

Clinical features and surgical outcomes of Duane retraction syndrome in Turkish patients

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土耳其人 Duane 眼球后退综合征的临床特点及手术疗效分析

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摘要

目的: 分析 Duane 眼球后退综合征(DRS)患者的临床特点及手术疗效。

方法: 评估 94 例 DRS 患者临床数据。记录完整的眼科数据, 包括年龄、性别、侧位、DRS 类型、偏角、异常头部姿势(AHP)、眼球后退、过冲及手术入路类型。

结果: 患者年龄为 15.4±9.18 岁, 其中 78 例男性, 16 例女性。单侧和双侧受累分别为 87% 和 13%。在单侧 DRS 患者中, 左眼占 65%。94 例患者中, 59.5% 的患者为 I 型, 29.7% 的患者为 II 型, 8.5% 的患者为 III 型, 2.1% 的患者为 IV 型。大多数患者(36, 38%)为嗜热性, 43 例(96%)患者术前 AHP 出现 10° 以上。有 40 例(43%)患者出现过度调校, 通常为 II 型。对 45 例(48%)患者进行手术治疗。共 32 例(78%)行水平直肌手术后获得了较好疗效, 24 例

(53%)患者 AHP 改善。

结论: 侧直肌的 Y 分裂和后襻固定在有明显过校的情况下都有令人满意的结果。垂直直肌转位增强术在限制外展方面取得了最佳效果。

关键词: Duane 眼球后退综合征; 斜视; 手术; 结果

Abstract

• **AIM:** To analyze the clinical features and surgical outcomes of Duane retraction syndrome (DRS) patients.

• **METHODS:** The clinical data of 94 DRS patients were evaluated. Complete ophthalmic data including age, sex, laterality, the type of DRS, angle of deviation, abnormal head posture (AHP), globe retraction, overshoots and the type of surgical approach were recorded.

• **RESULTS:** The average age of patients was 15.4±9.18 years, and there were 78 males and 16 females. Unilateral and bilateral involvement were found in 87% and 13% of patients, respectively. In unilateral DRS patients, 65% left eyes predominance were observed. Of the 94 patients, 59.5% of the patients were type I, 29.7% of the patients were type II, 8.5% of the patients were type III and 2.1% of the patients were type IV. Most of the patients were 36 (38%) esotropic and AHP over 10° was noted in 43 (96%) patients, preoperatively. There were 40 (43%) patients with overshoots which were more common in type II. Surgery was performed to 45 (48%) patients.

• **CONCLUSION:** An excellent surgical outcome was obtained in 32 (78%) patients that underwent horizontal rectus surgery and AHP improved in 24 (53%) patients. Y-splitting and posterior tenon fixation of lateral rectus both have satisfactory outcomes in the presence of significant overshoots. Foster augmentation with vertical rectus transposition achieved optimal results in abduction limitation.

• **KEYWORDS:** Duane retraction syndrome; strabismus; surgery; outcome

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INTRODUCTION

The prevalence of Duane retraction syndrome (DRS) has been reported to account for 1% - 2% of strabismus

cases^[1]. This syndrome is characterized by the congenital absence or hypoplasia of the abducens nucleus and subsequent aberrant innervation of the lateral rectus (LR) muscle by branches of the oculomotor nerve^[2]. Diagnosis of DRS is based on typical clinical features, including limitation of abduction and adduction, globe retraction with narrowing of the palpebral fissure on adduction, abnormal head posture (AHP), and overshoots (up- or downshoots) in adduction. Four subtypes of DRS have been described: type I, abduction deficiency of the involved eye and esotropia (ET); type II, limitation of adduction in the involved eye and exotropia (XT); type III, limitation of both adduction and abduction of the involved eye; and simultaneous abduction (synergistic divergence) of the involved eye that is now considered as type IV^[3-4]. Most patients with DRS do not require surgery, if they can compensate well with a mild degree of head positioning^[5]. The main objectives of surgery in DRS are to improve AHP, overshoots, severe globe retraction, limitation of ductions and deviation in the primary position as well as to extent field of binocular single vision^[1,5-6]. Surgical management of DRS can be very challenging in different age groups because of a wide spectrum of diversity. Previous studies included DRS case series from different regions of the world^[4-5,7]. The purpose of this study was to characterize the clinical features of DRS patients and to analyze outcomes of different surgical procedures to understand what to do in DRS patients.

SUBJECTS AND METHODS

This retrospective observational study was approved by the Institutional Review Board of Gulhane School of Medicine. The study adhered to the tenets of the Declaration of Helsinki and informed consent of all subjects were obtained. Four-ninth patients who presented to the tertiary care hospital between 2001 and 2011 with diagnosis of DRS were included in the study. Exclusion criteria were previous strabismus surgery performed elsewhere, postoperative follow-up less than 6mo, patients with the history of orbital trauma. The surgery was performed to improve deviation in the primary position, limitation of ductions, significant overshoots, severe globe retraction and to reduce AHP to under 10° , as previously reported^[5-10]. The medical records of patients were reviewed to obtain the age at presentation, sex, laterality, best corrected visual acuity (BCVA) (assessed by Snellen letters, tumbling "E", or by fixation patterns), refractive errors in spherical equivalent (SE), angle of deviation (measured in primary position, vertical and side gaze positions), AHP (measured with hand-held orthopedic goniometer), palpebral fissure narrowing/ globe retraction, overshoots, the type of DRS, and follow-up durations. Intraoperative force duction test were performed in all cases at the beginning of the surgery. Unilateral medial rectus (MR) recession was performed ≤ 25 PD esotropia, bilateral MR recession was performed > 25 PD in primary position. Unilateral LR recession was performed < 25 PD exotropia, bilateral LR recession was performed ≥ 25 PD in primary position. Bilateral large (11-12 mm) LR recession were

performed in type 4 DRS patients. Simultaneous recession of the LR and MR was performed for severe globe retraction. Y-splitting of LR (with or without recession) and posterior tenon fixation of LR were performed for patients with significant overshoots. Posterior tenon fixation of LR procedure was performed by disinsertion of LR and fixation of its insertion to the tenon. Vertical rectus transposition (VRT) with Foster suture augmentation was performed in type 1 DRS patients with limited abduction. Inferior oblique myectomy was performed in the case of significant residual upshoot. Successful motor alignment was defined as residual deviation of ≤ 10 PD primary position, whereas poor result was defined as residual deviation of < 10 PD. Patients with significant overshoots (disappearing of cornea more than 1/2 of its vertical size in adduction of involved eye) and severe globe retraction (more than 50% reduction in palpebral aperture height from the center of the palpebral fissure width compared with that of the fellow eye in abduction) were operated.

Statistical Analysis The surgical approaches and outcomes obtained from DRS patients that underwent surgery were separately recorded. The data were analyzed using SPSS statistical software for Windows (version 13.0.1, SPSS, Chicago, IL, USA). Descriptive statistics were performed to examine the clinical features and treatment results of DRS patients. The measurement data were expressed as the mean \pm standard deviation, and descriptive data were expressed as the number and percentage.

RESULTS

Seventy-eight (83%) of 94 patients were male and 16 (17%) were female. The average age was 15.4 ± 9.18 (range: 1-57) years. Eighty-two (87%) patients had unilateral involvement and 12 (13%) patients had bilateral involvement. In the unilateral patients, 61 (65%) had left eye involvement and 21 (22%) had right eye involvement. The clinical features of the patients with DRS are shown in Table 1.

Of the 94 patients, 27 (29%) patients were orthotropic, 36 (38%) patients were esotropic, and 31 (33%) patients were exotropic in the primary position. In addition to horizontal deviation, 7 (16%) patients were hypertropic. The average initial angle of deviation of the primary position was 22.02 ± 13.01 (range: 0-60) prism diopters (PD). The average final angle of deviation was 4.87 ± 4.92 (range: 0-18) PD in the primary position. Surgery was performed to 45 (48%) patients. A successful surgical outcome was obtained in 32 (78%) patients and a poor outcome was found in 7 (22%) patients who were operated for horizontal deviation (patients underwent VRT and posterior tenon fixation excluded) ($P < 0.0001$). Forty-three (96%) patients had \geq AHP 10° preoperatively. Type III patients with AHP $\geq 10^\circ$ was less than type I and type II patients. Fissure narrowing/ globe retraction on adduction was detected in 93 (99%) patients. Upshoots were observed in 32 (34%) and downshoots were observed in 8 (9%) patients, respectively. There were 40 (43%) patients with overshoots which were more common in

Table 1 Epidemiological characteristics and clinical features of DRS patients

Characteristics	Type I	Type II	Type III	Type IV
Number of patients	56	28	8	2
Age, a	13.71±8.69 (1-25)	18.89±9.96 (5-57)	13.63±7.73 (4-21)	21±0.0 (21)
Gender (M/F)	46/10	26/2	4/4	2/0
Laterality				
Right eye	10	9	2	0
Left eye	39	17	3	2
Bilateral	7	2	3	0
Spherical equivalent (D)	0.42±1.7 (-5 - 6)	0.21±1.5 (-3 - 6)	0.66±1.49 (0-5)	2±0.00 (2-2)
BCVA	0.88±0.21 (0.1-1)	0.9±0.15 (0.5-1)	0.78±0.36 (0.1-1)	1±0.00 (1-1)
Amblyopia	9	2	2	0
AHP ≥10°	25	14	2	2
Upshoot	9	21	2	0
Downshoot	4	3	1	0
Esotropia	31	2	3	0
Exotropia	2	26	1	2
Orthotropia	18	2	7	0

AHP: Abnormal head posture; BCVA: Best corrected visual acuity; D: Diopter.

type II 24 (26%) as compared with type I 13 (14%) and type III 3 (3%) patients. Amblyopia was detected in 13 (14%) patients. Slipped muscle was observed in 1 (2%) patient with type I after left eye MR recession. The abduction improved in 7 (16%) patients treated with VRT (with Foster suture augmentation), however, abduction limitations were not completely eliminated. In this study, overshoots were eliminated with Y-splitting of LR (with or without recession) in 13 (29%) patients, posterior tenon fixation of LR in 2 (4%) patients. Five (11%) patients with overshoots required second surgery in addition to Y-splitting procedure for residual overshoots. In two patients, posterior fixation suture was added and in 3 patients IO myectomy was added to Y-splitting of LR procedure. Two (4%) patients surgically treated for severe globe retraction showed modest improvement. Postoperatively, in two patients palpebral fissure increased from 5 mm to 8 mm and 9 mm, respectively. Abnormal head position was improved in 24 (53%) of the 43 patients, postoperatively. The average follow-up period was 11.91±15.5 (range: 6-84) mo. At the last follow-up, 17 (38%) patients were orthotropic, 16 (36%) patients were esotropic, and 12 (27%) patients were exotropic in the primary position.

DISCUSSION

Previous studies compared the clinical characteristics and surgical results of three types of DRS involving an old classification^[4-5,7]. In the current study, young adults comprised the majority of patients different from the previous studies. Furthermore, this study involved four types of DRS patients according to the current classification. In a study by Kekunnaya *et al*^[10], the average age at presentation was 13.84 ±13.29 years (range: 5mo-72 years). In the present study, the average age was 15.4±9.18 (range: 1-57) years. To our knowledge, this study included more patients with higher ages

than any previous report. Most of the previous studies reported female dominance^[8,11-14]. However, some studies did not find any significant sex difference between DRS types^[14-15]. This study consisted of 83% male and 17% female that might be a result of being followed-up by a tertiary military hospital.

In previous DRS case series, left eye involvement was more prevalent, with the rates of 65.8%, 74%, and 83.3%, respectively^[8,14-15]. In this study, left eye involvement was 65%, which was comparable with the literature. Mohan *et al*^[8] and Park *et al*^[14] reported type I and type III more than other types of DRS patients. Kekunnaya *et al*^[11] reported mostly type I patients involved unilateral or bilateral cases, followed by type III patients. In contrast to other studies, type I (60%) and type II (30%) patients were the most common types in the present study. In this study population, there were more type II patients than previous studies, which may be due to the fact that patients are referred from around the country. There has been only one previous study that included four types of DRS, consisting of 51% type I, 23% type II, 20% type III, and 5% type IV patients^[4]. In this study, similar to the study of Schliesser *et al*^[4], unilateral type I and type II patients were more common than the other types of DRS.

In previous studies, bilaterality was reported in 2.6%-20% of DRS patients, with a greater prevalence of female patients^[8,14,16-17]. In this study, bilaterality of 12 (13%) the patients was comparable with the literature and bilaterality was found to be more prevalent in males similar to the study of Khan *et al*^[18] study. Mohan *et al*^[8] reported 88% type I and 8% mixed type (type I in one eye and type III in the other eye) DRS in bilateral patients. Khan *et al*^[18] reported more type I (68%) and type III (24%) in bilateral patients, with mixed type DRS in two (5%) patients. Kekunnaya *et al*^[11] reported mixed type DRS (3.8%) (type I in one eye and type

II in the other eye) in bilateral patients. In the current study, bilaterality was found 58% in type I, 8% in type II and 33% in type III DRS without mixed type, respectively. The amblyopia prevalence varied from 5% – 34% in DRS patients^[15-16,19-20]. In some studies, amblyopia was attributed to strabismus, and in other studies, the major amblyopiogenic factor was anisometropia^[16-17]. Amblyopia was found in 13 (14%) patients in the present study.

In previous case series, overshoots were mostly associated with types I–II DRS and types I–III DRS, involving 37.7%–67% of patients^[4-5,8,11,16]. In this study, overshoots were eliminated in 20 (44%) patients which were mostly associated with type I and type II DRS. In the present study, AHP $\geq 10^\circ$ was found in 43 (96%) of the 45 operated patients preoperatively, which was more frequent than previous reports^[15-16]. AHP was significantly less common in type II than type I and type III DRS patients^[11]. In this study, type III patients with AHP $\geq 10^\circ$ was less than type I and type II patients.

Previous studies reported various results for the preoperative angle of deviation in primary position. Zhang *et al*^[15] reported that 32.3% of the patients were orthotropic, 25.4% of the patients were esotropic, and 35.3% of the patients were exotropic in primary position. Isenberg *et al*^[20] reported 43% orthotropic, 28% esotropic, and 29% exotropic DRS patients in their study, respectively. Park *et al*^[14] reported that 59% of the patients were orthotropic, 17.9% of the patients were esotropic, and 23.1% of the patients exotropic in primary position. In the current study, the most common form of strabismus was esotropia in 36 (38%), exotropia in 31 (33%) patients, respectively. The least common presentation was orthotropia in 27 (29%) patients in contrast to previous studies. Surgical approach to these patients is challenging that there is no standard method for patients. Surgeons should individualize their approach based on the amount of ocular deviation, field of single binocular vision, AHP, globe retraction, and overshoots^[6-9,20].

In contrast to previous reports, we preferred unilateral MR recession for esotropia ≤ 25 PD in case of unpredictable results of tight MR recession in young adult ages. Resecting the LR muscle of the involved eye has been shown to improve the limited abduction in selected patients^[22]. We did not perform recession only on the normal eye and resection procedure to any extraocular muscle. In esotropic type I patients, VRT with or without Foster augmentation improved the abduction^[23]. Severe globe retraction in exotropic type II was managed by recession of the MR and LR of the involved eye^[24]. Kubota *et al*^[25] performed MR recession in 76 (58%) esotropic and LR recession in 48 (35.4%) exotropic patients and reported 89% success in both primary position and AHP. Kalevar *et al* reported excellent surgical outcome in 78% of patients and 75% improvement in AHP^[5]. The present study involved 20 (44%) exotropic and 12 (27%) esotropic patients that underwent horizontal rectus recession. After surgery, excellent (78%) and poor outcomes (22%) correspond most closely

with Kalevar *et al*^[5] study, postoperative AHP was 53%, which was lower than previous reports^[9]. Rao *et al*^[26] performed a Y–splitting of LR (with recession) in 10 patients (1 orthophoric, 4 esotropic and 5 exotropic patients). They also performed MR recession in six of these patients due to severe globe retraction. The average age of the patients was 9.9 ± 6.9 years, and the improvement in AHP, angle of deviation, and overshoots were reported in all patients, postoperatively^[26]. Eisenbaum *et al*^[27] reported performing posterior fixation suture (Faden operation) on the vertical and horizontal muscles to treat overshoots in patients with DRS. In contrast to the report by Parks and Mitchell, a study by Awadein^[28] reported that inferior oblique weakening improved upshoots in selected patients^[29]. In the present study, Y–splitting of the LR was performed in 17 patients (1 orthophoric, 2 hypertropic and 14 exotropic patients). Significant improvement was observed in 12 (88%) patients treated with Y – splitting of LR (with or without LR recession). For the residual overshoots, the posterior fixation suture was added in two patients and inferior oblique myectomy was added in 3 patients to Y – splitting of LR procedure. In light of the results of Eisenbaum *et al*^[27], posterior fixation suture was more effective in DRS to improve upshoots. However, no significant effect of inferior oblique myectomy was detected on the upshoots in the current study. Comparable with Heo study, 2 (4%) patients with upshoots were significantly improved with posterior tenon fixation of LR. Kekunnaya *et al*^[9] reported that recession of a tight LR could reduce severe globe retraction, but could also increase the angle of the ET. In this study, fair to poor outcomes were 22% that might be related with single MR recession for primary position deviation ≤ 25 PD esotropia, combined horizontal rectus recession of involved eye for severe globe retraction and large angle exotropia in type 4 DRS. Medial rectus was advanced in two patients due to increase of exotropia in one patient with severe globe retraction and the other patient with adduction deficit caused by slipped MR in type 1 DRS. Patients that underwent VRT (with Foster suture) achieved satisfactory ocular alignment and abduction improvement in type 1 patients. Currently, no surgical procedure has satisfactory outcome for type IV patients^[4]. Bilateral large LR recession was performed in two type IV patients in the present study. In both cases, there was significant improvement in AHP, however postoperatively the patients were exotropic more than 10 PD in the primary position. In the present study, there was no postoperative complication (anterior segment ischemia, new onset vertical or torsional deviation) and an additional MR recession requirement in patients treated with VRT^[10,23].

The study included here was limited by its retrospective nature. However, as in previous reports, the limitations involved objective measurement of the globe retraction, overshoots, and AHP. To our knowledge, this is the first study that included all DRS types with mostly adult Turkish population, with follow-up for at least 6mo.

In this study, the majority of patients treated with surgery were young adults. Despite this sample population, there was 78% success in the angle of deviation in primary position, and 53% improvement in AHP, postoperatively. Satisfactory outcomes were obtained with Y-splitting and posterior tenon fixation of LR in patients with overshoots. It is noteworthy that there is a risk of slipped muscle in a tight MR and an undercorrection of heterotropia in combined horizontal rectus recession for severe globe retraction. Satisfactory ocular alignment obtained in patients treated with VRT with Foster suture, however, abduction limitations were not completely eliminated.

REFERENCES

1 Aygit ED, Kocamaz M, Inal A, Fazil K, Ocak OB, Akar S, Gokyigit B. Management of Duane retraction syndrome with prismatic glasses. *Clin Ophthalmol* 2017;11:697-700

2 Xia S, Li RL, Li YP, Qian XH, Chong V, Qi J. MRI findings in Duane's ocular retraction syndrome. *Clin Radiol* 2014;69(5):e191-e198

3 Huber A. Electrophysiology of the retraction syndromes. *Br J Ophthalmol* 1974;58:293-300

4 Schliesser JA, Sprunger DT, Helveston EM. Type 4 Duane syndrome. *J AAPOS* 2016;20(4):301-304

5 Kalevar A, Ong Tone S, Flanders M. Duane syndrome: clinical features and surgical management. *Can J Ophthalmol* 2015;50(4):310-313

6 Barbe ME, Scott WE, Kutschke PJ. A simplified approach to the treatment of Duane's syndrome. *Br J Ophthalmol* 2004;88(1):131-138

7 Akbari MR, Manouchehri V, Mirmohammadsadeghi A. Surgical treatment of Duane retraction syndrome. *J Curr Ophthalmol* 2017;29(4):248-257

8 Mohan K, Sharma A, Pandav SS. Differences in epidemiological and clinical characteristics between various types of Duane retraction syndrome in 331 patients. *J AAPOS* 2008;12(6):576-580

9 Kekunnaya R, Kraft S, Rao VB, Velez FG, Sachdeva V, Hunter DG. Surgical management of strabismus in Duane retraction syndrome. *J AAPOS* 2015;19(1):63-69

10 Kekunnaya R, Negalur M. Duane retraction syndrome: causes, effects and management strategies. *Clin Ophthalmol* 2017;11:1917-1930

11 Kekunnaya R, Gupta A, Sachdeva V, Krishnaiah S, Venkateshwar Rao B, Vashist U, Ray D. Duane retraction syndrome: series of 441 cases. *J Pediatr Ophthalmol Strabismus* 2012;49(3):164-169

12 Bhate M, Sachdeva V, Kekunnaya R. A high prevalence of exotropia in patients with duane retraction syndrome in a tertiary eye care center in south india. *J Pediatr Ophthalmol Strabismus* 2017;54(2):117-122

13 Sarfraz S, Zafar SN, Khan A. Duane's syndrome: surgical outcome and non ophthalmologic associations. *J Ayub Med Coll Abbottabad* 2014;26(3):328-330

14 Park WH, Son DH, Yoon SW, Baek SH, Kong SM. The clinical features of Korean patients with Duane's retraction syndrome. *Korean J Ophthalmol* 2005;19(2):132-135

15 Zhang F. Clinical features of 201 cases with Duane's retraction syndrome. *Chin Med J* 1997;110(10):789-791

16 Anvari F, Hatf E, Mohammadi SF, Eskandari A. Duane's retraction syndrome, a case series from Iran. *Int Ophthalmol* 2008;28(4):275-280

17 Tredici TD, von Noorden GK. Are anisometropia and amblyopia common in Duane's syndrome? *J Pediatr Ophthalmol Strabismus* 1985;22(1):23-25

18 Khan AO, Oystreck D. Clinical characteristics of bilateral Duane syndrome. *J AAPOS* 2006;10(3):198-201

19 Sekeroglu HT, Turan KE, Sevim DG, Sanac AS, Arslan U, Sener EC. Functional amblyopia and deficient binocular vision as initial clinical features in Duane's syndrome. *Binocul Vis Strabolog Q Simms Romano* 2013;28(3):176-180

20 Isenberg S, Urist MJ. Clinical observations in 101 consecutive patients with Duane's retraction syndrome. *Am J Ophthalmol* 1977;84(3):419-425

21 Saunders RA, Wilson ME, Bluestein EC, Sinatra RB. Surgery on the normal eye in Duane retraction syndrome. *J Pediatr Ophthalmol Strabismus* 1994;31(3):162-169

22 Kraft SP. Lateral rectus resection strabismus surgery in unilateral duane syndrome with esotropia and limited abduction. *Binocul Vis Strabismus Q* 2010;25(3):149-157

23 Akar S, Gokyigit B, Pekel G, Demircan A, Demirok A. Vertical muscle transposition augmented with lateral fixation (Foster) suture for Duane syndrome and sixth nerve palsy. *Eye (Lond)* 2013;27(10):1188-1195

24 Sprunger DT. Recession of both horizontal rectus muscles in Duane syndrome with globe retraction in primary position. *J AAPOS* 1997;1(1):31-33

25 Kubota N, Takahashi H, Hayashi T, Sakaue T, Maruo T. Outcome of surgery in 124 cases of Duane's retraction syndrome (DRS) treated by intraoperatively graduated recession of the medial rectus for esotropic DRS, and of the lateral rectus for exotropic DRS. *Binocul Vis Strabismus Q* 2001;16(1):15-22

26 Rao VB, Helveston EM, Sahare P. Treatment of upshoot and downshoot in Duane syndrome by recession and Y-splitting of the lateral rectus muscle. *J AAPOS* 2003;7(6):389-395

27 Eisenbaum AM, Parks MM. A study of various surgical approaches for the leash effect in Duane's syndrome. The joint session of the American Association for Pediatric Ophthalmology and Strabismus and the American Academy of Ophthalmology. 1989;5

28 Awadein A. Inferior oblique myectomy for upshoots mimicking inferior oblique overaction in Duane retraction syndrome. *J AAPOS* 2013;17(3):253-258

29 Parks MM, Mitchell PR. *Ophthalmoplegic syndromes and trauma*. In: Tasman W, Jaeger E, eds. *Duane's Clinical Ophthalmology*. Vol. 1 Chap. 20 Revised ed. Philadelphia: Lippincott Williams & Wilkins, Philadelphia 1998;9-12