SOUTHERN COLLEGE OF OPTOMETRY

Corneal Sagitta as a Predictor of Final Scleral Contact Lens Sagitta

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PURPOSE

The purpose of this study is to evaluate the relationship between corneal sagitta and the final scleral contact lens sagitta for non-surgical and post-operative corneas.

INTRODUCTION

Multiple studies have assessed the relationship of various corneal and scleral shape factors.[1-5] Comparisons between regular and irregular corneal shapes suggest there are some consistent findings which may provide a basis for initial scleral contact lens selection.[1,6-11] Studies are lacking which test the selection of initial scleral lens selection based on proposed rules of thumb though some have tried to intuitively apply biometric data from existing evidence.[2,6,12-14] Fit success is crucial for both patient satisfaction and practitioner efficiency. This study evaluates the association between corneal sagittal height and scleral lens sagittal height to improve fit success using Oculus Pentacam AXL (Oculus Inc., Arlington, WA).

METHODS

Retrospective study design using contact lens invoices and Pentacam AXL database. Subjects were excluded if they were seen outside the review period, had less than 6 months of successful wear, had missing Pentacam AXL data or unintelligible QS values, where lens sagitta was either unknown or measured to the transition zone rather than overall diameter.

Non-surgical and post-operative eyes were analyzed separately. Outcome variables assessed included Q-value; e-value; sag in flat and steep meridians at the 10mm chord; Flat, steep, mean (Km) and Kmax topography values; lens BC, sag and overall diameter (OAD). Surgical history and demographic data were collected. Data from both eyes were pooled for analysis after determining there was no statistically significant difference between eyes for the outcome measures. Data was tested for normalcy of its distribution by Shapiro-Wilk test.

RESULTS

The cohort consisted of 92 subjects (N=84 right eyes, N= 82) left eyes, and females to males (44:48). Mean age of subjects was 41.1 ± 12.5 (18 to 70 years). There were (N= 138 eyes) in the non-surgical group and (N= 38 eyes) in the surgical group. Outcome variables are presented in Table 1. Correlations between variables were tested *(Tables 2 and 3)*. Linear regressions were performed for non-surgical and post-op groups *(Figures 1 and 2)*.

TABLE 1: RESULTS OF RETROSPECTIVE ANALYSIS

Outcome	Non-surgical Group	Post-op Group
Flat K (D)	54.68+ 10.96 (range 30.2 to 80.3)	54.15 + 10.87 (range 30.2 to 80.3)
Steep K (D)	59.23 + 11.96 (range 42.1 to 9.9)	58.78 + 11.80 (range 42.1 to 92.9)
Kmax (D)	67.88 + 15.05 (range 42.2 to 111.0)	67.04 + 67.04 (range 42.2 to 111.0)
Astigmatism (D)	4.55 + 3.09D (range 0.10D to 5.81D)	7.61D + 5.11 (range 2.5 to 20.4)
Q-value	-1.04 + 0.81 (range -2.53 to 1.33)	0.27+ 1.16 (range -1.48 to 1.94)
e-value	0.84 + 0.54 (range -1.10 to 1.59)	-0.25 + 0.82 (range -1.13 to 1.03)
Sag in flat meridian 10mm chord (µm)	2014 + 257 (range 1617 to 2783)	2008 + 359 (range 1262 to 2372)
Sag in steep meridian 10mm chord (µm)	2095 + 286 (range 1603 to 3002)	2116 + 431 (range 1299 to 2624)
Diameter (mm)	15.9 + 0.6 (range 14.8 to 17.0)	15.9 + 0.5 (range 14.8 to 17.0)
Base Curve (mm)	7.74 + 0.5 (range 6.56 to 8.65)	7.64 + 1.03 (range 6.25 to 10.0)
Final Sag (µm)	4538 + 644 (range 5 to 6300)	4806 + 798 (range 3786 to 6119)
Correlation between final lens sag and flat meridian sag at the 10mm chord		
Pearson's r	0.35	0.82
Spearman's rs	0.34	0.82
Kendall's tau	0.24	0.64

TABLE 2: CORRELATION NON-SURGICAL GROUP

	Q-Value	Eccentricity	Flat 10mm	Steep 10mm	Mean 10mm	Flat K	Steep K	Astig	Kmax	Km	Base Curve	Diameter	Sag
Q-Value	–	-0.957	-0.136	-0.256	-0.216	-0.703	-0.675	-0.083	-0.645	-0.698	-0.008	0.022	0.091
	–	-0.988	-0.279	-0.379	-0.335	-0.743	-0.728	-0.265	-0.712	-0.742	0.049	-0.008	0.034
	–	-0.933	-0.183	-0.265	-0.231	-0.544	-0.523	-0.179	-0.511	-0.545	0.043	-0.003	0.025
Eccentricity	-0.957	–	0.013	0.160	0.098	0.595	0.569	0.065	0.515	0.590	0.095	-0.014	-0.142
	-0.988	–	0.220	0.332	0.281	0.694	0.677	0.207	0.665	0.691	0.022	0.029	-0.044
	-0.933	–	0.144	0.232	0.192	0.504	0.491	0.173	0.470	0.500	-0.020	0.019	-0.030
Flat 10mm	-0.136	0.013	–	0.879	0.954	0.736	0.716	0.147	0.682	0.733	-0.510	-0.008	**0.351**
	-0.279	0.220	–	0.906	0.954	0.797	0.792	0.241	0.733	0.801	-0.489	-0.041	**0.339**
	-0.183	0.144	–	0.730	0.828	0.602	0.601	0.198	0.535	0.610	-0.399	-0.030	**0.238**
Steep 10mm	-0.256	0.160	0.879	–	0.865	0.774	0.787	0.302	0.754	0.786	-0.506	0.016	0.307
	-0.379	0.332	0.906	–	0.880	0.803	0.816	0.313	0.799	0.813	-0.485	-0.023	0.308
	-0.265	0.232	0.730	–	0.700	0.617	0.626	0.223	0.568	0.631	-0.353	-0.018	0.226
Mean 10mm	-0.216	0.098	0.954	0.865	–	0.771	0.778	0.253	0.750	0.780	-0.520	0.038	0.350
	-0.335	0.281	0.954	0.880	–	0.797	0.821	0.328	0.770	0.811	-0.502	0.017	0.354
	-0.231	0.192	0.828	0.700	–	0.602	0.628	0.228	0.575	0.632	-0.373	0.009	0.253
Flat K	-0.703	0.595	0.736	0.774	0.771	–	0.965	0.143	0.917	0.993	-0.342	0.017	0.193
	-0.743	0.694	0.797	0.803	0.797	–	0.969	0.225	0.912	0.994	-0.346	-0.029	0.234
	-0.544	0.504	0.602	0.617	0.602	–	0.854	0.146	0.747	0.940	-0.244	-0.020	0.147
Steep K	-0.675	0.569	0.716	0.787	0.778	0.965	–	0.191	0.944	0.989	-0.345	0.046	0.207
	-0.728	0.677	0.792	0.816	0.821	0.969	–	0.424	0.942	0.987	-0.347	-0.014	0.224
	-0.523	0.481	0.601	0.626	0.628	0.854	–	0.292	0.802	0.907	-0.245	-0.011	0.145
Astig	-0.083	0.065	0.147	0.302	0.253	0.143	0.191	–	0.375	0.256	-0.118	0.111	0.112
	-0.265	0.257	0.241	0.313	0.328	0.225	0.424	–	0.424	0.308	-0.104	0.131	0.106
	-0.179	0.173	0.198	0.213	0.228	0.146	0.292	–	0.305	0.209	-0.069	0.106	0.074
Kmax	-0.645	0.515	0.682	0.754	0.750	0.917	0.944	0.375	–	0.937	-0.329	0.084	0.204
	-0.712	0.665	0.733	0.759	0.770	0.912	0.942	0.424	–	0.927	-0.334	0.045	0.226
	-0.511	0.470	0.535	0.568	0.575	0.747	0.802	0.305	–	0.773	-0.234	0.035	0.144
Km	-0.698	0.590	0.733	0.786	0.780	0.993	0.989	0.256	0.937	–	-0.345	0.030	0.199
	-0.742	0.691	0.801	0.813	0.811	0.994	0.987	0.308	0.927	–	-0.344	-0.030	0.203
	-0.545	0.500	0.610	0.631	0.621	0.940	0.917	0.209	0.773	–	-0.243	-0.020	0.140
Base Curve	-0.008	0.056	-0.510	-0.506	-0.520	-0.342	-0.345	-0.118	-0.329	-0.345	–	-0.036	-0.520
	0.049	-0.022	-0.489	-0.485	-0.502	-0.345	-0.347	-0.104	-0.334	-0.344	–	-0.104	-0.663
	0.043	-0.020	-0.399	-0.353	-0.373	-0.244	-0.245	-0.069	-0.234	-0.243	–	-0.084	-0.501
Diameter	0.022	-0.014	-0.008	0.016	0.038	0.017	0.046	0.111	0.084	0.030	-0.036	–	0.239
	-0.008	0.029	-0.041	-0.023	0.017	-0.029	-0.014	0.131	0.045	-0.030	-0.104	–	0.349
	-0.003	0.019	-0.030	-0.018	0.009	-0.020	-0.011	0.106	0.035	-0.020	-0.084	–	0.274
Sag	0.091	-0.142	0.351	0.307	0.350	0.193	0.207	0.112	0.204	0.199	-0.520	0.239	–
	0.034	-0.044	0.339	0.308	0.354	0.214	0.214	0.106	0.216	0.203	-0.663	0.349	–
	0.025	-0.030	0.238	0.216	0.293	0.147	0.145	0.074	0.144	0.140	-0.501	0.274	–

Pearson's r
Spearman's rs
Kendall's tau

TABLE 3: CORRELATION POST-OP GROUP

	PO Q-Value	PO Eccentricity	Flat 10mm	Steep 10mm	Mean 10mm	PO Flat K	PO Steep K	PO Km	PO Kmax	PO Base Curve	PO Diameter	PO Sag	PO Astig
PO Q-Value	–	-0.929	0.407	0.518	0.504	-0.561	-0.397	-0.439	0.103	-0.607	0.029	0.305	0.524
	–	-0.906	0.394	0.745	0.515	-0.442	0.055	-0.261	0.261	-0.717	0.057	0.455	0.491
	–	-0.809	0.289	0.556	0.422	-0.422	0.111	-0.289	0.244	-0.494	0.025	0.378	0.422
PO Eccentricity	-0.929	–	-0.187	-0.334	-0.263	0.664	0.430	0.603	0.107	0.435	0.041	-0.089	-0.303
	-0.906	–	-0.140	-0.559	-0.280	0.565	0.274	0.496	0.030	0.555	-0.015	-0.243	-0.274
	-0.809	–	-0.090	-0.360	-0.225	0.494	0.090	0.360	-0.045	0.341	0.000	-0.180	-0.225
Flat 10mm	0.407	-0.187	–	0.961	0.928	0.486	0.773	0.632	0.916	-0.884	0.321	**0.822**	0.524
	0.394	-0.140	–	0.782	0.964	0.406	0.867	0.624	0.891	-0.742	0.340	**0.818**	0.588
	0.289	-0.090	–	0.644	0.867	0.289	0.733	0.422	0.778	-0.529	0.221	**0.644**	0.422
Steep 10mm	0.518	-0.334	0.961	–	0.895	0.358	0.671	0.504	0.879	-0.607	0.383	**0.822**	0.552
	0.745	-0.559	0.782	–	0.794	0.139	0.576	0.358	0.770	-0.985	0.365	**0.794**	0.418
	0.556	-0.360	0.644	–	0.600	0.022	0.467	0.156	0.689	-0.944	0.270	**0.644**	0.333
Mean 10mm	0.504	-0.263	0.928	0.895	–	0.248	0.714	0.457	0.823	-0.753	0.423	**0.891**	0.781
	0.515	-0.280	0.964	0.794	–	0.236	0.770	0.455	0.842	-0.748	0.340	**0.830**	0.709
	0.422	-0.225	0.867	0.600	–	0.156	0.600	0.289	0.644	-0.594	0.221	**0.689**	0.556
PO Flat K	0.561	0.664	0.486	0.358	0.248	–	0.794	0.967	0.672	-0.281	0.140	0.332	0.222
	-0.442	0.565	0.406	0.139	0.236	–	0.636	0.952	0.479	-0.201	0.013	0.273	-0.261
	-0.422	0.494	0.289	0.022	0.156	–	0.467	0.857	0.333	-0.090	0.025	0.200	-0.200
PO Steep K	0.397	0.430	0.773	0.671	0.714	0.794	–	0.922	0.937	-0.490	0.471	0.778	0.425
	0.055	0.274	0.867	0.576	0.770	0.636	–	0.806	0.903	-0.523	0.308	0.733	0.430
	0.111	0.090	0.733	0.467	0.600	0.467	–	0.600	0.778	-0.405	0.221	0.556	0.333
PO Km	-0.429	0.603	0.632	0.504	0.457	0.967	0.922	–	0.808	-0.382	0.286	0.535	0.043
	-0.261	0.456	0.624	0.358	0.455	0.952	0.806	–	0.685	-0.389	0.208	0.515	-0.055
	-0.289	0.360	0.422	0.156	0.289	0.867	0.600	–	0.467	-0.225	0.172	0.333	-0.067
PO Kmax	0.103	0.107	0.916	0.879	0.823	0.672	0.937	0.808	–	-0.750	0.523	0.867	0.477
	0.261	0.030	0.891	0.770	0.842	0.479	0.903	0.685	–	-0.742	0.541	0.867	0.552
	0.244	-0.045	0.778	0.689	0.644	0.333	0.778	0.467	–	-0.629	0.417	0.689	0.467
PO Base Curve	-0.607	0.435	-0.884	-0.917	-0.753	-0.281	-0.490	-0.382	-0.750	–	-0.252	-0.566	-0.376
	-0.717	0.555	-0.742	-0.985	-0.748	-0.201	-0.523	-0.389	-0.742	–	-0.328	-0.748	-0.340
	-0.494	0.341	-0.529	-0.944	-0.594	-0.090	-0.405	-0.225	-0.629	–	-0.198	-0.584	-0.270
PO Diameter	0.029	0.041	0.321	0.383	0.423	0.140	0.471	0.286	0.523	-0.252	–	0.757	0.552
	0.057	-0.015	0.340	0.365	0.340	0.013	0.308	0.208	0.541	-0.328	–	0.686	0.371
	0.025	0.000	0.221	0.270	0.221	0.025	0.221	0.172	0.417	-0.198	–	0.564	0.270
PO Sag	0.305	-0.089	0.822	0.822	0.891	0.332	0.778	0.535	0.867	-0.666	0.757	–	0.761
	0.455	-0.243	0.818	0.794	0.830	0.273	0.733	0.515	0.867	-0.748	0.686	–	0.624
	0.378	-0.180	0.644	0.644	0.689	0.200	0.556	0.333	0.689	-0.584	0.564	–	0.511
PO Astig	0.524	-0.303	0.524	0.552	0.781	-0.222	0.425	0.043	0.477	-0.376	0.552	0.761	–
	0.491	-0.274	0.588	0.418	0.709	-0.261	0.430	-0.055	0.552	-0.340	0.371	0.624	–
	0.422	-0.225	0.422	0.333	0.556	-0.200	0.333	-0.067	0.467	-0.270	0.270	0.511	–

Pearson's r
Spearman's rs
Kendall's tau

FIGURE 1:
NON-SURGICAL GROUP

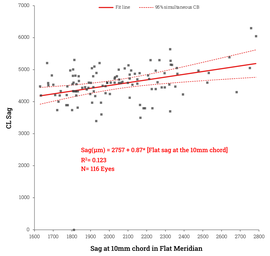
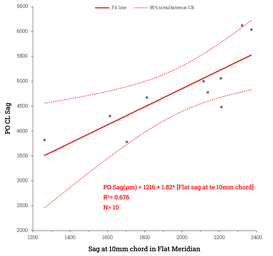


FIGURE 2:
NON-SURGICAL GROUP



DISCUSSION

Practitioners are challenged to accurately select first trial lenses. Chair time reduces profitability and fatigues patients when multiple lenses must be trial fit. This study demonstrates a linear relationship between final SL sag and the corneal sag at the 10mm chord in the flat meridian which is significantly different for non-surgical and post-operative corneas. There is a low to moderate degree of correlation between these two variables consistent with other studies.[10,15,16] Weber et al found positive correlations between lens sagittal depths and anterior chamber depth using a Pentacam and derived similar linear regression formulae for keratoconus patients to predict the scleral lens fit.[8]

Unique combinations of corneal-scleral curvatures and shapes confound creation of a universal equation for initial lens selection.

This study does reflect a broad cross section of moderate to advanced keratoconus patients encountered in a real world clinical setting.

LIMITATIONS

- Retrospective design
- Only subjects from outside the initial fitting period included
- Limited number of lens designs
- Various definitions of lens sag by manufacturers
- Wide variations in underlying pathologies, curvatures and corneal topography
- Not all subject files contained all outcome measures
- Linear regression limited to the 10 mm corneal chord
- Small sample size for post-operative eyes

CONCLUSIONS

Corneal sagittal height, determined by Pentacam AXL at the 10mm chord may be useful for predicting the final scleral contact lens sagitta for both non-surgical and post-operative corneas.

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