Original Article

Ocular structural changes in patients with Duane retraction syndrome: Does a correlation exist?

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Purpose: The purpose of this study was to investigate the structural changes (axial length, central macular thickness (CMT), subfoveal choroidal thickness, and keratometry) in subjects with unilateral Duane retraction syndrome (DRS) as compared with the normal fellow eye. **Methods:** In this prospective study, we included 34 subjects with unilateral DRS from January 2016 to December 2016 seen at our institute. Data was collected for axial length, keratometry using partial coherence interferometry, CMT, subfoveal choroidal thickness using the enhanced depth imaging-optical coherence tomography (EDI-OCT). All these measurements were compared between the affected and fellow eye. **Results:** During this period, we included 34 subjects with unilateral DRS (22 Type I, 1 Type II, and 11 Type III). The mean age (±SD) of subjects was 14 ± 8 years (range: 5–28 years). There were 15 males and 19 females. Eyes with DRS were significantly shorter (median axial length 22.4 mm, interquartile range (IQR): 21.56 - 23.17) as compared to fellow eye (median axial length 22.7 mm, IQR: 22.35-23.55), $P = 0.04$. Choroidal thickness, CMT, and average keratometry were similar in DRS and fellow eyes ($P = 0.39$, 0.06, and 0.11, respectively). A significant difference in axial length was found only between Type I and Type III DRS ($P = 0.03$). **Conclusion:** This study suggests that in subjects with DRS, the affected eye has shorter median axial length when compared with the fellow eye. Prevalence of refractive error in eye with DRS was higher compared to fellow eye. But, there was no difference in magnitude of refractive error found between eye with DRS and normal fellow eye.

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Duane retraction syndrome (DRS) is a congenital cranial dysinnervation disorder (C2D2), which results from the absence of normal innervation and a misinnervation of the lateral rectus muscle by the oculomotor nerve.[1-3] Based on the electrophysiological studies, Huber classified DRS into three types.[4] Type I DRS is characterized by limitation of abduction, Type II DRS presents with limitation of adduction and Type II DRS has a limitation of both adduction and abduction. All types of DRS are characterized by a reduction in the palpebral fissure height on attempted adduction which results from co-contraction of the lateral and medial rectus on attempted adduction.[5] Prior studies have shown that eye affected with DRS has a higher tendency for hypermetropia.[6,7] The reasons for this hypermetropic refractive error is still questionable. One plausible hypothesis might be that hypermetropia might be secondary to mechanical stress secondary to globe retraction, however, it needs to be investigated.

We carried out this study to investigate the structural changes in subjects with unilateral DRS as compared with the normal fellow eye and to investigate if any correlation existed between structural changes and refractive error in subjects with DRS.

Methods

This was a prospective study conducted at L V Prasad Eye Institute, Hyderabad during the period Jan 2016–Dec 2016. Prior institutional review board approval was taken from the IRB of our institute and the study adhered to the tenets of the Declaration of Helsinki. Informed consent was obtained from all the subjects before enrolling in the study. We included subjects older than 5 years of age with unilateral DRS Type I, II, or III. We excluded younger children (who are unlikely to cooperate for these measurements, subjects with high myopia (>-6.0 D), which influences retinal and choroidal thickness measurements), uncooperative subjects and subjects whose parents refused to give informed consent.

We enrolled consecutive subjects with unilateral DRS meeting the inclusion and exclusion criteria in our study. All subjects underwent comprehensive eye examination along with detailed squint evaluation and cycloplegic retinoscopy. Spectral

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-domain OCT (SD-OCT) (Cirrus OCT, Carl Zeiss Meditec, Dublin Germany) was performed and enhanced depth imaging-optical coherence tomography (EDI-OCT) was used to measure the choroidal and central macular thickness (CMT) by two masked examiners three times randomly (2 examiners took these readings on the same day at the same time). Axial length (AL) and keratometry (K) readings were performed using optical biometry (LENSTAR LS 900, Haag-Streit, Ohio USA).

Statistical analysis was performed using IBM SPSS statistics for windows, version 20. Normality of the data was tested using the Kolmogorov–Smirnov test (KS test). AL, keratometry, choroidal thickness, and CMT were compared between the eye with DRS and fellow eye by using Mann–Whitney U test. As there was only one subject with Type II DRS, it was excluded from subgroup analysis and Mann–Whitney test was used to compare the differences in structural parameters between Type I and Type III DRS. Kruskal–Wallis test is used to compare the difference between DRS Type I, Type III, and Normal eyes. Interobserver and intraobserver repeatability for subfoveal choroidal thickness and macular thickness were compared using concordance cross-correlation.

Results

During the study period, 34 subjects were included in the study, of which 22 subjects had DRS Type I, 11 were Type III, and 1 subject had Type II. The mean age (±SD) of subjects was 14 ± 8 years (5–28 years). There were 15 males and 19 females.

As seen in Table 1, eyes with DRS were significantly shorter (median axial length 22.4 mm, interquartile range (IQR): 21.56 - 23.17) as compared to fellow eye (median axial length 22.7 mm, IQR: 22.35-23.55), P =0.04. This explains a greater prevalence of hypermetropic refractive error in the eye with DRS (median: 0.25 D, IQR: -0.75 D to + 0.68 D) as compared to the normal eye, (median: Plano, IQR: - 0.68 to Plano). Distribution of refractive error among DRS eyes vs. normal eyes is provided in Table 2. The percentage of eyes with hyperopic refractive error was higher in the group with DRS (26.47%) compared to normals (14.70%). The total prevalence of refractive error is higher in the group with DRS Type III (75%) opposed to Type 1 (50%) [Fig. 1] was the amount of the refractive error did not show a statistically significant difference between eyes with Type I, Type III, control and combined (Type I and Type III together) DRS (P > 0.05). CMT, subfoveal choroidal thickness, and mean keratometry were similar in DRS and fellow eyes (P = 0.06, 0.39, and 0.11, respectively).

Subgroup analysis to compare structural parameters of the effected eye between Type I and Type III DRS showed a significant difference in axial length measurement between Type I and Type III DRS (P = 0.03) [Table 3]. There were no other differences in any of the parameters that were measured. Concordance cross-analysis showed good intra-observer repeatability (0.98 and 0.97 for macular thickness and choroidal thickness measurements, respectively) and interobserver variability (0.92 and 0.97 for macular thickness and choroidal thickness measurements, respectively).

Discussion

Although it is well known that DRS is a congenital cranial dysinnervation disorder (C2D2) and clinical characteristics of the disease are well reported, there is limited literature characterizing the structural differences in the eyes with DRS.

Similar to the previous studies, this study suggests that eyes with DRS are more likely to be hypermetropic.[6,7] The median refractive error in the DRS eyes was slight hypermetropic as compared to normal eyes. Kirkham *et al*.[6] reported in their series of 110 subjects, 90 (82%) subjects had a hypermetropia of > +1.5 D. In addition, 26 (23.6%) subjects had a refractive error ranging from + 4 to + 8 D sphere.

In a previous publication from our institute,[8] 139 (31.5%) cases had hypermetropia or hyperopic astigmatism, while 98 (22.2%) cases had myopia or myopic astigmatism, and 11 (2.5%) cases had a myopic refractive error in one eye and hypermetropia in the other eye. Thus, hypermetropia was observed in about 34% of the eyes of DRS in that series. In this study, the difference in the median refractive error did not reach statistical significance possibly due to sample size.

Further looking into the possible pathophysiology of the hypermetropia, this study suggests that eyes with DRS had shorter axial length compared to the contralateral normal eye. However, there was no statistically significant difference in the average keratometry. This suggests that the tendency of DRS eyes towards hypermetropia was secondary to the short axial

Table 1: The distribution of the ocular findings in our subjects in the eye with Duane retraction syndrome as compared to the normal fellow eye

	Eyes with DRS	Fellow eye	*P*
Axial length (mm)	22.45 (21.56-23.17)	22.73 (22.35-23.55)	0.04*
Keratometry, K (Diopter)	43.88 (43.27-44.71)	44.11 (42.94-44.81)	0.11
Central macular thickness, CMT (μm)	186 (179.2-193)	191.5 (181.2-200.5)	0.06
Choroidal thickness (μm)	379.5 (347.7-419)	377 (357-399)	0.39

Median with interquartile range (IQR) is provided. *Represents statistical significance

Table 2: The distribution of amount of the refractive error and the percentage of refractive error distribution in eyes with Duane retraction syndrome and normal eyes

Group	Median (IQR) (Diopter)	Myopes	Hyperopia	Emmetropia
Total (Type I, and Type III)	0.25 (-0.75D to +0.68)	32.35%	26.47%	41.76%
Type I DRS	0.25 (-0.68D to +0.5)	27.27%	22.73%	50%
Type III DRS	0 (-0.75D to +1.37)	41.66%	33.33%	25%
Normals	0 (-0.68D to plano)	23.52%	14.70%	61%

Table 3: Shows the ocular changes of the eye with DRS in Type I and Type III DRS. Median with interquartile range (IQR) is provided

	Type I DRS, *n* = 22	Type III DRS, *n* = 11	*P*-value
Axial length (mm)	22.65 (22.37 to 23.39)	21.44 (21.1 to 21.9)	0.03*
Keratometry, K(Diopter)	43.80 (42.15 to 44.48)	44.1 (43.6 to 45.09)	0.387
Central macular thickness, CMT (μm)	186 (180 to 191.75)	187 (178.25 to 195)	0.564
Choroidal thickness (μm)	374.5 (356.25 to 397.75)	378.5 (359.2 to 409.5)	0.665

*Represents statistically significant value

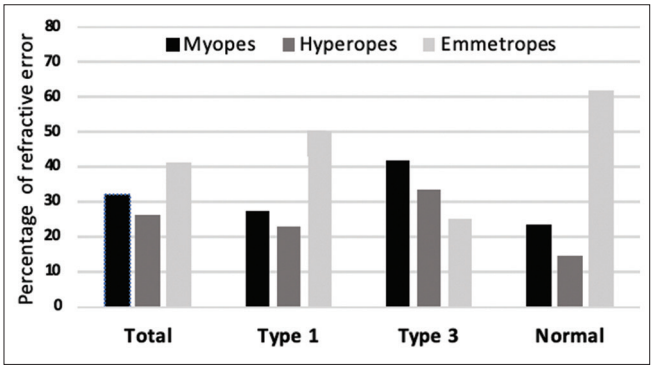

Figure 1: Distribution of the refractive error in all the groups of DRS and normals

length of these eyes. While this is expected but this has not been correlated before, and the authors hypothesize that this might result from the chronic structural changes in the eyeball secondary to the co-contraction of both lateral and medial rectus.

We also looked at the other structural changes such as in the CMT, and subfoveal choroidal thickness. Again, there is no prior literature comparing the CMT and subfoveal choroidal thickness in normal with DRS eyes. However, if we compare with the literature for CMT and subfoveal choroidal thickness among adults and children, it is observed that axial length and therefore refractive error tend to influence the subfoveal choroidal thickness. Chhablani *et al*.[9] reported that axial length had a negative correlation with the subfoveal choroidal thickness being more in hyperopic children. Yau *et al*.[10] studied CMT using swept-source OCT in 168 Chinese children aged 4–18 years. They also reported that the myopes had significantly thicker CMT (283.3 ± 57.3 μm, n = 56), than hyperopes (266.2 ± 55.31 μm, n = 60) and emmetropes (259.8 ± 28.7 μm, n = 52), P < 0.0001. They did not report any significant difference in CMT between hypermetropes and emmetropes.

Similarly, Jin *et al*.,[11] reported in a study on Chinese children that while subfoveal choroidal thickness was affected by the axial length with higher thickness in hyperopes, CMT was not significantly influenced by the axial length.

Given these perspectives from the existing literature, we expected a significant difference in the CMT but surprisingly there was no difference in the subfoveal choroidal thickness. This might be due to small sample size or due to ethnic variations. However, larger studies are needed to explore these observations.

Limitations of this study are small sample size, which precludes adequate representation of different subtypes of DRS. Despite these limitations, this study adds to the existing literature with new information on the structural parameters in subjects with DRS, and different subtypes of DRS. Further larger studies are needed to evaluate the differences in various structural parameters of eyes affected with DRS with normal eyes and different subtypes of DRS. Another aspect that might provide insight into these differences might be an analysis of the peripheral thickness of the retina at the muscle insertion with handheld imaging technology that may be helpful to understand the structural changes during the co-contraction.

Conclusion

This study showed a significant difference in axial length between Type I and Type III DRS. The possible explanation for this could be the eyes with Type III DRS are expected to have more tightness than type I DRS, which might lead to more structural changes in subjects with Type III DRS. This study did not show any other significant difference in refractive error. However, larger studies are needed to explore further these observations.

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Conflicts of interest

There are no conflicts of interest.

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