and clinical causes, "Am. J. Optom. & Physio. Optics, 52,pp 687- 692, 1975.

25. Hathaway, R. A., and Lowther, G. S., Factors influencing the rate of deposit formation on hydrophilic lenses, "Aust. J. Optom., 61, pp 92- 106, 1978.

26. Holden, Pain, Zantos, Observations on scanning electron microscopy of hydrophilic contact lenses, "Aust. J. Optom.", 57, pp 100-106, 1974.

27. Hathaway, R.J., and Lowther, G. E., Appearance of hydrophilic lens deposits as related to chemical etiology, "International Contact Clinic", pp 27-36, 1976.

28. Morgan, J. F., Blood chemistry gives new clues to coating on hydrophilic lenses, News paper clipping,source unknown, available in the F.S.C. lens deposit file, Big Rapids, MI. (USA).

29. Hill, R. M., Tear cholesterol and your contact lens patient, "Aust. J. Optom.", 58, pp 300-314, 1975.

30. Lowther, G. E., Effectiveness of an enzyme cleaner in removing deposits from hydrophilic lenses, "Am. J. Optom. & Physio. Optics", 54, pp76-82, 1977.

31. Hathaway, R. A., and Lowther, G. E., Softlens cleaners: their effectivness in removing deposits, "J. Amer. Optom. Assoc.", 49, pp 259-269, 1978.

32. Welder, F. C., Analysis of biomaterials deposited on soft contact lenses, "J. Biomed. Mat. Res.", 11, pp 525-531, 1977.