Refining Toric Soft Contact Lens Prescriptions

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Toric soft lenses have provided a new means for the correction of astigmatic refractive errors. However, difficulty in determining the correct prescription and the fluctuating visual acuity associated with these lenses have led to clinician and patient dissatisfaction. The sources of these problems are examined, and a systematic method for reducing them is presented. The utilization of over-refraction, both for determining the proper prescription and demonstrating the quality of vision to the patient before the final lenses are ordered, is discussed.

Introduction

At present there are seven manufacturers of toric soft contact lenses. The specific methods for determining the initial prescription are well delineated by each manufacturer. When the actual lenses are dispensed, however, the patient's vision is often worse than with the spectacle correction, and the patient and clinician are both disappointed. This discussion will review the methods by which the optimal toric lens prescription can be determined.

Methods and materials

Table I lists the toric soft lens manufacturers and the corresponding methods by which their lenses are marked for identifying the cylinder axis. The methods of indicating toric lens axes are varied and include scribe lines, engraved dots, laser trace, and truncation.

Three factors can cause visual acuity with toric lenses to be worse than with the spectacle correction: 1) the original refraction may be incorrect; 2) the lens provided by the manufacturer may not be the exact prescription ordered; or 3) the lens may rotate to an unpredicted position. The first of these errors is corrected simply by repeating the refraction. However, the second two errors are often difficult to determine, the major cause of error being unpredicted lens orientation.

Verification of either spherical or toric soft contact lens prescriptions is not practical for the clinician. Two methods are available for measuring these lenses, but they are quite inaccurate. Further, neither method is consistently capable of accuracy better than ±1 diopter.

The first method is to immerse the lens in a transparent chamber containing saline and measure the power with a lensometer. The measured value in saline is then multiplied by a conversion factor of approximately 4.5 to determine the power of the lens in air. Any error in the transparent chamber measurement will also be multiplied by the same conversion factor, so that a 0.25 D error in the lensometer reading would result in over 1.00 D of error for the calculated lens power in air.[1] The second technique involves blotting the lens surface dry and placing it on a lensometer.[2] The poor stability and clarity of the image obtained with a soft lens in this state make consistent readings difficult.

The final possibility, and the most common problem, is that the lens has rotated to an unpredicted position. Table II lists various methods by which this rotation angle can be measured for any toric lens. The rotation of the toric lens to an unpredicted position is the most common explanation for the reduction in visual acuity with a toric lens. The stability of the lens orientation determines the variability of visual acuity.

Discussion

Unstable and blurred vision with toric lenses is quite frustrating for both patient and clinician, and these factors have been the major deterrents to prescribing

Table I Soft toric contact lenses

Manufacturer	Spherical power	Cylindrical power	Markings for axis determination
American Hydron			
Hydron Toric	−20 to +20	−0.50 to −6.00	Truncation
Hydron Zero T	Plano to −5	−0.75 to −2.00	Truncation
Barnes Hind:			
Hydrocurve II	−6.00 to +3.00	−1.25, −2.00	One dot or scribe mark at 6 o'clock (daily wear). Three scribe marks 20° apart center at 6 o'clock (extended wear)
Bausch & Lomb:			
Bausch & Lomb Toric	−6.00 to +4.00	−0.75, −1.25, −1.75	Three scribe marks 30° apart at 6 o'clock
Ciba Vision Care:			
Torisoft	Plano to −6.00	−1.00, −1.75	3 and 9 o'clock scribe marks
Optech, Inc.:			
Freflex Toric	−20.00 to +20.00	Plano to −5.00	6 o'clock dot
Vistakon, Inc.:			
Hydromarc Toric	−5.00 to +4.00	−0.75 to −2.00	6 o'clock dot
Wesley Jessen:			
Durasoft TT Standard	−20 to +20	−1.25, −2.00	Truncation
Durasoft Custom	−20 to +20	−0.75 to −4.00	Truncation
Durasoft 2	−20 to +20	−0.75 to −2.50	Truncation

toric lenses. Although the original refraction is repeatable, verification of the toric lens power and the determination of axis rotation are difficult and time consuming. It is imperative that the manufacturers make available a reliable system for verifying soft lens power so that the clinician easily can measure this parameter.

Most manufacturers do not measure soft lens powers in the hydrated state but calculate them from the lens power fabricated in the dehydrated state. Although this method may result in some error, mislabeling the power of the lens by the manufacturer is not the most common problem. The remainder of our discussion will be limited to the more important problem of unpredicted rotation with a toric lens.

As seen in Table II, the methods available for estimating the rotation of the toric lens are quite varied. We have found that an eyepiece reticule graduated in 5° increments, although moderately expensive, is quite accurate for determining toric lens orientation. The reduction in visual acuity is dependent on both the power of the cylinder and the amount of rotation. Once the angle of the unexpected rotation is determined, the standard method of subtracting the counterclockwise rotation angle from the original prescription or adding a clockwise rotation angle to the original prescription should be done.[3]

Table II Methods for measuring toric soft lens orientation

1. Estimation by clock hour (30° = 1 clock hour)
2. Graduated reticule in the slit lamp eyepiece
3. Alignment of the slitlamp beam with markings on the lens (degrees of rotation read from base of slit lamp or other supplementary scale)
4. Projected photographic technique with slit lamp using film or video
5. Calculate from a spherocylindrical over-refraction
6. A marked plano lens in a trial frame

We have found, however, that refracting over the toric lens and using a programmable calculator allows us a second, equally accurate, measure of the rotation angle. The over-refraction is repeated to determine the variation in this angle. It is well known that lens rotation is a result of the dynamic interaction of many factors, including corneal curvature, lens parameters, amount and type of astigmatism, lid fissure size, tear film, and movement of the lids across the lens. We have found that for a given patient this rotation may be quite variable. The amount of variation is helpful in determining the possible futility of continued prescription modification. The patient is asked to wear the over-refraction in a trial frame to allow him to experience the variation in vision due to rotation. In order to demonstrate this variability in vision the cylinder power of the soft lens used must be near that of the final lens dispensed.

Demonstrating this variation to the patient is necessary, although patients differ in their tolerance of variable visual acuity. It also is important to explain to the patient that fluctuating vision is caused by the lens rotation. This explanation in many cases reassures the patient that it is not a result of a poorly fit lens. Further, it saves the clinician many contact lens changes in the future for a problem that is not an error in the prescription.

A number of small, hand-held programmable calculators are available to take the over-refraction and the power of the trial toric lens and compute the cylinder axis of the final toric lens.[4] We have simply modified the formulae for the solution of obliquely crossed-cylinders for this purpose.[5] We have found that measuring the rotation angle and repeating the over-refraction not only determines the stability of the lens axis, but also confirms the new prescription. When these values are contradictory it is often a result of the variation in the rotation in the toric lens.

The obliquely crossed-cylinder program is useful for over-refraction with spherocylindric spectacles as well as toric contact lenses. A complete listing of the program is shown in the appendix for the Texas Instruments Model 59 calculator along with specific clinical examples for spectacles and contact lenses.

Summary

Toric soft lenses have provided a new modality in the correction of astigmatic refractive errors. The inability of the clinician to verify the power of the contact lens continues to be a minor source of error in obtaining the appropriate toric lens prescription. The major source of error, the orientation angle, can be determined by many techniques but should be confirmed by calculation using the over-refraction and a simple programmable calculator. Using these techniques a greater number of successful toric contact lenses prescriptions can be obtained, reducing the frustration levels of both the clinician and the patient.

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APPENDIX I: SPECTACLE CALCULATIONS

Example 1: Aphakic spectacles

Present Rx: +10.00 +2.00 × 165°
Over-refraction: + 1.00 +1.00 × 15°

10.	S1	Present Rx
2.	C1	
165.	A1	
1.	S2	Over-refraction
1.	C2	
15.	A2	
11.18	SPH	True refractive error
2.65	CYL	
175.	AXIS	

In this example, an over-refraction is performed over the patient's present aphakic spectacles. Because the axes of the cylinders are oblique, the resultant prescription can only be obtained by an obliquely crossed cylinder solution. The relationship is as follows:

True Refractive Error = Present Rx + Over-refraction

Since the refraction is done over the patient's own spectacles, the resultant prescription will be at the vertex of the present spectacles. If the frames are not changed, there is no need to consider the vertex distance in contrast to the vertex calculations necessary with the phoropter or trial frame.

Example 2: High myopic spectacles

Present Rx: −10.00 +3.00 × 105°
Over-refraction: − 1.00 +1.00 × 150°

−10.	S1	Present Rx
3.	C1	
105.	A1	
−1.	S2	Over-refraction
1.	C2	
150.	A2	
−10.58	SPH	True refractive error
3.16	CYL	
114.	AXIS	

In this example, a patient with high myopia and astigmatism is over-refracted. The resultant prescription would be ordered as −10.50 +3.12 × 114°. The computer prints the resultant prescription to an accuracy of 0.01 D. The prescription should be rounded off to the nearest one-eighth or one-quarter of a diopter to avoid confusion.

APPENDIX II: TORIC CONTACT LENS CALCULATIONS

In using the program for toric contact lenses the problem is totally different. In this situation the "present" prescription is not known due to a rotation in the lens axis. In this case, however, the true refraction and the over-refraction are known, and the present Rx can be calculated as follows:

True refractive error = Present Rx + Over-refraction

and solving for present Rx:

Present Rx = True refractive error − Over-refraction

In short, the effective toric lens is equal to the true refractive error *minus* the over-refraction.

Therefore, when using the program for a toric contact lens, one must enter the true refractive error and subtract the over-refraction by entering the *negative* of the sphere and cylinder of the over-refraction to determine the effective toric lens, as shown in Examples 3-5.

Example 3: Toric contact lens that has rotated 20° clockwise

Refractive error:	−4.00 +4.00 × 150°
Over-refraction:	−1.37 +2.75 × 5°

−4.	S1	True refractive error
4.	C1	
150.	A1	
1.37	S2	*Negative* of the Over-refraction
−2.75	C2	
5.	A2	
−4.01	SPH	Effective toric lens
4.00	CYL	
130.	AXIS	

In this example, the true refractive error and the negative of the sphere and cylinder of the over-refraction are entered. The result is therefore the effective toric lens. Notice the sphere and cylinder are identical to the required original true refraction, but the axis is 130° instead of 150°. A new lens should be ordered with an axis 20° greater than the original prescription to compensate for this rotation. Therefore, the new toric lens ordered should be −4.00 +4.00 × 170°, twenty degrees greater than the true refractive error to compensate for the clockwise rotation.

Example 4: Toric contact lens that has rotated 20° counter-clockwise.

Refractive error:	−3.00 +5.00 × 25°
Over-refraction:	−1.75 +3.50 × 170°

−3.	S1	True refractive error
5.	C1	
25.	A1	
1.75	S2	*Negative* of the Over-refraction
−3.5	C2	
170.	A2	
−3.01	SPH	Effective toric lens
5.03	CYL	
45.	AXIS	

Once again, notice the sphere and cylinder are identical to the original refraction, but the axis is 45°. The contact lens has therefore rotated 20° counter-clockwise beyond the desired axis. The new toric lens order should be −3.00 +5.00 × 5°, twenty degrees less than the true refractive error to compensate for the counter-clockwise rotation.

Example 5: Toric contact lens which is mislabeled causing erroneous results.

Refractive error:	−4.00 +4.00 × 150°
Over-refraction:	−1.25 +1.75 × 180°

−4.	S1	True refractive error
4.	C1	
150.	A1	
1.25	S2	*Negative* of the Over-refraction
−1.75	C2	
180.	A2	
−3.36	SPH	Effective toric lens
3.47	CYL	
137.	AXIS	

Notice the sphere and cylinder of the effective toric lens are not equal to the true refraction. When this occurs it means *either* that the original true refraction is incorrect or the contact lens power is incorrect. Since an accurate check of the soft toric lens power is difficult, the refraction should be repeated first. If this agrees with the original refraction, the toric lens must not conform to the ordered specifications. In short, if the effective toric lens sphere and cylinder do not equal the original refraction, the error is *not* from lens rotation but is an error in the manufacturer's labeling of lens powers.

APPENDIX III: OBLIQUELY CROSSED-CYLINDER SOLUTION PROGRAM

000	76	LBL	013	02	2	026	04	4	039	02	2	052	69	OP
001	11	A	014	02	2	027	05	5	040	69	OP	053	04	04
002	42	STO	015	07	7	028	69	OP	041	03	03	054	69	OP
003	01	01	016	69	OP	029	02	02	042	03	3	055	05	05
004	22	INV	017	01	01	030	03	3	043	06	6	056	01	1
005	86	STF	018	02	2	031	06	6	044	03	3	057	05	5
006	01	01	019	07	7	032	00	0	045	06	6	058	04	4
007	25	CLR	020	01	1	033	00	0	046	01	1	059	05	5
008	69	OP	021	03	3	034	01	1	047	07	7	060	02	2
009	00	00	022	01	1	035	05	5	048	01	1	061	07	7
010	02	2	023	06	6	036	03	3	049	06	6	062	69	OP
011	03	3	024	01	1	037	05	5	050	00	0	063	01	01
012	03	3	025	03	3	038	03	3	051	00	0	064	02	2

065	04	4	132	03	3	199	94	+/−	266	00	0	333	06	6
066	03	3	133	00	0	200	42	STO	267	00	0	334	03	3
067	01	1	134	02	2	201	10	10	268	00	0	335	03	3
068	01	1	135	69	OP	202	43	RCL	269	00	0	336	02	2
069	06	6	136	04	04	203	01	01	270	00	0	337	03	3
070	01	1	137	43	RCL	204	42	STO	271	00	0	338	69	OP
071	07	7	138	03	03	205	07	07	272	00	0	339	04	04
072	03	3	139	69	OP	206	43	RCL	273	01	1	340	43	RCL
073	05	5	140	06	06	207	02	02	274	95	=	341	16	16
074	69	OP	141	91	R/S	208	42	STO	275	42	STO	342	58	FIX
075	02	02	142	76	LBL	209	08	08	276	12	12	343	02	02
076	03	3	143	16	A′	210	43	RCL	277	43	RCL	344	69	OP
077	06	6	144	42	STO	211	03	03	278	11	11	345	06	06
078	03	3	145	04	04	212	42	STO	279	55	÷	346	22	INV
079	02	2	146	03	3	213	09	09	280	43	RCL	347	58	FIX
080	02	2	147	06	6	214	43	RCL	281	12	12	348	87	IFF
081	07	7	148	00	0	215	04	04	282	95	=	349	01	01
082	04	4	149	03	3	216	42	STO	283	22	INV	350	03	03
083	01	1	150	69	OP	217	01	01	284	30	TAN	351	67	67
084	69	OP	151	04	04	218	43	RCL	285	85	+	352	43	RCL
085	03	03	152	43	RCL	219	05	05	286	01	1	353	14	14
086	03	3	153	04	04	220	42	STO	287	08	8	354	65	×
087	07	7	154	69	OP	221	02	02	288	00	0	355	02	2
088	02	2	155	06	06	222	43	RCL	289	95	=	356	95	=
089	04	4	156	91	R/S	223	06	06	290	55	÷	357	94	+/−
090	03	3	157	76	LBL	224	42	STO	291	02	2	358	85	+
091	02	2	158	17	B′	225	03	03	292	95	=	359	43	RCL
092	03	3	159	42	STO	226	43	RCL	293	42	STO	360	05	05
093	01	1	160	05	05	227	07	07	294	13	13	361	85	+
094	00	0	161	01	1	228	42	STO	295	43	RCL	362	43	RCL
095	00	0	162	05	5	229	04	04	296	10	10	363	02	02
096	69	OP	163	00	0	230	43	RCL	297	75	−	364	95	=
097	04	04	164	03	3	231	08	08	298	43	RCL	365	42	STO
098	69	OP	165	69	OP	232	42	STO	299	13	13	366	17	17
099	05	05	166	04	04	233	05	05	300	95	=	367	01	1
100	98	ADV	167	43	RCL	234	43	RCL	301	38	SIN	368	05	5
101	03	3	168	05	05	235	09	09	302	33	X^2	369	04	4
102	06	6	169	69	OP	236	42	STO	303	65	×	370	05	5
103	00	0	170	06	06	237	06	06	304	43	RCL	371	02	2
104	02	2	171	91	R/S	238	43	RCL	305	05	05	372	07	7
105	69	OP	172	76	LBL	239	10	10	306	95	=	373	69	OP
106	04	04	173	18	C′	240	65	×	307	42	STO	374	04	04
107	43	RCL	174	42	STO	241	02	2	308	14	14	375	43	RCL
108	01	01	175	06	06	242	95	=	309	43	RCL	376	17	17
109	69	OP	176	01	1	243	38	SIN	310	13	13	377	58	FIX
110	06	06	177	03	3	244	65	×	311	38	SIN	378	02	02
111	91	R/S	178	00	0	245	43	RCL	312	33	X^2	379	69	OP
112	76	LBL	179	03	3	246	05	05	313	65	×	380	06	06
113	12	B	180	69	OP	247	95	=	314	43	RCL	381	22	INV
114	42	STO	181	04	04	248	42	STO	315	02	02	382	58	FIX
115	02	02	182	43	RCL	249	11	11	316	95	=	383	87	IFF
116	01	1	183	06	06	250	43	RCL	317	85	+	384	01	01
117	05	5	184	69	OP	251	10	10	318	43	RCL	385	03	03
118	00	0	185	06	06	252	65	×	319	14	14	386	95	95
119	02	2	186	98	ADV	253	02	2	320	95	=	387	43	RCL
120	69	OP	187	43	RCL	254	95	=	321	42	STO	388	13	13
121	04	04	188	06	06	255	39	COS	322	14	14	389	85	+
122	43	RCL	189	75	−	256	65	×	323	85	+	390	43	RCL
123	02	02	190	43	RCL	257	43	RCL	324	43	RCL	391	03	03
124	69	OP	191	03	03	258	05	05	325	01	01	392	95	=
125	06	06	192	95	=	259	95	=	326	85	+	393	42	STO
126	91	R/S	193	42	STO	260	85	+	327	43	RCL	394	15	15
127	76	LBL	194	10	10	261	43	RCL	328	04	04	395	01	1
128	13	C	195	29	CP	262	02	02	329	95	=	396	08	8
129	42	STO	196	77	GE	263	85	+	330	42	STO	397	00	0
130	03	03	197	02	02	264	93	•	331	16	16	398	32	$X \gtrless T$
131	01	1	198	38	38	265	00	0	332	03	3	399	43	RCL

400	15	15
401	22	INV
402	77	GE
403	04	04
404	14	14
405	43	RCL
406	15	15
407	75	−
408	01	1
409	08	8
410	00	0
411	95	=
412	42	STO
413	15	15
414	01	1
415	03	3
416	04	4
417	04	4
418	02	2
419	04	4
420	03	3
421	06	6
422	69	OP
423	04	04
424	43	RCL
425	15	15
426	58	FIX
427	00	00
428	69	OP
429	06	06
430	22	INV
431	58	FIX
432	43	RCL
433	17	17
434	29	CP
435	77	GE
436	04	04
437	65	65
438	98	ADV
439	43	RCL
440	17	17
441	85	+
442	43	RCL
443	16	16
444	95	=
445	42	STO
446	16	16
447	43	RCL
448	17	17
449	94	+/−
450	42	STO
451	17	17
452	43	RCL
453	15	15
454	85	+
455	09	9
456	00	0
457	95	=
458	42	STO
459	15	15
460	86	STF
461	01	01
462	61	GTO
463	03	03
464	32	32
465	91	R/S
466	00	0
467	00	0
468	00	0
469	00	0
470	00	0
471	00	0
472	00	0
473	00	0
474	00	0
475	00	0
476	00	0
477	00	0
478	00	0
479	00	0