Refractive and Visual Outcomes in Unilateral Duane Retraction Syndrome: Influence of Ocular Motility

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Abstract

Objectives: To compare the refractive profiles and clinical characteristics of affected and fellow eyes in unilateral Duane retraction syndrome (DRS), emphasize subtype-related variations, and assess the impact of motility restriction and ocular findings on refractive status.

Materials and Methods: This retrospective cross-sectional study included 191 patients with unilateral DRS, comprising type I (n=162), type II (n=7), and type III (n=22). Best-corrected visual acuity (BCVA), cycloplegic autorefraction, astigmatism classification, and ocular alignment/motility findings were analyzed across DRS subtypes.

Results: The mean age at examination was 6.67±7.13 years, and 62.3% of the patients were female. Amblyopia was observed in 23.0% of patients, anisometropia in 18.6%, and abnormal head posture in 52.7% of patients. Esotropia (42.0%) was more prevalent than exotropia (11.7%), and the majority of patients (61.4%) exhibited grade 4 horizontal limitation. Compared with fellow eyes, DRS eyes exhibited a substantially lower BCVA ($p<0.001$), higher spherical power ($p=0.025$), and greater cylindrical power ($p<0.001$). In both DRS (60.7%) and non-DRS (72.3%) eyes, the predominant pattern was with-the-rule astigmatism. There were no discernible variations in astigmatism subtypes among motility limitation grades or DRS subtypes. The cylindrical refractive error was independently associated with abnormal head posture ($p=0.007$) and horizontal deviation type ($p=0.029$) according to multiple regression analysis.

Conclusion: Unilateral DRS is characterized by diminished visual function and increased refractive error, with cylindrical outcomes affected by head posture and type of deviation. The findings highlight the importance of integrating motility parameters into refractive evaluation and surgical planning in DRS.

Keywords: Duane retraction syndrome, refraction, astigmatism, ocular motility

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Introduction

Duane retraction syndrome (DRS) is a rare congenital cranial dysinnervation and ocular motility disorder characterized by anomalous innervation of the lateral rectus muscle by branches of the oculomotor nerve in the setting of an absent or hypoplastic abducens nerve.[1] This miswiring leads to a limitation in horizontal movement, most commonly in abduction, accompanied by globe retraction and narrowing of the palpebral fissure on attempted adduction. Vertical gaze abnormalities, particularly upshoots and downshoots, may present as associated clinical features. Based on electromyographic findings, Huber[2] classified DRS into three subtypes: Type I, characterized by limited abduction with near-normal adduction; Type II, defined by limited adduction with near-normal abduction; and Type III, which presents with limitations in both abduction and adduction.

The refractive error profile of DRS consistently demonstrates astigmatism, most commonly with-the-rule (WTR) as the predominant finding, whereas against-the-rule

(ATR) and oblique astigmatism show variable distribution across subtypes.[3] Khorrami-Nejad et al.[4] reported that affected eyes in unilateral DRS exhibited higher levels of astigmatism compared with fellow eyes in a large patient cohort. In contrast, Yuzbasıoglu et al.[5] found no significant differences in spherical, cylindrical, or spherical equivalent values, and further showed that the grade of ocular motility restriction was not significantly correlated with refractive errors, suggesting that restriction severity alone does not determine refractive status. Nevertheless, characteristic subtype-specific patterns, such as an increased prevalence of ATR in Types II and III, indicate that motility profiles may be associated with distinct refractive configurations.[3]

While movement restriction grade has been analyzed previously,[5] the potential influence of additional ocular motility findings, such as vertical deviation and type of horizontal deviation as well as abnormal head posture, on refractive status has not been systematically evaluated. In this study, we aimed to assess refractive errors and clinical characteristics in a large cohort of unilateral DRS patients, comparing affected and fellow eyes, identifying subtype-specific differences, and examining the combined effects of movement restriction grade and other ocular motility findings on refractive components.

Materials and Methods

Patient Selection

We retrospectively reviewed the medical records of patients diagnosed with DRS at Dokuz Eylül University Hospital, İzmir, between January 2000 and January 2024. Patients with a confirmed diagnosis were eligible for inclusion, while those with a history of ocular or cranial trauma, prior ocular surgery, high ametropia (spherical equivalent > ±6.00 diopter [D]), or other ocular/systemic disorders that could affect refractive status or ocular motility (e.g., keratoconus, thyroid eye disease, neuromuscular disorders) were excluded. Patients with high ametropia were not included because extreme refractive values may disproportionately influence the overall distribution and introduce instability in regression analyses. This approach was adopted to enable a more homogeneous assessment of refractive patterns specific to DRS. Patients with incomplete or inconsistent ophthalmologic examination data were also excluded. Demographic data and ophthalmic examination findings were collected from the records.

This study followed the Declaration of Helsinki, with approval from the Dokuz Eylül University Institutional Research Ethics Committee (decision no 2024/42-30, dated December 18, 2024). Informed consent was waived due to the retrospective nature of the study.

Ophthalmic Examination

All patients underwent a comprehensive ophthalmological examination, including best-corrected visual acuity (BCVA), slit-lamp biomicroscopy, fundus examination, and ocular motility assessment. BCVA was measured using a Snellen chart at a distance of 4 meters. Cycloplegic autorefraction was performed with a Nidek ARK-530 device 30 minutes after instillation of 1% cyclopentolate in both eyes, and measurements included sphere, cylinder, and axis values. For consistency of analysis, all cylindrical values were converted to the positive cylinder format, and subsequent calculations were performed using these values. Astigmatism was classified as WTR (steep meridian within 90±30 degrees), ATR (steep meridian within 180±30 degrees), or oblique (steep meridian outside WTR and ATR ranges). The spherical equivalent was calculated as the spherical value plus half of the cylindrical value. Anisometropia was defined as an interocular spherical equivalent difference of at least one D, and amblyopia was defined as a BCVA difference of two or more lines between the eyes or a BCVA of 20/30 or worse in either eye.

Ocular motility was evaluated with duction and version testing. In cooperative patients, ocular alignment was assessed using the prism cover test at both distance (6 m) and near (40 cm) in primary gaze. In younger or uncooperative children, alignment was evaluated using the Hirschberg or Krimsky methods. The manifest horizontal deviation in the primary gaze position was used for analysis. Primary and secondary deviations were not analyzed separately. Strabismus was defined as a manifest horizontal deviation greater than 5 prism D, while vertical deviation was defined as hypertropia or hypotropia greater than 2 prism D. Although these thresholds were used for clinical classification, quantitative deviation measurements were not consistently available for all patients; therefore, deviation magnitude was not included in the statistical analyses. Patients with no observable deviation in primary position were considered orthotropic. Patients were classified according to the Huber classification system (Types I-III), as described above. In addition to Huber's original classification, an exotropic variant Type IV, described in subsequent reports, was also included in the classification. This subtype is characterized by primary position exotropia with a compensatory contralateral head turn, full abduction, absent adduction, and simultaneous abduction of both eyes during contralateral gaze. The presence of upshoots, downshoots, and abnormal head posture was recorded during orthoptic evaluation.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as mean ± standard deviation for continuous variables and as frequencies and percentages for categorical variables. The normality of data distribution was assessed using the Shapiro-Wilk test. Comparisons of continuous variables between the affected (DRS) and unaffected (non-DRS) eyes were conducted using paired samples t-tests for normally distributed data. Differences in categorical variables, such as astigmatism subtypes across groups, were analyzed using the chi-square test. For comparisons among more than two independent groups (e.g., refractive components across DRS subtypes), one-way analysis of variance (ANOVA) was employed for normally distributed variables, followed by Tukey's Honestly Significant Difference (HSD) post-hoc test when appropriate.

Associations between the grade of horizontal duction limitation and astigmatism subtype were evaluated using the chi-square test. To identify factors independently associated with cylindrical refractive error in the affected eye, a multiple linear regression model was constructed, incorporating ocular motility characteristics and other relevant clinical parameters as predictor variables. For multiple linear regression analysis, multicollinearity was assessed using variance inflation factor (VIF) values. Regression assumptions including linearity, homoscedasticity, and normality of residuals were evaluated using standard residual diagnostic plots. A p value <0.05 was considered statistically significant for all analyses.

Results

A total of 191 patients diagnosed with unilateral DRS were included in the analysis. The mean age at examination was 6.67±7.13 years (range: 1-35 years). Of the participants, 119 (62.3%) were female and 72 (37.7%) were male. The right eye was affected in 54 cases (28.3%), whereas the left eye was affected in 137 cases (71.7%). Regarding clinical subtype distribution, Type I was the most common, observed in 162 patients (84.8%), followed by Type III in 22 patients (11.5%) and Type II in 7 patients (3.7%).

Anisometropia was present in 33 patients (18.6%), and amblyopia was detected in 40 patients (23.0%). Abnormal head posture was observed in 99 patients (52.7%). Vertical deviation was present in 7 patients (3.7%). Regarding horizontal deviation patterns, 79 patients (42.0%) had esotropia and 22 patients (11.7%) had exotropia.

Regarding the degree of horizontal limitation, most patients (61.4%) had grade 4 abduction/adduction limitation, followed by grade 3 (17.5%), grade 2 (15.9%), and grade 1 (5.3%) limitation (n=189).

Refractive Characteristics Across DRS Subtypes

Among the refractive components, only the spherical values of the non-DRS eyes showed a significant difference across subtypes (p=0.019). Post-hoc analysis for the non-DRS eye sphere values revealed a statistically significant difference between Type I and Type III subgroups (p=0.023, Tukey HSD). No other pairwise comparisons reached statistical significance. Among DRS subtypes, the spherical equivalent in non-DRS eyes showed a trend toward significance (p=0.056). No other significant differences were identified across subtypes in terms of BCVA or refractive components in DRS eyes. A detailed comparison of visual acuity and refractive parameters between DRS and non-DRS eyes, as well as across unilateral DRS subtypes, is provided in Table 1.

In DRS eyes, WTR astigmatism was the most common pattern, observed in 82 cases (60.7%), followed by oblique astigmatism in 24 cases (17.8%) and ATR astigmatism in

Table 1. Analysis of visual acuity and refractive components across unilateral DRS subtypes

	Eye	Total (n=191) (Mean ± SD)	Type I (n=162) (Mean ± SD)	Type II (n=7) (Mean ± SD)	Type III (n=22) (Mean ± SD)	p
BCVA	DRS eye	0.84±0.23	0.84±0.21	0.90±0.15	0.77±0.30	0.374
	Non-DRS eye	0.92±0.14	0.91±0.13	1.00±0.00	0.93±0.14	0.235
Sphere	DRS eye	0.61±1.72	0.77±1.65	0.54±2.64	0.01±1.78	0.236
	Non-DRS eye	0.42±1.49	0.63±1.55	-0.12±0.78	-0.39±1.12	**0.019**
Cylinder	DRS eye	0.80±0.72	0.75±0.57	0.75±0.57	1.08±1.34	0.184
	Non-DRS eye	0.58±0.58	0.52±0.46	0.79±0.57	0.82±0.91	0.064
SE	DRS eye	1.01±1.73	1.14±1.70	0.91±2.60	0.55±1.61	0.425
	Non-DRS eye	0.71±1.49	0.90±1.58	0.27±0.69	0.01±1.01	0.056

DRS: Duane retraction syndrome, BCVA: Best-corrected visual acuity, SD: Standard deviation, SE: Spherical equivalent

29 cases (21.5%) (n=135). No significant difference was observed between the affected eyes of unilateral DRS types and astigmatism subtypes. Table 2 presents the relationship between DRS type and astigmatism subtype in the affected eye.

Comparison Between Affected and Fellow Eyes

Paired samples analysis demonstrated a statistically significant difference in BCVA between DRS and non-DRS eyes (0.84±0.23 vs. 0.92±0.14, p<0.001). The mean spherical power was significantly higher in DRS eyes compared to non-DRS eyes (0.67±1.73 D vs. 0.48±1.53 D, p=0.025). Similarly, the cylindrical power was significantly greater in DRS eyes than in non-DRS eyes (0.80±0.71 D vs. 0.58±0.55 D, p<0.001).

In DRS eyes, the most prevalent pattern was WTR astigmatism, identified in 82 cases (60.7%). In non-DRS eyes, WTR astigmatism was also predominant (72.3%), while ATR astigmatism and oblique patterns were found in 25 (19.2%) and 11 (8.5%) cases, respectively (n=130).

Impact of Ocular Motility Parameters on Astigmatism

The distribution of astigmatism subtypes was similar across ocular motility limitation grades, with WTR astigmatism being the most common in all grades, and the degree of limitation did not significantly affect subtype distribution, as shown in Table 3. To further explore the potential influence of ocular motility characteristics and related clinical factors on refractive cylinder magnitude in the DRS eye, multiple linear regression analysis was performed. The overall model was statistically significant (F=3.600, p=0.027), explaining 56.2% of the variance in cylindrical value (R^2=0.562; adjusted R^2=0.406). Abnormal head posture (β=0.754, p=0.007), and the type of horizontal deviation (esotropia/exotropia) (β=-0.622, p=0.029) were independently associated with cylindrical refractive error. In contrast, ocular motility restriction grade (p=0.117) and vertical deviation (p=0.051) did not reach statistical significance. Multicollinearity analysis showed acceptable values with VIF values ranging between 1.35 and 2.08. The results of the multiple linear regression analysis are presented in Table 4.

Discussion

This study evaluated refractive characteristics, visual acuity, and ocular motility parameters in a large cohort of patients with unilateral DRS. By analyzing both affected and fellow eyes and incorporating multiple ocular motility-related variables, we were able to identify factors independently associated with refractive error patterns. To our knowledge, no previous study has simultaneously assessed the influence of movement restriction grade, abnormal head posture, vertical deviation, and horizontal deviation type on refractive components in DRS.

Table 2. Astigmatism subtypes in affected eyes according to DRS classification

DRS type	WTR astigmatism n (%)	ATR astigmatism n (%)	Oblique astigmatism n (%)	Total n (%)
Type I	71 (62.8)	22 (19.5)	20 (17.7)	113 (100.0)
Type II	2 (33.3)	4 (66.7)	0 (0.0)	6 (100.0)
Type III	9 (56.3)	3 (18.8)	4 (25.0)	16 (100.0)
Total	82 (60.7)	29 (21.5)	24 (17.8)	135 (100.0)

p=0.078 represents the overall chi-square test comparing the distribution of astigmatism subtypes (WTR, ATR, oblique) across DRS subtypes. DRS: Duane retraction syndrome, ATR: Against-the-rule, WTR: With-the-rule

Table 3. Distribution of astigmatism subtypes based on limitation grade in DRS

Horizontal ocular motility limitation grade	WTR astigmatism n (%)	ATR astigmatism n (%)	Oblique astigmatism n (%)	Total n (%)	p
1	4 (66.7)	2 (33.3)	0 (0.0)	6 (100.0)	0.731
2	13 (59.1)	6 (27.3)	3 (13.6)	22 (100.0)	
3	16 (69.6)	4 (17.4)	3 (13.0)	23 (100.0)	
4	49 (58.3)	17 (20.2)	18 (21.4)	84 (100.0)	
Total	82 (60.7)	29 (21.5)	24 (17.8)	135 (100.0)	

p value represents the overall chi-square test comparing the distribution of astigmatism subtypes (WTR, ATR, oblique) across different grades of ocular motility limitation. DRS: Duane retraction syndrome, WTR: With-the-rule, ATR: Against-the-rule

Table 4. Multiple linear regression analysis of factors associated with cylindrical value in DRS eyes

Predictor variable	B (unstandardized)	SE	β (standardized)	t	p
Horizontal deviation	-0.429	0.176	-0.622	-2.438	**0.029**
Abnormal head posture	0.780	0.248	0.754	3.149	**0.007**
Vertical deviation	0.783	0.368	0.477	2.130	0.051
Ocular motility restriction grade	-0.199	0.119	-0.409	-1.671	0.117

Model statistics: R^2=0.562, Adjusted R^2=0.406, F=3.600, p=0.027. DRS: Duane retraction syndrome, SE: Standard error

In our cohort, only the spherical values of the non-DRS eyes differed significantly across DRS subtypes, with a difference between Type I and Type III, whereas other refractive parameters showed no variation. Khorrami-Nejad et al.[4] investigated refractive conditions and amblyopia rates in 582 patients with DRS and reported the highest hyperopic spherical values in Type I and the lowest in Type III in both DRS and non-DRS eyes. They also noted higher cylindrical values in Type II and Type III compared with Type I non-DRS eyes. In another study, Khorrami-Nejad et al.[3] compared astigmatism in 312 DRS patients and found similar spherical and cylindrical values between affected and fellow eyes in unilateral cases. They further showed that WTR astigmatism was more common in Type I DRS, whereas ATR astigmatism predominated in Type III.

These subtype-specific restriction patterns may influence binocular vision and visual development. Distinct visual inputs from each eye can result in discrepancies in refractive error in the fellow, non-DRS eye. To better understand the refractive error observed in these eyes, the role of emmetropization must be taken into consideration. Emmetropization is the developmental process by which the eye adjusts its optical power and axial length to reduce refractive error. It functions as an interocular rather than an entirely independent monocular process. Therefore, the emmetropization of one eye may be influenced by motility restriction in the other, potentially explaining the presence of refractive error in non-DRS eyes.[6,7] Moreover, strabismus itself may interfere with the normal course of emmetropization, further contributing to refractive anomalies.[8]

The spherical difference observed between Type I and Type III non-DRS eyes may also be theoretically related to convergence mechanisms and binocular vision. Marella et al.[9] investigated convergence in DRS subtypes and reported that patients with Type III DRS exhibited poorer convergence compared with those with Type I, and it was also observed that patients with DRS had poorer binocular vision than healthy individuals. However, as convergence was not assessed in our study, no direct conclusions can be drawn regarding this association.

We found that DRS eyes had significantly poorer visual acuity and higher spherical and cylindrical refractive errors than their fellow eyes, a difference that may be attributed to anisometropic and strabismic amblyopia. Consistently, the amblyopia rate in our study was in line with previous reports.[10,11] Fixation is generally favored by the dominant eye, primarily determined by ocular alignment and relative visual acuity, which may contribute to the observed interocular differences in refractive parameters.[12] According to our findings, the presence of DRS was associated with an increased risk of hypermetropia in the affected eyes relative to their contralateral counterparts. Kekunnaya et al.[13] reported similar results and additionally observed shorter axial lengths in DRS eyes. Khorrami-Nejad et al.[3] also reported lower BCVA and higher cylinder values in affected eyes compared with fellow eyes, consistent with our results. These findings may be explained by abnormal innervation patterns or concurrent activation of the horizontal recti in DRS, which may generate mechanical forces on the globe, leading to corneal deformation and astigmatism. Our hypothesis is that aberrant innervation, co-contraction of the horizontal rectus muscles, and globe retraction in DRS may indirectly affect the ocular surface and visual development, thereby contributing to refractive patterns. Nonetheless, since these factors were not statistically assessed in the current study, a direct causal relationship cannot be determined. Moreover, the shorter axial length commonly observed in affected eyes predisposes them to hypermetropic refractive errors. Young et al.[14] similarly reported higher astigmatism values in DRS eyes compared to non-DRS eyes. However, Yuzbasıoglu et al.[5] found no significant differences in spherical or cylindrical refractive errors between DRS and non-DRS eyes. Given the congenital nature of DRS, early initiation of care and consistent follow-up in children may be particularly important for the timely detection and management of refractive errors and amblyopia.

In this study, WTR astigmatism was the most common subtype in both DRS and non-DRS eyes, with no significant difference in distribution. A previous study reported higher rates of WTR astigmatism in Type I DRS eyes and higher rates of ATR astigmatism in Type II and Type III DRS eyes.[3] However, Young et al.[14] demonstrated that DRS eyes exhibited higher rates of ATR astigmatism, while WTR astigmatism occurred at similar frequencies. Additionally, oblique astigmatism was found to be more prevalent in DRS eyes compared with fellow eyes.

Wang et al.[15] conducted a large-scale study of 21,415 children aged 5-13 years and found that WTR astigmatism was the most common pattern, whereas ATR and oblique astigmatism were less frequently observed. These results are consistent with our findings. Other researchers have proposed that increased eyelid pressure may also influence astigmatism and corneal topography.[16] Osaki et al.,[17] for example, investigated patients with hemifacial spasm and showed that botulinum toxin type A treatment reduced astigmatism by temporarily decreasing eyelid tension, thereby lessening the mechanical interaction between the cornea and eyelids. Based on this rationale, one might expect a higher prevalence of different astigmatism types in DRS and its subtypes compared with healthy individuals. Nevertheless, our findings were consistent with those reported in the general healthy population. The absence of a notable difference in astigmatism subtype distribution may suggest that DRS-related mechanical factors, including globe retraction, palpebral fissure narrowing, and horizontal rectus co-contraction, are inadequate alone to modify the overall astigmatic axis pattern, or that their effects may be mitigated by individual variations in corneal and lenticular components. However, it should be noted that the cylindrical values obtained by autorefractometry reflect total astigmatism. In the absence of corneal topographic measurements, the corneal and lenticular components of astigmatism could not be distinguished. Therefore, interpretations regarding mechanical effects should not be regarded as direct evidence, but rather as possible pathophysiological explanations.

Although the grade of ocular motility restriction did not significantly influence astigmatism subtype distribution, multiple linear regression analysis showed that abnormal head posture and the type of horizontal deviation were independently associated with cylindrical refractive error. The potential mechanism linking aberrant head posture to cylindrical refractive error may involve chronic compensatory head positioning, which may alter the habitual gaze position and the relationship between the eyelid and the cornea. In DRS, atypical head posture is mostly utilized to preserve binocular single vision and reduce diplopia; yet, extended non-primary gaze posture may alter palpebral fissure morphology, eyelid pressure distribution, and ocular surface biomechanics. These factors may contribute to changes in total astigmatism; however, the lack of corneal topography and quantitative head posture assessments in this investigation precludes the establishment of a direct causal relationship. There are limited studies in the literature examining changes in astigmatism and its subtypes in relation to ocular motility restriction. Yuzbasıoglu et al.[5] found no significant differences in astigmatism among different levels of movement restriction, consistent with our results. Abnormal head posture plays a crucial role in enabling DRS patients to sustain binocular vision, and it was observed in 52.7% of our patients, a rate comparable to previous reports.[18,19] Yeniad and Gezer[20] investigated the association between corneal topography and abnormal head posture in DRS and hypothesized that abnormal head position may result from distortions in corneal contour and lid structure, thereby reducing astigmatism and improving visual acuity.

In 2011, the Multi-Ethnic Pediatric Eye Disease Study and the Baltimore Pediatric Eye Disease Study Groups examined 9,970 children aged 6 to 72 months and established a correlation between astigmatism and strabismus, particularly exotropia.[21] The relationship between strabismus and astigmatism has also been investigated in studies assessing refractive errors before and after horizontal muscle surgery. Karakosta et al.[22] reported that astigmatism may increase or shift its axis toward WTR astigmatism. These results may underscore the importance of careful surgical planning, as the potential risk of postoperative astigmatism progression must be considered. Accordingly, the main contribution of our study is not merely to demonstrate the presence of refractive error but to identify its association with cylindrical refractive error and specific motility-related clinical features, particularly abnormal head posture and horizontal deviation type.

Study Limitations

The retrospective design may have introduced selection bias. Additionally, visual acuity measurements were analyzed in their original decimal (Snellen) format as documented in the medical records, rather than being converted to logarithm of the minimum angle of resolution values. Although age was initially included in the regression model, it was not found to be an independent predictor of cylindrical refractive error. Nevertheless, the wide age range may still influence refractive development, including emmetropization and astigmatic axis changes, and should be considered when interpreting the results. Moreover, the absence of corneal topography data limits our ability to distinguish whether the source of astigmatism is corneal or lenticular in origin. Therefore, the corneal origin of the observed astigmatism could not be directly demonstrated, and the interpretations regarding mechanical effects should be considered speculative and limited to possible pathophysiological explanations.

Another limitation is the absence of precise measurement of the degree of abnormal head posture, as well as the lack of a quantitative analysis assessing its correlation with refractive error. Furthermore, the distribution of participants across DRS subtypes was not well balanced, which may have reduced the robustness of subtype-specific comparisons. In addition, refractive examinations were performed at a single time point, precluding evaluation of longitudinal changes in refractive status. Patients with high ametropia were excluded to reduce the influence of extreme refractive values and improve the interpretability of regression analyses; however, this may limit the generalizability of the findings to DRS patients with high ametropia. Standardized quantitative deviation measurements and consistent documentation of the fixing/dominant eye were also unavailable, preventing analysis of deviation magnitude and potentially affecting the interpretation of visual acuity outcomes and interocular comparisons. Although affected-fellow eye comparisons partially controlled for individual variability, the fellow eye cannot be considered a fully independent healthy control; therefore, the findings should be interpreted primarily as interocular differences. Finally, as the study was conducted in a single tertiary referral center, the findings may not be fully generalizable to broader populations.

Conclusion

This study confirms that unilateral DRS eyes tend to exhibit poorer visual acuity and greater refractive error magnitude compared to fellow eyes, with WTR astigmatism being the predominant subtype in both. While movement restriction grade alone was not associated with astigmatism type, abnormal head posture and horizontal deviation type emerged as independent predictors of cylindrical refractive error. These findings underscore the importance of a comprehensive evaluation of ocular motility parameters when assessing refractive status in DRS, with potential implications for both refractive correction strategies and surgical planning.

Ethics

Ethics Committee Approval: This study followed the Declaration of Helsinki, with approval from the Dokuz Eylül University Institutional Research Ethics Committee (decision no 2024/42-30, dated December 18, 2024).

Informed Consent: Informed consent was waived due to the retrospective nature of the study.

Declarations

Authorship Contributions

Surgical and Medical Practices: A.Y., A.T.B., Concept: B.H.Ü., Ö.U.F., C.D.E., Design: B.H.Ü., Ö.U.F., C.D.E., Data Collection or Processing: B.H.Ü., Analysis or Interpretation: B.H.Ü., C.D.E., Literature Search: B.H.Ü., Writing: B.H.Ü., Ö.U.F., C.D.E., A.Y., A.T.B.

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