Are Contact Lenses Interchangeable?

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The literature search was conducted by three Advanced Practice Fellows at The Ohio State University College of Optometry. Each of the three Advanced Practice Fellows is in their second year of a two-year clinical fellowship that includes earning a Master's degree.

The report was prepared by Dr. Walline, the Associate Dean for Research at The Ohio State University College of Optometry. Dr. Walline is the Study Chair of the Bifocal Lenses In Nearsighted Kids (BLINK) Study, a multicenter, randomized clinical trial supported by the National Eye Institute, which aims to determine whether soft bifocal contact lenses slow the progression of nearsightedness in children.

All literature was gleaned from a PubMed search. PubMed comprises over 25 million citations for biomedical literature from MEDLINE, life science journals, and online books. PubMed citations and abstracts include the fields of biomedicine and health, covering portions of the life sciences, behavioral sciences, chemical sciences, and bioengineering. PubMed is a free resource developed and maintained by the National Center for Biotechnology Information, at the U.S. National Library of Medicine, located at the National Institutes of Health. All of the articles used come from peer-reviewed journals, meaning that prior to publication, the articles were reviewed and approved by experts in the field and editorial staff.

Each of the studies used in the review utilized a crossover design, meaning that every subject wore each contact lens brand. Therefore, differences reported by each of the studies is expected to be due to differences in the contact lenses, not differences in subject populations.

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Literature Search

A Pubmed literature search was conducted with the terms "contact lens" and "crossover," which resulted in 130 articles. All articles that obviously did not compare contact lenses, based on the title alone, were eliminated. Hard copies of the remaining 58 articles were divided them among three abstractors. Thirty-seven further articles were eliminated because they did not compare contact lenses using the same subjects or because they compared multifocal lenses based on vision only. In total, a total of 21 contact lens product crossover studies were found in the peer-reviewed literature, comparing 51 products (some products were used in multiple studies). All of the studies were reported since 2000, with the majority being reported since 2007. Most of the lenses in the studies were worn for a period of days to weeks, but a few studies compared lenses worn up to four months. Most of the studies were conducted in the United States, but included studies from Canada, Europe, and Australia. Almost every study included a minimum of 20 subjects. Every study involves subjects who wore each of the products tested in a crossover design. Of note, every single study reported at least one difference between lenses.

Vision

Not surprisingly, few differences were found for visual outcomes between the various spherical contact lenses. The optics of single vision contact lenses are very similar between brands, and the fit of the contact lens, unless it is extremely poor, typically does not affect vision. One study reported high contrast visual acuity differences after overnight wear between first generation silicone hydrogel contact lenses,[1] one reported greater fluctuation in vision with extended wear contact lenses than daily disposable,[2] and one reported differences in vision between various toric contact lenses.[3] Overall, there is very little difference in vision between various single vision contact lenses, unless comparing vision with toric contact lenses or overnight wear of contact lenses.

Comfort

Contact lens comfort is extremely variable, not only between patients but also throughout the day. Six of the 22 studies reported differences in comfort.[2, 4-8] The reports of comfort varied among the studies, but one consistent theme was that daily disposable contact lenses were more comfortable than frequent replacement contact lenses.[2, 6]

Redness

Dilation of conjunctival blood vessels, which may be the result of insufficient amounts of oxygen reaching the eye, results in increased redness of either the bulbar or limbal region. In one study, the redness of the limbal area was less after switching from a hydrogel, which allows less oxygen to diffuse through the contact lens, to a silicone hydrogel contact lens.[9]

Staining

Corneal staining results when epithelial cells are damaged or displaced. The cells may be damaged or displaced for a large number of reasons, including hypoxia, deposits, care products, lens fit, lens surface or edge irregularities, foreign bodies, and tear film disruption. Four studies found different levels of corneal staining, depending on contact lens wear, even when the same subjects wore each of the lenses.[7, 10-13] There was a difference in corneal staining even when two different silicone hydrogel daily disposable contact lenses with the same base curve were worn.[11] Damaged or displaced epithelial cells of the conjunctiva can also be caused by a variety of reasons, and differences in conjunctival staining were found between contact lenses,[11, 14] including two daily disposable silicone hydrogel contact lenses with the same base curve.[11] Even when similar contact lens materials and base curves were worn, both corneal and conjunctival physiology differed, resulting in differences exhibited in sodium fluorescein staining, which could ultimately increase the risk of harm due to the negative ramifications of epithelial call loss.

Staining Grid

The staining grid can be found at www.staininggrid.com and is a reference tool comparing the biocompatibility of various contact lens materials and multipurpose solutions. Lenses presoaked overnight in the multipurpose solution to be tested were inserted in the eyes of 30 successful hydrogel contact lens wearers. After two hours of wear, the lenses were removed and sodium fluorescein was instilled. Using cobalt and Wratten filters, corneal staining area was assessed in 10% increments in five corneal regions, and the regions were averaged. The percentages in each cell (Figure 1) represent the average percentage of the cornea which was stained for the 30 subjects.

Figure 1: The Andrasko Staining Grid. Proportions in cells indicate the average percentage of the cornea which was stained for the 30 subjects for each lens and solution combination. Green indicates less than 10% of the corneal area exhibits staining, and red indicates that more than 20% of the corneal area exhibits staining.

		Branded Solutions										Private Label Solutions			
		Unisol[3] 4 Saline	Clear Care[4]	OPTI-FREE® *EXPRESS*[1]	OPTI-FREE® RepleniSH[1]	OPTI-FREE® PureMoist[1]	Biotrue[3]	Renu Fresh[3]	Renu Sensitive[3]	Complete MPS[2]	Aquify[4]	Walmart MPS (Renu M+)	Target MPS (Renu M+)	CVS MPS (Renu M+)	Walgreen MPS (Renu M+)
Hydrogel	Acuvue[3] 2	1%	1%	2%	5%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Hydrogel	Proclear[4]	1%	1%	1%	2%	1%	28%	57%	23%	6%	12%	61%	54%	53%	42%
Hydrogel	Soflens[3] 66	1%	1%	1%	1%	1%	52%	73%	32%	17%	8%	66%	62%	63%	56%
Silicone-Hydrogels	Acuvue Advance[3]	1%	1%	1%	1%	1%	9%	13%	4%	12%	2%	16%	13%	12%	12%
Silicone-Hydrogels	Acuvue Oasys[3]	2%	1%	3%	5%	2%	1%	9%	5%	4%	3%	12%	8%	13%	10%
Silicone-Hydrogels	Biofinity[4]	2%	2%	3%	2%	1%	17%	4%	2%	2%	2%	4%	3%	3%	2%
Silicone-Hydrogels	Purevision[3]	2%	1%	4%	7%	3%	46%	73%	43%	15%	21%	71%	76%	No Testing Planned	No Testing Planned
Silicone-Hydrogels	O2 Optix[4]	2%	1%	2%	5%	1%	21%	24%	7%	3%	3%	41%	28%	28%	24%
Silicone-Hydrogels	Night & Day[4]	2%	1%	2%	3%	1%	17%	24%	11%	1%	3%	36%	24%	26%	22%
Updated: August 19, 2011		H_2O_2	POLYQUAD/ALDOX			PHMB/ Polyquaternium	BIGUANIDES (PHMB)								

From this information, it is clear that corneal physiology can be affected significantly differently, depending only upon the solution that is used in conjunction with a particular lens material. For example, when using a single private label contact lens solution, various contact lenses resulted in anywhere from 1 to 71% of the cornea exhibiting solution-induced corneal staining. In one of the reported studies, two different silicone hydrogel contact lenses with similar base curves (8.3 and 8.7 mm for one and 8.3 and 8.6 mm for the other) and overall diameters (14.0 mm for both) exhibited differing amounts of solution-induced corneal staining.

Eyelids
Hypersensitivity-related inflammation can frequently be detected in the tarsal conjunctiva under the eyelid. When this occurs, the conjunctiva exhibits small bumps with a central vessel, called papillae. They often indicate chronic irritation or allergies. One study found significantly greater papillary reaction resulting from one lens than another despite the fact that the lenses have similar base curves and the same overall diameter.[15]

Mucin Balls
Mucin balls are translucent spheres composed primarily of mucin that range in size from 20 to 200 µm. They leave depressions on the corneal epithelium that can be observed with sodium fluorescein. They are not typically associated with decreased lens-wearing comfort or compromised vision, but they illustrate a variety of physiologic reactions to various contact lenses. The modulus (stiffness) of the contact lens may be related to the number of mucin balls formed, and one study reported that the silicone hydrogel contact lens with the highest modulus (stiffest material) also exhibited more mucin balls.[1]

Protein Deposits
Proteins in the tears deposit on the contact lens surface, and can ultimately lead to worse vision and comfort. Even when controlling the multipurpose contact lens solution used to clean and disinfect contact lenses, differences in amounts and denaturation (which leads to greater binding of the protein to the contact lens surface) of proteins.[16, 17]

Blebs
Blebs are edematous endothelial cells that appear as dark spots on the back of the cornea. They can appear after as little as 10 to 20 minutes of contact lens wear, and they are the result of insufficient oxygen to the cornea. One study found that a hydrogel contact lens resulted in significantly more blebs than a silicone hydrogel contact lens that allowed more oxygen to reach the cornea.[18]

Corneal Swelling
Like blebs, corneal swelling is related to the amount of oxygen that reaches the cornea; less oxygen results in greater corneal swelling. As expected, a hydrogel contact lens, which allows less oxygen to reach the cornea, resulted in greater corneal swelling, both initially and one hour after removal of the contact lens.[19]

Tears
Healthy tears provide a smooth surface over the contact lens throughout the entire period between blinks. However, the tear film may become disrupted and lead to variable vision and poor comfort. The thicker the tear film, the less likely it is to become disrupted, and the thickness of the tear film can be clinically evaluated by the height of the tear meniscus, just above the lower eyelid. Several studies found differences in the tear breakup time[4, 11, 12] and meniscus height[12] between a variety of contact lenses. Excess tearing can become irritating to the patient and frequently signifies an issue with the contact lens. Two silicone hydrogel contact lenses resulted in varying amounts of excess tearing.[1]

Tears (Continued)
Tears consist of three layers: lipid (to provide a smooth surface and keep the tears from evaporating), aqueous (the bulk of the tear film), and mucin (to stick the tears to the eye). The thickness of each layer often indicates the vitality of that particular layer. Tear lipids can also deposit on the contact lens surface. Three studies found

differences in lipid layer thickness and lipid deposits, depending on the contact lens worn.[4, 17, 20] Differences in the thickness of the aqueous portion of the tear film were also detected.[4]

Conjunctival Indentation
The edges of soft contact lenses rest on the bulbar conjunctiva, and some contact lenses may affect the conjunctiva more than others, resulting in an indentation of the bulbar conjunctiva that can be viewed as an arc or ring of sodium fluorescein pooling peripheral to the limbus. Two daily disposable contact lenses with similar base curves and diameters exhibited varying conjunctival indentation,[11] probably as a result of the variation in edge design of the contact lenses.

Water Content
All contact lenses incorporate water into the material. Hydrogel contact lenses with higher amounts of water allow more oxygen to reach the cornea. However, water content may be related to contact lens comfort throughout the day. One study examined the water content of various contact lenses and found that dehydration of the contact lens differed, depending on the contact lens brand.[21]

Summary
Contact lenses are not merely pieces of plastic that inertly rest on the front of the eye. Several crossover studies that compared a variety of outcomes when fitting subjects with a variety of contact lenses showed that the subjects' physiological reactions and the contact lens parameters differed, based on the brand of contact lens used. Significant differences in reactions to reduced oxygen to the eye were found between hydrogel and silicone hydrogel contact lenses.[9, 18, 19] Differences in corneal and conjunctival staining were also found between hydrogel and silicone hydrogel contact lenses,[14] and they were even found when comparing only silicone hydrogel contact lenses.[7, 10-12, 15] The same was true even when the base curves and diameters were nearly identical.[11, 12] Corneal staining is a clinical sign that alerts the clinician to a potential increase in the risk of harm due to the negative ramifications of epithelial cell loss. Contact lenses can also affect the tear film, and breakup time, tear meniscus height, excess tearing, and layers of the tear film were all found to be different, depending on the contact lens brand worn.[4, 11, 12, 17, 20, 21]

Contact lenses differ from each other not only based on material (which affects oxygen permeability, tear film, water content, etc.), but also on other common parameters such as base curve and diameter. However, even with similar base curve and diameters, the eyes' physiological reaction can differ because contact lenses also differ on modulus (stiffness), wettability, edge design, etc. As these papers show, even when the same subjects wear various contact lenses, they experience different physiological reactions in relatively short periods of time. No single lens can provide a healthy ocular response for every single patient, and contact lenses are not freely interchangeable because each one reacts differently on the ocular surface. The fit of each particular contact lens and the ocular response must be evaluated over time in order to provide a healthy vision correction that minimizes the risk of potentially sight-threatening complications.

These data clearly show how the ocular response to each contact lens is significantly different and leads to a variety of physiological reactions, even when fitting the same patient with various lenses. Thus, maintaining and enforcing the current requirement that prescribers must include the specific brand and product name on patient prescriptions and prohibiting substitution is absolutely necessary to minimize the risk of potentially sight-threatening complications.

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