Clinical Performance Comparisons of Toric Soft Contact Lens Designs*

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*Part of a lecture presented at the Eleventh National Research Symposium, San Francisco, August 1984

ABSTRACT

Various lens design features have been utilized to properly orient toric hydrogel lenses. These include prism ballast, truncation, peri-ballast, thin zones, back surface toricity, and combinations of the above. Clinical performance of these designs in terms of orientation, stability of orientation over time, rotational velocity, subjective comfort, and corneal physiological response were explored. Results showed that no single lens was superior in all aspects compared. Guidelines are presented for lens selection based on different patient needs.

INTRODUCTION

Toric soft lenses have steadily improved in quality since their original introduction into the marketplace in the late '70s. Currently, lenses are available from many different manufacturers in a variety of lens designs, parameters, and materials.[1,2,3] As second and third generation lenses appear in the marketplace it becomes increasingly more challenging to choose the "best" lens/design for a given patient. As eyecare professionals, our decision should be based on several different factors which include stable lens orientation, stable visual response, subjective patient comfort, and good physiological response.

In an attempt to quantify the clinical performance of different toric lens designs, we compared lenses from several different manufacturers. The toric soft contact lenses included in the study are listed alphabetically in Table 1. For purposes of evaluating toric soft contact lenses, several special clinical techniques were employed in order to quantify the clinical performance of these specialty soft lenses.[4] The clinical comparisons conducted appear in Table 2.

1. Toric Lens Design Concept. The soft toric lenses evaluated in this study can be classified into four broad groups of lens design. The largest group is that of prism ballast. This includes the lenses manufactured by B&L, Barnes-Hind/Hydrocurve and Vistakon. As an extension to this group, the second classification includes the addition of an inferior truncation at the prism base and is found in the lenses manufactured by both Hydron and Wesley-Jessen. The remaining two lenses, those of Salvatori and Ciba Vision Care each fall into unique groups where similar versions of their designs are not available from other manufacturers. The Salvatori lens employs a design known as peri-ballast. Here the prismatic effect and consequent thickness profile changes are restricted to the carrier and do not extend into the optic zone.[5] The design of Ciba Vision Care utilizes a thin zone approach with slabbed-off regions at the superior and inferior portions of the lens.[6] These thin zones also result in a thickness profile change and similar to

TABLE 1
Soft Toric Lenses Compared

American Hydron Custom Toric
Barnes-Hind/Hydrocurve II Toric—45% Toric
Bausch & Lomb Toric
Ciba Torisoft
Salvatori Bal-Flange Toric (no longer available)
Vistakon Hydromarc Toric

TABLE 2
Clinical Comparisons

1. Toric Lens Design Concept
2. Center Thickness
3. Subjective Comfort
4. Orientation
5. Stability of Orientation
6. Rotational velocity
7. Pachometry

Salvatori design do not extend into the optic zone. As has been described by Hanks,[7] all six designs evaluated employ thickness profile changes in one form or another in order to achieve lens orientation as a result of lid pressures and what has been termed "The Watermelon Seed Principle."

Manufacturers of toric soft lenses include some type of special "marking" on the lens in order to enable the practitioner to see where a lens is orienting. The methods of "marking" are quite varied and include: scribe marks, engraved dots, laser trace lines and truncation. Usually the guide marks are at the prism base (270°) or in the horizontal meridian (0 and 180°). It should be pointed out that the marks serve as a reference point for cylinder axis location. They do *not* indicate actual cylinder axis. Table 3 lists the methods by which the various manufacturers mark their lenses.

TABLE 3
Lens Markings

American Hydron Custom Toric	truncation
Barnes-Hind/Hydrocurve II—45% Toric	6 o'clock dot
Bausch & Lomb Toric	three scribe marks 30° apart at 5, 6, 7 o'clock
Ciba Torisoft	3 and 9 o'clock scribe marks
Vistakon Hydromarc Toric	6 o'clock dot
Salvatori Bal-Flange	one scribe mark at 6 o'clock

2. Center Thickness. The center thickness of toric soft lenses is quoted in promotional literature as a key factor in the physiological response to a lens. This may be slightly misleading with toric lenses since design components such as prism ballast can add substantial thickness to the lens periphery, however center thickness still serves as an indicator of the overall lens geometry. Center thickness of lenses utilized in this study was measured using the Holden-Payor technique[8] which allows wet center thickness measurement with micron accuracy.

Measured values are the average for four lenses where each was measured three times. All lenses were −3.00 sphere power and −1.00D or −1.25D cylinder, axis 180. Results are listed in Table 4 and are arranged in rank order for the manufacturer's claimed center thickness value.

TABLE 4
Soft Toric Center Thickness
At −3.00D Sphere Power

Lens	Claimed	Measured
Salvatori Bal-Flange	.07 mm	.084 mm
Ciba Torisoft	.10	.095
Barnes-Hind/Hydrocurve II-45% Toric	.11	.131
Bausch & Lomb Toric	.13	.129
Hydron Custom Toric	.14	.142
Vistakon Hydromarc Toric	.14	.148

(n = 4 for each lens type)

The thinnest two lenses available were the Salvatori Bal-Flange and Ciba Torisoft, both with center thicknesses at −3.00 sphere power of less than .10mm. Lenses of a more standard center thickness were Barnes-Hind/Hydrocurve and B&L, each approximately .13mm, while Hydron and Hydromarc ranged from .14-.15mm.

It should be noted that among the different lens designs, the nominal center thickness values often vary with lens power and thus the thickness of −3.00D lenses may not be indicative of the center thickness for the entire power range.

3. Subjective Comfort. Subjective comfort of optimally fit lenses was rated by a group of 10 patients after two hours of wear. The criteria of an optimally or "well fitted" lens is listed in Table 5. In order to make the evaluations and the relative comparisons, patients were asked to rate their comfort on a 0-10 scale. On this scale, 10 was "excellent," while 0 "caused pain." A value of 6 was "comfortable," while dropping to 4 the lens was becoming "slightly uncomfortable" (Table 6). Once again, results are arranged in rank order and these are listed in Table 7.

The best subjective comfort result was achieved with the Ciba Vision Care Torisoft lens having the thin zone or double slab-off design approach. This is not surprising considering the geometry of the design with thinned areas extending under both the upper and lower lids, especially when compared to lenses having either a thick prism base, prismatic effect restricted to the peripheral carrier (peri-ballast), a truncation, or combinations of these features. Those prism ballast lenses having better subjective comfort, were also those which employed an inferior slab-off of the prism thickness in order to achieve a comfort chamber.

4. Lens Orientation/Axis Alignment. Practitioners familiar with the use of toric soft lenses will recognize that the stabilized toric lens orientation is usually nasal in direction. This is the result of the normal lid forces and, of course, the amount of rotation will vary depending upon the lens/eye fitting relationship, the particular design component used in the lens and the eyelid characteristics, such as tightness, lid angle, etc.[9,10]

Some practitioners prefer to make an arbitrary allowance for all of their toric soft lenses from one manufacturer to rotate a given average number of degrees once the lens has settled. Rather than observing and measuring the actual orientation for each individual patient, a

TABLE 5
Criteria of a Well-Fitted Toric Soft Contact Lens

Full corneal coverage

Good centration (concentric about the visible iris)

Satisfactory movement (in up gaze 0.5-1.0mm movement with the blink is ideal)

Satisfactory lens lag (in up gaze, lens lag of 0.5-1.0mm is ideal

Satisfactory patient comfort response

Stable lens orientation

TABLE 6
Lens Comfort Scale

10	Excellent (cannot be felt)
9	
8	Very Comfortable (just felt occasionally)
7	
6	Comfortable (noticeable but not irritating)
5	
4	Slightly Uncomfortable (slighly irritating or annoying)
3	
2	Very Uncomfortable (very irritating or annoying)
1	
0	Causes Pain (lens cannot be tolerated)

compensation for axis ordering is made based on this average value. When the stabilized lens orientation was measured for patients in this study, the mean results were all in a nasal direction. These are listed in Table 8. It should be noted, however, that the standard deviations are large, in most cases around ±14°. This high standard deviation is the result of the many individual differences between patients. It serves to illustrate how impractical it would be to merely assume that all B&L lenses, for example, would orient 10° nasal. Simply because this was the average does not mean that all patients will display this particular orientation.

The results for Table 8 are listed in rank order according to the amount of rotation. A lens with a rotation of 5° nasal is *not* necessarily better than one with rotation of 15° nasal. The more important feature is that the stabilized orientation position, once achieved, should be consistent and not fluctuating. Once the orientation is known, it can just as easily be compensated for by ordering the correct axis whether it is a 5° or 15° adjustment. Axis adjustment procedures have been previously described elsewhere.[11,12,13]

5. Stability of Orientation. For the successful use of any toric soft lenses, a consistently stable orientation is essential. A lens that orients correctly during a progress visit, but half an hour later is 30° away from this position and an hour later is 20° away in the opposite direction, would not be satisfactory or successful. In order to evaluate the stability of orientation, a technique was developed for relative comparisons. This involved accurate measurement of the lens orientation four times over a period of three hours.

TABLE 7
Soft Toric Lens Comfort

Lens	Mean	S.D.
Ciba Torisoft	7.8	(±1.7)
Bausch & Lomb Toric	6.5	(±2.2)
Vistakon Hydromarc Toric	5.8	(±1.7)
Barnes-Hind/Hydrocurve II-45% Toric	3.8	(±2.5)
Hydron Custom Toric	3.3	(±2.5)
Salvatori Bal-Flange	3.3	(±1.0)

(n = 10 for each lens type)

Once measured, the mean orientation was then calculated along with the standard deviation. The standard deviation was then used as an indication of orientation stability. For example, if a lens consistently oriented in exactly the same place all four times when it was measured, the standard deviation would be ±0.00. This obviously would be a very stable lens. On the other hand, if a lens fluctuated wildly over that four hour period, a very high standard deviation would result.

This evaluation technique was performed using the 10

TABLE 8
Stabilized Lens Orientation

Lens	Mean	S.D.
Salvatori Bal-Flange	4.2° Nasal	(±15.1)
Vistakon Hydromarc Toric	6.8° Nasal	(±14.1)
Hydron Custom Toric	9.2° Nasal	(±11.6)
Bausch & Lomb Toric	10.0° Nasal	(±14.3)
Ciba Torisoft	12.5° Nasal	(±12.3)
Barnes-Hind/Hydrocurve II-45% Toric	15.1° Nasal	(±14.9)

(n = 10 for each lens type)

patients included in the study and measurements were made four times over the three hour period. The results for standard deviation, as an indication of orientation stability, are listed in Table 9.

TABLE 9
Stability of Orientation

Lens	Average S.D.
Hydron Custom Toric	3.2
Vistakon Hydromarc Toric	5.4
Bausch & Lomb Toric	6.3
Ciba Torisoft	6.7
Barnes-Hind/Hydrocurve II-45% Toric	6.7
Salvatori Bal-Flange	9.1

(n = 10 for each lens type)

By viewing this table, it can be recognized that the most stable toric soft lens evaluated was that manufactured by Hydron with an average standard deviation of only ±3.2°. Very similar results were found for the next four lenses, all having average standard deviations between 5° and 7° as an indication of their orientation stability. These were those manufactured by Vistakon, B&L, Ciba, and Barnes-Hind/Hydrocurve. Least stable of all lenses evaluated was Salvatori with the measurement of orientation instability being almost three times as great as that found for the Hydron toric lens.

TABLE 10
Rotational Velocity*

Lens	Mean	S.D.
Hydron Custom Toric	5.2	(±4.4)
Salvatori Bal-Flange	5.0	(±3.5)
Bausch & Lomb Toric	3.9	(±1.9)
Barnes-Hind/Hydrocurve II-45% Toric	3.5	(±2.9)
Ciba Torisoft	3.2	(±2.0)
Vistakon Hydromarc Toric	2.1	(±1.4)

*degrees per second
(n = 10 for each lens type)

6. Rotational Velocity. Another area of specific interest for toric soft lenses is that of rotational velocity. This is the speed with which the lens will rotate in order to take up its orientation. The procedure for this evaluation involves the deliberate mislocation of an otherwise settled soft toric lens to move it 60° in a temporal direction from its resting position. Once the mislocation has been achieved, a stop-watch is used to time the rotation occurring to return the lens to its initial position. This is timed for a period of up to 60 seconds and the result is recorded as the velocity in degrees per second. This is an obvious indication of the lens's desire to return to its initial orientation. We consider that it also infers a comment about the enthusiasm of the lens to maintain orientation in the first place. Beyond that, it is also a direct measure of what should occur for lens return during an accidental mislocation—for example, a patient who rubs the eye while driving down the highway.

Results for patients in the study are shown in Table 10 and it can be seen that greatest rotational velocity was achieved for Hydron and Salvatori lenses at approximately 5° per second. With these lenses, if a patient rubbed their eye and the lens mislocated by 20°, it could be expected to return to its initial orientation within 4 seconds, on average. Lenses manufactured by B&L, Barnes-Hind/Hydrocurve and Ciba showed average rotational velocities between 3 and 4 degrees per second while the slowest lens in terms of rotation to regain its initial orientation was that manufactured by Vistakon with a clinically adequate velocity of approximately 2° per second.

7. Pachometry. The amount of corneal swelling for each of these toric soft lenses was measured in order to give a relative comparison of physiological response. While center thickness was compared earlier, other design features will also contribute to the lens fitting and thickness profile and therefore resultant oxygen transmission and physiological response. This comparison is further complicated by differences in the water content of materials used by each manufacturer. In order to include all of these variations, corneal swelling was included in our clinical comparisons.

Following an initial baseline measurement, central corneal thickness was measured after three hours wear while the other eye of each patient was monitored as a control.

Pachometric results are listed in Table 11 with the least corneal swelling seen for the Salvatori lens. This is not surprising considering the thinness of this lens in the optic zone. Similarly, the highest degree of corneal swelling, almost 5% after three hours, was seen with the Vistakon lens. This is also not surprising considering the thickness of the lens in a 43% water content material.

TABLE 11
Pachometry*

Lens	% Swelling
Salvatori Bal-Flange	2.6 ± 1.9
Ciba Torisoft	3.4 ± 2.5
Hydron Custom Toric	3.6 ± 3.3
Bausch & Lomb Toric	4.2 ± 2.5
Barnes-Hind/Hydrocurve II-45% Toric	4.3 ± 3.1
Vistakon Hydromarc Toric	4.9 ± 2.7

*After three hours of lens wear
(n = 10 for each lens type)

DISCUSSION

No one lens is clearly superior in all aspects compared. This is not surprising since the design of any specialty contact lens will involve some compromises from each manufacturer in order to achieve superior performance in an area they consider most important. What matters for the practitioner is that he/she can then use the strengths of each lens to suit the needs of particular patients.

TABLE 12
Examples of First Choice Toric Soft Lenses
Indicated For Different Patient Needs

Patient Need	Soft Toric Lens Design	
	Indicated	*Contraindicated*
comfort	Ciba, B&L	Salvatori, Hydron
physiological response	Salvatori, Ciba	Vistakon
rapid return from mislocation (e.g. sports)	Hydron, Salvatori	Vistakon
orientation stability (e.g. critical VA)	Hydron	Salvatori
absence of prism in optic zone	Ciba, Salvatori	All others

This study does not attempt to define a lens of choice based on actual patient dispensings with each lens type. However, it does point out the individual strengths of each lens type that, when tailored to the patient's requirements, can help to increase the degree of successful toric lens fittings. Decisions can be made as to the initial soft toric lens selected for patients having different needs, hobbies or occupations. Examples of results for this type of consideration are listed in Table 12.

With an understanding of the clinical comparisons and results reported in this paper, it can be seen that for a patient to whom subjective comfort is very important, best results could be expected with the Ciba Torisoft lens while the Salvatori Bal-Flange would not be a good initial choice. On the other hand, if the prime consideration is for a patient who will wear his/her toric soft lenses mainly for participation in sports and wants the lens to return rapidly to correct orientation in the event that it is mislocated during body contact, best results could be expected from either the Hydron or Salvatori design while the Vistakon Hydromarc lens would be least indicated and slowest to return and restore optimal visual acuity.

Many different patient situations can be considered, those listed are only examples. What becomes most important for the practitioner to remember is not the recommended lens for each situation, but rather the strengths and weaknesses of each of the lenses compared in order to be able to make the appropriate choice for each patient being served.

With further improvements in toric lens designs, materials, manufacturers quality control and parameter availability, the number of successful toric soft lens patients will continue to rise.

Acknowledgments

The authors thank George W. Mertz, OD, Lane L. Fujitani, OD, and Stephen E. Schock, OD, for their contributions during the development of the evaluation techniques and assistance in the data collection.

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Clinical Implications

The fitting and management of patients with toric lenses is extremely complex. Not only must the clinician be aware of patient factors such as the ratio of spherical to cylindrical corrective components, the patient's visual demands, and the patient's ultimate visual expectations, but also of a number of different lens designs and materials. The authors have done an excellent job in describing some of the most important factors to assess the performance of a specific toric lens.

The data presented would seem to indicate that having only one toric lens design in the office is indeed a handicap when trying to fit a diverse population. In light of the rather high S.D. on stabilized lens orientation, one might draw from the data the need for patients to be fit with inventory lenses or at the very least with diagnostic lenses with prescriptions somewhat close to that which the patient will ultimately receive.

The authors have done a fine job in illustrating potential applications for specific lens designs. It is up to the clinician to test new lens designs with some of the simpler office applicable methods described in this article, such as stability of orientation, rotational velocity, stabilized lens orientation, and comfort. In this fashion, the clinician will be better able to meet the needs of his patients and reduce chair time and cost overhead.

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