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What you should know about extended wear contact lenses

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Abstract
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WHAT YOU SHOULD KNOW ABOUT EXTENDED WEAR CONTACT LENSES

By
Leila M. Miyamoto
&
Linda M. Yoshimura

Senior Thesis Submitted as Partial
Fulfillment for the Doctor of Optometry
Degree. Spring, 1983.
Advisor: Lynn J. Coon, O.D.

Grade: A
The idea of an extended wear contact lens, is today, a rapidly growing interest to the curious public and therefore, must be of significant relevance to the practitioner. The allure of the public to these contact lenses can be attributed to the inherent feature of extended wear. In the past, the practitioner's interest has centered on therapeutic applications, such as for the correction of aphakia and the traumatic relief of pain. Over the last decade, extended wear contact lenses have evolved from therapeutic applications to more recently cosmetic use as in the correction of refractive error. With the recent approval by the FDA in the United States for such cosmetic applications, the waiting period is over for extended wear. Practitioners everywhere should become familiar, if not involved, with extended wear lenses, in order to better serve the inquisitive public.

"Extended wear" should imply "prolonged wear" (longer than the usual 12-16 hours of daily lens wear) in which lenses are worn daily, as well as, overnight on a regular basis. Here, lenses are removed only periodically for cleaning and disinfecting. The actual uninterrupted extended wear time interval can vary from several days to several weeks depending on the lens manufacturer and/or the practitioner's preferred regimen. Patients that lack proper motivation or the physical ability to insert and remove lenses would probably be unsuccessful under the limitations of a normal wearing schedule, but now would be successful under prolonged wear. On the other hand, the idea of "continuous wear", in which lenses that once fit can be forgotten until
replacement necessitates their removal, is an erroneous assumption and further implies the need for proper public education.\(^4\)

Maintaining normal corneal physiology necessitates most importantly that the lens for extended wear possess the proper physical characteristics. When comparing oxygen availability under open-eye versus closed-eye conditions, Hill and Carney found oxygen levels of 21% and 7% respectively.\(^5\) Thus, the oxygen available to the cornea under closed-eye conditions is reduced to only one-third of the open-eye condition level\(^6\) and corresponds to an oxygen tension of about 55 mm Hg as provided by the capillaries of the palpebral conjunctiva.\(^7\) The critical level of oxygen tension required by the cornea, to avoid edema, is 11.4 mm to 19.0 mm Hg or between 1.5% and 2.5% as reported by Polse and Mandell.\(^8\) However, DeCarle\(^9\) suggests a 5% to 8% equivalent oxygen level as being the minimal level necessary for normal corneal deturgescence. More recently, the work of Mandell and Farrell has yielded critical values of 23 to 37 mm Hg.\(^10\) Therefore, the oxygen transmissibility of the extended wear lens design is critical. Studies have shown that the transmissibility of hydrogel lenses to oxygen decreases with lens thickness and increases with lens hydration.\(^1,11\) These parameters then, must be balanced in order to optimize flexibility and durability.

In addition to the reduced oxygen availability to the cornea under eyelid closure, there are several other adverse effects to be noted. Increased corneal swelling results
from reduced tear evaporation causing hypotonicity of the tears and therefore, migration of water into the cornea. According to Fatt and Chaston, the majority of corneal swelling is due to changes in tear osmolarity rather than reduced oxygen tension as was previously thought. Furthermore, lid closure increases corneal temperature, leading to increased metabolic activity, which together with the acidic shift in tear pH, results in a greater demand for oxygen.

The fundamentals necessary for fitting extended wear contact lenses include a general knowledge of the theoretical lens and of ocular requirements. The practitioner must be aware of the advantages and disadvantages of different lens materials, patient selection, indications and contra-indications, fitting, and complications associated with extended wear lenses. Therefore, it is the intent of this thesis to provide an updated summary of these specific areas of concern as they relate to extended wear.
ADVANTAGES & DISADVANTAGES OF DIFFERENT LENS MATERIALS

In the past, many different lenses were studied on an extended wear basis, but these were not specifically designed for extended wear. At present, only 7 lenses are FDA approved for extended wear (see Table I). Five are for aphakic correction and two are for cosmetic correction. Each lens is an example of how the necessary requirements (a wettable surface, comfort, and high oxygen transmissibility) of an extended wear lens were met.

High water content lenses are immediately very comfortable, but a material so highly hydrophilic is "fragile and susceptible to dehydration and calcium deposits." High water content lenses may also be difficult to handle. Oxygen transmissibility is good due to high water content (Permalens, 71%; Sauflon PW, 79%; 70%).

Medium water content lenses (Hydrocurve II 45 & 55) are usually less fragile than the higher content lenses and easier to handle. Since they are of less water content (more tensile strength) the lenses can be made thinner to provide the needed oxygen transmissibility lost with decreased water content. Even with the decrease in center thickness "the combination of the medium range water content, relatively low inherent oxygen permeability of the polymers and the necessity of relatively thick lenses (for aphakes) all tend to produce a situation that when considered by the parameters of corneal oxygen requirements alone, can be considered marginal." The lenses do provide
relatively stable acuity and good fitting characteristics\textsuperscript{13} which should be better than the higher water content lens. Success rates with these lenses for aphakes are approximately 62%\textsuperscript{14} and for myopes 95\%\textsuperscript{14}. These lenses are susceptible to protein deposits.\textsuperscript{12}

C.S.I. lenses are of lower water content (38.5\%), but are of a different co-polymer and are designed as a thin membrane lens. Though not FDA approved they usually provide good vision for aphakes. The thinness can make it difficult to handle. Comfort is good due to its thin profile. Vision is reported as more stable than with higher water content lenses. Lens deposits are not as evident with these lenses. Replacement due to deposits was not necessary in 90\% of patients until 2 or more years.\textsuperscript{15}

Silicone lenses are hard, but more flexible than PMMA.\textsuperscript{16} The care and handling of the lenses is similar to that required by PMMA materials. Bacteria cannot penetrate the material and fluorescein and drugs can be used. Silicone is physiologically inert\textsuperscript{17} and stable.\textsuperscript{18} Being hard, comfort initially is usually not as good as with hydrogels. Lenses must be ionically treated and converted into a hydrophilic surface to be wettable. Both Danker and Dow-Corning lenses have such treatments. Silicone has high oxygen permeability (90\% transmitted through the lens).\textsuperscript{19} This is especially good for the higher plus power, thicker lenses of aphakes. When fitted properly excellent vision is provided.\textsuperscript{12} Thermal conductivity is excellent so the temperature and therefore oxygen consumption at the cornea does not increase.\textsuperscript{18} Mucus build
up does occur (but is not a significant problem). The surface
treatment degenerates with time necessitating retreatment (not as
effective) or replacement reportedly after one year of wear.\textsuperscript{16,20}

CAB is used in fitting aphakic patients with extended wear
lenses. CAB (cellulose acetate butyrate) has many of the same
advantages and disadvantages as silicone. CAB is heat sensitive
and must not be boiled. Organic solvents are reactive with CAB
and must not be used to clean the lenses. The material is highly
oxygen and carbon dioxide permeable and has 25\% greater thermal
conductivity than hydrogels.\textsuperscript{21} An advantage over silicone is its
natural lower surface tension and wetting angle. As compared to
PMMA the surface tension is 38\% lower and the wetting angle 18.5\%
lower.\textsuperscript{22} This facilitates the flow of tears around and between
the lens and eye and thereby creates a more comfortable lens as
compared to PMMA lenses. It is hypothesized that this action is
responsible for decreased mucoproteinaceous and mineral lens
deposits.\textsuperscript{13} Comfort with these lenses is not immediate, but
patients may adapt in 48-72 hours.\textsuperscript{23} CAB does not have FDA
extended wear approval.
<table>
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</table>

+ for more parameter & cost details see Contact Lens Care Guide52  
++ for listing of other lenses used for extended-wear, but not F.D.A.  
approved see Coon, et al., Table I  
* HEMA = hydroxyethyl methacrylate  
** MMA = methyl methacrylate  
*** CAB = cellulose acetate butyrate
Previously, patients considered for extended wear were selected based entirely on their therapeutic need. Patients requiring treatment for diseases of the anterior segment were considered especially good candidates for extended wear. Such therapeutic uses as protection for the anterior ocular surfaces, traumatic relief of pain, promotion of the re-epithelization of the cornea by interrupting lid contact with surface defects, as well as many others, have been discussed earlier in the literature. In these early therapeutic applications, the uncertain complications of extended wear were considered far less damaging than the apparent destructive or disabling ocular changes present with the injury or disease.

Today, with the improved lens materials designed especially for extended wear and the approval of the FDA for cosmetic applications, the population to whom extended wear can be applied has vastly increased. However, extended wear is not for everyone. It is the responsibility of the practitioner to exercise prudent and responsible judgement in determining whether a patient should attempt an extended wear program. The initial criteria established for all extended wear candidates is that they be strongly motivated, cooperative, reasonably intelligent, have good personal hygiene and the ability to return regularly for follow-up care, as well as afford the ongoing expenses of extended wear care. Thus, the most important step toward successful extended wear is careful and
wise patient selection. Long before actual fitting techniques are a consideration for success, proper patient screening must be initiated to determine individual eligibility for an extended wear regimen. In this way, the incidence of severe complications—those affecting visual acuity—following extended wear can be notably decreased.28

The population most indicated for extended wear is best divided on the basis of need and goals into the following categories:

Group I: Corneal Pathology (i.e. bullous keratopathy) - therapeutic applications necessitating a "bandage" lens;

Group II: The very young, old and physically or mentally debilitated, for whom a satisfactory spectacle Rx is not possible and who are unable to handle a contact lens on a daily basis;

Group III: Monocular and binocular aphakes or individuals with large refractive anomalies who could wear spectacles but would be best corrected with contact lenses and are unable to manage them easily;

Group IV: Cosmetic patients who wish to wear their lenses continuously for convenience;

Group V: Cosmetic patients who wish to wear their lenses on an intermittent overnight basis.3

The use of soft contact lenses29 as well as silicone lenses17 for therapeutic purposes has become increasingly significant among the recent advances in corneal treatment, and therefore,
those individuals categorized in Group I remain as primary candidates for extended wear. In addition, high power plus extended wear soft contact lenses have been used for optical occlusion in the treatment of strabismic amblyopia\textsuperscript{30}, thus demonstrating yet another possible therapeutic application.

In the event that a satisfactory spectacle prescription is not possible for certain patients, contact lenses may be indicated. Such is the case with individuals of Group II who are also characterized by their physical inability to handle daily lens insertion, removal and care. Therefore, extended wear is practically a necessity to these patients, who are often times elderly and suffering from tremor (i.e. Parkinson's disease), deformity, lack of dexterity (i.e. arthritis), or a lack of contralateral vision such that they are unable to see the contact lens to be inserted.\textsuperscript{24,31,32,33} In addition, the parents of an aphakic infant, who for obvious reasons can't handle daily lens care himself, may well appreciate the freedom extended wear can offer them.\textsuperscript{32} The handicapped or institutionalized patient may also be indicated for extended wear.\textsuperscript{1} Vision can be restored through prolonged lens wear, and the need for mastering lens handling can be eliminated.

To date, extended wear contact lenses have been used mainly with aphakic patients (Group III). Since the optical properties inherent with spectacles are eliminated and there are no added operative or severe postoperative complications as with the intraocular lens, extended wear contact lenses offer a unique alternative
for the correction of aphakia.\textsuperscript{22,34,35} Probably the most miserable aphakic patients are those with macular dysfunction. Since they lack central vision they are unable to handle contact lenses on a daily basis, yet spectacle correction removes their peripheral vision as well; thus, they resort to wearing nothing at all.\textsuperscript{36} Extended wear soft contact lenses can be extremely helpful in these cases, as their peripheral field is unimpaired and the paramacular area increases in focus.

Ordinarily, the aniseikonia produced by an intraocular lens in a monocular aphake is about 2\%. In comparing a contact lens correction for aphakia to that of an intraocular lens, it has been pointed out that aniseikonia can be reduced to less than 0.2\% by implementing a "calculated overplussed contact lens and a correcting lowpower spectacle."\textsuperscript{37} Thus, monocular aphakes, in particular, can benefit from an extended wear contact lens through the alleviation of annoying aniseikonic symptoms. Often the aphakic patient is elderly and may derive the benefits of eliminated lens handling as well.\textsuperscript{38} Certain complications resulting with the intraocular lens may necessitate its removal and thereby expose the patient to further danger, morbidity and expense by a secondary surgical intervention. With extended wear contact lenses, it is a simple task for the practitioner to merely remove the lens(es) should a complication develop.\textsuperscript{3,28,39} Those patients who have had the intraocular lens aborted, or who are contraindicated for a lens implant from the start or who do not wish to attempt an intraocular lens are indicated for extended wear contact lenses.\textsuperscript{3,25}
Finally, in considering extended wear as an alternative to the intraocular lens, it should be noted that estimation of the proper power required to correct the ametropia with an intraocular lens at distance and near is not possible. Therefore, glasses will need to be worn for fulltime wear following surgery. On the other hand, glasses need not be necessary, when extended wear contact lenses are prescribed using the "monovision" technique for presbyopes, such that one eye is corrected for distance vision and the other eye is corrected for near reading tasks.

Patients in Groups IV and V, demonstrate the cosmetic application of extended wear contact lenses. These individuals are capable of handling and caring for their lenses on a daily basis, but for convenience purposes are indicated for a prolonged wear regimen to correct their ametropia. Emergency relief help, such as paramedics, firemen or the physician on call, often find themselves in situations where time does not allow for conventional contact lenses to be inserted. Hobbies, such as mountain climbing, often involve being in areas where lens care is either impossible or impractical. Thus, patients with specific vocational or avocational demands can really appreciate the immediate and continuous clear vision that extended wear lenses can offer them upon awakening.

Once having related the above groupings to the patient's desires, the practitioner must then attempt to establish a risk vs benefit ratio. Utilizing subjective and objective findings the
patient's prefitting systemic and ocular characteristics are determined and the possibility of risk through complications is estimated. It is at this point, that professional judgement becomes the basis for proper patient selection. The practitioner must decide on the severity of any contraindicating characteristic that is uncovered. In cases where the predisposing factors to risk, although present, are deemed not too severe and are outweighed by the potential benefits, extended wear contact lenses may still be considered for the patient. Even when the risks appear extremely great, the benefits may be equally great and thus, a compromised prolonged wear duration may be attempted. Only through careful comparison between potential risks and benefits, can the practitioner intelligently select successful patients for extended wear.

The first and most important step in screening patients for extended wear, is to elicit a complete and accurate case history. Information regarding success or failure of previous lens wear is useful. Some practitioners believe that a patient should only attempt an extended wear program following a successful history of daily lens wear. Others, not quite as conservative, believe that although a patient experienced difficulty reaching 10-12 hours wear with a well-fit hydrogel lens, he or she may still be considered for extended wear; but only on an occasional overnight basis.

The patient's current health status, both ocular and systemic, deserves careful consideration. In an investigation by Lemp,
the effect of extended wear aphakic hydrophilic contact lenses on patients who had undergone penetrating keratoplasty was assessed. The results indicate that patients with grafted corneas are at special risk to developing vascularization of the graft with extended wear hydrophilic contact lenses.

Certain systemic problems such as thyroid malfunction, blood dyscrasia, hormonal imbalance and allergic sensitivities must be qualified and quantified as to their extent and effects. Untreated diabetes presents as a specific contraindication to extended wear due to the fluctuating physiological and unstable visual responses associated with the disease. In addition, healing processes are extremely slow in the uncontrolled diabetic and this may be an added risk should tissue complications occur. Therefore, this would be definite cause for discouraging any attempt with prolonged wear lenses.

Patients taking any medications at all, whether the drugs are taken intermittently or not, are subject to possible ocular side effects. For instance, antihistamines and oral contraceptives can induce extreme drying effects on the corneal surface resulting in discomfort due to a poorly wetting lens. If following a careful review of all medications utilized by the patient, it is considered a necessity that extended wear lenses still be attempted, the eye practitioner should elicit cooperation from the medical physician(s) involved in order to minimize the patient’s medicinal intake.

Certain occupational and living environments, as well as,
individual habits that a patient subscribes to, can be considered incompatible with extended wear. Vocations where an individual is around fumes, vapors, excessive levels of dust or pollutants (e.g. ranchers, miners, factory workers) are contraindicated\textsuperscript{12}, since these irritants may selectively bind to the lens material and remain in contact with the sensitive ocular surfaces for some time. On the other hand, the occupational demand of being at sea for extensive amounts of time has been known to facilitate lens success beyond expectations due to the clean and misty surroundings.\textsuperscript{5} Furthermore, flight attendants and pilots have developed severe cases of tissue breakdown as a result of drying of the corneal surface when in flight.\textsuperscript{5} Patients need to be forewarned and cautioned if these possible ocular hazards pertain to them. In addition, the individual with poor or underdeveloped habits concerning personal hygiene is also contraindicated due to the greater risk of infection that exists.\textsuperscript{28,42}

Currently, the flexible lens materials available that are designed especially for extended wear, do not always provide adequate visual correction. This is especially true in the case of irregular and high or oblique astigmats. Due to the resulting unacceptable vision with flexible and semi-flexible lenses, these particular ametropes are considered contraindications to extended wear of hydrophilic lenses. Instead, they would benefit more from a daily wear regimen utilizing firmer or rigid lens materials. Likewise, most cases of high myopia or hyperopia are contraindicated\textsuperscript{5} unless professional judgement deems extended wear to be more
beneficial in a specific case.

Following the case history and consultation, the practitioner should be completely familiarized with the patient's history. A decision as to whether or not to proceed should be made at this time. Those individuals with obvious and severe contraindications as uncovered through a detailed case history need not be burdened with further examination procedures and are considered ineligible to attempt an extended wear regimen at this point.

However, for those still eligible, the next step in the preliminary fitting process is the diagnostic evaluation. In general, similar criteria for successful daily wear of a contact lens are applied to extended wear. However, standards are more strict since corneal physiology is continually compromised during the extended wear period and no allowance for normalizing in the absence of a lens exists. Especially in the cosmetic application cases, where extended wear is not a necessity, excellence in corneal and conjunctival appearance is required, rather than mere adequacy.

A modern biomicroscope is essential to the practitioner fitting extended wear contact lenses. The additional slit lamp feature allowing photodocumentation is also beneficial. It is important to evaluate not only the corneal surface, but also the entire ocular structure and its surroundings. Eversion of the upper lid should be routine. The appearance of a Grade One or Two papillary or follicular response is considered
a contraindication. The size and shape of the pupils should be qualified and quantified, along with an evaluation of the pupillary reflex in response to dim and normal illumination levels. Lid margins and eyelashes should be clean and free of disease. The Meibomian gland orifices must be unobstructed and functioning properly. Careful inspection of the limbal areas, with attention to vessel ingrowth is required. Prefitting data including length of vessel infiltration, depth and location relative to the limbus and pupil is important and will be used to decide whether corneal avascularity has been maintained following extended wear. A predisposition to the possibility of a "red eyed" appearance upon lens drying and coating has been suggested for those individuals who present numerous vessels close to the conjunctival surface. These individuals are best forewarned of such a possibility and should consider its onset as an early warning signal for either a lens cleaning, a lens change, or a need for the eye to recuperate without lenses for awhile (rest period).

Corneal wettability, is an integrated process, involving the cornea, lacrimal function, the conjunctiva and its associated glands. Success in an extended wear regimen will greatly depend on the integrity of the tear layer. It should be smooth, consistent and relatively "clean", without secretions and debris. More importantly, there must be ample tears that are of a viscosity suitable to provide adequate hydration, lubrication and gaseous interchange. Patients with decreased tear production
(evidenced by Schirmer tear strip measurements) are contraindicated for a prolonged wearing duration as they are more subject to lens deposits.\textsuperscript{28} Measuring tear break-up time on every patient will uncover those who are likely to experience dry eye with prolonged lens wear, as well as, assist in predicting the frequency of lens replacement that will be required. In addition, close evaluation and documentation of those areas in which tear baring exists is critical. It is these areas of dryness, which are most susceptible to vessel infiltration following the oxygen deprivation that occurs with an extended wear regimen. Patients having a poor tear layer are especially contraindicated for high water content lenses. These lenses (60-80\% water) will perform as lower water content lenses (30-40\% water) on these patient's eyes, causing optical changes, variable astigmatism and a tight, dry, irritating fit.\textsuperscript{31}

Finally, preliminary fitting documentation is not complete without full explanation of the extent and location of any abnormality of the lids, sclera, conjunctiva, iris or cornea that may already be present. Conjunctival anomalies, such as a pterygium or pinguecula need to be noted and should alert the practitioner to consider the risk vs benefit ratio of extended wear lenses for this patient very carefully. The existence of any corneal opacification must be recorded in the patient's record and a determination of its interference with lens tolerance is then made. The instillation of 2\% fluorescein is helpful in localizing the opacity and evaluating the status of the corneal epithelium. In the event that fluorescein
staining results, further fitting considerations should be terminated and postponed until the causative agent has been discovered and eliminated. The exception, however, is the recurrent corneal erosion patient. The structural integrity of the cornea is important to immediate and long term successful lens wear. Note any elevation, depressions or thinning of the cornea through careful biomicroscope technique and utilize all methods of illumination and viewing to insure that a complete and thorough ocular analysis has been attempted.

If possible, clinical pachometry, either optical or ultrasound, should be performed in order to obtain a baseline value for corneal thickness prior to fitting. Readings should have clinical reliability and repeatability to be significant.\textsuperscript{31} It has been suggested that successful candidates for extended wear with hydrogel lenses may be preselected based on corneal thickness and central corneal endothelial cell densities.\textsuperscript{14} Patients with corneal thicknesses of more than 0.54 mm before fitting and/or central corneal endothelial cell densities of less than 1,200/mm\textsuperscript{2} are contraindicated due to the increased likelihood of failure.

Next, the ophthalmoscope provides the practitioner with the tool necessary to evaluate the refractive potential or visual prognosis of a patient.\textsuperscript{5} Realistic visual expectations need to be realized by both patient and doctor. Examination of the ocular media from front to back will show relative clarity, minimal debris and opacification in the ideal patient. The aphake
with obvious lens debris may be in need of some repair surgery and should thus be referred back to the surgeon. Careful evaluation of the integrity of both the vitreous and retina can eliminate later frustration that may develop when little visual improvement results after numerous lens applications and changes. Identifying causes for decreased acuity, such as macular edema, detachment, exudation, or degeneration that may be a result of surgery, will allow for more realistic visual goals to be correctly prognosed.

After the status of all ocular structures has been established, Farkas et al. further stress a need to evaluate the overall visual process as it relates to extended wear lenses. A good refraction, including keratometric findings, should be completed at distance and at near. Through comparison of the cylinder correction, both power and axis, as determined by K's and the refraction at distance, any elements of residual astigmatism can be uncovered. With the flexible lens materials of extended wear, the astigmatic component is often unmasked and a visual compromise is inevitable. In cases where the need for extended wear is great, as with the arthritic monocular aphake or the infant binocular aphake, this slightly compromised vision may be a mere price to pay when considering the benefits gained. However, for those whose need for extended wear is not demanding and who have considerable astigmatic corrections, a recommendation for a daily wear regimen with a less flexible lens type would be more indicated. In addition, Farkas et al. suggest
some interesting and more complex optical systems to employ when attempting to maximize the visual result. For example, they propose the techniques of "monovision" for the presbyope, or binocular balancing and astigmatic spectacle over-correct for the monocular aphake. They insist on a holistic approach in which the visual process is considered as the sum total of the input of the two eyes and recommend this approach even when fitting the monocular aphake.

There is universal agreement that these preliminary steps to fitting extended wear are indeed imperative. The decision to terminate consideration for extended wear at this point or to continue to attempt fitting will depend largely on the individual practitioner's philosophies and professional judgement. A survey of the most current literature indicates proponents of more conservative philosophies, as well as, those in support of what could be labeled more "liberal" policies. For instance, the opinion that cosmetic application of extended wear lenses should not even be attempted once uncovering any of the contraindications described previously has been voiced and recognized. On the other hand, the application of a risk vs benefit ratio, when utilized intelligently, has also been employed. With this reasoning, the presence of a contraindicating factor does not necessarily assume failure. Although the prognosis is less than desirable, fitting may be attempted should the want and need for prolonged wear be great enough. Weissman stresses the fact that a definite need be demonstrated however, and cautions
against extended wear for convenience sake alone--to eliminate the bother of daily care. Although he would agree that extended wear lenses are of great value to the aphake with poor or no dexterity, the sole benefit of convenience does not, in his opinion, compensate for the risks involved with an extended wear regimen.

In some situations it is desirable to postpone a definite decision until the patient has experienced one night of continuous wear. In the absence of any contraindications, this patient can be released without undue concern, since present extended wear materials allow a single night's wear without significant risk.

After the decision to attempt extended wear has been discussed and the patient is aware of the commitment to return for follow-up visits, it must be stressed to the patient that successful wear cannot be guaranteed. Certain unknown factors indicating rejection of the lens(es) may develop any time in the future, and may necessitate termination or a compromised wearing duration solely at the practitioner's discretion. In this way, the doctor demonstrates patient control, which is especially imperative in all extended wear cases.

In summary, patients falling in the categories of Groups I-V as previously mentioned, are indicated for extended wear contact lenses. The "physiological, psychological, environmental, and occupational" contraindications, as well as, the burden of financial obligation for continuing follow-up care, need to be assessed for each individual patient. Careful patient selection,
therefore, depends on the following: 1) information gathered during a complete and thorough case history; 2) the results of a diagnostic evaluation in which the needs and deficiencies of the ocular structures, both physical and visual, have been determined; and 3) the individual practitioner's philosophy of providing extended wear contact lens care. Whether fitting is to be continued or not, communication between doctor and patient must be clear so that mutual understanding exists. A patient should realize why he or she may be ineligible for extended wear. Likewise, in cases where an intermittent schedule of extended wear is advised due to reasons other than for convenience, it is important that the patient understand the basis for such a recommendation. False expectations that lead to disappointment can be avoided by effectively communicating reasonable goals of success to the patient based on his or her individual ocular status.
Currently, hydrogel lenses seem to be most commonly utilized by practitioners fitting extended wear. The theoretical lens of choice is selected based on the patient's history and the results of the diagnostic evaluation. The patient's lifestyle and ocular needs, as well as, his individual extended wear goals should be considered.

In most cases, hydrogel extended wear contact lenses are simple to fit and because they are of such high water content or so very thin a good mechanical fit (a lens which centers and moves well) often results. According to Weissman, a lens with a base curve usually about 1 mm flatter than mean K or between 8.4 and 8.8 mm with an overall diameter of 14.0 to 14.5 mm will exhibit the mechanical properties associated with a well-fit soft contact lens. Patients possessing extremes in corneal curvature will of course require either steeper or flatter initial lens design. In any event, a word to the wise deserves special emphasis: Always fit the lens as loose as possible initially, and anticipate some tightening of the fit with wear. Select the initial power of the lens based on the spherical equivalent of the patient's best refractive correction adjusted to the corneal plane. Depending on the patient's experience with initial lens wear, the water content or thickness of the hydrogel lenses may require variation and necessitate further lens changes. If at all possible, it is advantageous to have the final trial lens be the one that is dispensed to the patient. Often times, an
ordered lens is not an exact replication and thus, differences in performance may result when placed on the eye.

In fitting hydrogel lenses, it is important that the concept of "the wetter the lens, the better" be transmitted to the patient. A dry lens or an insufficient supply of tears can only lead to trouble. As a prophylactic measure, demand the copious use of artificial tears. Instruct the patient to instill drops every three hours during the first few days and eventually use them four times a day. Some eyes are drier than others and the frequency of instillation may be varied accordingly. Also, patients may be recommended to irrigate the eyes with a saline solution three times a day (i.e. upon waking, in the afternoon, and before bed). In this way, the lens is kept soft and flexible and debris in and around the eye is removed.

Previous experience with the Cooper Permalens for extended wear has been successful for most (80%) of the aphakic patients fitted. In his study, Manchester chose to ignore keratometric readings (as recommended by the lens manufacturers) and rather insert a lens of 8.6 mm base curve and diameter of 14.5 mm on every patient initially. A previous refraction determined the specific lens power needed to complete the actual parameters of the lens of first approximation. A loose fit was considered satisfactory at this point, since the lens was expected to tighten with wear. If several lens changes were necessary (to steepen the base curve to either 8.0 or 8.3 mm or decrease the diameter to 14.0 mm) an over-refraction was repeated with each
new lens. In general, most investigators have found once again, that fitting larger and flatter lenses is advantageous.\textsuperscript{13,35,39,44} Follow-up entailed an examination the following day, and then once a week for one month and finally, once every month for one year.\textsuperscript{35,43} Specifically, the findings of this study\textsuperscript{43} led to the conclusion that the presence of dry eyes is not a contraindication to the wearing of a Cooper Permalens provided the patient is followed closely and is responsible in using artificial tear drops regularly. In addition, it was concluded that those patients who were failures with the Cooper Permalens, would more than likely be successful with other types of hydrogel extended wear lenses.\textsuperscript{43,45} Especially in cases where the need is marked and failure with other types of lens systems has already occurred, evaluation with hydrophilic lenses from all manufacturers should be made prior to advocating discontinuance or the decreased wear of soft contact lenses.\textsuperscript{24}

In another study, Kracher et al.\textsuperscript{39} fit the Cooper Permalens on unilateral aphakes. He confirmed the need for a flat-fitting contact lens and changed his initial steep fitting regime to fit the lens from 0.2- to 0.5- mm flatter than the flattest K. The lens diameter was 1- to 1.5 mm greater than the corneal diameter. This resulted in fewer tight lens syndromes and better results overall. The criterion for a good fit was as follows: 1) the lens exhibited less than 0.3 mm movement with blinking; 2) good centration was achieved in all fields of gaze and 3) stable vision with an overcorrection was obtained. Re-evaluation was done on a schedule similar to that used by Manchester.
Specific studies with the Sauflon PW lens indicate that there exists good circumstantial clinical evidence to suggest that the rate of lens deposition is affected by the mode of fit. In particular, patients wearing rather steep-fitting lenses were noted to encounter white deposits (much like those of calcium phosphate) with higher incidence. Thus, another reason for fitting hydrogels loosely (more flat) has been established.

Another study with Sauflon PW lenses found decentering to be a problem. However, this was later remedied as the lens is now available in a larger diameter (13.7 mm available previously; 14.4 mm diameter available currently) with flatter base curves. The initial lens was chosen with a base curve flatter than the flattest keratometric reading and successful results for treating aphakia were reported.

The feasibility of the Hydrocurve II55 lens for extended wear for myopic subjects has been studied by Miller, et al. In their study, the fitting criteria considered important were: 1) free movement of the lens upon blinking; 1-3 mm movement was desirable with 3-4 mm displacement upon upward gaze; 2) at least 1 mm edge overlap of the limbus; and 3) The "loosest" lens that remained stable was the lens of choice to be fit. Patients attempted daily wear first and then, if successful were allowed to attempt extended wear. The conclusion of this study proved extended wear of Hydrocurve II55 soft contact lenses to be safe and effective with normal myopic eyes over a seven month
period under carefully controlled circumstances.

Finally, although not FDA approved, the thin membrane C.S.I. crofilcon A lens was investigated for extended wear in aphakes by Davis.\textsuperscript{15} Optimum fitting criteria were as follows: 1) good centration with less than 1 mm movement upon normal blinking; 2) resulting vision equal to that theoretically expected without fluctuation with blinking; and 3) lens sensation limited to an awareness or a total absence of sensation. It was found that the C.S.I. lens allowed ease of fitting and predictability of performance as its major advantage.

In some cases, high amounts of corneal toricity may indicate a firm lens design to be the best approach. Also, patients undergoing glaucoma control treatment through the instillation of drops may continue to do so without interruption because of lens wear.\textsuperscript{33} In deciding which rigid lens to fit, the practitioner should utilize the concept of matching a patient's ocular deficiencies to the lens attributes.\textsuperscript{13,48} For example, the predisposed dry eye patient may best be served by fitting a CAB lens design, which if made thin enough, possesses excellent wetting characteristics. Due to the unique properties of the CAB material, problems of patient tolerance to the presence of a rigid lens in the eye have been minimized.\textsuperscript{22} On the other hand, the patient with adequate tear function who requires high oxygen levels based on previous lens wear, may be better off with a silicone design, where 90\% oxygen is transmitted. Furthermore, the individual whose tear function is excellent and has demonstrated
a low corneal metabolism in previous wear may succeed using a silicone co-polymer or a slightly thicker CAB lens type. In deciding to fit a gas permeable lens, the practitioner has available a wider range of parameters to select from (i.e. larger diameters or steeper base curves) and thus, may obtain better lens stability.\textsuperscript{21}

The success of extended wear of CAB contact lenses in aphakic patients has been demonstrated on a research basis only.\textsuperscript{21,23} In a study by Garcia\textsuperscript{21}, lenses were fit on the mean K reading or slightly steeper and an 80% success rate was achieved. The resulting fit was evaluated based on fluorescein patterns, exchange of fluorescein and lens movement. CAB lenses of minimal thickness, in which a gradual buildup of wearing time was followed, have demonstrated to give good results.\textsuperscript{32} In fitting CAB lenses on a prolonged wearing schedule, the patient must be fully aware that an unapproved modality of wear is being attempted and that it is at his own risk that the patient consents to this method of treatment. Recommended follow-up visits are scheduled daily or every other day for the first week and weekly thereafter for the next month. Routine removal of the lenses for cleaning has not been required, but rather when the lenses appeared soiled or patients complained of problems.\textsuperscript{32} In the absence of any complications or complaints, the re-evaluation interval may be increased to 2-3 month periods. However, patients should be instructed to seek advice by calling immediately upon the first indications of redness, irritation or decreased vision.

Extended wear of silicone lenses for the correction of aphakia
is FDA approved and its success has been reported in the literature by several authors. Kaye in fitting the Danker silicone lens found it convenient to have only one variable (the base curve) to consider, as the diameter of the lens is constant and available in only one size (11.0 mm). He stresses the importance of delaying fitting until the eye has healed sufficiently such that constant K readings can be obtained. Specifically, he utilized a steep fitting technique in which lenses were fit a minimum of 1.00D steeper than the flattest K reading. This technique however, has been questioned as leading to possible mechanical problems for the average surgical aphake, especially in the superior periphery. Lens centration was found to be generally inferior limbal due to lens weight, corneal topography and lids. Upon blinking, 1 mm movement is ideal. Less than 1mm movement indicates a need to flatten the base curve by 1.00D and likewise, excessive movement may be corrected by steepening the primary curve by 1.00D. Kaye makes little use of the fluorescein pattern to evaluate the fit of the lens and relies mostly on the patient's subjective symptoms and his own objective viewpoint when examining the eye under white light. His preferred recall schedule is as follows: 1) 24 hours after first insertion; 2) 5-7 days (1 week) later; 3) weekly intervals for four weeks; 4) twice a month for one month; 5) once a month for three months and 6) once every three months. In this way, the patient is well-monitored and a routine cleaning of the lens can be insured upon each visit. The lens treatment on silicone lenses is of particular concern and
necessitates weekly cleaning to increase the lens life expectancy and to remove the mucus adhering to both surfaces of the lens. In addition, the patient should be advised to insert drops of either Sterilettes, Adsorbotear or Adapettes daily as a regular part of their lens hygiene program. Again, educating the patient to either call or remove the lenses upon 1) any sudden increase in lens awareness; 2) any sensation of pain; 3) inflammation of the eye; 4) or the onset of symptoms out of the ordinary (e.g. excessive lacrimation, discharge, extreme or unusual photophobia, or a continual burning sensation) is extremely imperative.

Silicone extended wear contact lenses have also been used successfully with aphakic infants and children. Unlike Kaye, Rogers found the major fitting disadvantage of the Danker silicone lens to be the fact that only one lens diameter (11.0 mm) was available. In his opinion, multiple diameters would make fitting easier. Particularly, in the case of infants the correction of the refractive error should follow surgery almost immediately. Thus, fitting procedures should begin at the time of surgery or shortly thereafter. By obtaining good vision early through the use of extended wear contact lenses, it is hoped that amblyopia can be prevented, that binocular vision be maintained, and that visual and psychological development may proceed in a near normal fashion. Keratometric readings for small infants were usually found to be unreliable for determining lens parameters and thus, a trial and error fitting procedure first with hard lenses may be necessary. Rogers in his study, found the best fit in children to be obtained
with a flat fitting lens that was 0 to 0.5 diopters steeper than the approximated corneal curvature. Since these lenses can be worn for an extended period of time, the problem of parental compliance during daily insertion and removal has been eliminated and a better visual result in these aphakic children was noted. 20, 49

Once the lens of optimum choice has been determined and fit, the first step in proper patient management begins. That is, educating and informing the patient about what to expect in the event of possible problems with their lenses. This needs to be done before releasing the patient from the office. Warn the patient to be aware of the signs and symptoms of corneal stress, such as increased injection, discomfort and/or blurry vision. 31 An information package given to the patient, reviewing the possible adverse reactions is also recommended. 14 Instruction on lens removal and lens centration should always be attempted. 48 In cases where adequate lens handling cannot and will not be accomplished by the patient, it is beneficial to instruct a friend, family member or neighbor to assist when necessary in these abilities. 48 Stress the importance of seeking care immediately whenever the patient feels a change in his vision or ocular health status has occurred. 47, 50 In the event of an emergency, the patient should know who to call and what procedures to follow to receive prompt adequate care. 31 Reports of serious complications have mainly been associated with the inability or negligence to contact the practitioner with sufficient speed. 42

Various philosophies exist concerning how quickly a patient
should begin to be on an extended wear regimen. In some cases, where the patient is extremely motivated and no contraindications have been elicited in the preliminary pre-fitting procedures, lenses may be dispensed and worn immediately all day and all night. However, a majority seem to prefer to fit new patients first with daily wear. In doing so, several functions are achieved: 1) The patient gains experience and confidence in handling and cleaning the lenses; 2) The physiological adaptation period for the cornea is gradual rather than immediate; 3) There is an opportunity for the practitioner to evaluate the fit and lens acceptance at a moderate wearing level before moving to an extended wear duration and thereby minimize potential risk. Following an interval (ranging from 2 days to as long as 2 months) of successful daily wear, the practitioner can be more assured of lens tolerance with extended wear.

Exceptional cases, such as the physically or visually limited patient or the individual fit with a fragile, high water content lens, will probably necessitate immediate extended wear. In these instances, it is best to insert the lenses early in the morning and have the patient return later the same day for evaluation after a full days wear. In every case, a 24-hour evaluation subsequent to the first night of sleeping without lens removal is advised. At that point in time, the apparent ocular status will usually be indicative of the need and frequency of the follow-up care to come.

Several factors are involved in deciding on how often and
when a patient must return for re-evaluations. For example, the proposed wearing schedule (how long and how often lenses are actually being worn) is an important consideration. Others include whether or not the patient is capable of handling and caring for his own lenses, the ability of the patient to tolerate extended wear and the amount of environmental and tear debris to which the lens is exposed. It is not enough to instruct the patient to return to the office "as needed". There are many complications--neovascularization, corneal curvature changes, and incipient giant papillary conjunctivitis--that may arise without the patient's awareness. Therefore, it is the responsibility of the practitioner to establish the follow-up schedule and properly instruct the patient as to the importance of compliance in this area--they must show up for their follow-up exams regardless of whether or not they feel they are having any problems.

The methods and procedures involved in progress evaluations of extended wear patients are more or less the same as those used with daily wear patients. Differences will result in the areas of time intervals between subsequent appointments and the criterion used to determine success. The clinical techniques employed are as follows: 1) Visual acuities through the lenses at near and far; vision should be stable with visual acuities remaining constant; 2) Biomicroscopy with the lens in place to determine proper lens centration and movement, as well as, the degree of tear debris and lens coating that may be occurring. Strict lid margin hygiene with baby shampoo and more frequent lens
cleaning may be advised for the patient exhibiting lens deposition.\textsuperscript{28} Careful technique utilizing high and low magnification, all types of illumination and variance in viewing angles should be employed to evaluate all ocular-related structures, including the corneal surface; 3) Keratometry over the lens may uncover useful information concerning lens flexure and stability. In addition, the smoothness and integrity of the anterior surface of the lens can be evaluated; 4) Corneal pachometry to determine any changes in corneal thickness; an increase of greater than 0.05 mm is significant and the lens should probably be removed in most cases.\textsuperscript{28} A flatter or more highly hydrophilic lens may be attempted at a later date in hopes of increasing the supply of oxygen to the cornea; 5) Retinoscopy offers an indication of lens movement and optic zone juncture interference with the pupil. An overrefraction with binocular and near testing in applicable cases should be performed; 6) Examination of the lens as it is removed can indicate the wet or dry nature of the eyes. Also, the debris coating on the lens is noted. An idea of lens deterioration, as evaluated by lens transparency and integrity can be obtained; 7) Biomicroscopy without the lens in place and with the instillation of 2\% fluorescein is repeated and all findings documented for later comparison with future developments. Isolated punctate staining occupying less than 2\% of the corneal surface is considered "normal"; more than 2\% of the corneal surface involved is considered vital.\textsuperscript{51} Observance of the epithelial and endothelial layers may indicate possible complications
before they develop into emergencies. Thin vertical striae in Descemet's membrane appear with 6% corneal swelling. By the time obvious folds in Descemet's are visible, 10% corneal swelling has occurred and visual acuity is decreased. A reduction in the wearing schedule may suffice at this time, rather than abandoning extended wear altogether; 8) Lid eversion to uncover any follicular or papillary response, as well as to observe the superior limbal region for possible neovascularization; 9) Keratometry should be repeated at all visits in order to assess any induced changes in corneal curvature and toricity; 10) Corneal anesthesiometry readings should also be taken periodically to insure minimal nerve response loss. Notations of the patient's progress and any changes in ocular status should be documented on the patient's record.

Thus, it is obvious that safe and successful fitting of extended wear contact lenses entails a greater degree of involvement and time on the part of the practitioner. The need for constant and cautious follow-up care leads to the notion that the practitioner becomes "truly married to his extended wear contact lens patient."
COMPLICATIONS

In the past, many studies have reported severe complications due to extended wear contact lenses. Some of these were tabulated by Coon, Miller, and Meier. Corneal ulceration, acute congestive keratopathy, deep corneal vascularization, and even blindness were listed. In the more recent studies very few list any complications as serious. This could be due to the increased knowledge in the field and the use of FDA approved lenses which are specifically designed for extended wear. The complications to be discussed will be based on the more recent studies and will not include complications from therapeutic use.

The first part of this section will deal with complications of hydrogel lenses. Rigid-type lenses will be discussed next. Table II lists rates of different complications in a number of studies reviewed.

Prolonged wear of contact lenses, hydrogels in particular, has two major complications. One of these is hypoxia and lens deposits is the other. Other complications include conjunctivitis, subepithelial infiltrates, corneal abrasions, decreased corneal sensitivity, and follicular hypertrophy.

Hypoxia causes lens intolerance or "overwear" symptoms such as corneal edema, perilimbal injection, epithelial disruptions, vertical striae of Descemet's membrane, endothelial changes, decreased visual acuity, photophobia, pain, and neovascularization. Hypoxia is due to decreased oxygen tension at
the cornea due to lens wear. Any contact lens decreases oxygen transmissibility to the cornea and hypoxia results if the oxygen tension falls below a critical level. Recent studies claim higher critical values than previously stated, anywhere from 20-37 mmHg\(^{54,55}\). According to the studies by Weissman no FDA approved extended wear contact lens meets his criterion of 20 mmHg (the point of first corneal compromise) under the closed eye conditions\(^{54}\). It should also be noted that this minimum may be artificially high for aphakes\(^{11,12,23}\). The response of the aphakic versus the phakic eye of unilateral aphakes show the aphakic eye has less of a hypoxic response to the wearing of contact lenses\(^{56}\).

The first symptoms of hypoxia is corneal swelling. Edema of greater than 6% will cause vertical striae of Descemet's membrane\(^{57}\). Greater swelling could cause folds and/or decrease in visual acuity\(^{31}\). An 8-12% edema was reported after the wearing of Permalens, Hydrocurve II\(^{55}\) and Sauflor PW for 3 hours in the closed eye condition\(^{11}\). This amount of edema corresponded to the amount predicted by the lenses' water content or oxygen transmissibilities under open and closed eye conditions.

A 3-4% swelling of the cornea is normally due to increased tonicity of the tears in the closed eye state and 6-8% swelling is caused by the hypoxic condition\(^7\). Weissman\(^{31}\) speculates that the 2/3 of the day spent in the open eye condition counteracts the deprivation of overnight wear and therefore, leads to successful wearing of extended wear lenses.
High water content lenses can cause the normal level of evaporation from the eye to decrease "due to the influence of the volume of water in the lens on tear tonicity levels" and therefore, decreasing the amount of thinning of the cornea during the waking hours of the wearer. As much as 5% difference in thinning between the extended wear patient and one without lenses has been measured (3% vs 8% thinning). This contradicts the speculation of Weissman, but in the study of Larke and Hirji the initial swelling, as measured by pachometry, for the first few weeks of extended wear decreases gradually to close to prefitting norms in phakic patients. Another study indicates a return to baseline thickness after 3 months. A study by Schoessler and Barr on 8 myopic patients found a return to baseline in most patients in several months with the first month being critical for edematous changes. Some patients actually showed thinning over the 18 month study which was unexplained. Failures due to corneal edema usually occurs within the first 30 days of continuous wear, most within the first 2 weeks. If the initial corneal swelling is greater than 5% but eventually drops to 3-4% this should be acceptable as the eye normally experiences this amount of edema in sleep. It would seem the cornea can adjust to the extended wear condition gradually and studies which don't include continuous use over a relatively long period are not reflective of the true clinical situation.

Binder and Woodward in a study of Hydrocurve II 45 and 55, and Sauflon PW found that an increase in baseline pachometry
reading of 0.03 mm was significant. An increase of 0.08 mm or greater from the corneal thickness baseline was always associated with a decrease in acuity of one or two lines. Patients with edema without visual loss were switched to higher water content contact lenses and were successful. Edema was the major reason for failure as expressed as greater than 0.08 mm increase in corneal thickness and a decrease in visual acuity of 1-2 lines. Binder and Woodward\textsuperscript{14} also found that patients with corneal thickness of greater than 0.54 mm before fitting and corneal endothelial cell densities of less than 1,200/mm\textsuperscript{2} developed hypoxia. They suggest that these measures can be used to pre-select successful candidates for extended wear.

Corneal edema can easily go unnoticed and without a pachometer cannot be quantified. Many studies did not report any corneal edema as measured without a pachometer\textsuperscript{39,44,47}, but these studies also reported no corneal endothelial changes such as vertical striae or a decrease in endothelial cell count both of which corroborate a level of non-significant edema.

Neovascularization of the cornea has been thought to be caused by long term edema and hypoxia.\textsuperscript{31} It is seen, not uncommonly, with daily wear of soft contact lenses. In the Stark and Martin\textsuperscript{44} study particular attention was given to corneal neovascularization. Vessel in-growth, superiorly and inferiorly, was measured and compared between myopic patients after extended wear of Permalens and a non-wearing control group. Duration of wear ranged from 4-6.5 years. Of the 207 eyes fitted the mean
neovascularization was 1.02 ± .47 mm superiorly (range 0-3mm) and 0.39 ± 0.25 mm inferiorly (range 0-1.25mm). This was significantly more than the control group (0.358 ± 0.225, range 0.2-1.2 mm, superiorly; 0.133 ± 0.062, range 0-0.25mm, inferiorly). In only 8.7% of extended wear patients was the in-growth more than 1.5mm (FDA definition of corneal neovascularization). The maximum in-growth was 3.0 mm which occurred in 1 eye only. In certain patients the extent of vessel in-growth was as far as the area covered by the superior lid. In no case was vision adversely affected or extended wear discontinued. It is important to note that the degree of in-growth did not correlate with the duration of wear. The amount of the growth seems dependent on the individual physiology of a particular eye. Other studies would support this, neovascularization, if present, was not progressive (over a follow-up period of 14 months60, 2 years39) and no preventative measures were taken. Binder and Woodward14 used artificial tears, increased blinking, and looser fits to control neovascularization from progressing. The use of corticosteroids were not used and not recommended.14,60 Neovascularization is a complication which the practitioner should be expecting. The majority of studies report some vessel in-growth. The highest rate was reported in myopic wearers (8.7%).44 This higher rate in myopes as compared to aphakes could be due to the decreased oxygen demand in aphakic eyes56 which therefore experience less hypoxia and neovascularization. It, also, could be due to the natural increase in peripheral thickness of minus lenses.
Other corneal decompensations include epithelial disruptions and subepithelial infiltrates. Epithelial disruptions, such as superficial punctate keratitis (SPK), are thought to result from the eruptions of epithelial microvesicles. These form under hypoxic conditions of the cornea. Coon, et. al. state that there was very mild stippling of extended wear patients' corneas, but all patients had patent corneal epithelia at the final examination of the study. Therefore, they believe "epithelial regeneration proceeds despite the continuance of extended wear". Minimal SPK was found in most patients, but patients were asymptomatic and wearing was not interrupted. Larke and Hirji did pre-extended wear slit lamp exams and found almost all patients had isolated SPK on less than 2% of the corneal surface. This percentage was not significantly different from the post-extended wear (Sauflon 85) exams. A baseline amount of SPK is present in non-wearers and should be accounted for. In an extended wear of C.S.I. study corneal staining was found in 51% of patients prior to wear and only 15% of patients after continuous wear. In this case marginally dry corneas were protected by lens wear and actually healed. Many cases of reported SPK "complication" due to extended wear may result from just this type of situation. Moderate staining, indicative of insufficient ocular secretion, prior to extended wear resulted in moderate to significant staining once extended wear began and these patients were discontinued.

In only three studies reviewed did any corneal abrasion occur. Mild to severe staining at or near the superior
limbus was usually caused by decentered lenses.\textsuperscript{12} Overall epithelial problems due to extended wear were minimal. In fact, soft extended wear lenses seem to have a therapeutic effect for marginally dry eyes.

Corneal sensitivity has been reported to decrease with Sauflon 85\textsuperscript{51} and actually to initially increase with Hydrocurve II 55 extended wear.\textsuperscript{47} This is an area of importance which requires more attention.

Subepithelial infiltrates, alone, were very rare. Infiltrates usually occurred concurrent with conjunctivitis. Kracher, et. al.\textsuperscript{39} report infiltrates usually occur singly (some eyes had up to 6). They believe the sign resulted from tight lens syndrome and did resolve itself spontaneously with removal of lenses. No scarring resulted. Healing of infiltrates can take a few days to 6 months.\textsuperscript{12}

 Conjunctivitis is seen more frequently with extended wear than daily wear of contact lenses\textsuperscript{61} and often this is in conjunction with colds and allergic rhinitis.\textsuperscript{12} The incidence of conjunctivitis varied from 0-19\% (see Table II). The average rate is 5.4\% for FDA approved hydrogels. If cultures were taken, they were negative.\textsuperscript{14,39} However, due to the serious consequences of untreated infection each case of conjunctivitis requires appropriate action. Lenses must be removed. If properly monitored the practitioner may await spontaneous recovery\textsuperscript{39} which can occur within 48-72 hours.\textsuperscript{14} Cordrey\textsuperscript{42} recommends referral to an ophthalmologist and no lens wear till good eye health is insured. Ing\textsuperscript{46} actually treated one of his cases without interruption of lens
wear with success. His other cases (3) were treated with lenses removed. It was shown that the bacterial flora of an extended wear user and a non-wearer are not significantly different.\textsuperscript{62} It is generally believed that sterile conjunctivitis is caused by an allergic reaction to preservatives used in contact lens solutions.

Follicular hypertrophy of the upper tarsal plate conjunctiva is common in most cases of extended wear, but it is not usually severe.\textsuperscript{47} Stark and Martin sight it as the most frequent cause of discontinuing extended wear for a medical reason (83.3\% of all patients discontinued). There are three hypotheses for this hypertrophy. One links the hypertrophy to a delayed hypersensitivity reaction to deposits on the lenses.\textsuperscript{12,47} As tear fluid protein react with the lens surface it is altered in configuration (or even denatured) and the immune system no longer recognizes it as self and therefore an inflammatory response ensues.\textsuperscript{42} Conjunctival sampling shows an increase of cellular infiltrates (lymphocytes).\textsuperscript{47} The second hypothesis though generally not recognized links hypertrophy to hypoxia of the cornea.\textsuperscript{47} In order to increase oxygen to the corneal surface follicular and papillary hypertrophy is thought to occur. The other recognized mechanism is mechanical abrasive effects.

The complications discussed above are few and relatively mild. There was no permanent decrease in visual acuity, significant change in refraction, or damage to the eye in cases where a patient was discontinued for medical reasons.\textsuperscript{15,39,44,51} No permanent sequelae resulted. No serious complication such as
ulceration occurred in these more recent studies though it has been reported in the past and could occur under certain circumstances such as poor patient management. A case of sterile endophthalmitis was associated with soft extended wear contact lenses.\textsuperscript{50} The patient was aphakic and fitted 7 weeks post-operatively. Within 48 hours the symptoms occurred. Though it cannot be definitely stated that extended wear was the cause this is only one case out of hundreds.

As a note of interest, approximately 50\% of failures due to any cause occur within the first 30 days of wear and 79\%-88\% of failures occurred within the first 90 days for C.S.I., Permalens, and Sauflon PW.\textsuperscript{15,63}

The second major complication of extended wear of hydrogel lenses is lens spoilage. The reported incidence of deposits are varied, ranging from 7\%-82\%, but the true incidence could be higher since not all deposits can be visualized with a slit lamp.\textsuperscript{64} Formation of deposits can occur as early as 48 hours with extended wear, the majority form within 3 weeks to 6 months.\textsuperscript{64} Binder and Woodward\textsuperscript{14} found within one week of extended wear of lenses 20\% of lenses were affected, but only 3.3\% needed replacement of lenses. These deposits can be tolerated to a degree and replacement is not required unless vision is affected or the patient is too uncomfortable.

The main causes of spoilage are deposits of mucoproteinlipid and inorganic calcareous deposits, microbial invasion, various extrinsic factors, manufacturer's defects, lens aging and decay.\textsuperscript{64}
Tripathi, et. al. \textsuperscript{64} conducted a thorough study of lens spoilage. They found that 80\% of 300 spoiled lenses had mucoprotein-lipid deposits with or without calcareous material. Calcium was a major component. Jenson and Prause \textsuperscript{65} found calcium deposits on 66.7\% of lenses examined. Mucopolysaccharides were present on 66.7\% of lenses, also. Chlorine was found on 20\% of lenses. No significant amount of lipid was found. Protein analysis was insufficient. Tripathi, et. al. \textsuperscript{64} state altered ocular secretions and tear chemistry, and inherent or acquired defects in lens material cause deposits. Hydrophilic lenses were particularly prone to proteinaceous tear deposits. Discrete lipid deposits occur due to a combination of dryness and a stressed lens (decreased structural integrity of lens surface). Patt \textsuperscript{66} examined high water content lenses and found the pore size in these to be 3 times larger than the lower content lenses. He believes this could serve as a reservoir for drugs, hormones, and enzymes. If true, the presence of these substances in the matrix could serve as a point of attachment to other materials leading to the formation of deposits. Drugs have been used to treat extended wear patients while lenses were on and no adverse effects were seen. The list of drugs used include phospholine iodide, pilocarpine, chloramphenicol, and timoptic.\textsuperscript{43} Silicone lenses had more affinity for lipids.\textsuperscript{18}

Both mucoprotein-lipid and calcium deposits incidence increased if the patient had dry eye syndrome\textsuperscript{28} or even just poorly wetting lenses.\textsuperscript{64} A decrease in lysozyme results in increased mucus precipitation in a dry eye. Also, drying tends to accumulate
calcium salts. A dry atmosphere and poor blinking combined with altered tear composition or a polymer breakdown will exacerbate accumulation of lens deposits. Manchester in his Permalens study had 2 failures due to dry eye in which visual acuity dropped from 20/20 to 20/100 in 1 hour because there was accumulation of thick dry secretion on the lens. The patient with mild blepharitis is also more prone to deposits probably caused by increased and/or altered tear secretions.

To minimize deposits the use of enzymatic cleaners (papain) and detergents are recommended. This may help, but once deposits form they are usually recurrent. Tripathi, et al. discovered recurrent deposits occur due to the pits, cracks, and crevices left in the lens surface after enzymatic cleanings or in a new lens due to manufacturer defects or acquired defects. Any defect in the surface or a polymer breakdown (exposed hydroxyl sites) serves as a point deposition or even microbial inoculation. Other regimens are the frequent use of artificial tears, baby shampoo lid margin scrubs, and voluntary blinking. An unique approach to the problem was found by Kersley and Kerr. Extended wear patients used unit-dosage, sterile, unpreserved normal saline in an eye wash twice a day. One sachet a day was used, one quarter in an eye cup morning and evening. The cup is held to the eye to wash the lids, lashes, and lenses. Deposits, "red eye" (irritation) was not prevented, but were significantly deterred. In a comparison of the 6 month period before and the 6 month period after eye wash use the rates of red eye and lens
replacement decreased by half. The rate of replacement due to deposits alone decreased by 60%.

The rate of lens replacement is also a concern and relates to the rate of lens deposits. Cavanaugh, et. al. investigated this in a number of different extended wear lenses. Permalens needed replacement of 25% of lenses in 1 year and Sauflon PW needed 36% per year replaced (4% due to deposits). C.S.I. was found to need replacement of 9.5% per year (3% due to deposits 15).

Silicone lenses have certain advantages over hydrogel lenses. They are physiologically inert, stable, and can be handled as hard lenses. Oxygen transmissibility and thermal conductivity are also excellent. In both studies reviewed, lenses were fit on aphakic children. One study also included therapeutic use. The ages ranged from 3 weeks to 22 years.

Complications with extended wear of silicone lenses are few and minor. Edema is not significant. Neovascularization was also rare, it occurred in 1 patient who was discontinued. In another case, the patient was lost to follow-up and had a completely vascularized cornea. Epithelial disruptions and infiltrates are also rare. Conjunctivitis does not occur to any greater extent than with hydrogels. No follicular hypertrophy was reported. In 2 cases (5.9%) intolerance to the lens developed after 1 year. Both were discontinued. A main objection to the lens was discomfort on initial fitting. 40% of attempted fits are never fitted. Rogers reports that he had a 25% lens loss rate which is comparable to the hydrogel rate, but Gurland.
reports in young children (less than 2 years) the rate can be as high as 5 lenses/year. Overall, this is understandable considering the population involved and even positive with regard to Rogers relatively low rate. Lens life is about 1 year since the surface treatment does wear off. Mucus and lipid deposits can contribute to this wear, but can be controlled somewhat if lenses are fit flat enough and wetting solution is used 1-2 times a day. The mucus can be irritating and is a source of complaint. Overall, silicone lenses are good extended wear lenses and are superior to hydrogels in a number of areas. The degradation of the hydrophilic surface treatment is a major disadvantage.

The complications of CAB were few. Edema was present and caused 5.8% of eyes to fail with extended wear in one study. One of these cases was due to a more serious condition. After 7 months of problem free wear edema with striate keratopathy and iritis occurred. One failure was related to a previous pathological condition (progressive endothelial corneal dystrophy). Kaplan and Trimber measured corneal thickness in phakic eyes without contact lens wear and aphakic eyes wearing extended wear CABs of their unilateral aphakes. They found, respectively, thicknesses of 0.515 mm vs 0.548 mm. The difference is 0.033 mm. As discussed earlier an increase of 0.03 mm is significant, but not serious. This level of increase is still very much lower than the critical 0.08 mm increase at which extended wear should be discontinued. Also, Kaplan and Trimber found that the thickness of the cornea gradually decreased with time in extended wear. An earlier study
by Garcia\textsuperscript{33} states no corneal edema was seen. Neovascularization and follicular hypertrophy was not reported.\textsuperscript{21,22,33} Other minor problems are the same as those associated with PMMA wear. 2.9\% failed extended wear due to repeated dislocation of lens and loss of lenses.\textsuperscript{21} No significant ocular infections were reported.\textsuperscript{21,33} Bacterial flora of the eye is not changed by the extended wear of CAB.\textsuperscript{21,33} Handling and decentering lenses are a problem to some patients as CABs are not tinted. The lenses do accumulate some mucus deposits which are annoying. The use of artificial tears help to minimize this, but are not totally efficient.\textsuperscript{21} Overall, CAB has an 80\% success rate.\textsuperscript{21,33}
<table>
<thead>
<tr>
<th>Lens</th>
<th>Type</th>
<th>N*(eyes)</th>
<th>Success with Motivation (%)</th>
<th>Range of Wear Time</th>
<th>Average Cleaning Interval</th>
<th>Visual Acuity (%)⁺</th>
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</thead>
<tbody>
<tr>
<td>Permalens</td>
<td>myopic</td>
<td>207</td>
<td>NA</td>
<td>3-8 yr</td>
<td>4 m</td>
<td>82 (20/30)</td>
</tr>
<tr>
<td>Permalens</td>
<td>aphakic</td>
<td>116</td>
<td>80</td>
<td>1 m +</td>
<td>NA</td>
<td>95 (20/40)++</td>
</tr>
<tr>
<td>Permalens</td>
<td>aphakic</td>
<td>177/148</td>
<td>80</td>
<td>3-24 m</td>
<td>2 m</td>
<td>97 (20/40)++</td>
</tr>
<tr>
<td>Permalens</td>
<td>aphakic</td>
<td>142/116</td>
<td>91</td>
<td>4-22 m</td>
<td>1 m</td>
<td>91 (20/40)++</td>
</tr>
<tr>
<td>Sauflon FW</td>
<td>aphakic</td>
<td>23/21</td>
<td>83</td>
<td>3-14 m</td>
<td>6 m</td>
<td>100 (20/40)++</td>
</tr>
<tr>
<td>Sauflon FW</td>
<td>myopic</td>
<td>2</td>
<td>100</td>
<td>2-20 m</td>
<td>as needed</td>
<td>100 (20/40)</td>
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<tr>
<td>Hydrocurve</td>
<td>aphakic</td>
<td>12</td>
<td>75</td>
<td>2-17 m</td>
<td>as needed</td>
<td>100 (20/40)</td>
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<tr>
<td>II 45</td>
<td>myopic</td>
<td>26</td>
<td>92</td>
<td>5-16 m</td>
<td>1 wk</td>
<td>100 (20/40)</td>
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<tr>
<td>Hydrocurve</td>
<td>aphakic</td>
<td>14</td>
<td>64</td>
<td>2-7 m</td>
<td>1 wk</td>
<td>100 (20/40)</td>
</tr>
<tr>
<td>II 55</td>
<td>myopic</td>
<td>6</td>
<td>100</td>
<td>20 m</td>
<td>1 wk</td>
<td>100 (20/40)</td>
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<tr>
<td>Hydrocurve</td>
<td>aphakic</td>
<td>10</td>
<td>60</td>
<td>3-13 m</td>
<td>1 wk</td>
<td>100 (20/40)</td>
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<tr>
<td>Silicone</td>
<td>aphakic</td>
<td>32**</td>
<td>100</td>
<td>?</td>
<td>4-6 wk</td>
<td>as good as glasses</td>
</tr>
<tr>
<td>(pediatric)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAB</td>
<td>aphakic</td>
<td>137</td>
<td>80</td>
<td>3-60 m</td>
<td>4-7 d</td>
<td>as good as glasses</td>
</tr>
<tr>
<td>CSI</td>
<td>aphakic</td>
<td>128</td>
<td>84</td>
<td>9-27 m</td>
<td>?</td>
<td>88 (20/40)</td>
</tr>
</tbody>
</table>

* # of eyes recruited/# actually fitted
** # of patients
⁺ with over-correction for aphakes
++ patients with no pathology
<table>
<thead>
<tr>
<th>Lens</th>
<th>Corneal edema (%) and mm</th>
<th>Neovascularization (%) and mm</th>
<th>Superficial punctate keratitis</th>
<th>Corneal staining</th>
<th>Infil-trates</th>
<th>Conjunctivitis</th>
<th>Conjunctival injection</th>
<th>Follicular conjunctivitis</th>
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<tbody>
<tr>
<td>Permalens 44</td>
<td>0</td>
<td>8.7/0 (1.5mm +)</td>
<td>.3/.3</td>
<td>3.3/1.1</td>
<td>0</td>
<td>0</td>
<td>.9/0</td>
<td>7.2/7.2</td>
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<tr>
<td>Permalens 43</td>
<td>8.6/8.6</td>
<td>2/0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Permalens 39</td>
<td>.7/.7</td>
<td>2 (1mm)</td>
<td>4 (2mm +)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5.4/1.3^-1</td>
<td>2.7/0</td>
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<tr>
<td>Permalens 35</td>
<td>.8/.8</td>
<td>25 (1mm)</td>
<td>2.9 (-2mm)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.7/1.7</td>
<td>6.9/9^-</td>
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<tr>
<td>Sauflon PW 46</td>
<td>8.7/4.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Sauflon PW 14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Hydrovurse 14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>II 45</td>
<td>0</td>
<td>50/28</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>6^-</td>
<td>0/0</td>
</tr>
<tr>
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<td>0</td>
<td>40/30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0/0</td>
</tr>
<tr>
<td>Silicone 20</td>
<td>6/6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.1/3.1</td>
<td>8.3/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>CAB 21</td>
<td>5.8/5.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>.7/7</td>
<td>0/0</td>
</tr>
<tr>
<td>CSI 15</td>
<td>7.7/3.6</td>
<td>1.1/0</td>
<td>0</td>
<td>0</td>
<td>15/5</td>
<td>0</td>
<td>0</td>
<td>3.5/0</td>
</tr>
</tbody>
</table>

*** all with complications/discontinued from study
- culture negative
1 with infiltrates
CONCLUSION

The perfect lens material for extended wear has not been developed yet, but each new generation of lenses improve on fit and comfort and lessens complications. Each lens type has specific problems related to its material and/or its water content such as handling, oxygen transmissibility, lens deposits and lens life.

Lens deposits are a problem common to all lenses. They are a particularly annoying problem in extended wear contact lenses. Deposits occur on most lenses, but the amount detectable varies with the method used. Most deposits are mucoprotein-lipid and inorganic calcareous deposits. The life of a lens is affected by deposits, various extrinsic factors (such as cleaning regimen and handling), and manufacturer's defects which can play an important role. Once deposits occur they are usually recurrent. Enzymatic cleaner used to remove these deposits or manufacturer's defects can cause microscopic surface defects which serve as points of deposition or microbial invasion.

The complications of extended wear contact lenses are basically identical to those of daily wear contacts, but are more acute. With proper care the complications elicited such as edema, injection, endothelial changes, neovascularization, epithelial disruption, subepithelial infiltrates, conjunctivitis, and follicular hypertrophy will have no permanent sequelae. The more recent studies show that serious complications are lessening
in frequency, but the practitioner should be aware that corneal ulceration, iridocyclitis, endophthalmitis, etc. could occur in any particular patient.

The success rate of patients with motivation wearing extended wear contact lenses was on the average 80-90% (see Table II). Considering that the lens materials are marginal to fair in meeting the physiological demands of the cornea this result is remarkable. These rates of success in carefully controlled and monitored investigational studies by experts may not be reproducible in clinical practice unless equally meticulous care is taken by the practitioner.

Extended wear of contact lenses can be safe and relatively successful if intelligent patient selection, meticulous fitting and strict follow-up care is provided. The benefits of extended wear need to be clear and realized by each patient. Proper motivation must be present in order that good cooperation and compliance be elicited at all times from the patient. Since the costs of extended wear contact lenses are high initially and remain higher than daily wear lenses throughout their use, the benefits must outweigh this disadvantage in the patient's mind or discontinuance of lens wear may occur. In addition, "the patient must be sufficiently intelligent and fully-educated to respond to complications with cessation of lens wear" and prompt professional attention.

In the event that extended wear contact lenses are to be integrated into a practice, the following changes in office
routine will most likely be needed: 1) Aside from a well-equipped office, it is preferable to have readily available trial fitting sets for each of the types of approved extended wear lens products as well as a good stock of inventories of each kind. At the very least, a full inventory of the lens preferred by the practitioner and a fitting set of the other types is advisable. If a large number of patients are to be seen, some of the investigational lenses should also be available. Better success can be achieved by recognizing that no one lens is ideal for all patients. 13, 27

2) Delegation of responsibility and better usage of ancillary personnel in order that professional time be applied properly2, 26; use of audio-visual aids to assist in educating the patient on the handling and care of the lenses; 3) The addition of fitting contracts to avoid misunderstandings, and service agreements to stress the importance of follow-up care 26, 71; and 4) Adjustment in current fee schedules. "Charging the same fee for extended wear as for daily wear is financial suicide."2 Most importantly, the practitioner must remain readily accessible. That is, be available to answer any arising questions, to attempt to solve potential complaints and to see the patients when they require attention. These alterations in office procedures can be compensated for by the rewarding and beneficial results of a properly managed extended wear practice.

Currently, the long term effects of extended wear contact lenses are unknown. Therefore, the decision to fit these lenses must be accompanied by full knowledge of the available lenses,
aspects of patient management, complications and alterations in office management that may become necessary. Due to the increased public interest in extended wear, all practitioners should remain informed of the latest developments. Survey of the recent literature indicates extended wear to be an encouraging specialty of contact lens practice, which necessitates diligence and caution.
REFERENCES


